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Effective Pages

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SECTION 1

GENERAL DESCRIPTION

1.1 The Big Disc Control Unit (CU) interfaces the P857 system with up to two serial-connected high-speed disc drives (the 40-Mbyte CDC-9760 and the 80-Mbyte CDC-9762). The CU includes a built-in Direct Memory Access channel (DMA-CU) which manages all data transfers directly between memory and the high-speed control-unit/device. CPU registers are not used, and there is no need for program control except for starting the exchange and testing status at the completion. A 0.7usec memory is mandatory for a system using this CU.

1.2 The CU is contained on a single printed-circuit card of the standard P857 system size. The CU logic is microprogram-controlled, thus facilitating future adaption to different disc drives of the same range.

1.3 DEVICE

1.4 Characteristics

The device handled by the Big Disc CU is the CDC-9760 or CDC-9762 with the following characteristics:

DISC PACK	CDC 876
Number of discs	5
Recording surfaces	5 (plus 1 servo, 4 cover)
Tracks per surface (number of cylinders)	404 (+7 spares) -- CDC 9760 808 (+14 spares) -- CDC 9762
Speed	3600 RPM
Diameter	
Number of heads	5 recording; 1 servo
Recording mode	MFM
Density inner track	6038 bpi
Density outer track	4038 bpi

CAPACITY	
Bits per word	16
~~Bits~~ per track	10080 maximum (unformatted)
Words per discpack	20 million -- CDC 9760 40 million -- CDC 9762

PERFORMANCE	
Access time (head positioning)	30ms average 7ms minimum (adjacent cylinders) 55ms maximum (cylinder 0 to 410/820) plus 0 to 16ms (one revolution) in worst case for reading home address by the CU.
Latency time (1/2 revolution)	8.33ms
Bit transfer rate	9.677Mhz (approximately 0.103µsec/bit or 1.65µsec/word)
Word transfer rate on DMA channel	600,000 words/second

1.5 Discpack Loading/Unloading

To unload the discpack from the drive:

- Switch off power by pressing-off START.
- Open the top cover and ensure that the disc rotation has stopped.
- Loosen the discpack by rotating the handle in the center of the pack counter-clockwise.
- Remove the discpack and attach it to the protective cover.

To load the discpack:

- Open the top cover of the drive unit.
- Remove the discpack from its protective cover and place it in the drive.
- Tighten the discpack in place by rotating the handle clockwise.
- Close the cover and switch on.

1.6 DISC ORGANISATION

There are five disc surfaces used for recording data, and one surface prerecorded with indexing pulses. Each surface is organised into 411 (or 822) concentric tracks. The data is written bit-serially along a track. A single track position common to all surfaces is called a cylinder, thus, there are 411 (or 822) concentric cylinders with five data tracks per cylinder. The cylinders are numbered 0 to 410 (or 0 to 821) from the outer edge towards the center. Programming uses only 404 (or 808) tracks on each surface; the remaining tracks are provided as spares in case of defects in any track.

1.7 One head is provided for each disc surface. The six heads (including the servo head) are always positioned together to a single cylinder. The required track of a cylinder is obtained by selecting one of the five data heads.

1.8 Tracks

A disc track consists of a single channel on one surface of a disc. The length of a track is one revolution of the disc. One index pulse per revolution, prerecorded for each cylinder on the servo disc, is used by the CU to synchronize the tracks.

1.9 DATA FORMAT

1.10 Records

Data are recorded bit-serially on a track, with the bits grouped into 16-bit words by the CU. The most-significant bit of each word is written or read first. Data are grouped into blocks of words called records. A record is a variable-length block of data transferred with a single write or read command. The data capacities used with this Big Disc CU are:

- Track -- 10080 words maximum (unformatted).
- Record -- 2 words minimum.
  - -- 4095 words maximum without chaining of memory buffer.
  - -- 9930 words maximum with memory buffers chained.
- Records per Track -- from 1 through 64, for example:
  - One 9930-word record.
  - Four 2k records.
  - Thirty-two 256-word records.
  - Thirty-nine 205-word records.
  - Sixty-four 105-word records.

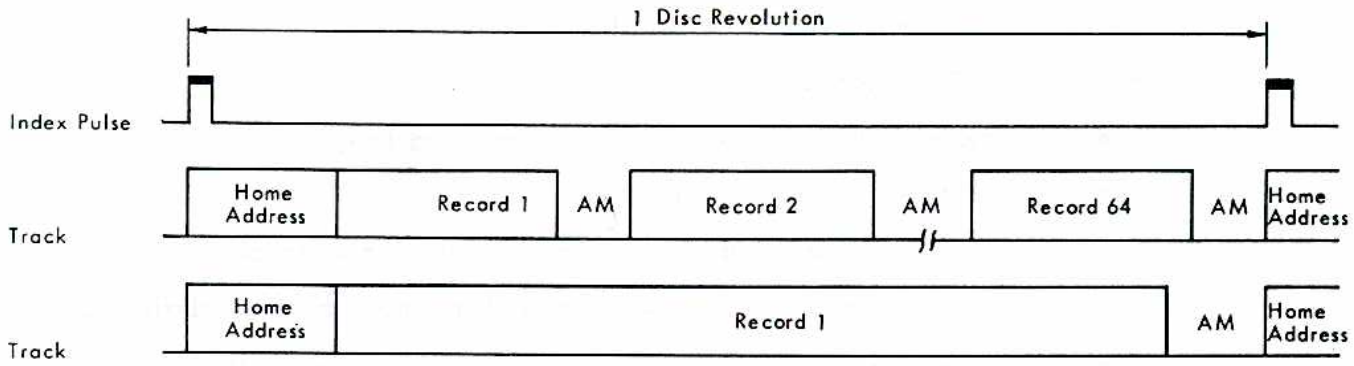
In general, length $= \frac{9930-50N}{N}$ where N is number of records.

1.11 Track Layout

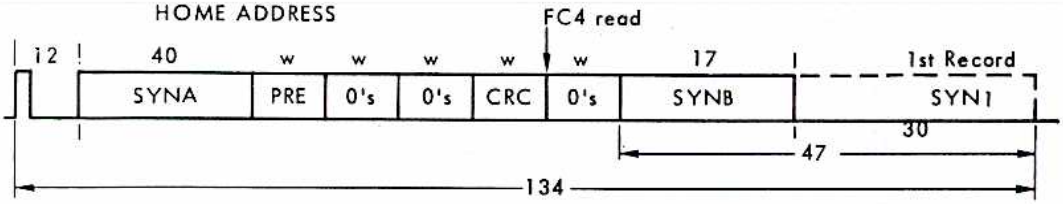
The start of all tracks are synchronized with an index pulse from the servo disc. Each track contains a Home Address followed by one or more records, as illustrated opposite.

- AM -- Address Mark: without flux transition, after each record.
- SYNA -- Synchronization area of all Zeros, for read circuitry.
- PRE -- Preamble, including first-One, flag bit, and either cylinder number or record length.
- FLAG -- 0 bit = good track; 1 bit = bad track.
- DATA -- 16-bit data words: only part of record exchanged with memory.
- CRC -- Cyclic Redundancy Check word (16 bits) written once.
- SYN2 -- Synchronization area of all Zeros, for detecting the end-of-record gap (AM).

