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**IBM Series/1
4963 Disk Subsystem
Description**

Preface

This manual contains the required information for the reader to operate and program the 4963 Disk Subsystem. It is intended as a reference for those with an interest in the physical characteristics and operation of the disk subsystem. It is assumed that the reader has a background in data processing operations and terminology and a working knowledge of binary and hexadecimal numbering systems. This manual describes the disk subsystem and its operation as a storage device designed for use with an IBM Series/1 processor. Chapter 1 describes the characteristics and capacities of the disk storage units, and the functions of the Series/1 4963 attachment feature.

Chapter 2 describes how data is arranged on the disk surfaces.

Chapter 3 describes how the processor transfers data to and from the disk subsystem. Included are descriptions of the Operate I/O instruction and its associated commands, status information, condition codes, error recovery procedure, and diagnostic operations.

Appendix A lists the I/O Commands, the control words for the Start and Start Cycle Steal

Diagnostic commands, the cycle steal status words, condition codes, and status interrupt information.

Prerequisite Publications

- *IBM Series/1 System Summary*, GA34-0035
- *IBM Series/1 4955 Processor and Processor Features Description*, GA34-0021, or
- *IBM Series/1 4953 Processor and Processor Features Description*, GA34-0022, or
- *IBM Series/1 4952 Processor and Processor Features Description*, GA34-0084

Related Publications

- *IBM Series/1 Installation Manual—Physical Planning*, GA34-0029
- *IBM Series/1 Configurator*, GA34-0042
- *IBM Series/1 Operator's Guide*, GA34-0039
- *IBM Series/1 Customer Site Preparation Manual*, SA34-0050-1

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Chapter 1. Introduction

The IBM Series/1 4963 Disk Subsystem provides direct access storage when used with an IBM Series/1 processor. The subsystem consists of a Series/1 4963 Disk Subsystem Attachment

Feature, one primary disk storage unit, and up to three expansion disk storage units.

The disk storage units are designated as physical units 0, 1, 2, and 3. They are installed in the Series/1 as shown in Figure 1-1, with unit 0

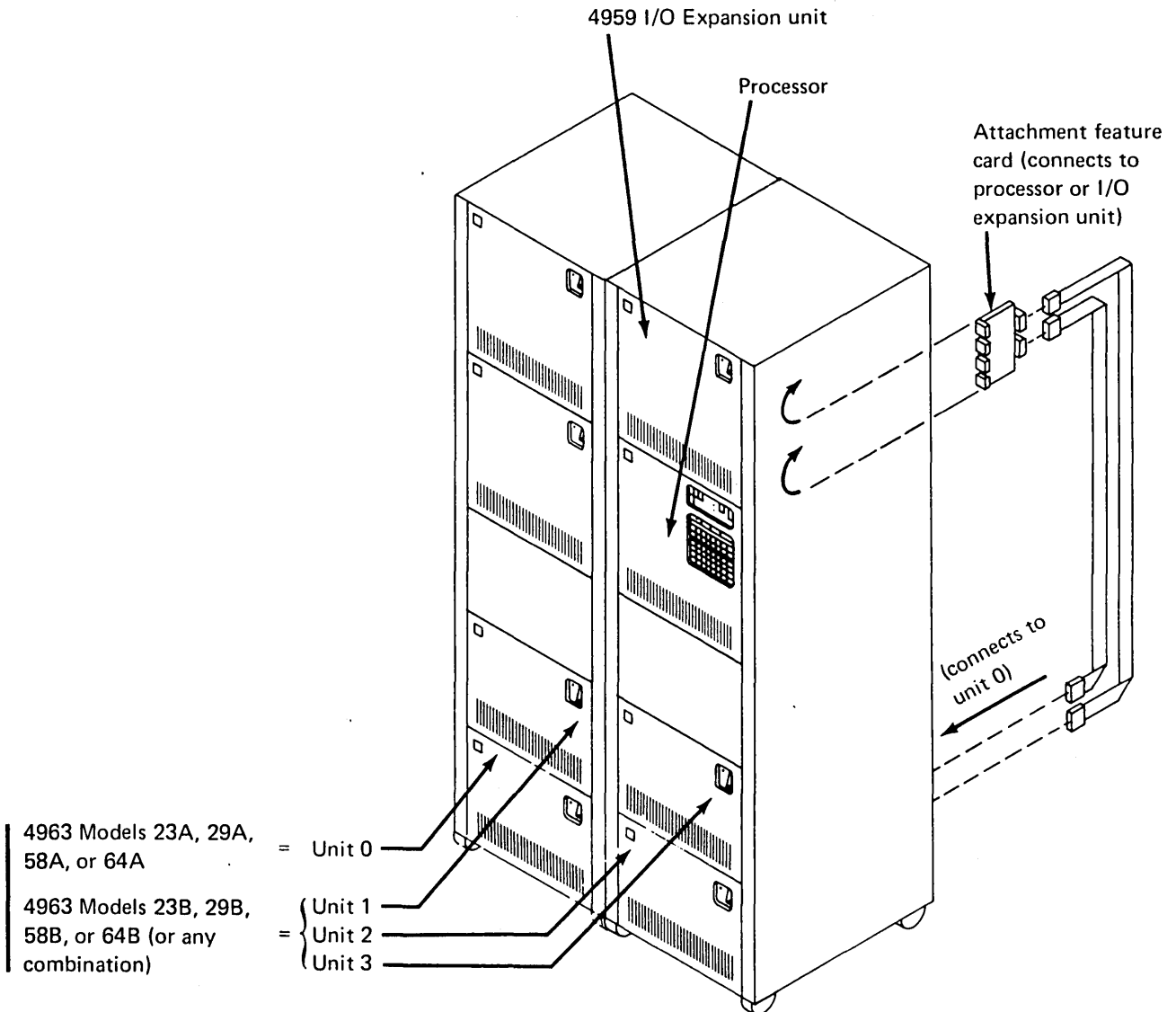


Figure 1-1. IBM Series/1 4963 Disk Subsystem

always as the primary unit. This arrangement is required by cabling and service considerations and applies to any additional groups of 4963 disk storage units. Two I/O addresses are used if one or two disk storage units are attached; four I/O addresses are used if three or four disk storage units are attached.

As individual units, the 4963 disk storage units consist of multiple fixed disks, a movable head access mechanism, an eight fixed head feature, the disk drive electronics that record and retrieve data to and from the disk, and the cables that connect the disk storage unit to the attachment. The disks and access mechanism are sealed in an enclosure to:

- eliminate disk handling
- reduce exposure to external contaminants
- eliminate preventive maintenance

Models

Four primary and four expansion models of the subsystem are available. Primary models contain the disk unit controls, which control both the primary and the expansion models. The following list describes the 4963 disk storage units by model number and storage capacity.

Primary Disk Storage Units

Model	Capacity moving heads	Capacity fixed heads
23A	23,461,888 bytes	131,072 bytes
29A	29,327,360 bytes	not featured
58A	58,654,720 bytes	131,072 bytes
64A	64,520,192 bytes	not featured

Expansion Disk Storage Units

Model	Capacity moving heads	Capacity fixed heads
23B	23,461,888 bytes	131,072 bytes
29B	29,327,360 bytes	not featured
58B	58,654,720 bytes	131,072 bytes
64B	64,520,192 bytes	not featured

Any model of the 4963 located in physical unit 0 or 1 can be designated as the processor's primary or alternate IPL device.

Disk Specifications

The functional specifications of the disk unit are:

Access times	
Average rotational delay (latency)	9.6 ms (nominal)
Moving head average access time*	27.0 ms (maximum)
Moving head single track access time	9.0 ms (maximum)
Data transfer rate	1,031,000 bytes/second (nominal-instantaneous)
Transferred from disk to storage	
	426,666 bytes/second (time average per track)
Disk rotation speed	3125 RPM (nominal)
Data bytes per record	256 bytes
Records per sector	2 records
Sectors per track	32 usable 1 alternate
Data bytes per track	16,384
Total data tracks accessible per moving head	360
Usable tracks	358
Tracks reserved for alternate sector usage	1
Tracks reserved for write diagnostic purposes	1

Data Capacities (358 tracks)

Models	Moving heads	Total bytes	Fixed heads	Total bytes
23A & 23B	4	23,461,888	8	131,072
29A & 29B	5	29,327,360	0	0
58A & 58B	10	58,654,720	8	131,072
64A & 64B	11	64,520,192	0	0

Disk Attachment

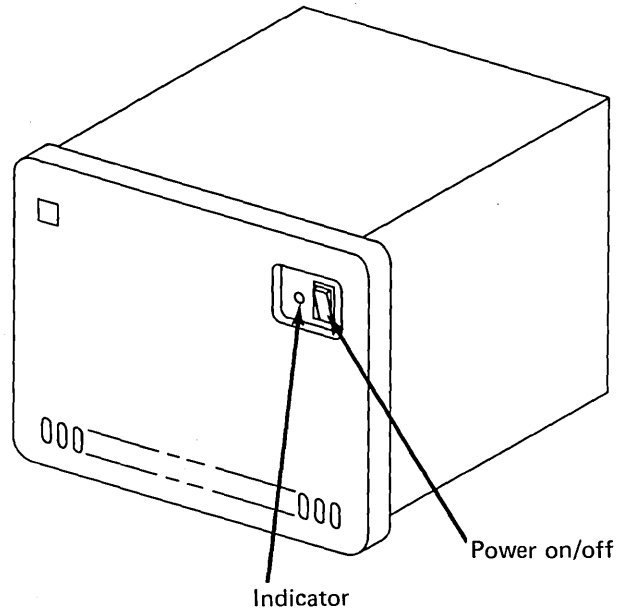
The attachment used with the subsystem is a cycle-steal device that controls up to four disk storage units. The attachment feature physically connects and logically adapts the processor I/O channel to the disk storage units.

The attachment:

- Interprets the Operate I/O instruction's immediate device control block (IDCB)
- Executes the IDCB command
- Reads the device control block (DCB) specified by the cycle-steal IDCB, in cycle-steal mode
- Starts and stops cycle-steal data transfers
- Monitors and checks accuracy of all data transfers
- Furnishes status information, reports condition codes, and presents interrupt requests to the processor
- Performs automatic error-recovery procedures when so instructed by the program
- Provides for alternate sector processing, at programmers option, when defective sectors have been previously reassigned by programming
- Provides for variable-length IPL records, up to 64K bytes in variable locations on the first 16 cylinders
- Provides attachment circuit testing with or without disconnecting the attachment-to-disk-unit control cables
- Optimizes data transfers when instructions are issued to more than one disk unit

Operator Controls and Indicators

The 4963 Disk Storage Unit has a Power On/Off switch and an indicator, both located on the front of the machine. The indicator is used for circuit testing and is not a power on or ready indicator. These are the only operator controls on the unit.



* Average access times include head settling but not latency. The average access time is defined as the average of all possible access lengths performed from each cylinder on the disk unit.

Chapter 2. Disk Data Format

This chapter describes how data is formatted on the disk by cylinder, track, and sector.

Disk Surfaces

All disk surfaces are available for data, except one area of one disk, which is used for servo coding. Servo coding defines data head positioning and track and sector boundaries.

Tracks

A track is the area covered by the data heads during one disk revolution. There are 360 addressable tracks per head. Tracks 0 through 357 are used for data. Track 358 is reserved for alternate sector usage. Track 359 is reserved for write diagnostic purposes.

Cylinders

A cylinder is a group of tracks having a common radius. The number of tracks per cylinder depends on the disk storage unit model. For example, a Model 58A or 58B has 10 tracks per cylinder (one track per movable head). The actuator positions the data heads at cylinder locations.

The program addresses a cylinder, then selects a data head and reads or writes on a track. There are 360 addressable cylinders per disk storage unit.

Sectors

A sector is one segment of an equally divided track. Each sector includes the identification (ID) field, in which the flag byte, sector, head, and cylinder address is recorded, and the data field, which includes two data records of 256 bytes each (Figure 2-1).

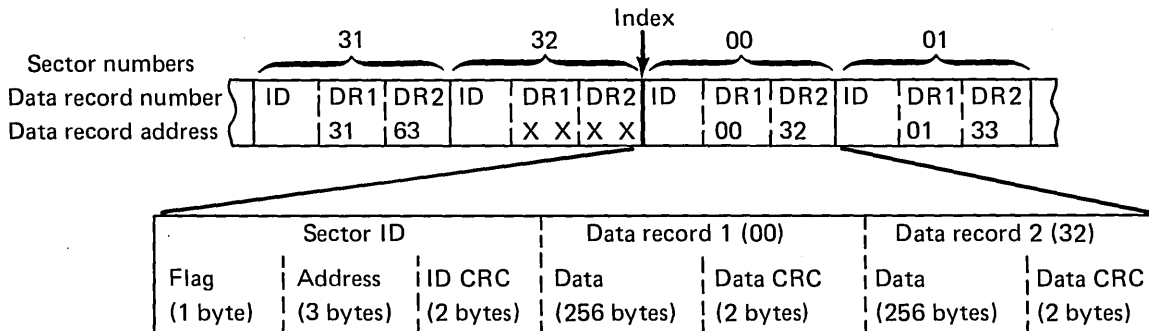


Figure 2-1. Sector format

Sectors are numbered from 0 through 32. Sectors 0 through 31 are addressable. Sector 32 is used as an alternate for the first defective sector detected, and unless logically displaced, always precedes the index code. For movable heads, logical sector numbering is skewed eight sectors from one data surface to the next, skewing 32 sectors every fourth data surface (Figure 2-2). Skewing the

sector numbers enables head switching from sector 31 of a disk surface to sector 0 of the adjacent data surface, within a cylinder, without a full revolution of the disks (Figure 2-2). Fixed heads do not have skewed sector numbering. Bit 7 of the sector ID number is always written as 0 on the disk surface, causing the ID on disk (Figure 2-2) to increment in even numbers.

Physical sector numbers	Logical sector numbers							
	ID on disk	Heads 0, 4, 8*	ID on disk	Heads 1, 5*, 9*	ID on disk	Heads 2, 6*, 10*	ID on disk	Heads 3, 7*
0	00	0	30	24	20	16	10	8
1	02	1	32	25	22	17	12	9
2	04	2	34	26	24	18	14	10
3	06	3	36	27	26	19	16	11
4	08	4	38	28	28	20	18	12
5	0A	5	3A	29	2A	21	1A	13
6	0C	6	3C	30	2C	22	1C	14
7	0E	7	3E	31	2E	23	1E	15
8	10	8	00	0	30	24	20	16
9	12	9	02	1	32	25	22	17
10	14	10	04	2	34	26	24	18
11	16	11	06	3	36	27	26	19
12	18	12	08	4	38	28	28	20
13	1A	13	0A	5	3A	29	2A	21
14	1C	14	0C	6	3C	30	2C	22
15	1E	15	0E	7	3E	31	2E	23
16	20	16	10	8	00	0	30	24
17	22	17	12	9	02	1	32	25
18	24	18	14	10	04	2	34	26
19	26	19	16	11	06	3	36	27
20	28	20	18	12	08	4	38	28
21	2A	21	1A	13	0A	5	3A	29
22	2C	22	1C	14	0C	6	3C	30
23	2E	23	1E	15	0E	7	3E	31
24	30	24	20	16	10	8	00	0
25	32	25	22	17	12	9	02	1
26	34	26	24	18	14	10	04	2
27	36	27	26	19	16	11	06	3
28	38	28	28	20	18	12	08	4
29	3A	29	2A	21	1A	13	0A	5
30	3C	30	2C	22	1C	14	0C	6
31	3E	31	2E	23	1E	15	0E	7
32	40	32	40	32	40	32	40	32

Sector 32 (hex 40) is the alternate sector and precedes the index code, unless logically displaced.

*These heads are available on Models 58A and B, and 64A and B only. Movable head numbering remains the same with the fixed head feature because movable head 0 is replaced and therefore not addressed.

Figure 2-2. Sector numbering

The "Primary" defective sector is the first defective sector detected on a track. This sector is reassigned as sector 32 by the user. Data and the original sector ID of the defective sector are displaced one sector, as are all subsequent sectors, to the end of the track (Figure 2-3). Subsequent processing of the primary defective sector is done automatically by the system.

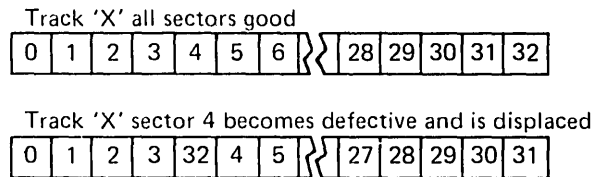


Figure 2-3. Sector displacement

A secondary defective sector is any sector subsequent to the primary defective sector. The following is a recommended method for assigning secondary defective sectors.

Scatter Method

If a second sector on a track becomes defective, that sector can be assigned to the closest available alternate (spare) sector by the sector reassignment program. The program begins by testing track 0 (head 0 for non fixed-head disk units) or track 1 (head 1 for fixed-head disk units) of the same cylinder for an unused alternate sector (sector 32). If the alternate sector has been used, the next track is tested. If all of the alternate sectors on a cylinder have been tested and the program determines that they are in use, a seek to the next higher cylinder is performed (current cylinder number +1). If an unused alternate sector is not found on any of the tracks on this cylinder, a seek to the opposite direction is performed (previous current cylinder number -1). Seeking and testing is continued until an unused alternate sector is found.

Movable Head Sequence

1. Test all the tracks on the same cylinder for an unused alternate sector beginning with track 0 or track 1.
2. If an unused alternate is not found, seek to the next higher cylinder (current cylinder +1) and test all the tracks for an unused alternate sector.

3. If an unused alternate is not found, seek to the next lower cylinder (previous current cylinder -1) and test all the tracks for an unused alternate sector.
4. If an unused alternate is not found, continue to seek and test each track on a cylinder, alternately incrementing and decrementing the cylinder number (+2, -2, +3, -3, etc.) until an unused alternate sector is found. If a cylinder boundary is encountered, such as cylinder 000 or 358 (cylinder 359 not used), the seek direction will be away from the boundary.

Fixed-head Sequence

1. Test the eight fixed-head tracks, beginning with fixed-head 0 for an unused alternate sector.
2. If an unused alternate is not found, seek to cylinder 000 and test all the tracks, beginning with moveable head 1, for an unused alternate sector.
3. If an unused alternate is not found, seek to cylinder 001 and test all the tracks for an unused alternate sector.
4. If an unused alternate is not found, continue seeking to the next higher cylinder number and testing the tracks until an unused alternate sector is found.

If the spare sector on a track has already been assigned as an alternate sector for another track when the track develops its first defective sector, the following sequence is recommended:

1. Read the alternate sector's ID area and data (data records 1 and 2).
2. Assign the first defective sector on this track using the displacement method.
3. Seek to the cylinder of previously assigned alternate sector.
4. Assign this second defective sector using the scatter method.

Flag Byte

The flag byte defines the status of the sector, and whether an alternate sector has been assigned. It also indicates whether the sector was defined as defective by the factory or if the defect occurred while the disk storage unit was in use. When set equal to 1, the bits of this byte indicate:

Bit	Meaning
0	Defective data record 2
1	Defective data record 1
2	User assigned defect
3	Protected data area—Assigned to the first good sector of the alternate cylinder by factory
4	Sector displaced
5	Sector reassigned to alternate cylinder
6	Factory assigned defect
7	Assigned alternate sector

Bits 0, 1, and 3 have specific meaning at the factory, but can be used in other ID fields and defined as programmable protect bits by user. If bit 6 is set equal to 1 by the factory, it should remain so to preserve the integrity of the disk.