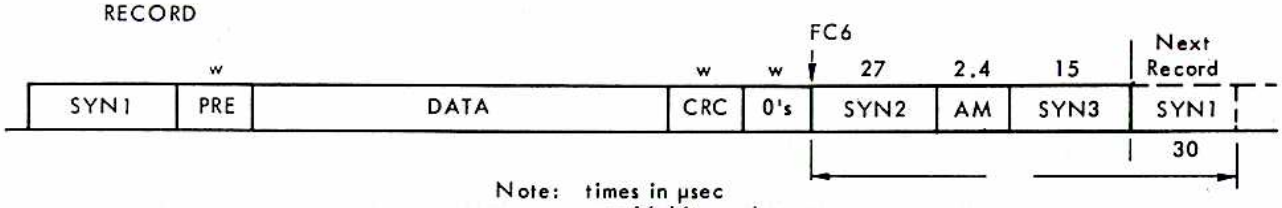
TRACK LAYOUT



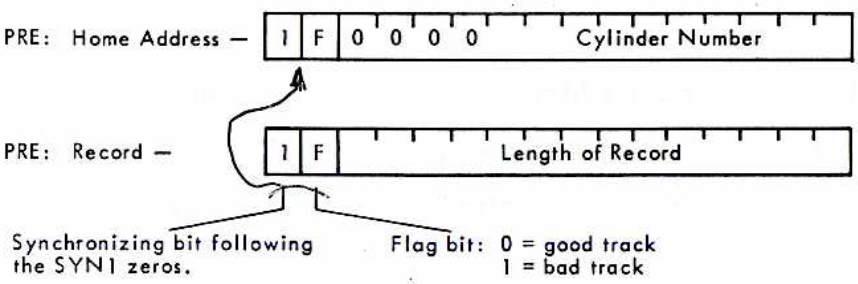
HOME ADDRESS



RECORD

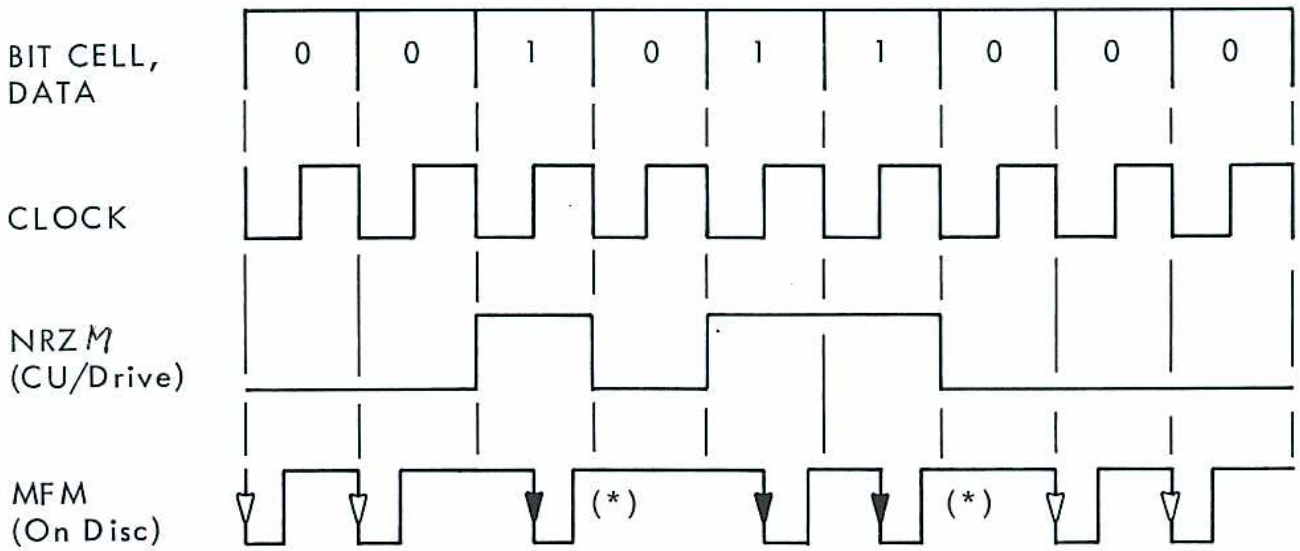


Note: times in μsec
w = 16-bit word



1.12 Recording Technique

Bit-serial data between the Control Unit and the disc drive are transferred in the Non Return to Zero (NRZ) mode. The data are stored on the discs in the MFM mode. The disc drive does the necessary translating between the two codes. Both recording techniques are shown in the following diagram:



NRZ: a 1-bit is a high at the center of the bit cell.
a 0-bit is a low at the center of the bit cell.

MFM: a 1-bit is a negative edge (▼) at the center of the bit cell.
a 0-bit is a negative edge (▽) at the start of the bit cell,

(*) except the negative pulse is omitted for the first 0 following a 1-bit.

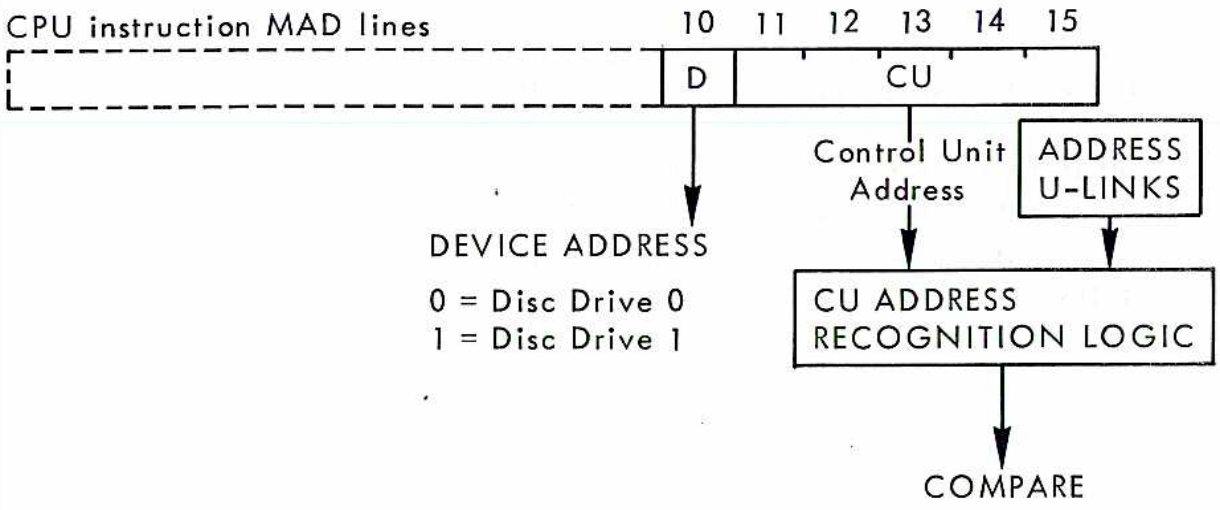
1.13 INTERRUPTS/BUS CONTROL

The Big Disc CU uses the system external interrupts via the GP Bus BIEC lines. This system interrupt is used at the completion of a complete record transfer or, with the use of Command Chaining, at the completion of a set of commands which may include numerous record transfers and seek operations. The CU interrupt is also sent in the case of some error conditions. The interrupt priority level is set by U-link jumpers on the CU card (Figure 1-1). The CU does not use system interrupts for data transfers.

1.14 The CU controls its memory data transfers with direct Bus control. The CU requests Bus control (with BUSRN) every 1.6μsec (600,000 words/sec), but an internal latency of 100μsec is provided to accept momentary Bus loads.

1.15 ADDRESSING

The CU address is established by U-links on the CU card (Figure 1-1). The address of the CU and the device is specified by the CPU command on the GP-Bus MAD lines, bits 10-15. The requested address is compared with the actual address set on the U-links; when the address compares, the CU is selected for operation with the disc specified by MAD bit 10.



1.16 PHYSICAL

One Big Disc CU card (Figure 1-1) can be plugged into an M4 cabinet, and two can be plugged into an M5 cabinet. Top and Bottom one

1.17 Connectors

The four CU card connectors are shown on Figure 1-1. A device B-cable from each disc is plugged onto connectors 1 and 2. A device A-cable, attatched to both discs, is plugged onto connector 5. Card connector 3 is attached to the syster GP Bus by plugging the card into the cabinet.

1.18 Interface

The CU--Device interface is listed in Table 1-1. The CU--CPU/Memory interface is the standard GP Bus; this interface is listed in Table 1-2.

1.19 U-Links

Adjustable U-links are provided for encoding the CU address and for encoding the CU interrupt code on the BIEC lines. The locations of both sets of U-links are shown on Figure 2-13.

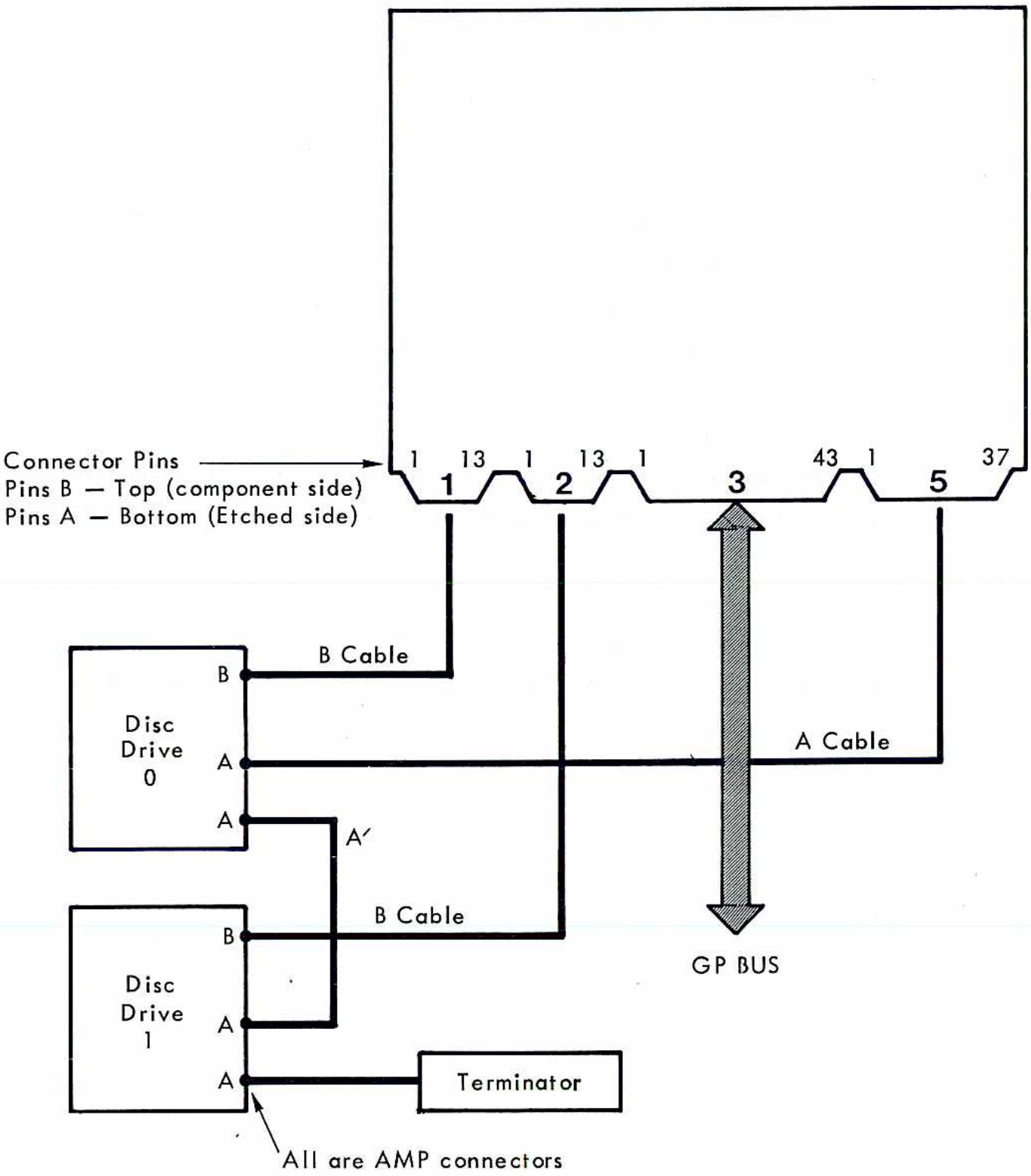


Figure 1-1 Connectors

Table 1-1 CU - Device Interface

Signal	Con. 5	AMP Con.	Device Name, Remarks	Logic Sheet
A Cable Output Signals				
SEL, N	A37, B37	25, 22	UNIT SELECT, Disc Selection	i
TAG1, N	A12, B12	49, 46	Cylinder Selection	i
TAG2, N	A13, B13	51, 48	Head Selection	i
TAG3, N	A25, B25	55, 52	Control Selection	i
BUS0, N	A8, B8	26, 23		
BUS1, N	A9, B9	27, 24		
BUS2, N	A10, B10	31, 28		
BUS3, N	A11, B11	32, 29		
BUS4, N	A31, B31	33, 30		
BUS5, N	A32, B32	37, 34	Bit 0-9, Data Lines	d
BUS6, N	A33, B33	32, 35 38		
BUS7, N	A34, B34	39, 36		
BUS8, N	A35, B35	43, 40		
BUS9, N	A36, B36	44, 41		
AD0, N	A7, B7	4, 1		h
AD1, N	A28, B28	5, 2		i
AD2, N	A29, B29	7, 3	UNIT SELECT 0-3, Disc Address	i
AD3, N	A30, B30	12, 8		i
OCD, N	A6, B6	20, 16	Open Cable Detector	h
A Cable Input Signals				
IND, N	A3, B3	13, 10	INDEX Pulse	g
SEC, N	A27, B27	77, 74	Not Used (grounded)	
SER, N	A5, B5	78, 75	SEEK ERROR	g
ONCIL, N	A1, B1	18, 15	ON CYLINDER	i
RDY, N	A4, B4	21, 17	UNIT READY	g
AMF, N	A2, B2	45, 42	ADDRESS MARK FOUND	i
FAULT, N	A26, B26	14, 11	Not Used (grounded)	
INHA	A14 B14		Strap	i
B Cable Output Signals (1 set for each disc) disc0 = con.1 discl = con.2				
WDL, N	B1, B2	B, A	Write Data Line (bit serial)	d
Ground	B5	D		
WRC, N	A11, A12	J, H	Write Clock	i
Ground	B11	E		
B Cable Input Signals (1 set for each disc)				
RCP, N	A1, A2	X, W	Read Clock Pulse	h
Ground	B3	Y		
RD, N	A3, A4	V, U	Read Data (bit serial from disc)	e
Ground	B4	T		
WCP, N	A9, A10	N, M	SERVO CLOCK, Write Clock Pulse	d
Ground	B10	K		
SKEND,	A5, A6	CC, AA	Seek End	i
USL,	A7, A8	BB, DD	Unit Selected	i
INHB	B6 B7		Strap	i

Table 1-2 GP Bus Interface (Connector 3)

3A01	+18 V	c
3A02	BIEC0	a c
3A03	BIEC2	a c
3A04	BIEC4	a c
3A05	SCEIN	a c
3A06	+16 V	b
3A07	0 V	
3A08	BIO 00N	
3A09	BIO 02N	
3A10	BIO 04N	
3A11	BIO 06N	
3A12	BIO 08N	
3A13	BIO 10N	
3A14	BIO 12N	
3A15	BIO 14N	
3A16	OKO *	a c d
3A17	PWFN	a c
3A18	0 V	
3A19	+ 5 V	
3A20	+ 5 V	
3A21	0 V	
3A22	0 V	
3A23	BR (CU-4)	c
3A24	0 V	
3A25	0 V	
3A26	WRITE *	
3A27	CHA *	
3A28	TRMN *	
3A29	TMRN	
3A30	TMEN	a c d
3A31	TMPN	a c d
3A32	TPMN	a c d
3A33	0 V	
3A34	ACN	a c
3A35	SPYC *	a c d
3A36	BUSRN *	a c d
3A37	MSN *	a c d
3A38	BSYN *	a c d
3A39	CLEARN	a c d
3A40	0 V	
3A41	BR (CU-2)	c
3A42	BR (CU-3)	c
3A43	BR (CU-1)	c

3B01	-18 V	c
3B02	Chassis Ground	c
3B03	BIEC1	a c
3B04	BIEC3	a c
3B05	BIEC5	a c
3B06	+16 V	b
3B07	0 V	
3B08	BIO 01N	
3B09	BIO 03N	
3B10	BIO 05N	
3B11	BIO 07N	
3B12	BIO 09N	
3B13	BIO 11N	
3B14	BIO 13N	
3B15	BIO 15N	
3B16	OKI *	c d
3B17	RSLN	a b c
3B18	- 5 V	b
3B19	+ 5 V	
3B20	+ 5 V	
3B21	0 V	
3B22	0 V	
3B23	+ 5 V Battery	
3B24		
3B25	+16 VM	b
3B26	MAD 15	
3B27	MAD 14	
3B28	MAD 13	
3B29	MAD 12	
3B30	MAD 11	
3B31	MAD 10	
3B32	MAD 09	
3B33	MAD 08	
3B34	MAD 07 *	
3B35	MAD 06 *	
3B36	MAD 05 *	
3B37	MAD 04	
3B38	MAD 03	
3B39	MAD 02 *	
3B40	MAD 01 *	
3B41	MAD 00 *	
3B42	MAD 64 *	
3B43	MAD128	

a- CPU only
b- Memory only
c- Control Unit only
d- IOP only

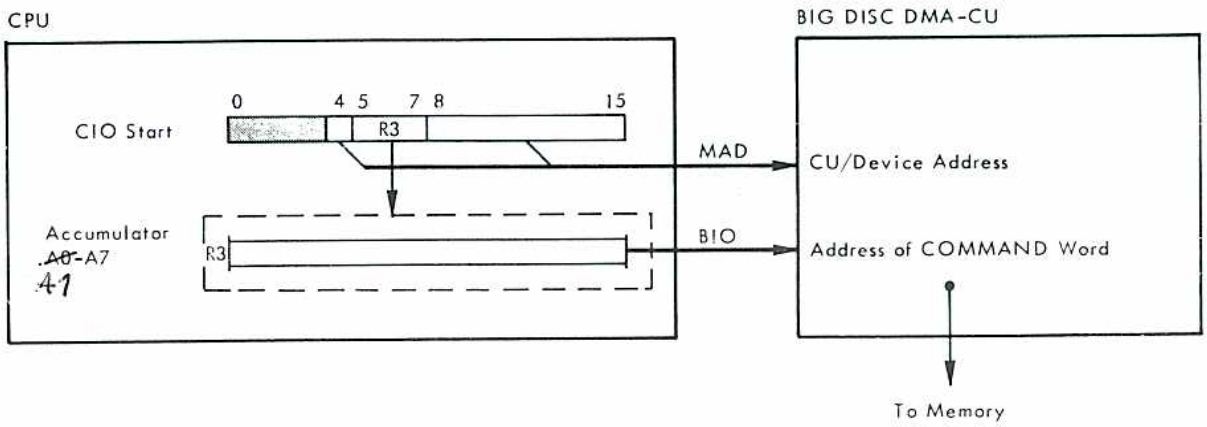
* CU use only on DMA (main chassis)

1.20 OPERATING SEQUENCE

The general programming sequence is shown in Figure 1-2. For read or write operations with the Disc CU, the memory must be pre-loaded with Command and Control Words. Examples of these words positioned in memory (within the first 32k locations) are shown in Figure 1-3. Contents of the Command and Control Words are shown in Figure 1-4. All Control Words associated with a Command Word must be located immediately following the Command Word; only the Command-Word address is sent to the CU.