Address

The address bytes contain the sector, head, and cylinder numbers that identify a particular sector. The following chart shows the bit meanings for the address bytes:

Sector number		Head number		Cylinder number	
0	7	0	6	7	0
7	0	7	0	7	7
Bit	Value	Bit	Value	Bit	Value
0	**	0	**	7	256
1	32	1	*	0	128
2	16	2	8	1	64
3	8	3	4	2	32
4	4	4	2	3	16
5	2	5	1	4	8
6	1	6	**	5	4
7	**			6	2
				7	1

*Designates a fixed head when equal to a one.
 **These bits must be zero.

Data Records 1 and 2

Each sector contains two 256-byte records designated data record 1 and data record 2. Two revolutions of the disk are required to process an entire track. Logical record number order is used when processing multiple records. That is, data record 1 of all sectors of a track is processed before data record 2 of any record of the same track. The logical record number for data record 2 is 32 greater than the record number for data record 1. Each record is addressed individually. The following chart shows the codes used to address sectors and records.

CRC

The CRC bytes are used to check reading and writing accuracy. Three separate two-byte CRC codes are written on the disk. These represent the ID field CRC, the data record 1 CRC, and the data record 2 CRC. A new CRC is electronically developed as data is read from the disk. The developed CRC is then compared to the CRC read from the disk and if the two CRCs are not equal, the disk storage unit signals that an error has occurred.

Sector number		Data record 1 record number		Data record 2 record number	
Decimal	Binary	Decimal	Binary	Decimal	Binary
00	000000	00	000000	32	100000
01	000001	01	000001	33	100001
02	000010	02	000010	34	100010
03	000011	03	000011	35	100011
31	011111	31	011111	63	111111
32	100000	Reserved for alternate sector usage			

Chapter 3. Operations

This chapter describes how the processor transfers data to and from the disk unit. It includes descriptions of the Operate I/O instruction and its associated commands, status words, and condition codes. The processor initiates all disk operations by issuing an Operate I/O instruction, and then uses the processor I/O channel to transfer data to and from the disk unit.

The Operate I/O instruction is a privileged instruction. Its effective address (the combination of the R2 and address fields) points to an immediate device control block (IDCB) in processor storage. The IDCB contains a command, a device address, and an immediate data field (see Figure 3-1). The command defines the type of I/O operation; the device address identifies the device on which the operation is to be performed. Disk storage units within the subsystem are designated as physical units 0, 1, 2, and 3. The device address for the primary unit (physical unit 0) can be any even address from 0 to 254 within the following parameters:

- If one or two units are installed (a primary unit or a primary unit and an expansion unit), the device address of the primary unit must be divisible by 2.

- If three or four units are installed (a primary unit with either two or three expansion units), the device address of the primary unit must be divisible by 4.

Expansion unit device addresses are sequentially numbered in ascending order immediately following the primary unit's device address.

Examples:

primary unit device address	= 6
expansion unit device address	= 7
or	
primary unit device address	= C
expansion unit device address	= D
expansion unit device address	= E
expansion unit device address	= F

The use of the information in the IDCB's immediate data field depends on the mode of operation. For direct program control (DPC) operations, the immediate data field is used as a data word; for cycle-steal operations, this field points to a device control block (DCB) that contains additional information needed to perform the operation. The IDCB must be on a fullword boundary. Refer to an appropriate processor description manual listed in the Preface for a more detailed description.

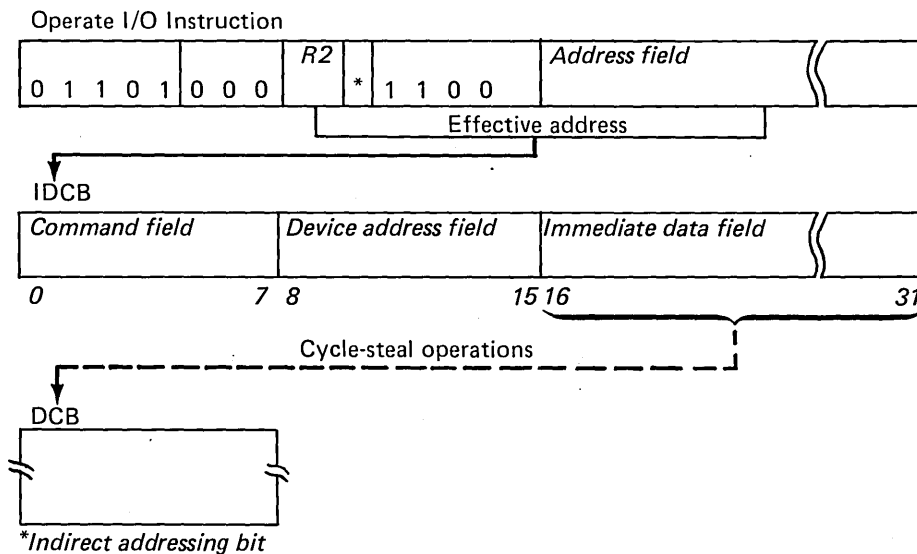


Figure 3-1. Operate I/O instruction

Read ID

IDCB (immediate device control block)

Command field								Device address field							
0	0	1	0	0	0	0	0	X	X	X	X	X	X	X	X
0								15							
20								00-FF							

Immediate data field																															
Data word																															
16																31															

This command transfers the identification (ID) word from the disk unit to the immediate data field of the IDCB. After command execution, the immediate data field contains:

Immediate data field															
16				19 20 21				23 24				29 30 31			

Bits 16–19 class code (subsystem configuration)

20 reserved

21–23 base address divisibility code:

bit	21	22	23	base address divisibility of
value	0	0	1	2
	0	1	0	4

24–29 4963 disk unit

30 1 = cycle steal device

0 = not cycle steal device

31 1 = OEM device

0 = IBM device

The Attachment Feature ID is used to determine the existing subsystem configuration. For example, a Read ID command issued to device address 8 (first device) contains 3206 in the immediate data field.

Immediate data field																							
0	0	1	1	0	0	1	0	0	0	0	0	0	1	1	0								
16								22								31							
Base address divisible by 4																							

This indicates a base divisibility of 4, and that a 4963 is attached. A second Read ID command must be issued to base address plus 3, or in this case, to base address 11. Because the fourth disk unit in this example is not attached, a condition code of 0 is posted. If a fourth disk unit is attached, the condition code in value is not 0.

As another example, assume that two disk units are attached and a Read Device ID command issued to base device address 6 contains 3106 in the immediate data field. This indicates a base divisibility of 2 and that a 4963 is attached. A second Read Device ID command is issued to base address plus 1, or in this case to base address 7. Since a second disk unit is attached, the condition code in value is not 0.

Device Reset

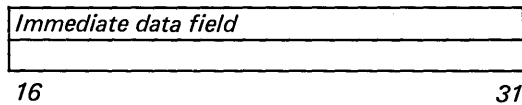
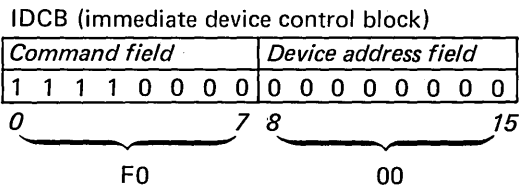
IDCB (immediate device control block)

Command field								Device address field							
0	1	1	0	1	1	1	1	X	X	X	X	X	X	X	X
0								15							
6F								00-FF							

Immediate data field																															
Zeros																															
16																31															

This command resets any pending interrupt requests or busy condition in the disk unit. The prepare level and the residual address are not affected. The immediate data field is not used.

Halt I/O

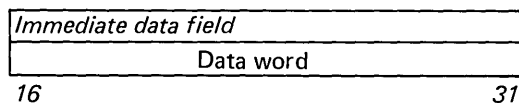
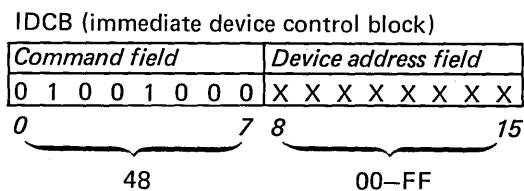


This is a channel-directed command that halts all I/O activity on the I/O channel and resets all devices. The immediate data field of the IDCB is not used. Any pending interrupt or busy condition is reset. The prepare level and the residual address are not affected.

Diagnostic Commands

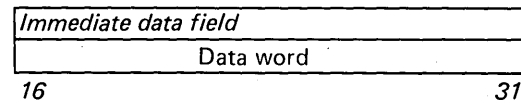
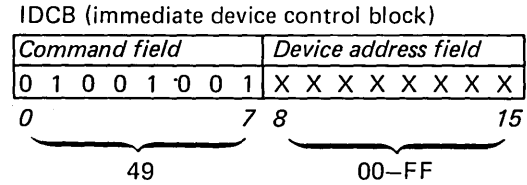
The following commands are used to test 4963 subsystem operations in DPC mode.

Load Sense Diagnostic Word 1



This command moves data from the IDCB to the disk unit control's data buffer register.

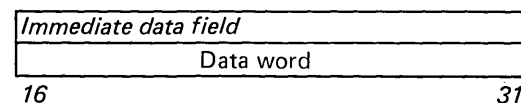
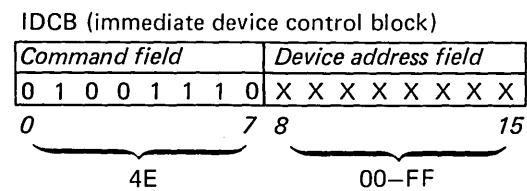
Load Sense Diagnostic Word 2



This command allows the disk unit controls and the disk attachment to operate in single-cycle mode for diagnostic purposes. A diagnostic register is read into the immediate data field and has the following significance:

Bit	Meaning
0-11	Unassigned
12	Diagnostic control
13	Single-cycle control
14	Diagnostic instruction
15	Unassigned

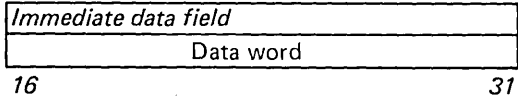
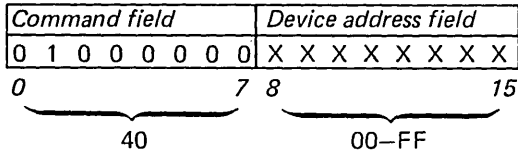
Attachment Storage Diagnostic



This command instructs the attachment to execute a storage diagnostic test. Any detected failure in the attachment storage is reported as an exception interrupt request with more status available. The attachment equipment check bit (10), in cycle steal status word 4, is set to 1 if an error occurred. The data word of the Write Immediate command is not used, but is checked for parity. A normal device-end interrupt indicates a successful storage check. This is an interrupt causing operation.

Load Disk Unit Control Block 0

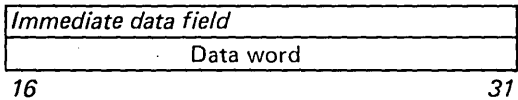
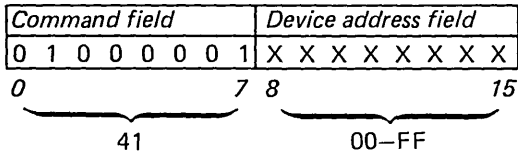
IDCB (immediate device control block)



This command moves the first word of the disk unit control block into the immediate data field.

Attachment General Diagnostic Test

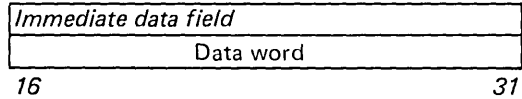
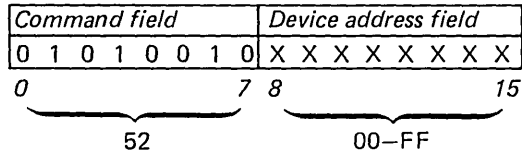
IDCB (immediate device control block)



This command causes the attachment to test its data registers and control latches. Any detected failure causes an exception interrupt request with the attachment equipment check bit (10) set to 1 in cycle-steal status word 4.

Load Seek Required Address Direct

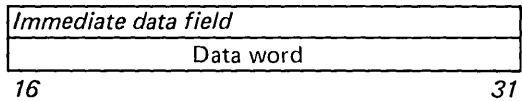
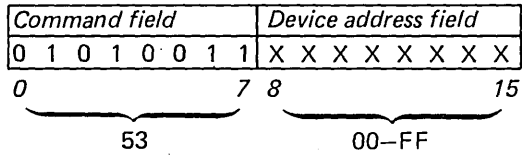
IDCB (immediate device control block)



This is a special diagnostic command and must be issued sequentially prior to the Load Seek Control Direct command.

Load Seek Control Direct

IDCB (immediate device control block)



These commands are special diagnostic commands for the disk unit controls. They perform special diagnostic wrap functions and must be issued in this sequence, Load Seek Required Address Direct command followed by a Load Seek Control Direct command. The immediate data field from these commands is not used. The correct head and cylinder numbers must be loaded in the disk unit controls prior to issuing these commands. Loading the head and cylinder numbers can be accomplished by issuing a Start command that includes a DCB.

Note: Word 2 of the DCB is always loaded into the disk unit controls even though it is not required to perform the operation.

Sense Disk Unit Diagnostic Wrap

IDCB (immediate device control block)

Command field	Device address field
0 1 0 1 0 1 1 1	X X X X X X X X
0	7 8 15
57	00-FF

Immediate data field
Data word
16 31

This command causes the disk unit control to read the low-order byte of the cylinder number. This byte contains error information if read following an error. An interrupt request is presented at the completion of the execution. This byte is read into processor storage via the cycle steal status operation. The sense byte bit definitions are listed under status words 11 and 12 of the start cycle steal status operation found later in this chapter.

Disk Speed Timing Diagnostic

IDCB (immediate device control block)

Command field	Device address field
0 1 0 1 1 0 1 0	X X X X X X X X
0	7 8 15
5A	00-FF

Immediate data field
Data word
16 31

This command times the disk for 20 revolutions and returns the loop count in diagnostic sense bytes 1 and 2. The using system can calculate the elapsed time with the following formula:

$$T(\text{time in microseconds}) = (10509 * B_1 + 41 * B_2) .55$$

Resolution is less than 40 microseconds, not counting disk unit control's oscillator error.

B₁ = Disk Unit Diagnostic Sense Byte 1 (start cycle steal status word 11 bits 0-7).

B₂ (start 2 = Disk Unit Diagnostic Sense Byte 2 (cycle steal status word 11 bits 8-15).

In order to read the sense bytes into storage, a start cycle steal status operation must be initiated. The sense byte bit definitions are listed under status words 11 and 12 of the start cycle steal status operation found later in this chapter.

Note: The diagnostic timing commands require dedication of the attachment such that no other operations will be serviced during execution of the command. Therefore, timing diagnostics cannot be used during normal operation without the risk of degrading performance. Also, channel activity during execution could degrade the timing resolution.

Disk Unit Control Diagnostic

IDCB (immediate device control block)

Command field	Device address field
0 1 0 1 1 1 0 1	X X X X X X X X
0	7 8 15
5D	00-FF

Immediate data field
Data word
16 31

This command allows access to the disk unit controls to operate in an interleaved or noninterleaved mode. The IBM Series/1 4963 Disk Subsystem operates in interleaved mode only.

Note: A disk unit control reset or a system reset will reset the format (interleaved or noninterleaved) to the original state designated by the "jumper" wiring.

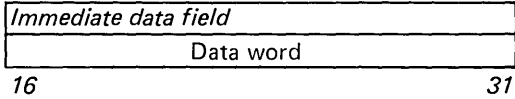
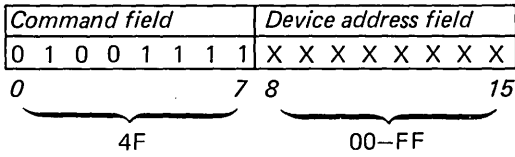
The immediate data field for this command performs the following operations:

- 04AE - Set format (interleaved)
- 05AE - Set format (noninterleaved)

These operations set the format for interleaved or noninterleaved operations. This operation overrides the state of a format originally designated by "jumper" wiring.

Diagnostic Reset Disk Unit Controls

IDCB (immediate device control block)

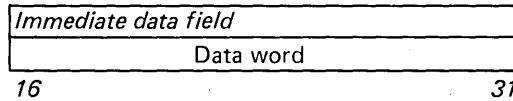
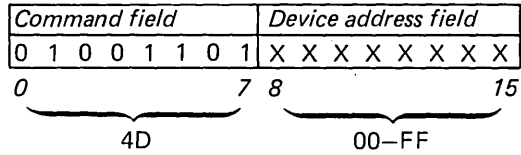


This command resets the disk unit controls. All disk unit operations in progress, but not yet interrupted to the attachment, are terminated and end with an error or unpredictable results. Therefore, its use should be limited to diagnostic purposes only.

Force End Operation

This command sets the end operation trigger equal to 1, and causes the disk unit to post status, terminate any file operations in progress at the next end store time, terminate the data transfer to the system, and interrupt the system with end operation and any other interrupt conditions on. The end operation interrupt is transmitted to the processor only if an operation is in progress.

IDCB (immediate device control block)



Cycle Steal

Command execution in cycle-steal mode permits overlapping an I/O operation with processor operations and other I/O operations (see Figure 3-3). As is true for other commands, the processor transfers the IDCB under direct program control from processor storage to the disk unit **1**, and after the disk unit accepts the IDCB, it sends a condition code back to the processor **2**. But now the processor is free to continue with other operations while the disk unit uses the information in the IDCB to execute the command. The IDCB's immediate data field contains the address of a DCB. This eight-word DCB contains parameters that define and control the I/O operation. The disk unit "steals" the DCB words **3** and the data **4** it needs to execute the operation. DCBs and RSBs are cycle stolen with address key equal to 0. Each data transfer reduces a preset byte count in DCB word 6. When the data transfer ends (byte count equals 0), an interrupt request is sent to the processor. The processor then accepts the interrupt condition code and an interrupt ID word from the disk unit.

Start

IDCB (immediate device control block)

Command field	Device address field
0 1 1 1 0 0 0 0	X X X X X X X X
0 7	8 15
70	00-FF

Immediate data field
DCB address
16 31

The Start command initiates I/O disk operations that transfer data to or from processor storage in cycle-steal mode. An interrupt request is sent to the processor when the I/O operation ends. The control information and parameters required for a particular disk operation must be stored in the DCB associated with that operation.

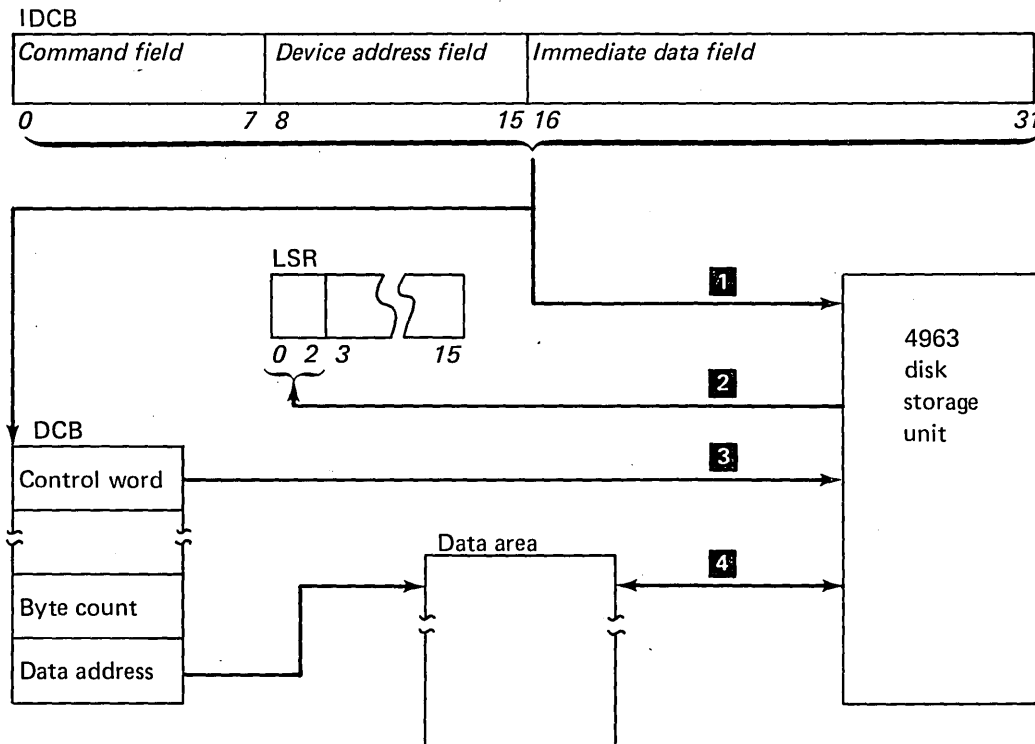


Figure 3-3. Cycle-steal operation

The eight data words in the DCB and their bit configurations are explained here and illustrated in Figure 3-4.

DCB Word 0—Control Word

This is a 16-bit word that defines the cycle-steal operation. This word contains two bytes of control parameters to be used with the particular Start command to be performed.

Bit 0 Chaining flag. When this bit equals 1, it tells the disk unit to perform a chaining operation. Chaining means the disk unit completes the current operation but does not present an interrupt request to

the processor. Instead, the disk unit fetches the next DCB in the chain and performs the next operation. DCB word 5 tells the disk unit where to look for the next DCB. Chaining continues until a DCB is fetched that has the chaining bit in the control word (DCB word 0) equal to 0, indicating the last operation in the chain. If an error occurs, chaining to succeeding DCBs is automatically suspended, and an interrupt request is sent to the processor. Normally, an interrupt is not requested until the disk unit has completed the last operation in the chain. DCB chaining for the 4963 is valid only for a Start command.

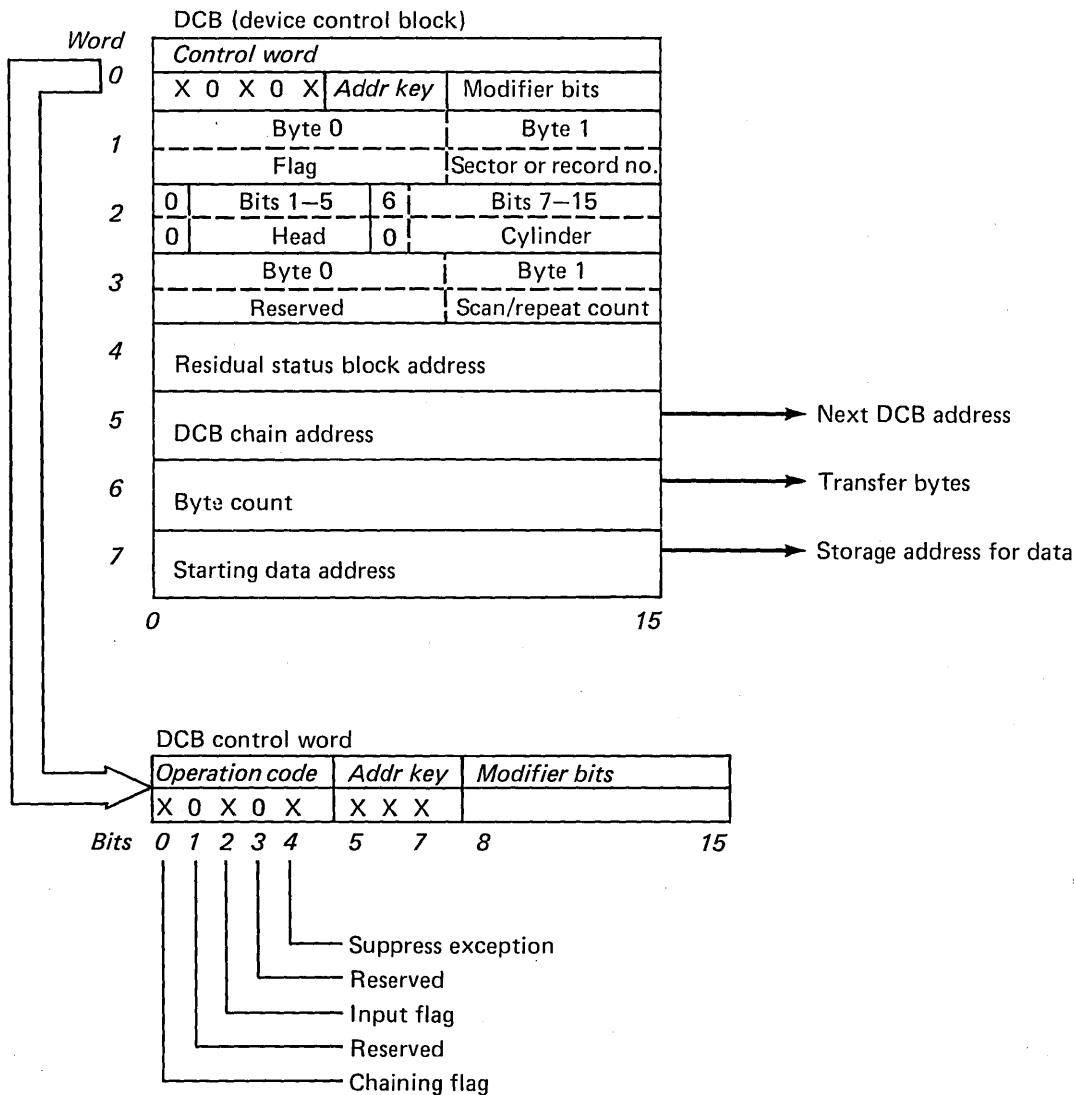
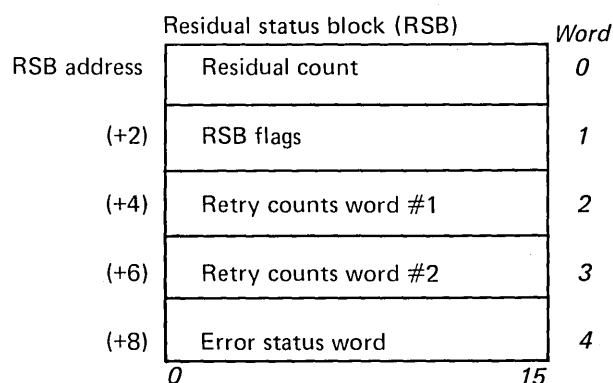


Figure 3-4. Device control block

- Bit 1 This bit is not used and must remain 0 or a DCB specification check occurs.
- Bit 2 Input flag. The condition of this bit determines the direction that data is to be transferred. When this bit equals 1, data transfers from the disk unit into processor storage. When this bit equals 0, the cycle-steal data transfer is from processor storage to the disk unit.
- Bit 3 This bit is not used and must remain 0 or a DCB specification check occurs.
- Bit 4 Suppress exception (SE). When this bit equals 1, it suppresses the reporting of some exception conditions that otherwise would cause an exception interrupt request.

When this bit equals 1, automatic error recovery procedures are invoked and the disk unit status is stored at the address specified by the residual status block (RSB) address field of DCB word 4, before chaining or terminating. A data integrity problem exists if automatic retry occurs during a read-disk operation. (See Figure 3-5.) The residual status block is not stored if a permanent error condition has occurred. The SE bit also initiates automatic alternate sector processing. If a defective sector has been assigned an alternate address, and the SE bit equals 1, the disk access mechanism seeks to the alternate address, processes the data as indicated, and returns to the original track to complete the operation.

The residual status block is available at the end of the operation that uses suppress exception. The format and a description of the residual status block words follow:



- Word 0—residual count—always 0 for 4963 subsystem
- Word 1—residual status block flags
 - Bit 0 end of chain
 - Bit 1 retry
 - Bits 2–14 reserved
 - Bit 15 no exception
- Word 2—retry count word 1—temporary error retry counts
 - Bits 0–3 cyclic redundancy check (CRC)
 - Bits 4–7 write echo check
 - Bits 8–11 missing sector pulse
 - Bit 12 data unsafe
 - Bit 13 not ready
 - Bits 14–15 reserved
- Word 3—retry counts word 2—extension of temporary error retry counts
 - Bits 0–3 no record found
 - Bit 4 storage data check
 - Bit 5 invalid storage address
 - Bit 6 protect check
 - Bit 7 interface data check
 - Bit 8 disk unit interface parity check
 - Bits 9–11 reserved
 - Bits 12–15 write error
- Word 4—error status word
 - Bits 0–2 reserved
 - Bit 3 an assigned alternate sector has been successfully processed
 - Bit 4 temporary error retry operation has been retried by the attachment error count of one or more in RSB words 2 or 3 configuration
 - 0 0 0 reserved
 - 0 0 1 reserved
 - 0 1 0 model 29A & B (no fixed heads)
 - 0 1 1 model 64A & B (no fixed heads)
 - 1 0 0 disk unit not attached
 - 1 0 1 reserved
 - 1 1 0 model 23A & B (eight fixed heads)
 - 1 1 1 model 58A & B (eight fixed heads)
 - Bit 8 scan not equal, a requested scan operation has not been met
 - Bit 9 scan equal—an equal condition has occurred on a scan operation
 - Bits 10–12 reserved
 - Bit 13 end of disk—an operation has caused automatic cylinder switching to the customer engineer (CE) cylinder (359), which is reserved for diagnostic purposes
 - Bits 14–15 reserved

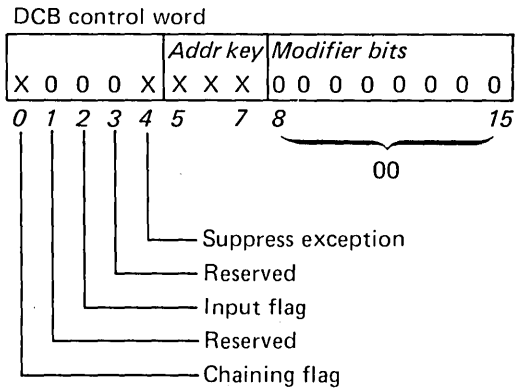
Bits 5–7 Address key. This is a three-bit key that the disk unit presents during data transfers to verify that the program has authorization to access processor storage. An incorrect address key causes an exception interrupt (condition code 2).

Bits 8–15 Modifier field. The bits in this field describe the specific cycle-steal operation requested with this DCB.

The disk operations initiated with a Start command are:

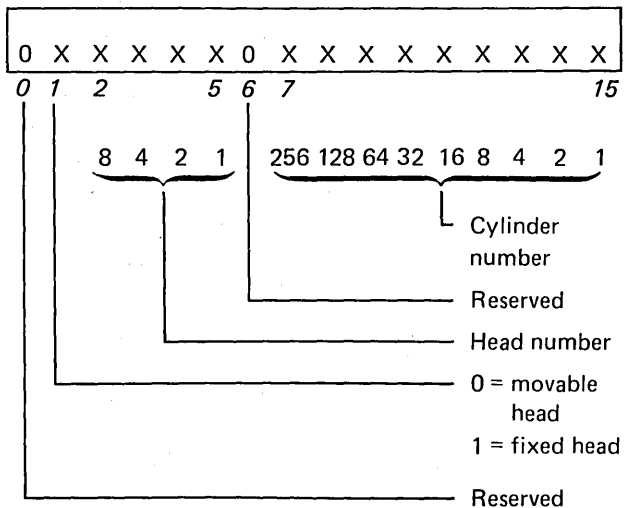
	Bit 2	Bits 8–15
Seek	0	0000 0000
Recalibrate	0	0000 0001
Calibrate	0	0000 1001
Overlapped seek	0	0000 1000
Timed seek diagnostic	0	0000 1011
Read data	1	0001 X000
Read verify	0	0001 X001
Read data repeat	1	0001 X010
Read disk unit data buffer diagnostic	1	0001 0011
Read sector ID	1	0001 X100
Read sector ID extended	1	0001 X101
Read diagnostic record 1	1	0001 X110
Read diagnostic record 2	1	0001 X111
Write data	0	0010 X000
Write data with read verify	0	0010 X001
Write data repeat	0	0010 X010
Write data repeat with read verify	0	0010 X011
Write sector ID with read verify	0	0010 X101
Write sector ID extended with read verify	0	0010 X111
Write data security with read verify	0	1010 X001
Scan equal	1	0011 X000
Scan low/equal	1	0011 X001
Scan high/equal	1	0011 X010

Seek



Disk unit I/O operations requiring head movement or selection, must be preceded by a seek operation unless seeking is implied in the DCB. An implied seek requires longer access time. The seek operation causes the movable heads to seek to the cylinder number, and select the head number specified in DCB word 2.

DCB word 2



Programming note: Erroneous data results during a read-disk operation* if automatic retries occur (SE bit equal to 1). To maintain data integrity, the user program events shown in the flowchart are recommended. This problem will be corrected by an engineering change.

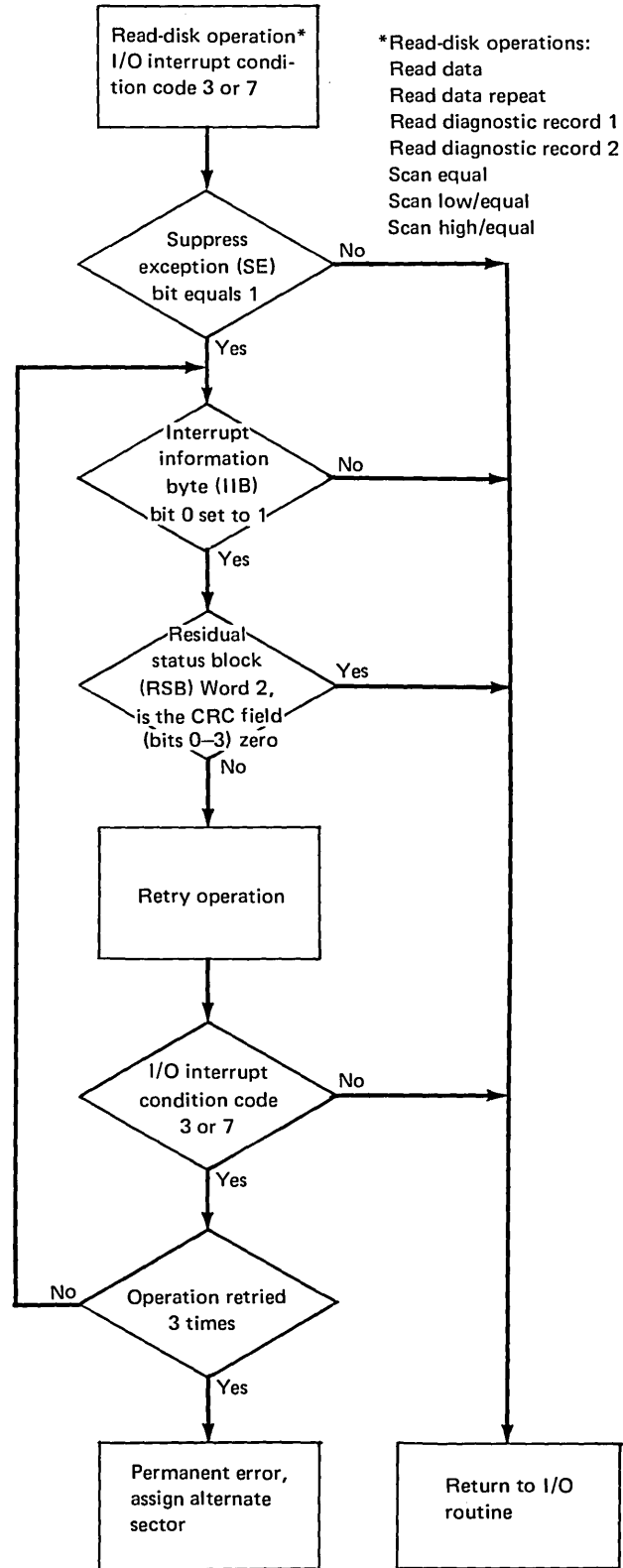


Figure 3-5. Programming recommendations

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Bits 5-7 Address key. This is a three-bit key that the disk unit presents during data transfers to verify that the program has authorization to access processor storage. An incorrect address key causes an exception interrupt (condition code 2).

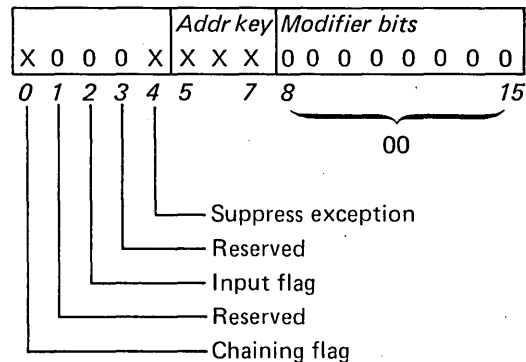
Bits 8-15 Modifier field. The bits in this field describe the specific cycle-steal operation requested with this DCB.

The disk operations initiated with a Start command are:

	Bit 2	Bits 8-15
Seek	0	0000 0000
Recalibrate	0	0000 0001
Calibrate	0	0000 1001
Overlapped seek	0	0000 1000
Timed seek diagnostic	0	0000 1011
Read data	1	0001 X000
Read verify	0	0001 X001
Read data repeat	1	0001 X010
Read disk unit data buffer diagnostic	1	0001 X011
Read sector ID	1	0001 X100
Read sector ID extended	1	0001 X101
Read diagnostic record 1	1	0001 X110
Read diagnostic record 2	1	0001 X111
Write data	0	0010 X000
Write data with read verify	0	0010 X001
Write data repeat	0	0010 X010
Write data repeat with read verify	0	0010 X011
Write sector ID with read verify	0	0010 X101
Write sector ID extended with read verify	0	0010 X111
Write data security with read verify	0	1010 X001
Scan equal	1	0011 X000
Scan low/equal	1	0011 X001
Scan high/equal	1	0011 X010

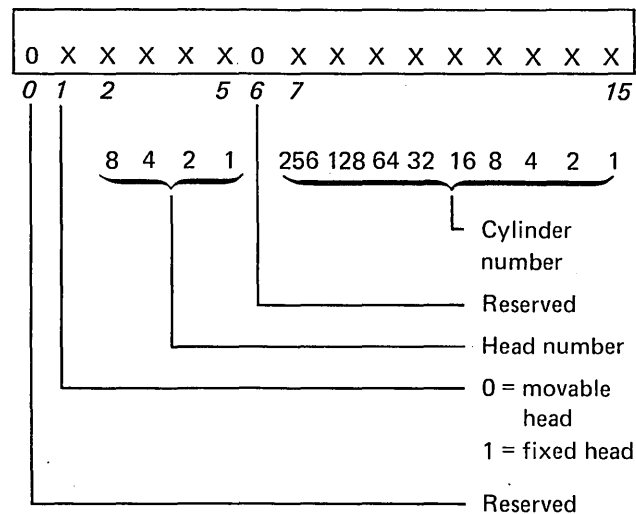
Seek

DCB control word



Disk unit I/O operations requiring head movement or selection, must be preceded by a seek operation unless seeking is implied in the DCB. An implied seek requires longer access time. The seek operation causes the movable heads to seek to the cylinder number, and select the head number specified in DCB word 2.