1.21 Obtaining Data Address

A CIO Start instruction (following diagram) includes the address of the CU and the device, and specifies the R3 location of the Command-Word address. During the CIO Start command, the CU receives its address on the Bus MAD lines and the Command-Word address on the Bus BIO lines. The CU obtains the Command Word and the associated Control Words directly from memory.



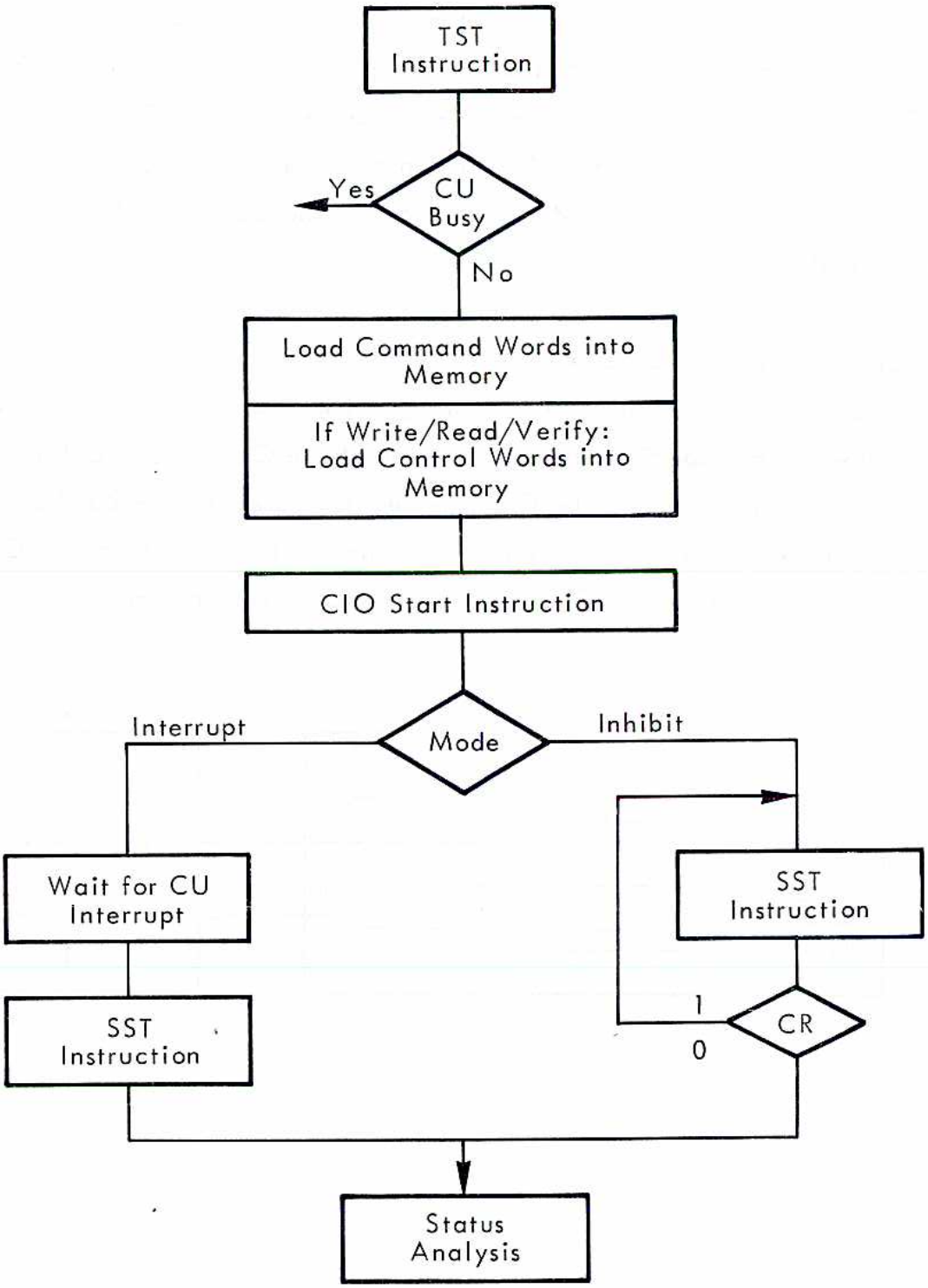
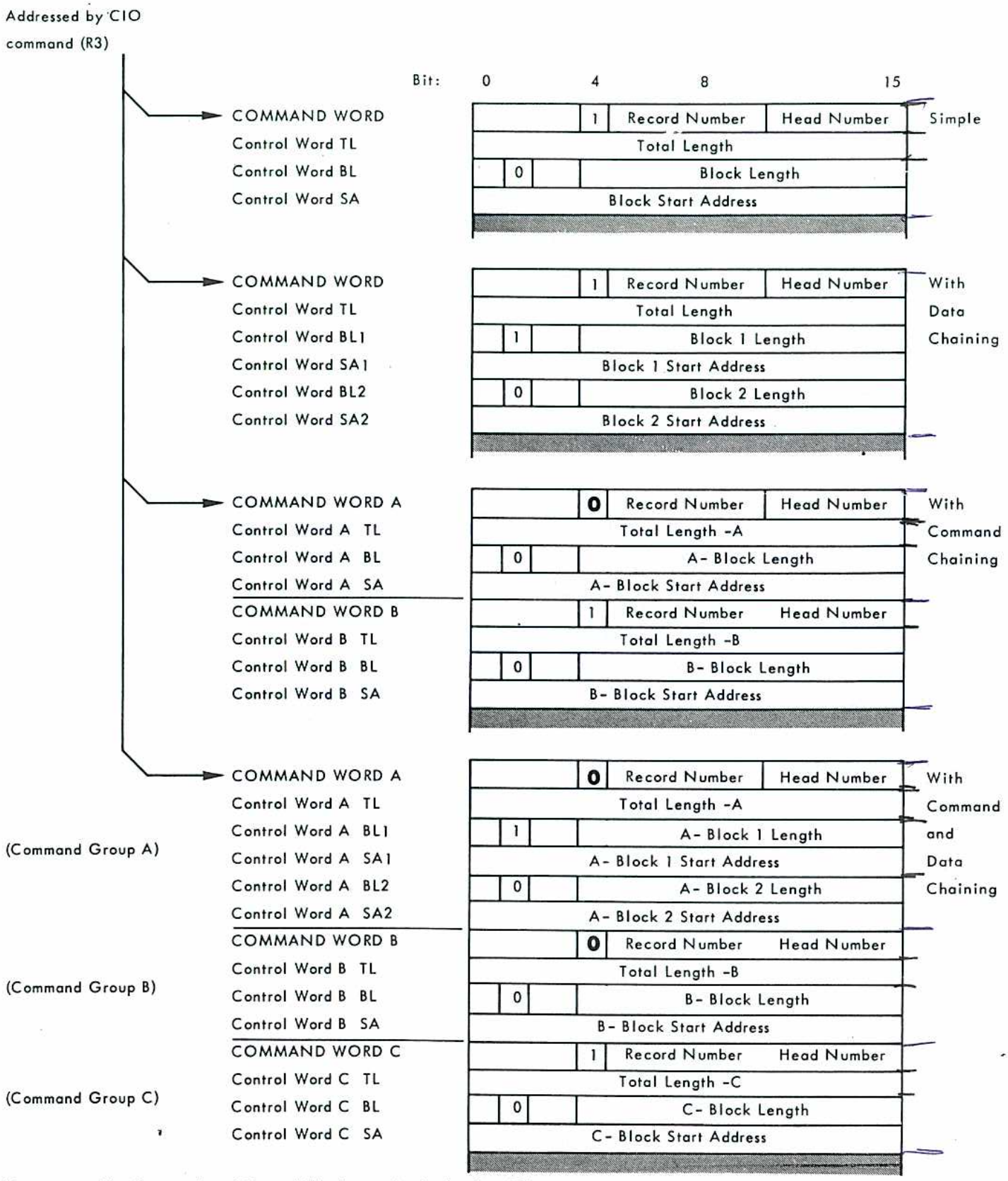


Figure 1-2 General Programming Rules



Notes:
- The Command and Control Words must be in the first 32k memory locations.
- The data blocks may be anywhere in memory and in any order, regardless of Command Chaining or Data Chaining.
- For a one-block record (no Data Chaining), Total Length and Block Length are the same.
- If Data Chaining, TL must equal the sum of all BL.