DCB word 2

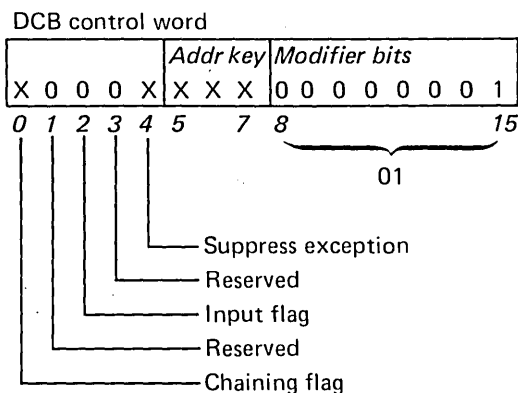


If a fixed head is specified in the DCB, the head is selected and the cylinder is ignored. The DCB associated with a seek operation is transferred from processor storage in cycle-steal mode. An interrupt request is sent to the processor when the disk unit completes the operation. A condition code and interrupt ID word are transferred to the processor when the interrupt is serviced.

Programming considerations:

- If an invalid head is specified in the DCB, no error will be reported until a command is executed that uses the selected head.
- An error condition is returned if a time-out occurs and the seek operation is not complete.

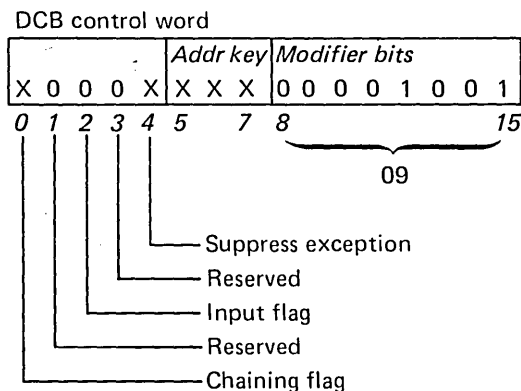
Recalibrate



The recalibrate operation causes the access mechanism to move to cylinder 0, head 1. When the disk unit completes the operation, an interrupt request is sent to the processor, and ready and home conditions are set in the disk unit control block. When the interrupt request is serviced, a condition code and an interrupt ID word are transferred to the processor.

The control information and parameters required for a recalibrate operation must be stored in a DCB containing a control word (DCB word 0) that specifies a recalibrate operation to the disk unit.

Calibrate

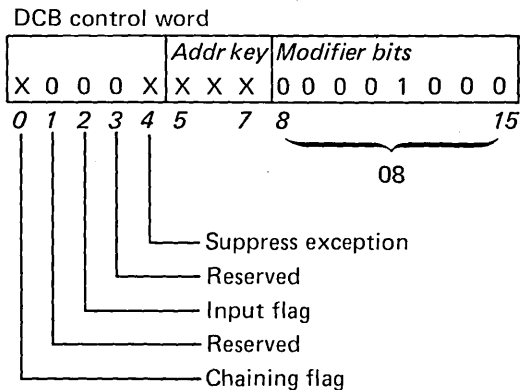


An excessive access time could indicate that a servo mechanism is out of calibration. This operation calibrates the servo mechanism by causing the following events:

1. Executes a recalibrate operation
2. Executes a 128-track seek operation
3. Executes a recalibrate operation

At the end of the second recalibrate operation, the servo mechanism is calibrated, and ready and home conditions are set in the cycle-steal status block. A power on reset causes a calibrate operation. DCB words 1, 2, 3, 6, and 7 are not used for this operation, but are fetched and must have correct parity.

Overlapped Seek

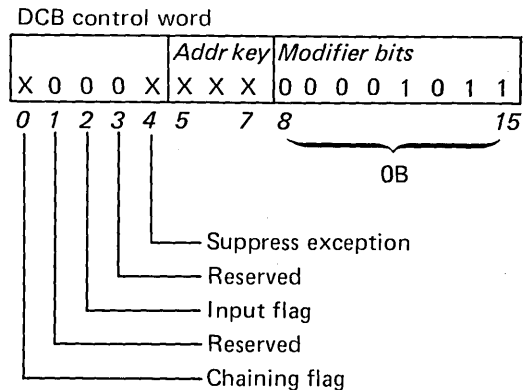


The overlapped seek operation allows overlapping of moving-head seeks with fixed head read, write, or scan operations. This operation can be immediately followed by a seek, or implied seek, to a fixed head. The overlapped seek operation posts an end-operation interrupt after the seek operation is initiated to the disk unit, not on completion, as does the seek operation.

Programming considerations:

- Errors occurring subsequent to the end operation interrupt will not cause an interrupt unless another command to the disk unit is in process when the error is detected.
- If the overlapped seek operation is followed by an operation that requires a moving-head seek before the previous moving-head seek is completed, it results in the second seek being executed after the first overlapped seek is complete.

Timed Seek Diagnostic



This operation measures the elapsed time from when the seek operation begins until the seek-complete interrupt is received. An excessive access time could indicate the need to calibrate the access mechanism. This can be done by turning disk unit power off and then on again, or by initiating a calibrate operation. Counts are returned in diagnostic sense bytes 1 and 2 of cycle steal status word 11. To read the sense bytes into storage, a Start Cycle Steal Status command must be issued. The elapsed time can be calculated by using the following formula:

$$T(\text{time in microseconds}) = (10509 \cdot B_1 + 41 \cdot B_2) \cdot 55$$

B_1 = Disk unit diagnostic sense byte 1 (cycle steal status word 11, bits 0–7).

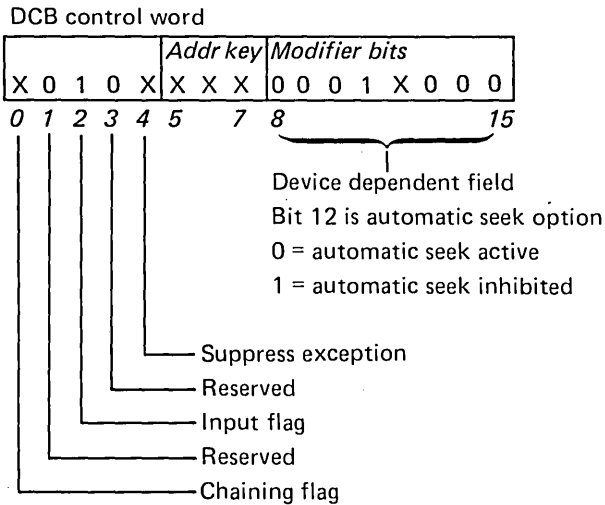
B_2 = Disk unit diagnostic sense byte 2 (cycle steal status word 12, bits 8–15).

Note: To read the sense bytes into storage, a cycle steal status operation must be initiated. Cycle steal status word 11 contains the sense bytes.

Resolution is less than 40 microseconds, excluding the disk unit control's oscillator error. See Chapter 2 for access times.

Note: Diagnostic timing commands require dedication of the attachment such that no other operations are serviced during execution of this operation. Therefore, timing diagnostics cannot be used during normal operation without the risk of degrading performance. Also, channel activity during execution may degrade the timing resolution.

Read Data



This operation causes data to be read from the disk unit into processor storage in cycle-steal mode. The DCB contains the data address search argument and byte count necessary to complete the operation.

The record is specified by the search argument and is transferred to processor storage as indicated by the data address field of the DCB. The byte count specifies the number of bytes to be transferred. The byte count must be an even number to reflect word boundaries.

If after one revolution, a record has not been found, a no-record-found error is posted, as well as any other errors present.

Up to 65,534 bytes (two bytes less than 256 records) can be read without regard to track or cylinder boundaries and without intermediate interrupts.

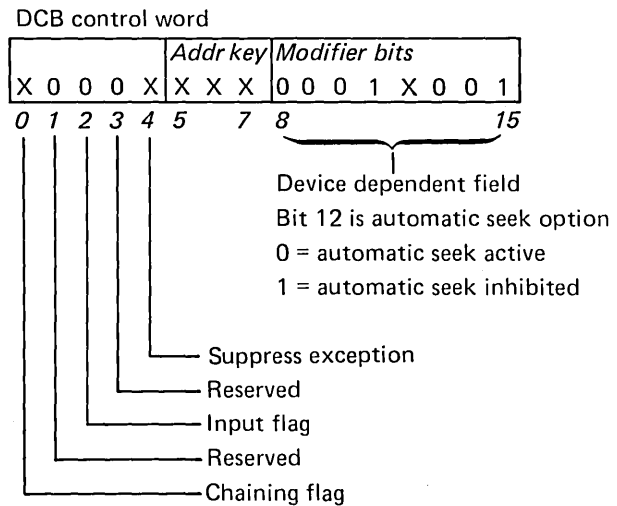
The error recovery procedure for this operation is determined by the setting of control word 0 bit 4. When the SE bit equals 1, the attachment retries the operation eight times before posting a permanent error. When the operation is finished, the status is stored at the location indicated by the residual status block address in the DCB unless an exception condition occurs. In this case, status is available to a Start Cycle Steal Status command.

Note: If a permanent CRC error (data field) is encountered, the data record read from the disk on the last retry will be transferred (cycle steal) to processor storage before the end-operation interrupt is posted.

If the SE bit equals 0, there are no retries attempted and any errors result in an exception end of the operation with status available to a Start Cycle Steal Status command.

This operation supports the auto seek option (bit 12) in the control word of the DCB. If bit 12 equals 0, the search argument is checked against the current location and automatic head and cylinder switching takes place at logical end of track. When bit 12 equals 1, the disk unit returns a no-record-found error, if after one revolution, a record has not been found. Also, no data transfer takes place if the correct cylinder and head are not selected.

Read Verify



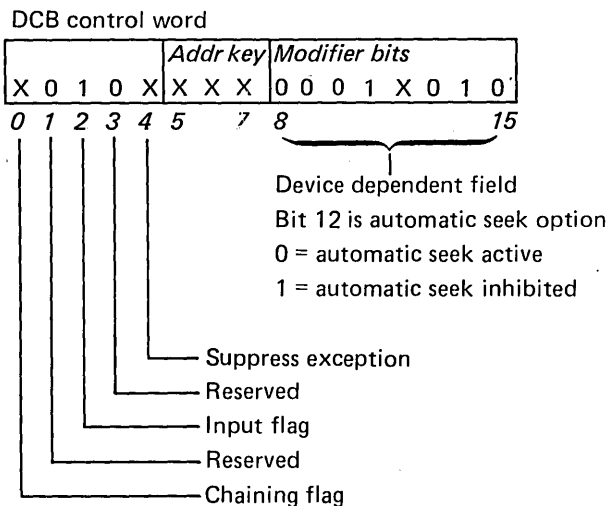
This operation is used to validate data written on the disk. It operates as does the read data operation except no data is transferred to processor storage during the performance of the operation. This operation would normally use the search argument of a previous write data operation. The DCB contains the byte count, the residual status block address, and the search argument.

The error recovery procedure for this operation is determined by the setting of control word bit 4. When the SE bit equals 1, the attachment retries the operation eight times before posting a permanent error. When the operation is completed, the status is stored at the location indicated by the residual status block address in the DCB, unless an exception occurs. In this case, status is available to a Start Cycle Steal Status command.

If the SE bit equals 0, the attachment does not retry the operation and any errors will result in an exception end of the operation with status available to a Start Cycle Steal Status command.

This operation supports the auto seek option (bit 12) in the control word of the DCB. If bit 12 equals 0, the search argument is checked against the current location and a seek operation is initiated as required. When bit 12 equals 1, the attachment returns a no-record-found error and no data transfer takes place if the correct cylinder and head are not selected.

Read Data Repeat



This operation is similar to a read data operation except only data for the last record read is transferred to processor storage. All records up to the last record are not transferred but are instead verified for correct CRC error. Only full records may be specified. The byte count in the DCB must be 256 or an exception interrupt occurs with DCB specification check active in the ISB. The number of records to be operated on is contained in the

scan/repeat byte of the DCB and must be the number of full records involved in the operation minus one.

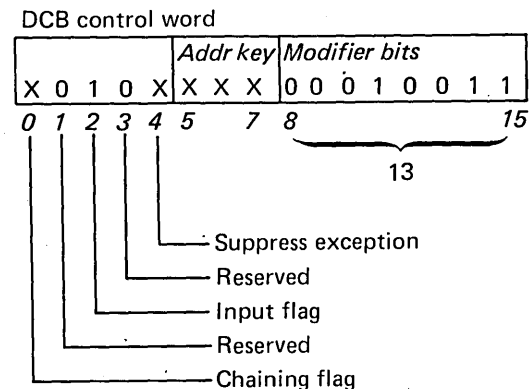
If bit 12 of the control word modifier equals 0, and the record count has not been reduced to 0, automatic head and cylinder switching takes place at logical end of track. Up to 65,536 bytes (256 full records) may be involved in this operation without regard to track or cylinder boundaries and without intermediate interrupts. Regardless of the number of records operated on, only the last 256 bytes of data are transferred to storage.

The error recovery procedure for this operation is determined by the setting of control word bit 4. When the SE bit equals 1, the attachment retries the operation eight times before posting a permanent error. When the operation is finished, the status is stored at the location indicated by the residual status block address in the DCB, if there was no permanent error. After a permanent error, the status is available to a Start Cycle Steal Status command.

If the SE bit equals 0, the attachment does not retry the operation and any errors result in the end of the operation with status available to a Start Cycle Steal Status command.

This operation supports the auto seek option (bit 12) in the control word of the DCB. If bit 12 equals 0, the search argument is checked against the current location and a seek operation is initiated as required. When bit 12 equals 1, the attachment returns a no-record-found error, and no data transfer takes place if the correct cylinder and head are not selected.

Read Disk Unit Data Buffer Diagnostic



This operation causes the disk unit to cycle steal one 256-byte record from the designated disk unit data buffer into processor storage. The DCB contains the data address, buffer number, and byte count needed by the operation.

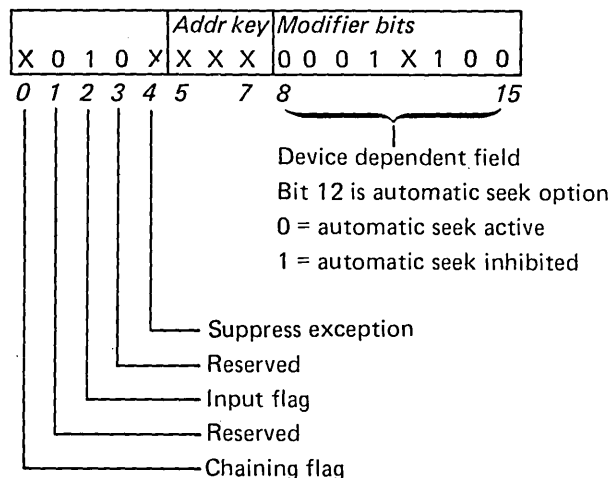
The buffer number must be specified in word 3 (8-15) of the DCB. The associated byte count must be specified in word 6 of the DCB.

Valid buffer number	Byte count	Buffer being read
Word 3 (8-15)	Word 6	
00	0100	DUC buffer area
01	0100	Data buffer area 1
10	0100	Data buffer area 2
11	0100	Data buffer area 3

Note: There is no DCB specification check for this operation.

Read Sector ID

DCB control word



This operation transfers the ID field of a sector into processor storage at the data address specified in the DCB. The count in the byte count field of the DCB is used to determine the number of sector IDs to be read into processor storage. The byte count must be four bytes per sector up to a maximum of 33 sectors per track.

The sector ID field is as follows:

Flag byte	Sector number
0 1 2 3 4 5 6 7	0 1 2 3 4 5 6 7
F F F F F F F F	0 S S S S S S S 0

Head number	Cylinder number
0 1 2 3 4 5 6 7	0 1 2 3 4 5 6 7
0 H H H H H 0 C	C C C C C C C C

The starting ID on the track is determined from the sector/record number in word 1 of the DCB. A 00 denotes the first sector ID following index. A count of 01 denotes the second, and so forth.

Head switching does not take place with this operation. All transfers crossing "index" will continue on the same track until logical end of track.

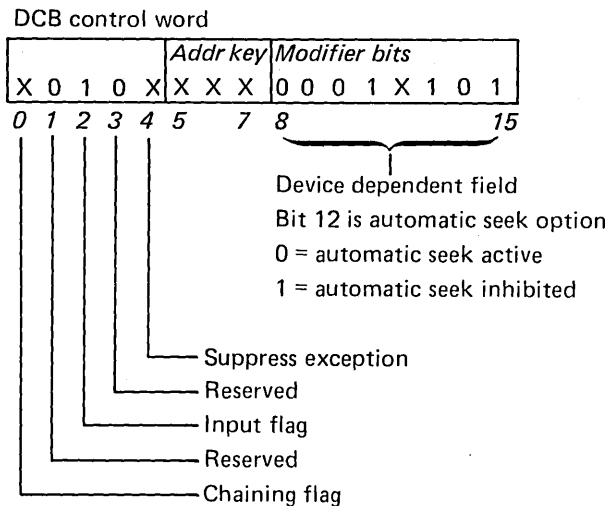
The error recovery procedure for this operation is determined by the setting of control word bit 4. When the SE bit equals 1, the attachment retries the operation eight times before posting a permanent error. When the operation is completed, the status is stored at the location indicated by the residual status block address in the DCB, unless an exception condition occurs. In which case, status is available to a Start Cycle Steal Status command.

If the SE bit equals 0, the attachment does not retry the operation, and a CRC error results in hex FF (all bits equal 1 in all four bytes) being inserted into the ID data area for the attempted ID. The read sector ID operation is then resumed, and continues to the end of the operation with status available to a Start Cycle Steal Status command.

This operation supports the auto seek option (bit 12) in the control word of the DCB. If bit 12 equals 0, the search argument (word 2) is checked against the current location and a seek operation is initiated as required.

Note that read sector ID and read sector ID extended do not require word 2 of the DCB except where auto seek is called for.

Read Sector ID Extended



This operation transfers the ID field of a sector, which has been displaced by 64 bytes from its normal location on the disk, into processor storage at the data address specified in the DCB. The byte count field must be four bytes per sector up to a maximum of 33 sectors per track.

The starting ID on the track is determined from the sector/record number in word 1 of the DCB. A 00 denotes the first sector ID following index. A 01 denotes the second, and so forth.

Head switching does not take place with this operation. All transfers crossing "index" will continue on the same track until logical end of track.

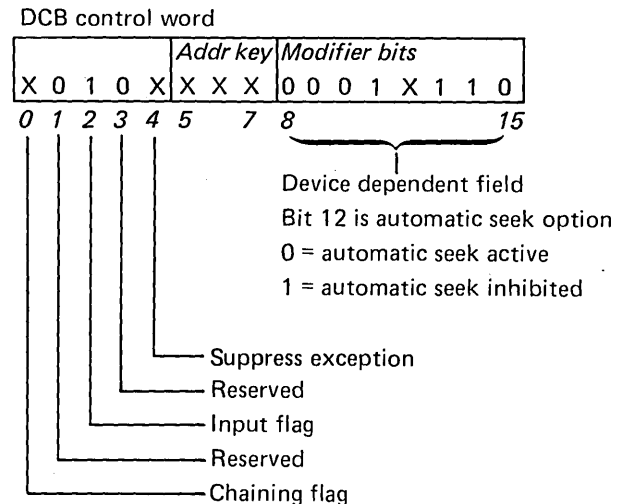
The error recovery procedure for this operation is determined by the setting of control word bit 4. When the SE bit equals 1, the attachment retries the operation eight times before posting a permanent error. When the operation is finished, the status is stored at the location pointed to by the residual status block address in the DCB, unless an exception condition occurs. In this case, status is available to a Start Cycle Steal Status command.

If the SE bit equals 0, the attachment does not retry the operation and a CRC error results in hex FF being inserted into the ID data area for the attempted ID. The read sector ID operation is then resumed, and continues to the end of the operation with status available to a Start Cycle Steal Status command.

This operation supports the auto seek option (bit 12) in the control word of the DCB. If bit 12 equals 0, the search argument (word 2) is checked against the current location and a seek operation is initiated as required.

Note that read sector ID and read sector ID extended do not require word 2 of the DCB except where auto seek is called for.

Read Diagnostic Record 1



This operation is used to recover the first data record associated with a defective sector ID.

The starting ID on the track is determined from the sector/record number in word 1 of the DCB. A 00 denotes the first sector ID following index. A 01 denotes the second, and so forth.

The byte count in the DCB must be 256 bytes and the sector number must be the physical sector containing the record to be recovered.

Most automatic error recovery procedures are not supported under the read diagnostic operation. Only disk unit parity check and data check conditions are retried if the SE bit equals 1.

Note: If a permanent CRC error (data field) is encountered, the data record that was read from the disk on the last attempt to retry the operation, will be transferred (cycle steal) to the system before the end-operation interrupt is posted.

This operation supports the auto seek option (bit 12) in the control word of the DCB. If bit 12 equals 0, the search argument is checked against the current location and a seek operation is initiated, as required.

Note that the read diagnostic record 1 and read diagnostic record 2 operations do not require word 2 of the DCB except where auto seek is called for.

Alternate Sector Assignment. If a recurring error condition, such as no record found or cyclic redundancy check, indicates that a sector has become defective, the two data records from that sector should be assigned to an alternate sector. The defective sector should be flagged as defective and further reference to it should be directed to the alternate sector by placing the alternate sector address in the defective sector ID.

If the original sector indicates a defective ID field, data recovery is accomplished by read data diagnostic record 1 and read data diagnostic record 2 operations. Defects in the data records may require backup or reconstruction by other means. Data records are assigned to sector 32 of the original cylinder, or to an available sector elsewhere on the disk.

The ID of the selected alternate sector is written to be identical to the original sector, except for the flag byte. The flag bits are written to show it as an assigned alternate sector, if it resides on an alternate cylinder. If it is written on the original track as the primary alternate, it has the displaced sector bit equal to 1, as do all sectors continuing to the end of the track.

The recovered or reconstructed data should be written into the newly defined alternate sector and the data should then be verified. Then the original sector's ID should be written to reflect the address of the alternate sector and the ID should then be verified. The flag byte is written to show it as a defective sector. If the write ID operation or the verify operation fails due to the original defect, then the ID must be written skewed, and verified using the write ID extended command.

User-written programs designed for this function must implement the same type of support to preserve the integrity of the disk unit data.

Alternate Cylinder Assignment

A secondary defective sector can be reassigned to an alternate track on the same or a different cylinder.

The first nondefective sector of the alternate cylinder for each movable head contains factory-written version information about defective sectors. The information consists of the address of each defective sector under the fixed heads and the address of each defective sector for that movable head. Note that the alternate cylinder for every movable head contains the defective sector information for all fixed heads.

Factory Reassignment of Sectors

When the factory determines that a sector is defective, the sector is reassigned as a displaced sector. The flag field for the defective sector is:

X	X	0	0	1	0	1	0
0							7

Bits 0 and 1 will be set to reflect the location within the sector of the defect. If bits 0 and 1 both equal 0, the defect is in the ID area, and the ID area of the defective sector is displaced 64 bytes farther into the track.

The address assigned to the address field of the defective sector is X'20'.

The flag field for all other sectors after they have been displaced is:

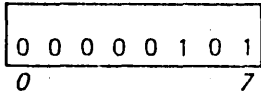
0	0	0	0	1	0	0	0
0							7

The address fields of the displaced sectors contain the same information as if the sectors had not been displaced.

If the alternate sector on the track has been used, the defective sector is reassigned to the alternate cylinder. In this situation, the flag field of the defective sector contains:

X	X	0	0	0	1	1	0
0							7

The address field of the defective sector contains the address of a sector in the alternate cylinder to which the defective sector has been assigned. The address field of the alternate cylinder sector receiving the reassigned sector is set to the address of the reassigned sector. The flag field of the reassigned sector in the alternate cylinder contains:



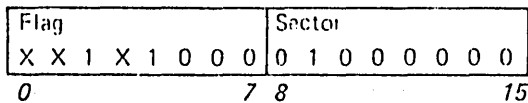
If the defective sector is displaced or assigned to the alternate cylinder, the sector address is written in the first unassigned nondefective sector on the alternate cylinder for that head.

Alternate cylinder data is originally written on cylinder 64, and is moved to cylinder 358 at the factory, prior to customer shipment. Replacement disk enclosures will need a program to move original data from cylinder 64 to cylinder 358.

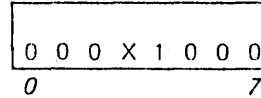
User Reassignment of Sectors

When a sector becomes defective during use, reassign it using the following steps:

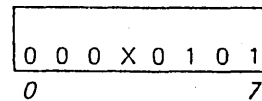
1. Read the sector ID of sector 32 on that track.
2. Examine the flag field to determine if sector 32 has been reassigned (displaced bit equals 1).
3. If sector 32 has not been reassigned:
 - a. Read the data from the defective sector.
 - b. Rewrite the sector ID of the defective sector as:



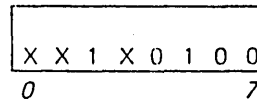
- c. Read the data and sector ID fields from the next sector.
- d. Write the sector ID of the previous sector in the address field of the sector just read. Write the flag field as:



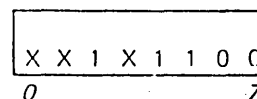
- e. Write the data from the previous sector into the sector that was just reassigned.
 - f. Repeat steps c through e until all sectors following the defective sector have been displaced.
4. If sector 32 has been displaced (indicating that this is the second defect for this track) reassign the defective sector to an alternate track or cylinder using the following steps:
 - a. Read the data from the defective sector.
 - b. Locate an unused nondefective alternate sector. The scatter method of locating a sector is recommended. Any sector following the first good sector whose flag field equals 0 is an unassigned nondefective alternate sector.
 - c. Write the address of the defective sector in the address field of the unassigned alternate sector of an alternate track or cylinder. Write the flag field as:



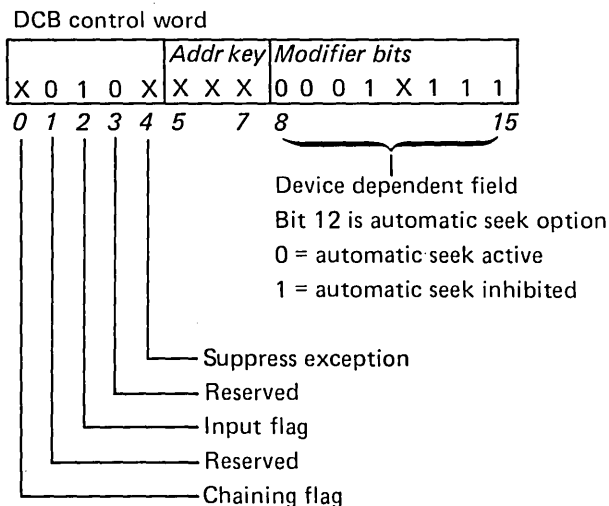
- d. Write the address of the alternate sector assigned in step c above in the address field of the defective sector. If the second defective sector occurs at a location between logical sector 0 and the first defective sector, write the flag field as:



If the second defective sector occurs at a location after the first defective sector, write the flag field as:

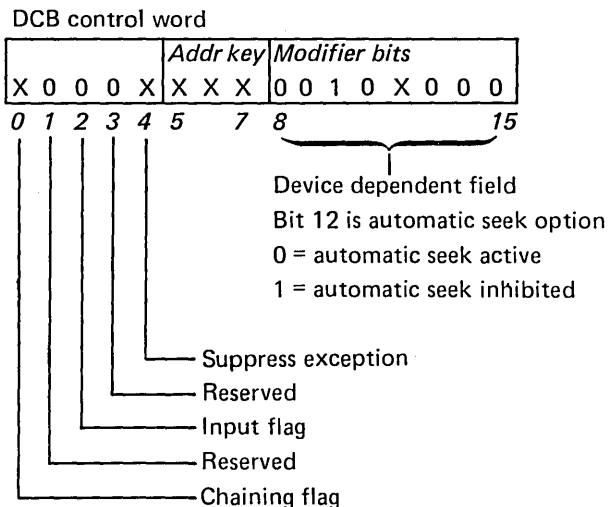


Read Diagnostic Record 2



This operation is identical to read diagnostic record 1 except that it is used to recover the second data record associated with a defective sector ID.

Write Data



This operation transfers data to the disk unit from the data area designated by the DCB data address, starting at the search argument location specified in the DCB.

If bit 12 of the control-word modifier equals 0, automatic head and cylinder switching takes place at logical end of track. Up to 65,534 bytes (two bytes less than 256 records) may be written without regard to track or cylinder boundaries and without intermediate interrupts. If the byte count goes to 0 before the end of the complete 256-byte record, the attachment "pads" the remainder of that record with 0's.

The error recovery procedure for this operation is determined by the setting of control word bit 4. When the SE bit equals 0, the attachment retries the operation four times before posting a permanent error. When the operation is finished, the status is stored at the location indicated by the residual status block address in the DCB, unless a permanent error occurs, in which case, the status is available to a Start Cycle Steal Status command. If the write data with verify option is used, only one read operation is used each time the operation is retried.

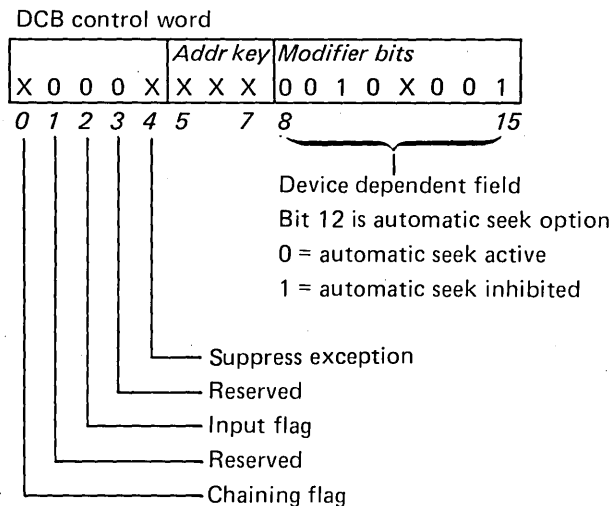
If the SE bit equals 0, the attachment does not retry the operation and any errors will result in the end of the operation with status available to a Start Cycle Steal Status command.

This operation supports the auto seek option (bit 12) in the control word of the DCB. If bit 12 equals 0, the search argument is checked against the current location and a seek operation is initiated as required. When bit 12 equals 1, the attachment returns a no-record-found error, and no data transfer takes place if the correct cylinder and head are not selected.

Fixed Head Data Integrity. Fixed heads physically contact the disk surface when the disk unit power is off and data could be destroyed. Data under the fixed heads can be protected if the following precautions are taken:

- Read and store the identifier and data fields before the disk subsystem power is turned off, and write the same identifier and data fields after the disk subsystem power is restored.
- Do not remove the disk unit from the system enclosure.
- Do not execute the write diagnostic program.

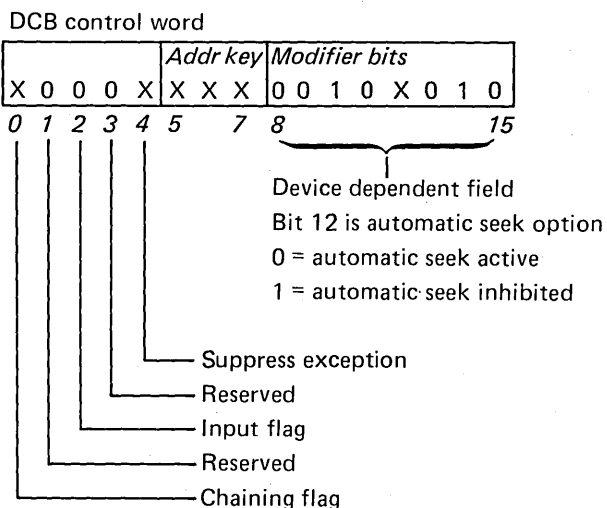
Write Data with Read Verify



This operation is the same as the write data operation except that data is automatically read back and CRC checked before the operation is completed.

It is recommended that the write data with read verify operation be used instead of separate operations so that automatic error recovery procedures can retry both the write and verify operations if the verify operation fails.

Write Data Repeat



This operation is similar to a write data operation except data is transferred to the disk in full-record increments only and all records are written with the same data. The byte count in the DCB must be 256 or an exception interrupt occurs with a DCB specification check active in the ISB. The attachment transfers the 256 bytes of data addressed by the data address word in the DCB and writes it into the record specified by the search argument. Each successive record is written with the same 256 bytes of data until the end of the operation. The number of records to be written is contained in the scan/repeat count byte of DCB word 3, and is one less than the number of full records to be written.

If bit 12 of the control word modifier equals 0, automatic head and cylinder switching takes place at logical end of track. Up to 65,536 bytes (256 full records) can be written without regard to track or cylinder boundaries and without intermediate interrupts. Regardless of the number of records written, only 256 bytes of data are transferred to the attachment. Therefore, this operation is well suited for initializing large data areas on the disk where minimal storage is needed.

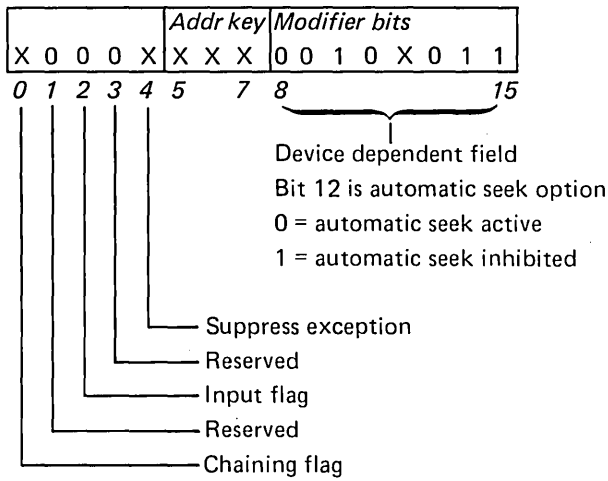
The error recovery procedure for this operation is determined by the setting of control word bit 4. When the SE bit equals 1, the attachment retries the operation four times before posting a permanent error. When the operation is finished, the status is stored at the location indicated by the residual status block address in the DCB, if there was no permanent error. After a permanent error, the status is available to a Start Cycle Steal Status command. If the write data repeat with read verify operation is used, the verify operation is retried eight times for each time the operation is write retried.

If the SE bit equals 0, the attachment does not retry the operation and any errors result in the end of the operation with status available to a Start Cycle Steal Status command.

This operation supports the auto seek option (bit 12) in the control word of the DCB. If bit 12 equals 0, the search argument is checked against the current location, and a seek operation is initiated as required. When bit 12 equals 1, the attachment returns a no-record-found error, and no data transfer takes place if the correct cylinder and head are not selected.

Write Data Repeat with Read Verify

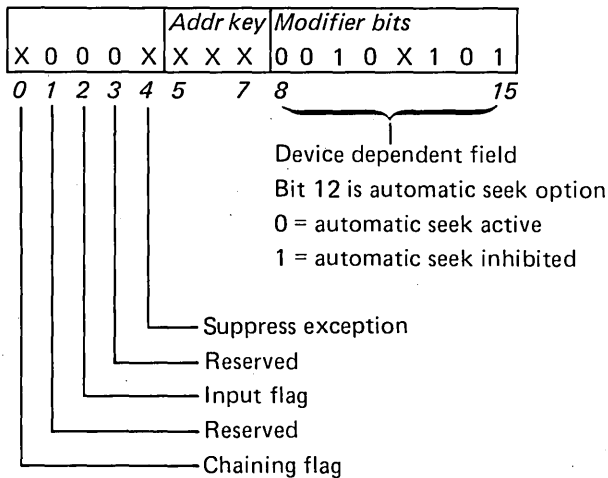
DCB control word



This operation is the same as write data repeat except that data is automatically read back and CRC checked before the operation is completed. It is recommended that the write data repeat with read verify operation be used instead of separate operations so that automatic error recovery procedures can retry both the write and verify operations if the verify operation fails.

Write Sector ID with Read Verify

DCB control word



This operation writes four bytes of sector ID information onto a specified sector. The data pointed to by the data address field in the DCB is written into the sector ID field specified by the physical sector number byte in the DCB. A write

ID with read verify operation causes the written data to be automatically read back and CRC checked before the operation is completed.

The sector ID field is as follows:

Flag byte								Sector number							
0	1	2	3	4	5	6	7	0	1	2	3	4	5	6	7
F	F	F	F	F	F	F	F	0	S	S	S	S	S	S	0

Head number								Cylinder number							
0	1	2	3	4	5	6	7	0	1	2	3	4	5	6	7
0	H	H	H	H	H	0	C	C	C	C	C	C	C	C	C

The physical sector number byte in the DCB is used as the starting location to write on the disk. A 0 in this byte specifies the first sector after index, a 1 specifies the second sector after index, and so forth to the end of the track.

The byte count is specified as a multiple of 4 up to a maximum of one full track (132 bytes). Head switching does not take place with this operation. All transfers crossing "index" will continue on the same track until logical end of track.

During initialize operations, a read ID must be executed before write ID to preserve the integrity of the flag byte bits, set at factory for defective sectors. A previously flagged defective sector should not be rewritten as valid. It might pass as valid the second time but could become defective again resulting in loss of user data.