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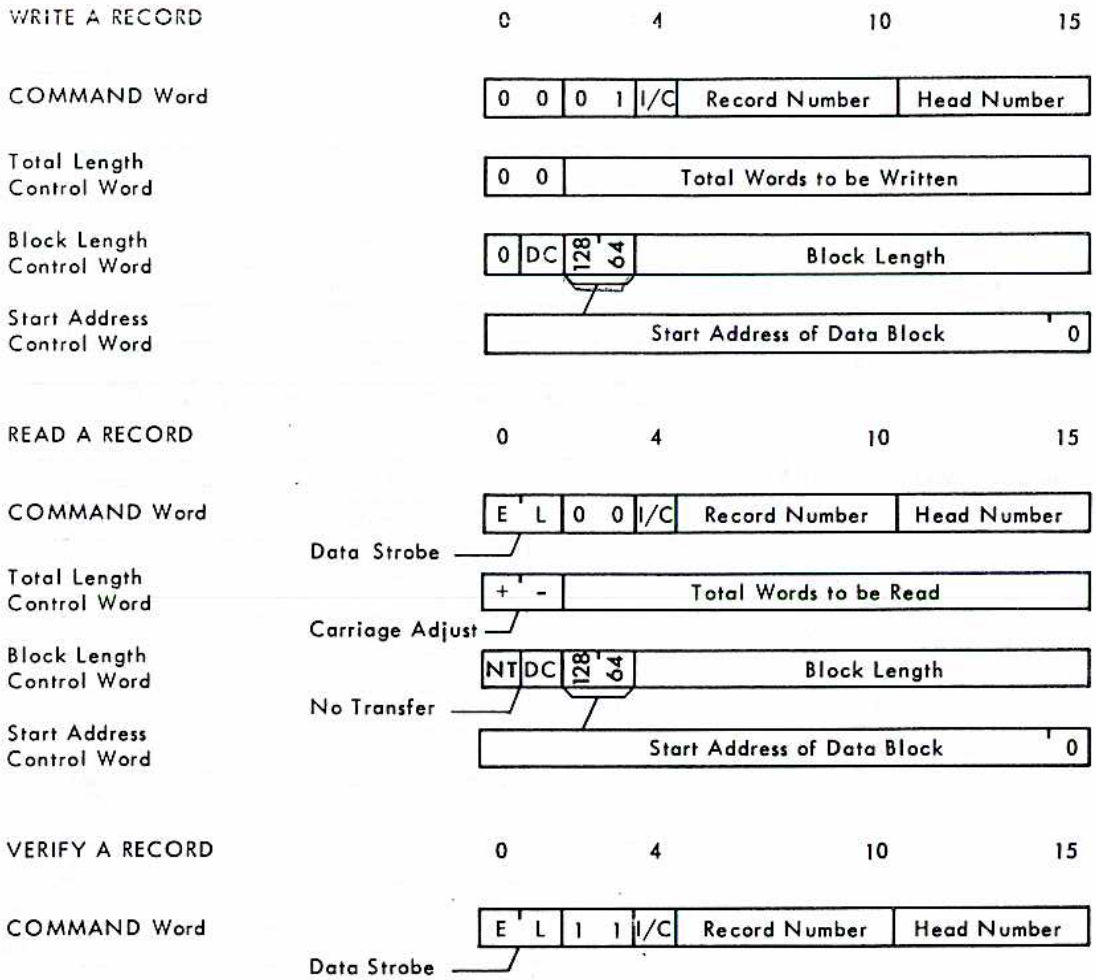
Figure 1-3 Examples of Command and Control Words In Memory



All 3 Control Words are the same as for Read A Record

I/C : Interrupt/Command-Chain bit. 1 = Interrupt enabled
0 = Command Chain

DC : Data-Chain bit. 1 = Data Chain

Data Strobe : E = 1 for early read strobe.
L = 1 for late read strobe.

Carriage Adjust : + = 1 for moving carriage forward 200μinch
- = 1 for moving carriage backward 200μinch

For data-recovery retrys during Read operations.

No Transfer : NT = 1 means read the data block normally, but do not transfer the data to memory (logic blocks the Bus-Request signal).

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Figure 1-4 Command and Control Words Format

1.22 Disc Location. The Command Word contains the record number and head number. A specific cylinder is selected by positioning the heads with a Seek command prior to the CIO Start.

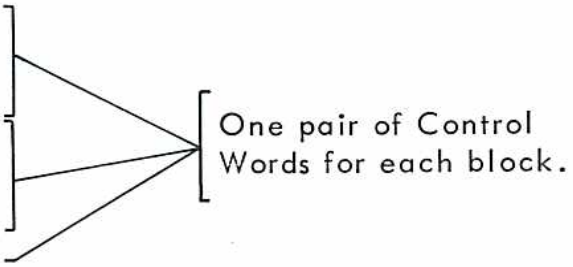
1.23 Memory Data Location. The Control Words specify the start address and the length of the memory data area. If no data chaining is used, the memory data is located in a single block; three Control Words specify:

1. Total record length (number of words of data).
2. Block length (same as tatal length in this case).
3. Start address of memory data area (always an even number).

1.24 Data Chaining

Data chaining allows many memory blocks to be assembled into a single record. The various blocks of data can be located in different parts of memory, and all are transferred to or from a single record under CU control following a single CIO Start command. When data chaining is used, the Command Word is followed by:

1. Total-Record-Length Control Word.
2. Block length of first data block.
3. Start address of first data block.
4. Block length of next data block.
5. Start address of next data block.
n. Continued for all data blocks.



Data chaining is specified to the CU by bit 1 being set in every block-length Control Word except the last one of the group. Bit one being set thus indicates: "another pair of block Control Words follows this pair."

1.25 Command Chaining

Command chaining allows many records to be transferred to or from the disc with a single CIO Start command. A single chained routine may include any combinat of read, write, verify, or seek commands. The memory is pre-loaded with a Command Group for each record to be transferred or each head-motion required (Figure 1-3). Each Command Group comprises a single Command Word and all

its related Control Words. Data chaining within a Command Group is independent of Command Chaining. Command Chaining is specified by bit 4 of the Command Word, as follows:

bit 4 = 0: Command Chaining

bit 4 = 1: Interrupt Enabled

1.26 If Zero, the Command Chaining bit inhibits the normal Interrupt signal at the end of a record transfer. The CU can accept commands, with or without command chaining, simultaneously for both disc units. The CU first performs the complete transfer for one disc (including all data and command chaining), then the CU switches to the second disc when the whole group of commands has been completed for the first disc (usually after a Seek operation has been started).

1.27 If an error occurs during the execution of a command, the CU ends the operation and sends an interrupt to the CPU even if the Command Chaining bit is set to block interrupts. In this case, the operation must be restarted with another ~~COF~~ CIO Start command.

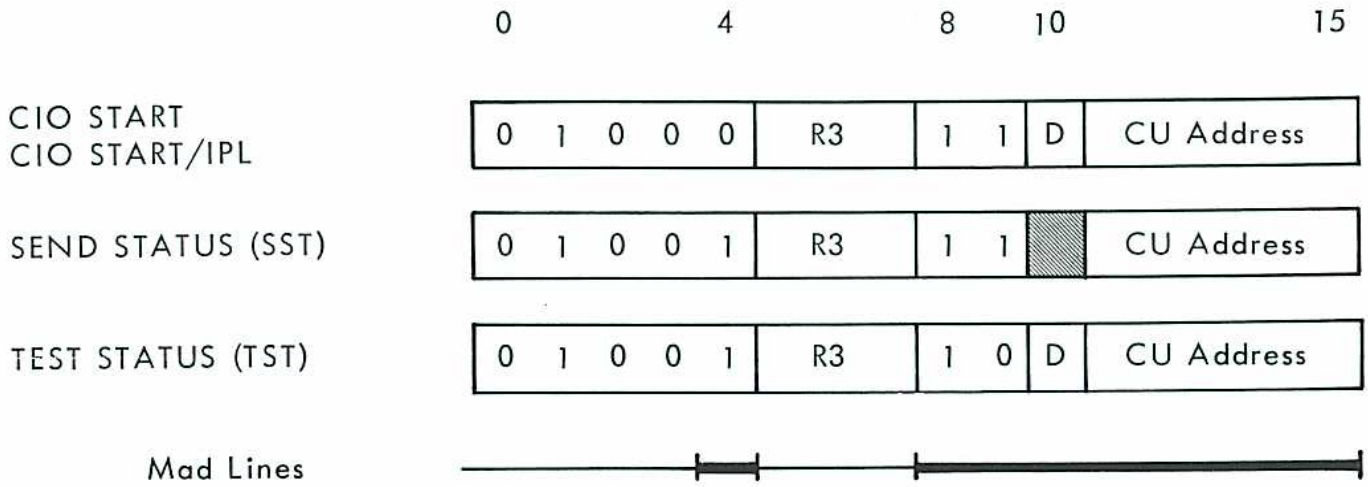
1.28 Cyclic Redundancy Check (CRC)

The CRC characters are calculated and written for every Write operation, including Write Home Address. The written CRC is the remainder of the division of the DATA polynomial by: $1 + X^2 + \ldots X^{16}$. When reading, the DATA and CRC polynomial is divided by the same polynomial. If the new remainder is not zero, Parity Error (status bit 13) is set.

1.29 I/O INSTRUCTIONS AND COMMANDS

The Big Disc CU requires only three CIO instructions for CPU control: CIO Start, Send Status, and Test Status. The CU uses the address received with the CIO Start to obtain a Command Word directly from memory which specifies the specific type of operation: Seek, Seek-to-zero, Write Home Address, Write A Record, Read A Record, or Verify A Record. The formats of all these Instruction and Command Words are shown together in Figure 1-4. The instructions and commands are described in the following paragraphs.

CIO INSTRUCTIONS IN CPU



COMMAND WORDS OBTAINED FROM MEMORY BY CU

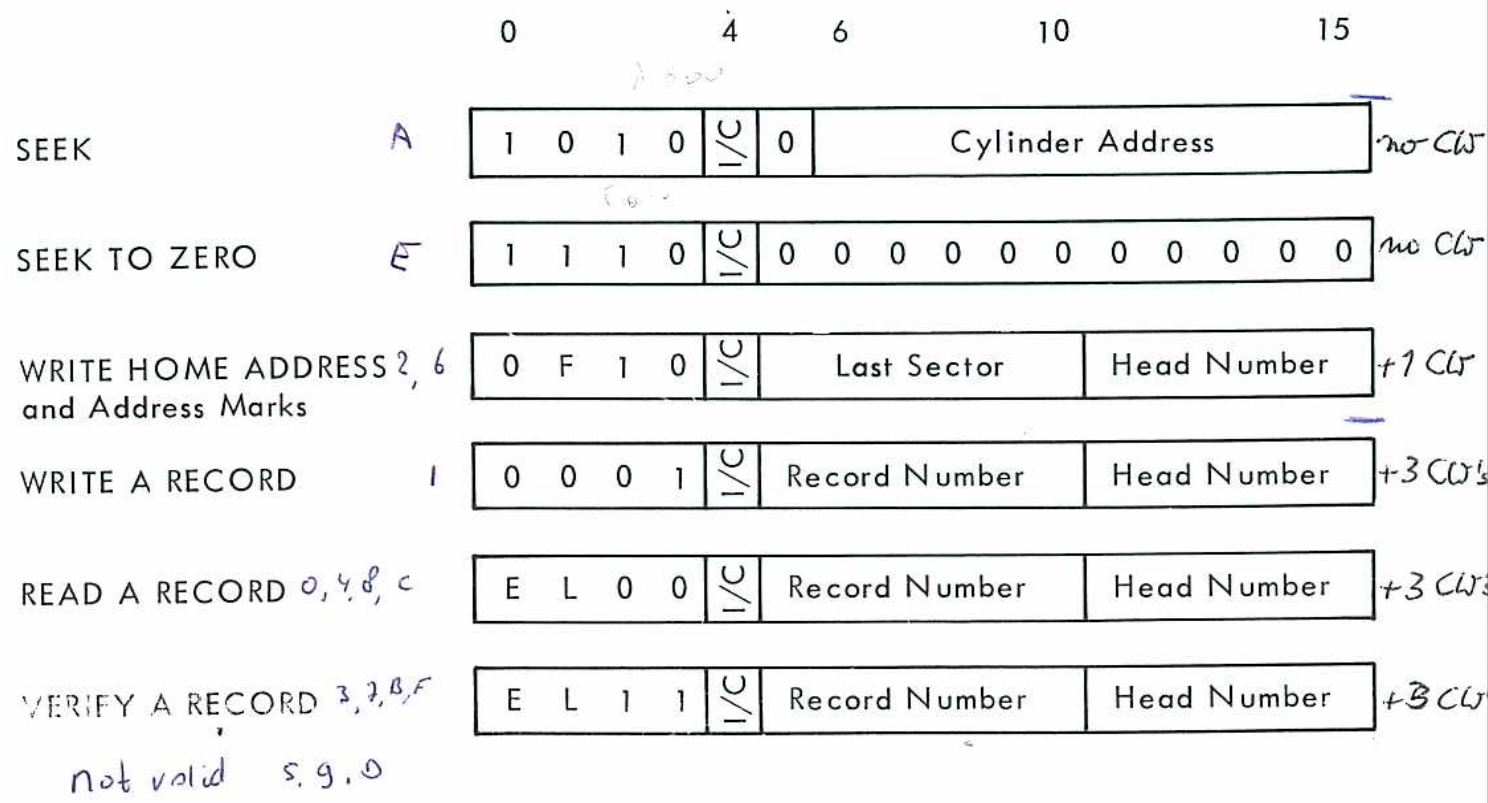
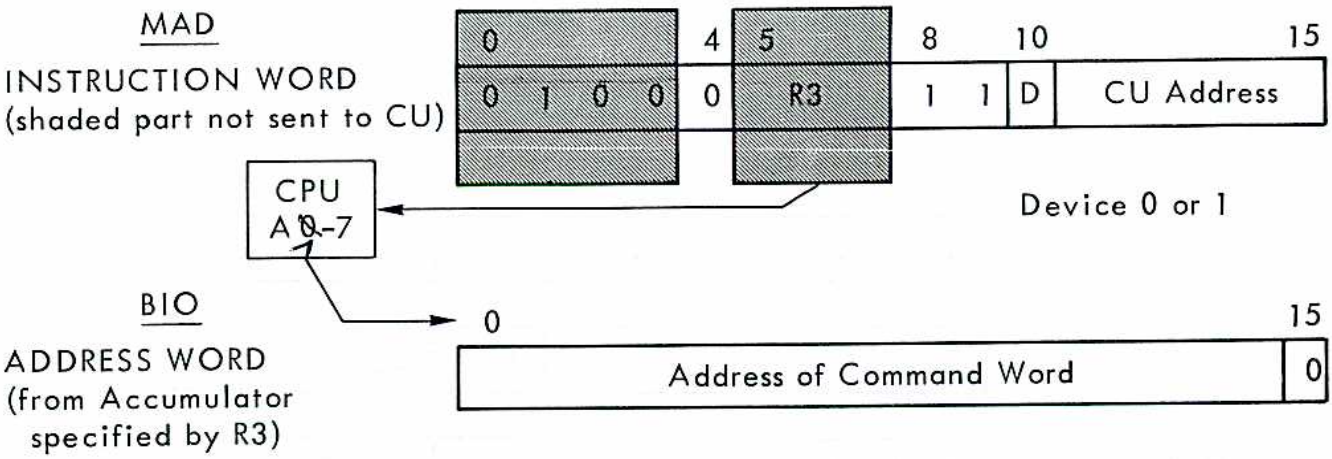


Figure 1-5 Instruction/Command-Word Formats

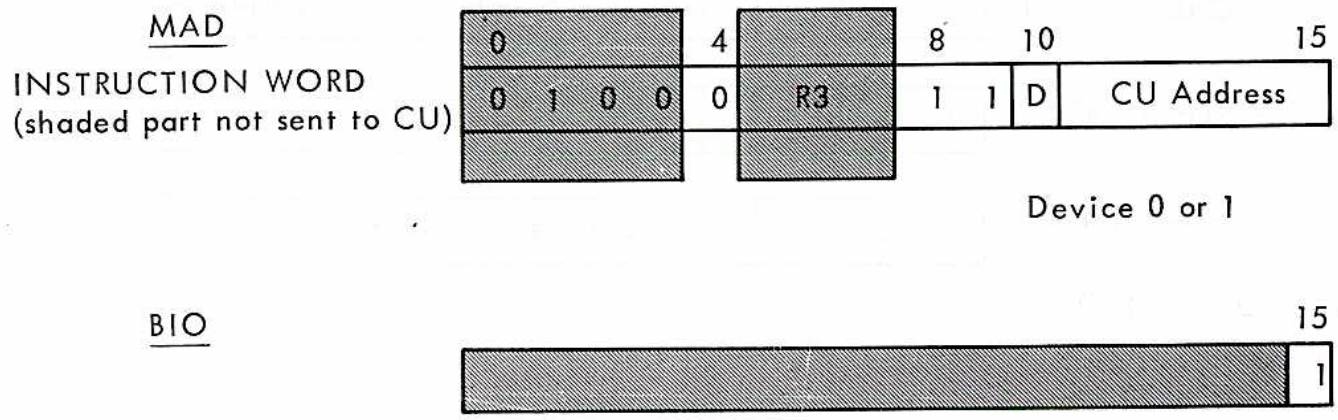
1.30 CIO Start



The CIO Start instruction is used, after a group of commands has been programmed in the main memory, to begin CU operation. The CIO Start is accepted if the CU is not already performing an operation on the addressed disc unit.