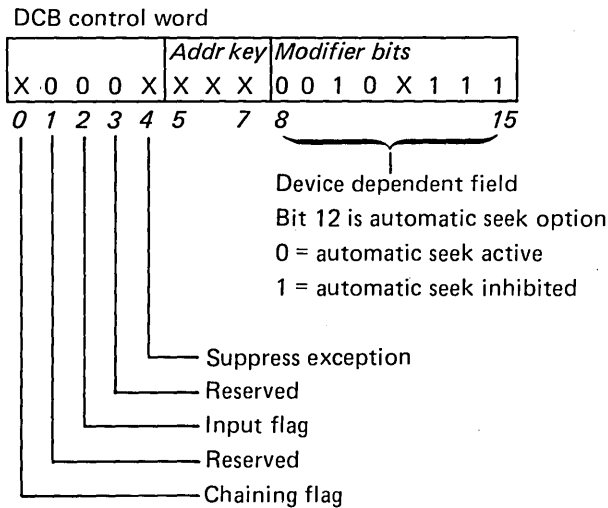
When writing sector IDs for fixed heads, the cylinder number must be written as hex 1FF.

The error recovery procedure for this operation operates in accordance with the control word bit 4 (SE setting). When the SE bit equals 1, the attachment retries the operation four times before posting a permanent error. When the operation is finished, the status is stored at the location indicated by the residual status block address in the DCB, unless a permanent error occurs, in which case, the status is available to a Start Cycle Steal Status command.

If the SE bit equals 0, the attachment does not retry the operation and any errors result in the end of the operation with status available to a Start Cycle Steal Status command.

This operation does not support the auto seek option (bit 12) in the control word of the DCB. If bit 12 equals 0, a DCB specification check occurs.

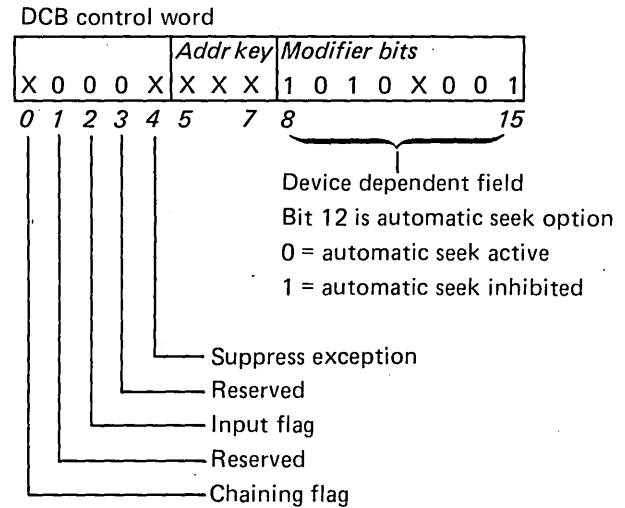
Write Sector ID Extended with Read Verify



This operation is similar to the write sector ID with read verify operation with one exception. The sector ID information is written onto the disk 64 bytes past the normal location to compensate for a surface defect in the normal location. Because of this displacement, the data area of the sector is destroyed. This operation, therefore, is only to be used where a disk defect prevents writing the ID in the normal position and is only used for flagging a defective sector. The defective sector flag bit must always be active when using this operation. All options available to a write sector ID with read verify operation are also available to a write sector ID extended with read verify operation.

Note: If multiple sector IDs are specified in the byte count (greater than 4), all IDs will be written skewed.

Write Data Security with Read Verify



This operation can be used to overwrite existing data with 0's. The byte count specifies the number of bytes to be written as 0's. This byte count must be even or a DCB specification check is returned. The data address given in the DCB is ignored.

Automatic head and cylinder switching takes place when, at logical end of track, further data transfer is required. Up to 65,536 bytes (256 records) can be written without regard to track or cylinder boundaries and without intermediate interrupts. If the byte count goes to 0 before the end of a complete 256 byte record, the attachment "pads" the remainder of that record with 0's. Therefore, in effect, only full sections are padded by this operation.

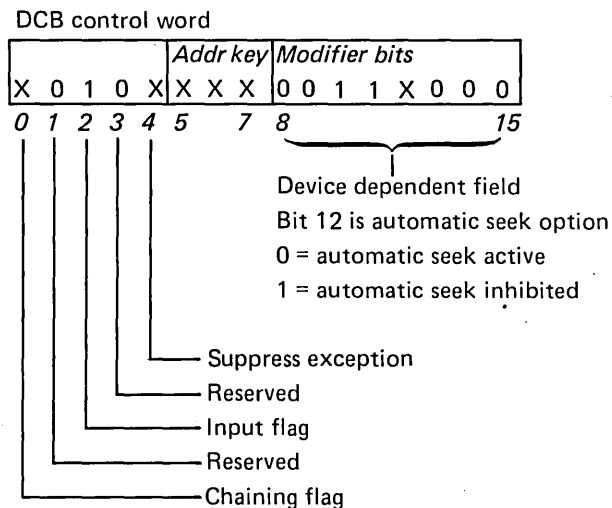
The error recovery procedure for this operation is determined by the setting of control word bit 4. When the SE bit equals 1, the attachment retries the operation four times before posting a permanent error. When the operation is finished, the status is stored at the location indicated by the residual status block address in the DCB, unless a permanent error occurs, in which case, the status is available to a Start Cycle Steal Status command.

If the SE bit equals 0, the attachment does not retry the operation and any errors will result in the end of the operation with status available to a Start Cycle Steal Status command.

This operation supports the auto seek option (bit 12) in the control word of the DCB. If bit 12 equals 0, the search argument is checked against

the current location and a seek operation is initiated, as required. When bit 12 equals 1, the attachment returns a no-record-found error, and no data transfer takes place if the correct cylinder and head are not selected.

Scan Equal



This operation causes a data comparison search to be conducted between a scan argument record and data records contained on a given disk unit. A single 256-byte record, the scan argument record, is transferred from storage to the disk unit. The starting addresses of the scan argument record are specified in DCB word 7, data address. The DCB record number, head, and cylinder specify the starting point on the disk unit for the search. The number of data records to be searched is defined by the DCB scan repeat count field. If an equal condition is found, 258 bytes of data will be transferred to storage, otherwise, no transfer of data to storage will occur. The byte count for all scan operations in the DCB must be 258 or an exception interrupt occurs with DCB specification check set in the ISB. The interrupt information byte (IIB) and the residual status block both contain status bits indicating whether or not an equal condition was found.

The scan argument record (256 bytes) can contain multiple scan arguments. The delimiter between each scan argument contained within the entire scan argument record is hex FF. The delimiter byte itself (hex FF) causes a comparison of immediately previous data. When an hex FF is encountered, the equal condition is tested. If valid,

the data comparison is terminated and the rest of the disk unit data record is placed into the scan argument record in the attachment. The total scan data record, the modified scan argument record, is now returned to storage at the original location specified. The length of the scan data record returned is 258 bytes. The two additional bytes are required for turnaround time. Hence, 258 bytes of storage should be allocated to receive the scan data record, if the equal condition is found. Note that only the first 256 bytes of the original scan argument record are used in the search operation.

If a not equal condition occurs after the hex FF byte delimiter, the search continues. If the last byte of the last scan argument occupies the 256th byte of the scan argument record, it is assumed that there is a delimiter byte hex FF in byte position 257. If the equal condition is found on the 256th byte, the original scan argument record is returned to storage.

The input flag, bit 2 of the DCB control word, must equal 1 for this scan operation.

The error recovery procedure for this operation is determined by the setting of control word bit 4. If the SE bit equals 1, the attachment retries the operation eight times before posting a permanent error. When the operation is finished, the status is stored at the location indicated by the residual status block address in the DCB, unless a permanent error occurs, in which case, the status is available to a Start Cycle Steal Status command.

If the SE bit equals 0, the attachment does not retry the operation and any errors result in the end of the operation with status available to a Start Cycle Steal Status command.

This operation supports the auto seek option (bit 12) in the control word of the DCB. If bit 12 equals 0, the attachment checks the search argument against the current location and initiates a seek operation as required. If bit 12 equals 1, the attachment returns a no-record-found error, and no data transfer takes place if the correct cylinder and head are not selected.

The scan operation stops with the first scan hit, permanent error, or when the scan/repeat count is 0.

Scanning starts with the data record pointed to by the search argument in the DCB. The number of records to be scanned is determined by the scan/repeat count byte in the DCB. A count of 0

causes one record to be scanned, a count of 1 for two records, and so forth to 256 records maximum. Automatic head and cylinder switching is supported.

Note: If an error occurs that prevents reading data (for example, no record found), the residual address points to the last byte of the DCB and the residual count is 258. This indicates that the search argument record was read from processor storage into the disk unit, and no data was transferred to processor storage.

The same residual address and residual byte count indication is returned if a 'scan not equal' condition is encountered.

		Scan argument record read from storage		Data record on the disk		Scan data record read into storage	
Word	0	S.A.	S.A.	FD0	FD1	S.A.	S.A.
	1	S.A.	S.A.	FD2	FD3	S.A.	S.A.
	2	S.A.	S.A.	FD4	FD5	S.A.	S.A.
	3	S.A.	S.A.	FD6	FD7	S.A.	S.A.
	4	X'FF'	X'FF'*	FD8	FD9	'FF'	'FF'
	5	X'FF'	X'FF'*	FD10	FD11	'FF'	'FF'
	6	S.A.	S.A.	FD12	FD13	S.A.	S.A.
	7	S.A.	S.A.	FD14	FD15	S.A.	S.A.
	8	X'FF'	YY**	FD16	FD17	X'FF'	YY***
	9	XX	XX	FD18	FD19	FD16	FD17
	10	XX	XX	FD20	FD21	FD18	FD19

127	XX	XX	FD254	FD255	FD252	FD253	
128	XX	XX			FD254	FD255	

*'FF' causes Scan Equal to be tested.

**'FF' causes Scan Equal to be tested again.

***These two bytes allow storage address turnaround.

S.A. = Scan argument (for data comparison).

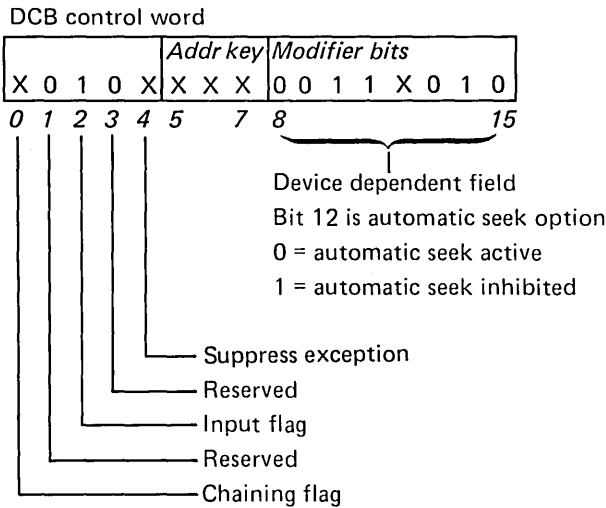
FD = Disk unit data (byte) N as read from disk unit.

XX = Not used

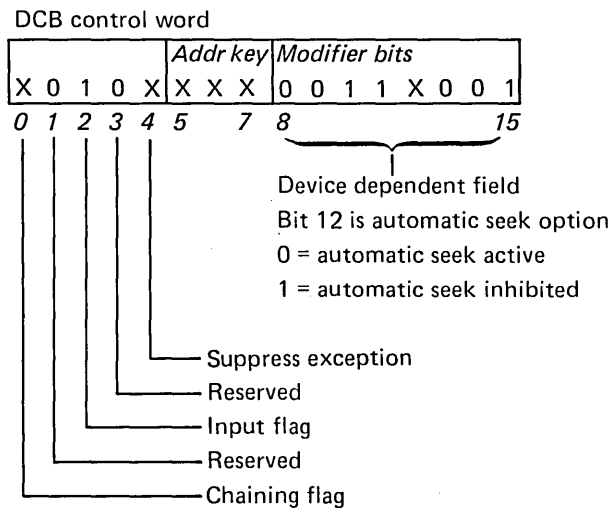
YY = This byte does not get altered in the transfer.

It's contents are neither examined or used by the attachment.

Scan High or Equal



Scan Low or Equal



These operations operate in the same sequence as the scan equal except for the data compare. The following table summarizes the compare operations:

Scan equal	Scan argument	=	Disk unit data
Scan high or equal	Scan argument	<=	Disk unit data
Scan low or equal	Scan argument	>=	Disk unit data

'Scan equal' and 'scan not equal' bits are used together to define the status of the scan commands. These status indicators are posted in both the residual status block and the cycle-steal

status block. Note carefully the interpretation of the scan equal and scan not equal bits. The scan not equal bit, when equal to 1, indicates that the requested scan condition was not met. The scan equal bit, when equal to 1, indicates the *equality* condition only. Thus, for example, the scan low or equal condition could have been met (scan not equal to 0). Now the scan equal bit = 0 indicates that the disk unit data was less than the scan argument.

Operation	Data compare	Scan not equal	Scan equal
Scan equal	Equal	0	1
	Not equal	1	0
Scan low or equal	Equal	0	1
	Low	0	0
	High	1	0
Scan high or equal	Equal	0	1
	Low	1	0
	High	0	0

DCB Word 1—Flag, Sector or Record Number

The flag byte (bits 0–7) describes the condition of the sectors.

DCB word 1 flag

X	X	X	X	X	X	X	X
0	1	2	3	4	5	6	7

The following bits are described as when equal to 1:

- Bit 0—defective data field 2—assigned at factory.
- Bit 1—defective data field 1—assigned at factory.
- Bit 2—user assigned defect.
- Bit 3—protected data area—assigned at factory to first good sector of alternate cylinder.
- Bit 4—sector displaced.
- Bit 5—sector reassigned to alternate cylinder.
- Bit 6—defective sector assigned at factory (when this bit equals 1, it must be maintained to preserve the integrity of the disk).
- Bit 7—Assigned alternate sector.

The sector/record number byte (bits 8–15) contains the identity of the sector or the data record to be processed.

The six bits of information must be right-justified within the byte.

DCB word 1 sector or record

X	X	X	X	X	X	X	X
8	9	10	11	12	13	14	15

Sector numbers are used for the following operations:

- Read sector ID
- Read sector ID extended
- Write sector ID
- Write sector ID extended
- Read diagnostic

Data and scan operations use the data record number.

DCB Word 2—Head and Cylinder

0	H	H	H	H	0	C	C	C	C	C	C	C	C	C	
0	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15

This word contains the head and cylinder number to be selected. The head number is located in bits 1–5 of the first byte. The cylinder number is located in bits 7–15 of the remainder of the word. Bits 0 and 6 must be written as 0's, otherwise a DCB check occurs.

DCB Word 3—Scan/Repeat Count

This word contains the record count for the total length involved with a scan operation or multiple read/write operations.

DCB Word 4—Residual Status Block Address

The address contained in this word points to five words that are the beginning of a processor storage area where the residual status block is stored. The residual status block is stored only when the SE bit equals 1, and a permanent error did not occur.

DCB Word 5—Chaining Address

This word contains the location of the next DCB to be executed. If the chain address is odd, an interrupt is posted and a DCB specification check is set in the ISB. The chaining address is not checked unless the chaining flag (bit 0) equals 1 in control word 0.

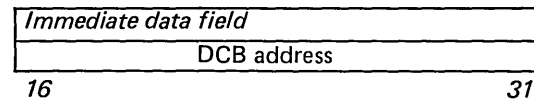
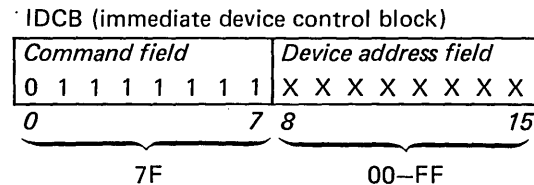
DCB Word 6—Byte Count

This word contains a 16-bit unsigned integer representing the number of data bytes to be transferred for the current DCB. If the byte count equals 0, no data is transferred. An odd byte count causes a DCB specification check. When the byte count is greater than the maximum allowed for a particular operation, an interrupt is posted and the DCB specification check (bit 3) is set to 1 in the ISB.

DCB Word 7—Data Address

This word contains the starting storage address for the data associated with the operation to be performed. An odd byte count in this word causes a DCB specification check.

Start Cycle Steal Status



The Start Cycle Steal Status command causes 13 words of status information to be transferred, in cycle-steal mode, from the 4963 to processor storage. The information is used to determine the status of an operation that did not execute correctly. The processor storage data address is specified in word 7 of the applicable DCB. This command causes the 4963 to present an interrupt request when execution is complete. The format of the DCB follows:

DCB (device control block)	
Word	Control word
0	0 0 1 0 0 Addr key 0 0 0 0 0 0 0 0
	4 5 7 8 15
1	Not used (zeros)
2	Not used (zeros)
3	Not used (zeros)
4	Not used (zeros)
5	Not used (zeros)
6	Byte count
	0 0 0 1 1 0 1 0
7	Data address
	0 15

The 13 words of status information have the following format and meaning.

Word 0	Residual address
1	Residual count
2	Retry counts word 1
3	Retry counts word 2
4	Error status word 1
5	Error status word 2
6	Last DCB address
7	Current head and cylinder
8	Previous head and cylinder
9	Flag, sector, record
10	Head, cylinder
11	Disk unit diagnostic sense bytes 1 and 2
12	Disk unit diagnostic sense byte 3 and wrap

Status Word 0—Residual Address

This address is the processor storage location of the last attempted cycle-steal transfer associated with a Start command. This address might be a DCB address or a data address. If the last transfer attempted was a word transfer, the residual address points to the odd byte of the word. If an error occurs during a start cycle steal status operation, this address is not altered. A device reset, system reset, or a Halt I/O command might cause the residual address to be indeterminate. Only a power-on reset resets the residual address to 0.

Status Word 1—Residual Count

This word contains the residual byte count of data requested for the last DCB operation. The count reflects the number of bytes of data not transferred by the last operation that can be retried, or the last individual operation if none can be retried.

Status Word 2—Retry Counts Word 1

This word contains temporary-error retry counts. The error conditions and their respective bit fields are as follows:

Bits	
0–3	CRC check
4–7	Write echo check
8–11	Missing sector pulse
12	Data unsafe
13	Disk unit not ready
14–15	Spare

Status Word 3—Retry Counts Word 2

This word is an extension of the temporary-error retry counts. The error conditions and their respective bit fields are:

Bits	
0–3	No record found
4	Storage data check
5	Invalid storage address
6	Protect check
7	Interface data check
8	Disk unit interface parity check
9–11	Reserved
12–15	Write error

Status Word 4—Error Status Word 1

The following bit format and respective error conditions are described with the bits equal to 1, unless otherwise specified.

Bit 0	Permanent error. A permanent error has occurred. When the suppress exception bit equals 0, any error causes bit 0 to be set to 1.
Bit 1	Attachment detected interface parity check. A parity error has been detected.
Bit 2	Attachment time-out. An operation has taken too long.
Bit 3	Alternate sector processed. A data record has been sought that has been reassigned to an alternate sector and automatic alternate sector processing is being used.