- In no CU recognizes the address code on MAD11-15, the CPU condition register is set to 3 (CR=11).
- If the command is not accepted by the CU, the CPU condition register is set to one (CR=01), and nothing is altered in the CU.
- If the command is accepted, the condition register is reset (CR=00); the CU fetches the Command and Control Words, executes the operation (including any specified chaining), and then sends an interrupt on the BIEC lines.

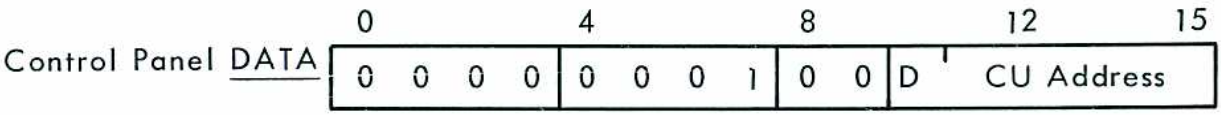
1.31 CIO Start/IPL



A special CIO Start/IPL instruction is used to transfer an Initial Program Loader (IPL) from the disc to the memory. The IPL is assumed to be already located on

the disc, beginning at the physical disc sector 0. The CIO Start/IPL instruction word format is identical to the standard CIO Start instruction. The IPL address word specified by the contents of R3, however, is for an odd-numbered memory address.

1.32 The CIO Start/IPL can be used by any P852/P856/P857 system with the IPL option on the CPU card. The IPL sequence is obtained by setting the control panel DATA switches to:



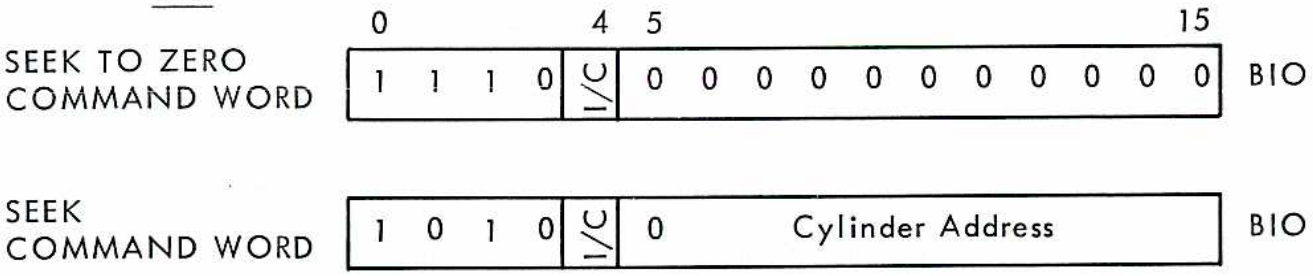
and then pressing control panel INST, MC, IPL.

1.33 The first 64 words of the IPL programmed on the disc must be written as in the following chart. This first part overwrites part of the normal bootstrap. The body of the IPL, which may gave any length, starts at octal address /80 (128_{10}

1	10	19	41
ZERO	EQU	*	
	LDR	A6,A15	TAKE THE C.U.ADDRESS
	ANK	A6,/3F	
	ADS	A6,SST	
SST	SST	A7,0	WAIT FOR SECTOR END
	RB(4)	* -2	
	AB	/80	
	RORG	ZERO+/7A	
	DATA	0	
	DATA	0	
	RORG	ZERO+/80	
START	EQU	*	START IPL

1.34 Seek, Seek-to-Zero

BIO



- Cylinder address accepted by Control Unit: 0 - 1023
  by 9760 drive : 0 - 410
  by 9762 drive : 0 - 821
- Bit 4 -- Interrupt/Command Chaining. 1 = Interrupt enabled;
  0 = inhibit interrupt for command chaining at end of Seek.

The Seek commands are used to move the disc heads from their current location to a specified cylinder. (Seek-to-Zero always moves the heads to cylinder zero.) It is valid to perform a Seek command to the cylinder where the heads are currently positioned (no displacement). The Seek Command word is obtained from memory following a CIO Start command, or following some other operation which specified Command Chaining. When the CU receives either Seek command:

- Seek is initiated on the selected disc drive.
- The CU is free to accept commands for the other drive.
- Seek is completed by the selected drive.
- CU completes current operation, if any, on the other drive, and then performs a read operation to verify the cylinder number from the home-address record of the new cylinder.

Two possible status bits may be set as a result of the verification. Seek Error status (bit 6) can be set two ways:

a. The cylinder number read from the home-address record of the new cylinder does not compare with the cylinder address in the command word.

b. The disc drive sends a SEEK ERROR signal, indicating the drive was unable to complete a move within 500ms, or the carriage has moved to a position outside of the recording field, or an address greater than 410/821 has been sent. A disc-drive Seek Error can only be cleared by performing a Seek-to-Zero command.

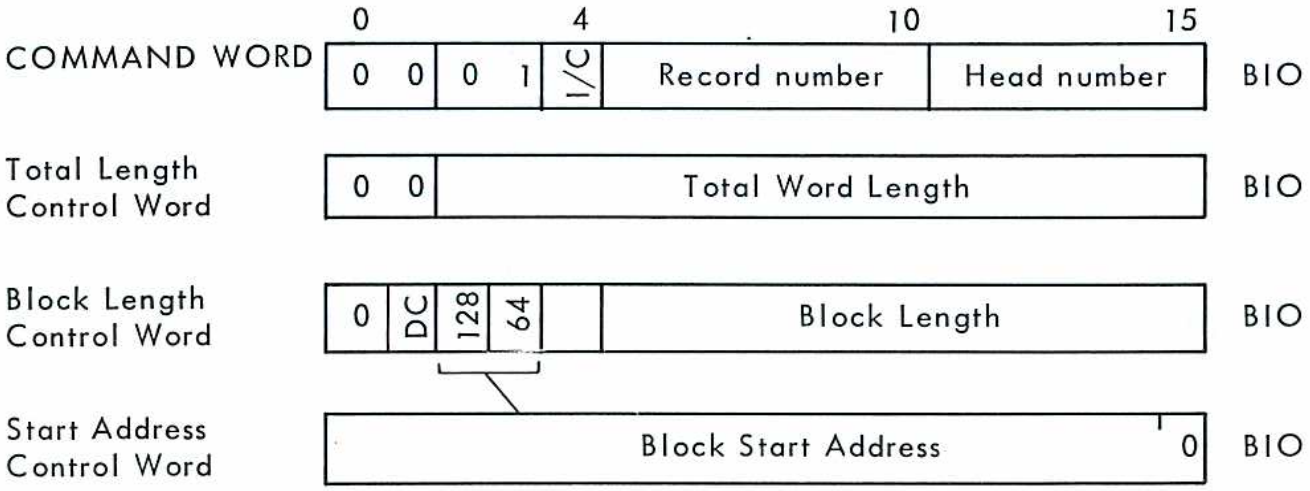
Bad Track status (bit 2) is set if the Bad-Track Flag bit is set in the home-address record of the new cylinder.

1.35 At the completion of the Seek operation's read check:

- If the Interrupt/Command-Chain bit (bit 4) was set, the CU places its interrupt code on the BIEC lines to request an interrupt.
- If the Interrupt/Command-Chain bit was Zero, the CU adds 2 (word increment of 1) to the current Command-Word address and fetches the next Command Word from memory.

1.36 Write A Record

If a record is being updated, the length of the new record must be equal to the old one. If a different record is being written, the following records on the addressed track become non-significant.