- Bit 4 Temporary error retry. A temporary error condition has occurred, and the operation that revealed it has been retried and cleared before the end of the retry count.
- Bit 5-7 Disk unit configuration. This three-bit field reflects the disk unit capacity.
- Bits 5, 6, 7 Specifies**
- | | |
|-----|-----------------------------------|
| 000 | reserved |
| 001 | reserved |
| 010 | model 29A & B (no fixed heads) |
| 011 | model 64A & B (no fixed heads) |
| 100 | disk unit not attached |
| 101 | reserved |
| 110 | model 23A & B (eight fixed heads) |
| 111 | model 58A & B (eight fixed heads) |
- Bit 8 Scan not equal. A request for a scan operation has not been met.
- Bit 9 Scan equal. An equal condition has occurred on a scan operation.
- Bit 10 Attachment equipment check. A circuit error has been detected by the attachment.
- Bit 11 Write error. A permanent CRC check has occurred on a write data with read verify operation. Setting the suppress exception (SE) bit to 1 permits the write operation to be retried up to four times before the write error is posted.
- Bit 12 Cycle steal status error. An error has occurred while obtaining status from the disk unit during the execution of a start cycle steal status operation.
- Bit 13 End of disk. An attempt has been made to use cylinder 359 for other than write diagnostic purposes, or to select a nonexistent fixed head.
- Bit 14 Attachment load time-out. This bit is set to 1 if a cable circuit sequence has timed out.
- Bit 15 Disk unit interface error. Any of the following conditions have been detected in the disk unit.
- Cable open
 - Missing control sample
 - Daisy bus parity check
 - Disk unit failed to reset interrupt

Status Word 5—Error Status Word 2

The following bit format and respective error conditions are described with the bits set to 1, unless otherwise specified.

- Bit 0 Cyclic redundancy check. A permanent cyclic redundancy check has occurred during a sector ID or data record read operation. If the SE bit equals 1, the attachment retries the operation eight times posting a permanent error. A cyclic redundancy check, in an ID field, during an ID search operation is posted as a no record found error, not as a CRC check.
- Bit 1 Disk unit parity check. An internal parity check in the disk unit controls has been detected. This check cannot be retried by the disk unit controls.
- Bit 2 Disk unit detected interface parity check. A parity error has been detected on the data bus or tag bus on the cable between the disk controls and the attachment feature. This check cannot be retried by the disk controls.
- Bit 3 Write gate return check. Write gate is active in the disk controls but not in the disk unit. If the SE bit equals 1, the attachment retries the operation four times posting a permanent error.
- Bit 4 No record found. A sector is addressed, but cannot be found within one revolution. This error occurs if the suppress exception bit equals 0, or if the retry count is 0.
- Bit 5 Invalid operation parameter. The disk controller has detected an invalid operation parameter. The conditions that cause this bit to be set to 1 are:
- Invalid operation modifier byte
 - Byte count greater than hex 84 (132 decimal) for write sector ID and read sector ID operations
 - Bit 0 or 6 in DCB word 2 does not equal 0

- Record number is greater than 63 for read/write scan commands (DCB word 1)
 - Sector number is greater than 32 for read ID, write ID, and read diagnostic commands (DCB word 1)
- Bit 6 Missing sector pulse. The dedicated cable for this disk unit has an active “missing sector pulse” line. If the SE bit equals 1, the attachment retries the operation eight times before posting a permanent error.
- Bit 7 Disk unit time-out. A disk operation has not been completed in a specified time. It forces an exception interrupt.
- Bit 8 Fixed head not selected. Movable head operations are attempted or executed.
- Bit 9 Brake applied. An error has occurred that caused the disk brake to be applied while the disk is still being driven.
- Bit 10 Track unavailable. An access request has specified a nonexistent cylinder.
- Bit 11 Disk unit tag code error. The disk unit has encountered an illegal tag code.
- Bit 12 Data unsafe. This is caused by any of the following conditions in the disk unit:
- Write or read mode and multiple module select error
 - Write and data servo unsafe
 - Write and no write transitions
 - Not write and write current detected
 - Write and not on track and moving head selected
 - Write and read
 - Write and head short detected
 - Write and movable head selected during sector pulse
 - Write and not ready
- Bit 13 Seek incomplete. Access motion is in progress.
- Bit 14 Home. A successful power-on sequence or a recalibrate operation to the disk unit has been completed.
- Bit 15 Not ready. The disk unit has not come to a complete ready condition.

Status Word 6—Last DCB Address

This word contains the starting address of the last DCB used by the attachment.

Status Word 7—Current Head/Cylinder

This word contains the head and cylinder address of the current physical access location on the disk unit. A system reset will set this word to hex 8000.

Status Word 8—Previous Head/Cylinder

This word contains the head and cylinder address of the previous location of the access mechanism. The first seek performed, following a system reset, sets this word to hex 8000. This invalid head/cylinder number is used by the disk unit controls as a flag to indicate that another seek for the next auto-seek operation is required.

Status Word 9—Flag/Sector/Record

This word is used, with status word 10, to identify the last record on the disk unit that access was completed or attempted during the last DCB operation.

Status Word 10—Head/Cylinder

This word is used, with status word 9, to identify the last record number on the disk unit that access to was completed or attempted during the last DCB operation. This number represents the last record access attempted during the last retry of the operation, if a permanent error occurs and the SE bit equals 1. Therefore, it does not necessarily represent the highest record number attempted to be accessed during all previous attempts of the operation.

Status Word 11—Disk Unit Diagnostic Sense Byte 1&2

Diagnostic sense byte 1 occupies the high-order byte, and diagnostic sense byte 2 occupies the low-order byte.

Diagnostic Sense Byte 1

- Bit 0 On track. This bit indicates the ability of the servo to maintain the position of the data cylinder within $\pm 10\%$ of track center.
- Bit 1 Linear region normal. This bit sets the linear boundaries of the servo loop. This bit is set to 1 for even tracks, and 0 for odd tracks.

- Bit 2 Not index sector pulses. This bit is set to 0 if either an "INDEX" or a "SECTOR" pulse is detected.
- Bit 3 Out direction. This bit indicates the seek direction of the actuator.
- Bit 4 Not drive out. Logical level indication of voice coil driver out.
- Bit 5 Not drive in. Logical level indication of voice coil driver in.
- Bit 6 Tag parity error. An error condition between the disk unit controls and the disk unit has been detected. This sense bit separates parity errors from tag parity errors.
- Bit 7 Read-only-storage digital-to-analog error. This bit indicates a missing read-only-storage bit in the disk unit. This bit is latched and is set by an error. A reset occurs as each seek begins.

Diagnostic sense byte 2

- Bit 0 Behind home. This bit indicates the position of the heads. When set to 1, the heads are over the cylinder located between the landing zone and track 0.
- Bit 1 Missing clocks divided by 2. This bit set to 1 indicates missing clock pulses used for sector and index generation. A divider circuit is provided for maintenance purposes to ensure detection of pulses during worst-case sampling periods.
- Bit 2 Not missing clock error latch. This bit set to 1 indicates servo clock pulses are detected.
- Bit 3 Coil current low. This bit set to 1 indicates the coil current is low. This is a maintenance dedicated circuit.
- Bit 4 Missing servo signal. This bit set to 1 indicates the loss of the dedicated servo signal. A loss of servo signal is indicated when more than six consecutive pulses are expected but not detected. This is a maintenance dedicated circuit.
- Bit 5 Off data track. This bit set to 1 indicates the ability of the data servo to maintain the position of the data cylinder within $\pm 10\%$ center of track.

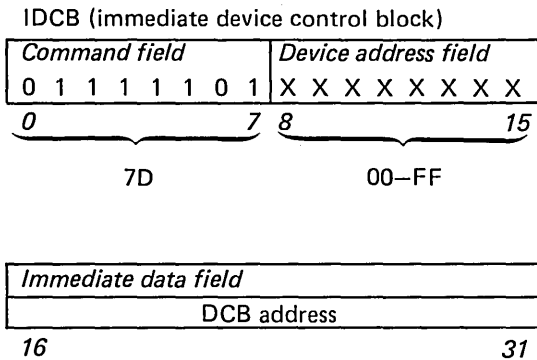
- Bit 6 Not missing position error signal. This bit set to 0 indicates the loss of one or more position-error signals in the servo loop and the loss of servo automatic gain control. This is a maintenance dedicated circuit.
- Bit 7 Counter 5 in sync. This bit set to 1 indicates that the phased-lock oscillator is in sync with the clock.

Status Word 12—Disk Unit Diagnostic Sense Byte 3 and Wrap Byte

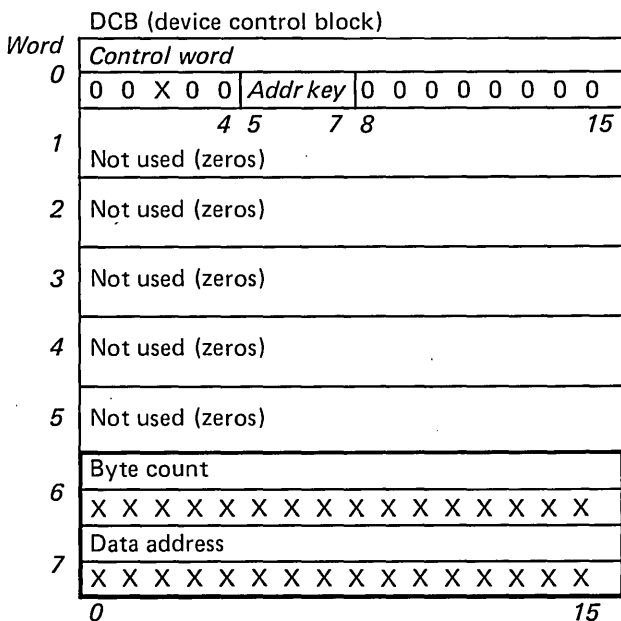
Diagnostic byte 3 occupies the high-order byte and diagnostic wrap byte occupies the low-order byte.

- Bit 0 Not shift. This bit to 0 indicates a set seek operation is set.
- Bit 1 Not off track and write. This bit set to 0 indicates an 'off track' condition during a write operation, an unsafe condition.
- Bit 2 Not outside automatic gain control window. This bit set to 0 indicates the logic level of the data servo signals in the data servo loop.
- Bit 3 Not automatic gain control freeze. This bit set to 0 indicates the existence of an automatic gain control freeze to the data servo loop.
- Bit 4 Demand pulsing. This bit set to 1 indicates missing servo demodulator pulse. This is a maintenance dedicated circuit.
- Bit 5 Not read and write. This bit set to 0 indicates an unsafe condition where read and write are active simultaneously.
- Bit 6 Not servo protect and write. This bit set to 0 indicates an unsafe condition where an attempt has been made to write over the data servo pattern.
- Bit 7 Illegal move. This bit set to 1 indicates that the sense line that separates parity errors is active due to a tag value of 000 being posted to the disk unit.
- Bits 8–15 Disk unit cylinder number. This is the lower-order byte of the cylinder number from the disk unit if it is preceded by the Sense Disk Unit Diagnostic Wrap command.

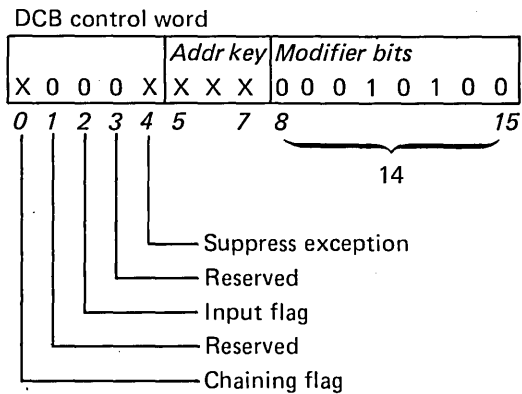
Start Cycle Steal Diagnostic



The Start Cycle Steal Diagnostic command and the operations performed by the command, are described in this section. The format of the DCB for this command is as follows:



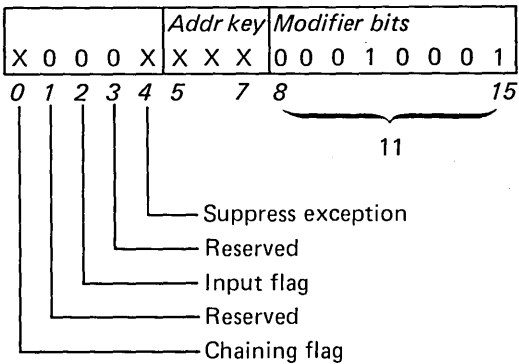
Attachment Diagnostic Write Test



This diagnostic operation exercises the data bus of the attachment feature as in a write operation. During the execution of this operation, the attachment feature isolates itself electrically from the disk unit controls. The attachment feature cycle steals words from processor storage beginning at the data address location specified in the DCB and continues until the specified byte count is 0. Only even byte counts are accepted. The data is checked for parity errors only. If a parity error occurs for any of the words transferred, the attachment feature posts an exception interrupt. The error is noted as an equipment check in cycle steal status word 4. A cycle-steal error on the Series/1 I/O attachment is reported in bits 4-7 of the ISB. The byte count is not DCB specification checked.

Attachment Write Diagnostic Patch

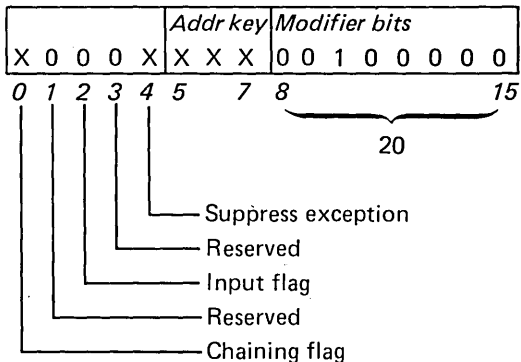
DCB control word



This diagnostic operation is used to write the first 512 bytes of the attachment storage with special patch data provided from the system. Special tests are provided throughout the read-only storage to check for the presence of patch flags in storage. These flags can be used to patch the microcode and provide the temporary fixes until a new read-only storage diagnostic is released. The byte count must be 512. The byte count is not DCB specification checked.

Write Disk Unit Control Block Diagnostic

DCB control word

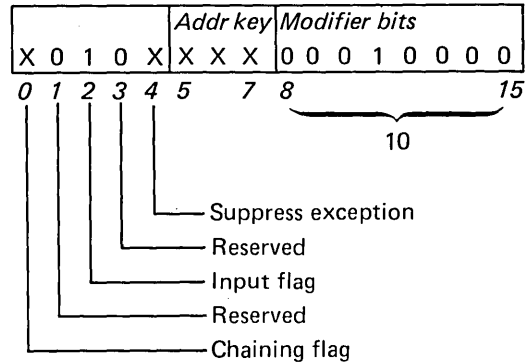


This diagnostic operation is used to write the disk unit control block of the selected disk unit. Up to 16 words can be written, depending on the byte count in the DCB. The byte count can be any number between 2 and 32. The disk unit control block is written in ascending order, starting with word 0.

Note: If a byte count greater than 32 is specified, the selected disk unit control block wraps continuously until the byte count is 0. The byte count is not DCB specification checked.

Attachment Read Diagnostic Patch

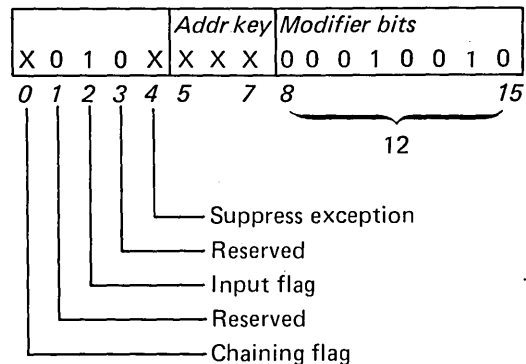
DCB control word



This diagnostic operation is used to read the first 512 bytes of the attachment storage into the system. The purpose is to check for the presence of old patch information if a new patch is to be added, or to verify that a patch was written correctly. The byte count must be 512. The byte count is not DCB specification checked.

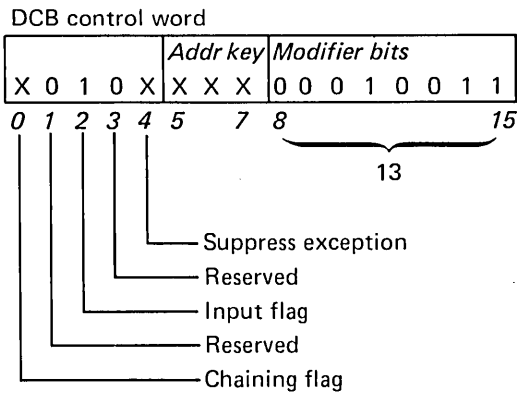
Attachment Read Only Storage Diagnostic

DCB control word



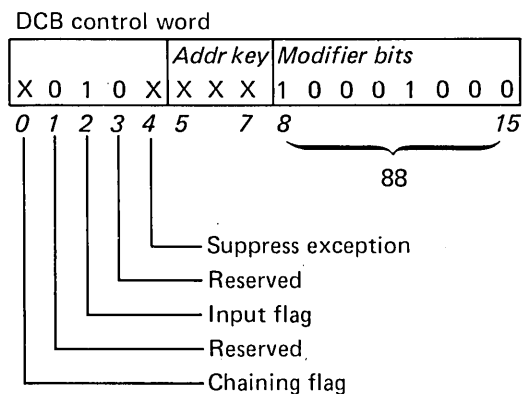
This operation causes the attachment feature to generate a read-only storage check-sum word and to cycle steal two words into storage. The word stored at the location indicated by the data address in the DCB is the reference check-sum total, and the word stored at the data address plus 2 contains the calculated check-sum total. The byte count must be set to 4. The byte count is not DCB specification checked.

Attachment Diagnostic Read Test



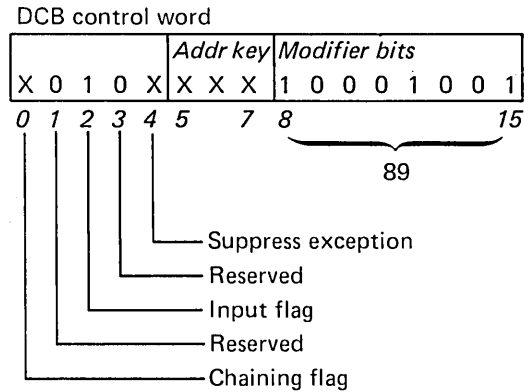
This diagnostic operation exercises the data bus of the attachment feature as in a read operation. The byte count is set to the number of bytes to be stored beginning at the data address location specified in the DCB. The byte count must be even or a DCB specification check is returned. A minimum count of 256 is recommended. Upon completion of the operation the first word in storage at the data address location should contain hex 0000, the second word should be hex 0101, the third word hex 0202, and so on. Each byte in each word is incremented modulo 256. The attachment feature is electrically isolated from the disk unit controls during this operation.

Read Diagnostic Word 1



This operation cycle steals a word from the attachment data buffer register in the disk unit controls to the location indicated by the data address in the DCB. The byte count must be 2. The byte count is not specification checked.

Read Diagnostic Word 2



This command cycle steals a word from register 2 in the disk unit controls to the location indicated by the data address in the DCB. The byte count must be 2. The bit significance of the word is:

Bit	Meaning
0-5	Not used
6	Reserved
11	Controls cycle complete
12	Diagnostic control
13	Not used
14	Diagnostic control
15	Diagnostic load program store

The byte count is not DCB specification checked.

Condition Codes and Status Information

Condition Codes

A condition code is reported to the processor (1) at the completion of every Operate I/O instruction and (2) upon presentation of a priority interrupt request. The condition code is available in the even, carry, and overflow bit positions of the level status register (LSR) in the processor. For information on the LSR, refer to an appropriate processor description manual listed under "Prerequisite Publications" in the Preface. For commands that do not cause interrupts, the condition code reported after the instruction is executed is the only status information required or available.

Operate I/O Instruction

Condition Code 0—Device Not Attached

This code is reported by the channel when the 4963 is not attached to the Series/1.

Condition Code 1—Busy

This code is reported by the 4963 when it is unable to execute a command because it is in the busy state. The 4963 enters the busy state upon acceptance of a command that requires an interrupt for termination. The 4963 exits the busy state when the attachment accepts the interrupt.

Condition Code 2—Busy After Reset

This code is reported by the 4963 when it is unable to execute a command because of a reset and the 4963 has not had sufficient time to return to the inactive state. There is no interrupt to indicate termination of this condition.

Condition Code 3—Command Reject

This code is reported by the 4963 or the channel when:

- A command is issued that is outside the 4963 command set.
- The 4963 is in an improper state to execute the command.
- The IDCBC contains an incorrect parameter, such as an odd-byte DCB address, or an incorrect function/modifier combination.

When the 4963 reports command reject, it does not fetch the DCB.

Condition Code 4—Not Used

Condition Code 5—Interface Data Check

This code is reported by the 4963 or the channel when a parity error is detected on the I/O data bus during a data transfer.

Condition Code 6—Controller Busy

This code is reported by the attachment when the controller is busy and is always followed by a controller end interrupt.

Condition Code 7—Satisfactory

This code is reported by the 4963 when it accepts a command.

Interrupt

Condition Code 0—Controller End

This code is reported by the attachment when controller busy has been previously reported. The code indicates that the 4963 attachment is now free to accept I/O commands. The device address reported with the condition code is always the lowest address of the devices serviced by the system.

Condition Code 1—Not Reported by 4963 Disk Subsystem

Condition Code 2—Exception

This code is reported when an error or exception condition is associated with the priority interrupt. This condition is described in the interrupt status byte (ISB) and further described in the 26 bytes of status information contained in the cycle steal status block.

Condition Code 3—Device End

This code is reported when no error exception or attention conditions occur during the I/O operation and a normal termination of the operation has occurred.

Condition Code 4—Attention

This code is reported when the 4963 becomes ready after being in the not ready state. Along with the interrupt condition code, the attachment also transfers an interrupt ID word which provides additional information on interrupting conditions.

Condition Code 5—Not Reported by 4963 Disk Subsystem

Condition Code 6—Attention and Exception

This code is reported when attention and exception are both present.

Condition Code 7—Attention and Device End

This code is reported when attention and device end are both present.

- Bit 4 Storage data check. This bit is set to 1 during cycle steal output operations only. It indicates that the storage location accessed during the current output cycle contained incorrect parity. The parity in processor storage is not corrected. The attachment issues the status in the ISB and terminates the operation. Condition code 2 is reported at interrupt accept time.
- Bit 5 Invalid storage address. This bit is set to 1 as a result of a cycle-steal I/O operation when the processor storage address, presented by the 4963 for data or DCB access, exceeds the specified address space. The attachment records the status and terminates the operation. Condition code 2 is reported at interrupt accept time.
- Bit 6 Protect check. This bit is set to 1 when the 4963 attempts to access a processor storage location without the correct storage protect key. For a more detailed description, refer to an appropriate processor description manual listed under "Prerequisite Publications" in the Preface of this manual. The operation is terminated and condition code 2 is reported at interrupt accept time.
- Bit 7 Interface data check. This bit is set to 1 when a parity error is detected on a cycle-steal data transfer. The condition can be detected by the 4963 or by the channel. In either case, the operation is terminated and an interrupt is reported to the processor.
- Condition code 2 is presented at interrupt accept time. (See Appendix A. Reference Information for condition code and status information.)

Error Recovery Procedures

The following error recovery procedures are initiated by the 4963 subsystem when an error occurs with the suppress exception bit equal to 1. If an error occurs and the suppress exception bit equals 0, the following user program events are recommended:

- A read operation is retried a minimum of eight times prior to posting a permanent read error.
- A write operation is retried a minimum of four times prior to posting a permanent write error. Each write-verify operation is followed by one read operation. A rewrite occurs only if the read operations fail.
- Unresolved errors result in termination of the operation. The program should issue a message and an error log to the operator at termination.
- The information placed in the flag byte (bits 2 through 7) during the factory's alternate sector assignment procedures should be rewritten during all write ID operations.

The user program must implement the required error recovery procedures if all DCBs use the SE bit option. The attachment handles all error recovery procedure requirements under the SE bit option, except those listed below under Actions. The check conditions can be tested in the ISB, and words 4 and 5 of the cycle steal status block.

Actions. The following processor actions allow for the entire error recovery procedure to be repeated once prior to posting a permanent error, requiring operator intervention. It is intended that the user retry the error recovery procedures to distinguish a permanent error from a transient condition.

1. Initiate a device reset operation.
2. Initiate a calibrate operation.
3. Reseek to the original track.

4. Retry the original operation. If still unsuccessful, issue an operator message and exit the error recovery procedures.
5. Ensure that the device is powered on, and is prepared to allow interrupts, and to wait for an attention interrupt. An operator message can be used here. Exit the error recovery procedures.

Note: If end of disk is expected, due to the manner in which the user handles multiple sector read or write operations, then the error recovery procedure is to calculate the next disk address, the starting record search argument, and the proper byte count to the operation. If end of disk is not normally expected, there might be an error in the user program or in the hardware. Therefore, initiate a device reset operation.

Resets

Several methods of resetting controls and registers are available.

Power-on Reset. Resets residual address register, prepare register, last sector register, data register (16 bits), and cycle steal request.

System Reset. Resets prepare register, last sector register, and cycle steal request.

Initial Program Load (IPL). Resets prepare register, last sector register, and cycle steal request.

Halt I/O Command. Resets last sector register and cycle steal request.

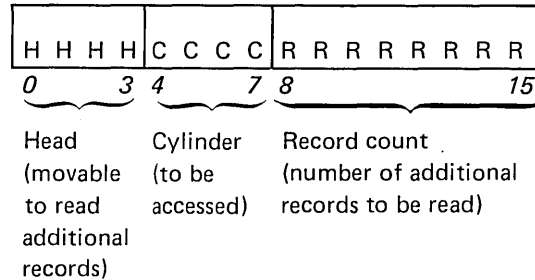
Device Reset Command. Resets last sector register.

Initial Program Load (IPL)

The 4963 attachment supports IPL from the primary and secondary disk units. Disk 0 and disk 1 can be designated as primary or secondary, interchangeably, and designation is done by the user, through hardware jumpers.

At IPL, when the designated disk unit is ready, and the IPL signal is received from the Series/1 I/O channel, the attachment initiates a recalibrate operation, and the disk unit positions itself to cylinder 0, head number 1. After recalibration, the attachment issues a read data operation for logical record 0, byte count 256, and a storage starting address of 0. If an error occurs during the read operation, the attachment retries both the recalibrate, and the read data operations up to eight times before the system stops with the LOAD indicator on.

The attachment can transfer up to 256 data records into processor storage. After the first data record is transferred, the attachment reads the last word transferred to determine if further records are to be transferred, transparent to the user, and where they are to be stored. Specifically, the bit configuration of the last word is as follows:



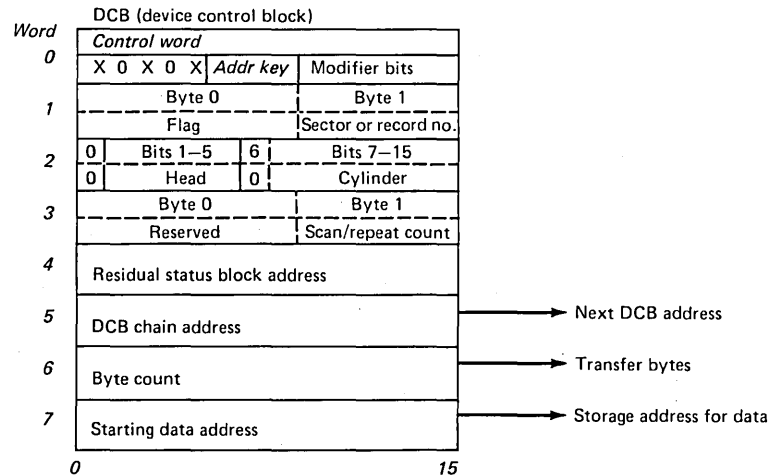
A record count of 0 in the second byte of the last word means no additional records are to be transferred into processor storage.

Appendix A. Reference Summary

4963 Disk Subsystem

I/O Commands

Hex	Command	IO Instruction CC's reported
60	Prepare	0,5,7
20	Read ID	0,5,7
6F	Device Reset	0,7
F0	Halt I/O	not reported
48	Load Sense Diagnostic Word 1	0,5,7
49	Load Sense Diagnostic Word 2	0,5,7
4E	Attachment Storage Diagnostic	0,5,7
40	Load Disk Unit Control Block 0	0,5,7
41	Attachment General Diagnostic Test	0,5,7
52	Load Seek Required Address Direct	0,5,7
53	Load Seek Control Direct	0,5,7
54	Sense Disk Unit Direct	0,5,7
55	Sense Disk Unit Diagnostic Bytes 1,2,3	0,5,7
56	Sense Disk Unit Diagnostic Bytes 1,2,3, Multiple Sample Test	0,5,7
57	Sense Disk Unit Diagnostic Wrap	0,5,7
5A	Disk Speed Timing Diagnostic	0,5,7
5D	Disk Unit Control Diagnostic	0,5,7
4F	Diagnostic Reset Disk Unit Controls	0,5,7
4D	Force End Operation	0,5,7
70	Start	0,1,2,3,5,6,7
7F	Start Cycle Steal Status	0,1,2,3,5,6,7
7D	Start Cycle Steal Diagnostic	0,1,2,3,5,6,7



Control Word (Start command)

Bit	Meaning
0	Chaining flag
1	Not used—must be zero
2	Input flag
3	Not used—must be zero
4	Suppress exception
5–7	Cycle steal address key
8–15	Disk operation field
	0000 0000 Seek
	0000 0001 Recalibrate
	0000 1001 Calibrate
	0000 1000 Overlapped seek
	0000 1011 Timed seek diagnostic
	0001 X000 Read data
	0001 X001 Read verify
	0001 X010 Read data repeat
	0001 0011 Read disk unit data buffer diagnostic
	0001 X100 Read sector ID
	0001 X101 Read sector ID extended
	0001 X110 Read diagnostic record 1
	0001 X111 Read diagnostic record 2
	0010 X000 Write data
	0010 X001 Write data with read verify
	0010 X010 Write data repeat
	0010 X011 Write data repeat with read verify
	0010 X101 Write sector ID with read verify
	0010 X111 Write sector ID extended with read verify
	1010 X001 Write data security with read verify
	0011 X000 Scan equal
	0011 X010 Scan high or equal
	0011 X001 Scan low or equal

Control Word (Start Cycle Steal Diagnostic command)

Bit	Meaning
0	Chaining flag
1	Not used—must be zero
2	Input flag
3	Not used—must be zero
4	Suppress exception
5–7	Cycle steal address key
8–15	Modifier bits (operation)
	0001 0001 Attachment write diagnostic patch
	0010 0000 Write disk unit control block diagnostic
	0001 0000 Attachment read diagnostic patch
	0001 0010 Attachment read only storage diagnostic
	0001 0011 Attachment diagnostic read test
	1000 1000 Read diagnostic word 1
	1000 1001 Read diagnostic word 2

Cycle Steal Status Words

Word 0—Residual Address

Bit	Meaning
0–15	DCB/data address

Word 1—Residual Count

Bit	Meaning
0–15	Residual byte count of data of last DCB operation

Word 2—Retry Counts Word 1

Bit	Meaning
0–3	CRC check
4–7	Write echo check
8–11	Missing sector pulse
12	Data unsafe
13	Disk unit not ready
14–15	Spare

Word 3—Retry Counts Word 2

Bit	Meaning
0–3	No record found
4	Storage data check
5	Invalid storage address
6	Protect check
7	Interface data check
8	Disk unit interface parity check
9–11	Reserved
12–15	Write error

Word 4—Error Status Word 1

Bit	Meaning
0	Permanent error
1	Interface parity check
2	Attachment time-out
3	Alternate sector processed
4	Temporary error retry
5–7	Disk unit configuration
	5 6 7
	0 0 0 reserved
	0 0 1 reserved
	0 1 0 model 29A & B (no fixed heads)
	0 1 1 model 64A & B (no fixed heads)
	1 0 0 disk unit not attached
	1 0 1 reserved
	1 1 0 model 23A & B (eight fixed heads)
	1 1 1 model 58A & B (eight fixed heads)
8	Scan not equal
9	Scan equal

10	Attachment equipment check
11	Write error
12	Cycle steal status error
13	End of disk
14	Attachment load time-out
15	Disk unit interface error

Word 5—Error Status Word 2

Bit	Meaning
0	Cyclic redundancy check
1	Disk unit parity check
2	Disk unit detected interface parity check
3	Write gate return check
4	No record found
5	Invalid operation parameter
6	Missing sector pulse
7	Disk unit time-out
8	Fixed head not selected
9	Brake applied
10	Track unavailable
11	Disk unit tag code error
12	Data unsafe
13	Seek incomplete
14	Home
15	Not ready

Word 6—Last DCB Address

Bit	Meaning
0-15	Address of last DCB used

Word 7—Current Head and Cylinder

Bit	Meaning
0-15	Head and cylinder Address of current disk access location

Word 8—Previous Head and Cylinder

Bit	Meaning
0-15	Head and cylinder address of previous disk access location

Word 9—Flag, Sector or Record

Bit	Meaning
0-15	Last record attempted during last DCB operation

Word 10—Head and Cylinder

Bit	Meaning
0-15	Head and cylinder for last record attempted

Word 11—Disk Unit Diagnostic Sense Byte 1&2
(Diagnostic Sense Byte 1 is the high-order byte)

Bit	Meaning
0	On track
1	Linear region normal
2	Not index/sector pulses
3	Out direction
4	Not drive out
5	Not drive in
6	Tag parity error
7	Read-only-storage digital-to-analog error

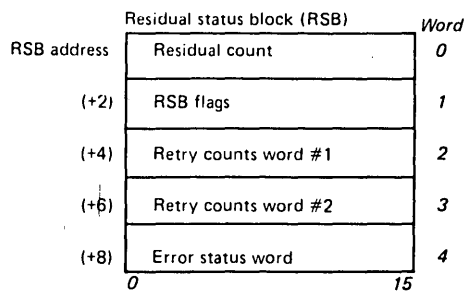
(Diagnostic Sense Byte 2 is the low-order byte)

Bit	Meaning
0	Behind home
1	Missing clocks divided by two
2	Not missing clocks error latch
3	Coil current low
4	Missing servo signal
5	Off data track
6	Not missing position error signal
7	Counter 5 in sync

Word 12—Disk Unit Diagnostic Sense Byte 3 and Wrap Byte

Bit	Meaning
0	Not shift
1	Not off track and write
2	Not outside automatic gain control window
3	Not automatic gain control freeze
4	Demand pulsing
5	Not read and write
6	Not servo protect and write
7	Illegal move
8–15	Disk unit cylinder number or interface error bits

Residual Status Block



Word 0—Residual Count

Always 0 for 4963 subsystem.

Word 1—Residual Status Block Flags

Bit	Meaning
0	End of chain
1	Retry
2–14	Reserved
15	No exception

Word 2—Retry Count Word 1

Bit	Meaning
0–3	Cyclic redundancy check (CRC)
4–7	Write echo check
8–11	Missing sector pulse
12	Data unsafe
13	Not ready
14–15	Reserved

Word 3—Retry Counts Word 2

Bit	Meaning
0–3	No record found
4	Storage data check
5	Invalid storage address
6	Protect check
7	Interface data check
8	Disk unit interface parity check
9–11	Reserved
12–15	Write error

Word 4—Error Status Word

Bit	Meaning
0–2	Reserved
3	Alternate sector processed
4	Temporary error retry
5–7	Configuration
	5 6 7
	0 0 0 reserved
	0 0 1 reserved
	0 1 0 model 29A & B (no fixed heads)
	0 1 1 model 64A & B (no fixed heads)
	1 0 0 disk unit not attached
	1 0 1 reserved
	1 1 0 model 23A & B (eight fixed heads)
	1 1 1 model 58A & B (eight fixed heads)
8	Scan not equal
9	Scan equal

Condition Codes

Operate I/O Instruction

Condition Code 0	Device Not Attached
Condition Code 1	Busy
Condition Code 2	Busy After Reset
Condition Code 3	Command Reject
Condition Code 4	Not used
Condition Code 5	Interface Data Check
Condition Code 6	Controller Busy
Condition Code 7	Satisfactory

Interrupt

Condition Code 0	Controller End
Condition Code 1	Not used
Condition Code 2	Exception
Condition Code 3	Device End
Condition Code 4	Attention
Condition Code 5	Not used
Condition Code 6	Attention and Exception
Condition Code 7	Attention and Device End

Status

Interrupt Identification Word

Bit	Meaning
0	Permissive device end
1	Scan not equal
2	Scan equal
3-7	Reserved

Interrupt Status Byte

Bit	Meaning
0	Device dependent status available
1	Delayed command reject
2	Incorrect record length
3	DCB specification check
4	Storage data check
5	Invalid storage address
6	Protect check
7	Interface data check

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READER'S COMMENT FORM

GA34-0051-0

**IBM Series/1 4963 Disk Subsystem
Description**

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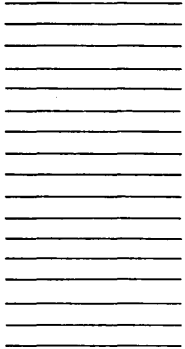
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Description

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This Technical Newsletter provides replacement pages for the subject publication. Pages to be inserted and/or removed are:

title page, edition notice page	3-19, 3-20
1-1, 1-2	3-29, 3-30
2-1 through 2-4	A-3 through A-6
2-5, 2-6 (added)	X-3, X-4
3-11, 3-12	

A technical change to the text or to an illustration is indicated by a vertical line to the left of the change.

Summary of Amendments

This TNL incorporates additional models of the 4963 Disk Subsystem.

Note. Please file this cover letter at the back of the manual to provide a record of changes.



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This Technical Newsletter provides replacement pages for the subject publication. Pages to be inserted and/or removed are:

- 3-11
- 3-12
- 3-12.1 (added)
- 3-12.2 (added)

A technical change to the text or to an illustration is indicated by a vertical line to the left of the change.

Summary of Amendments

This TNL provides programming recommendations when performing error-recovery procedures following read-disk operations. The problem described will be corrected by an engineering change and a subsequent TNL will be released.

Note. Please file this cover letter at the back of the manual to provide a record of changes.



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