- Head number accepted by Control Unit: 0-31
  by disc drive : 0- 4
- Record number is 0-63
- Command Word bit 4 (I/C): 1 = Interrupt enabled
  0 = Command Chaining
- BL Control Word bit 1 (DC): 1 = Data Chaining
- The 2 most-significant bits of the Start Address are in bits 2 and 3 of the Block-Length Control Word.

This command is used to write a record onto the currently-selected disc cylinder. The record number and head number are specified in the Command Word. The

ommand Word is obtained from memory following a CIO Start command, or llowing some other operation which specified Command Chaining. If record 0 specified, this new record is written immediately after the home record; if cord N is specified, the new record is written following record N-1. The length the record, the length of the first block are all obtained from three Control ords which are grouped with the Command Word in memory. The sequence of peration is:

- The Command Word is fetched from memory and the Write-A-Record command is decoded.
- Three Control Words are fetched from the three memory locations immediately succeeding the Command Word.
- The CU writes the first block of data into the record.
- If the Block-Length Control Word specified Data Chaining, the CU fetches the next two Control Words from memory and writes the next block of data into the same record.
- When a Block-Length Control Word does not specify Data Chaining, the record is complete when that block is written.
- If any error conditions are detected during the write operation, the pertinent Error Status bits are set and an interrupt is sent to the CPU (either when the error occurs or at the completion of the operation).

t the correct completion of the write operation (no errors):

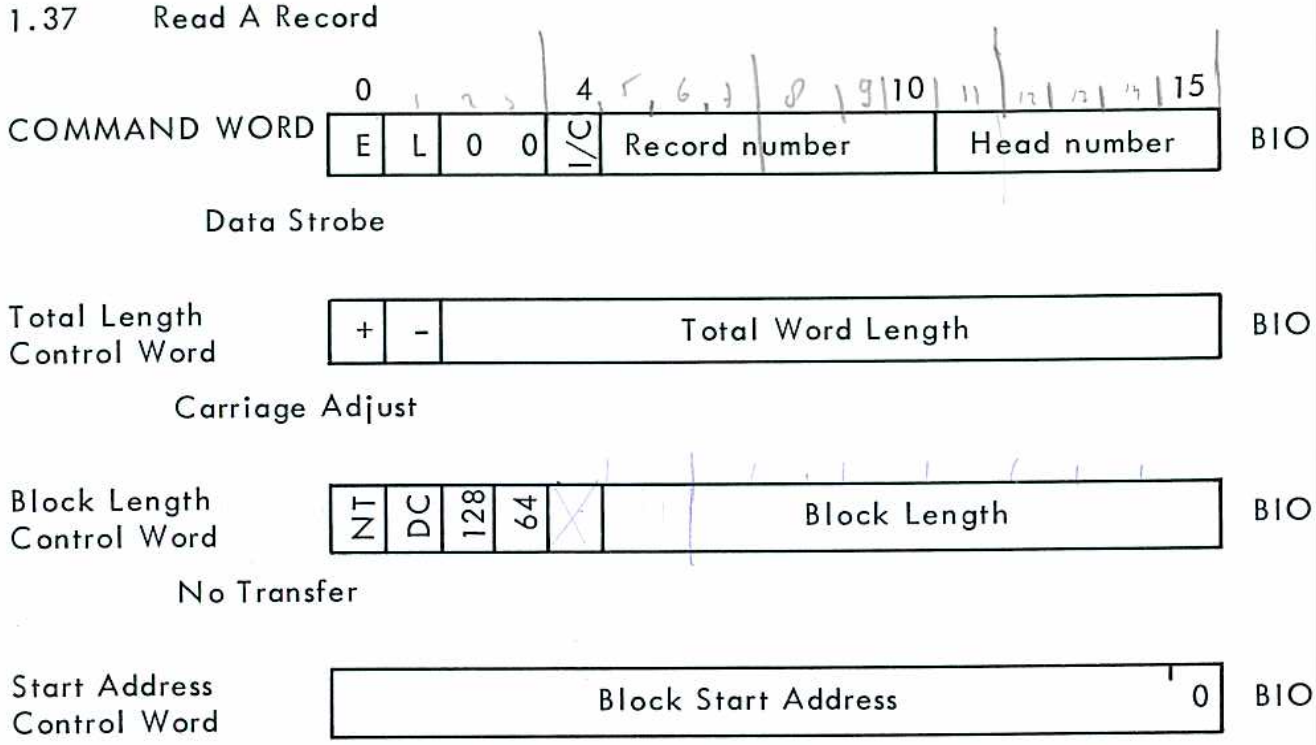
- If the Interrupt/Command-Chain bit was set, the CU places its interrupt code on the BIEC lines to request an interrupt.
- If the Interrupt/Command-Chain bit was Zero, the CU adds 2 (word increment of 1) to the current Command/Control-Word address and fetches the next Command Word from memory.

rror Status bits may be set as follows:

- Not Operable Drive (status bit 15) is set if the selected disc drive is not operable.
- Throughput Error (status bit 14) is set if the CU is not able to access the addressed memory block within 100usec.
- Incorrect Length (status bit 12) is set, and writing stops, if the writing is not completed before the end of a track.

- Record Not Found (status bit 4) is set if the CU does not locate the record (N-1) preceeding the specified record (N).
- Flag Bad Track (status bit 2) is set if the Bad-Track Flag bit is set in the addressed record. This status bit will cause an interrupt only if the Command-Word Interrupt Control bit is set.

1.37 Read A Record



- Head number accepted by Control Unit: 0-31
  by disc unit : 0- 4
- Record number is 0-63
- Command Word bit 4 (I/C): 1 = Interrupt enabled
  0 = Command Chaining
- BL Control Word bit 1 (DC): 1 = Data Chaining
- The 2 most-significant bits of the Start Address are in bits 2 and 3 of the Block-Length Control Word.
- Data Strobe: E=1 for early read strobe
  L=1 for late read strobe
- Carriage Adjust: +=1 to move carriage forward 200µinch
  -=1 to move carriage backward 200µinch

  For Data-Recovery Retrys
- No Transfer: NT = 1 means read data block normally but do not transfer the data to memory (logic inhibits Bus-Request signal).

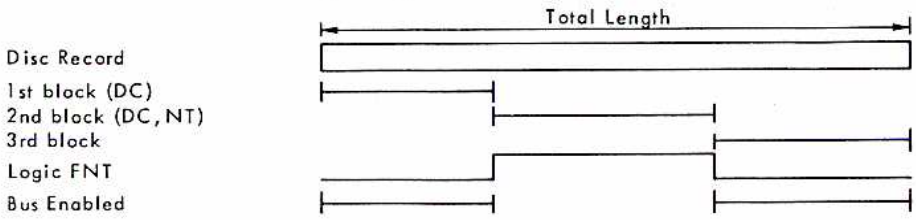
This command is used to read a record from the currently-selected disc cylinder. The record number and head number are specified in the Command Word. The Command Word is obtained from memory following a CIO Start command, or following some other operation which specified Command Chaining. The sequence of operation is:

- The Command Word is fetched from memory and the Read-A- Record command is decoded.
- Three Control Words are fetched from the three memory locations immediately succeeding the Command Word.
- The CU reads the first block of data from the record.
- If the Block-Length Control Word specified Data Chaining, the CU fetches the next two Control Words from memory and reads the next block of data from the same record.
- When a Block-Length Control Word does not specify Data Chaining, the record is complete when that block has been read.
- If any error conditions are detected during the read operation, the pertinent Error Status bits are set and an interrupt is sent to the CPU (either when the error occurs or at the completion of the operation).

At the correct completion of the read operation (no errors):

- If the Interrupt/Command-Chain bit was set, the CU places its interrupt code on the BIEC lines to request an interrupt.
- If the Interrupt/Command-Chain bit was Zero, the CU adds 2 (word increment of 1) to the current Command/Control-Word address and fetches the next Command Word from memory.

1.38 No-Transfer operations may be used (in conjunction with data chaining) to read selected portions of a record for transfer to memory. If, for example, the center part of a record is to be omitted, a Read operation is performed in three sections (data chaining specified twice). The NT bit is set for the second block of the transfer and is stored in logic by FNT, as follows:



1.39 Retry Operations. The Data-Strobe and Carriage-Adjust bits in the Command and Control Words are set by programming to recover read errors. These four bits are all Zero for a normal read operation. Following a read error, marginal data can be recovered by an early or late data strobe, or the carriage shifted forward or backward (left or right of the track center), or some combination of the two methods. The first retrys should be with the early/late data strobe because each carriage adjust adds a 16msec delay. A data-recovery routine should include three retrys at each of the nine different combinations of data strobe and carriage adjust before an error is considered irrecoverable. A suggested sequence of retrys is:

Retry	Data Strobe E	Data Strobe L	Carriage Adjust +	Carriage Adjust -
1, 2, 3	0	0	0	0
4, 5, 6	0	1	0	0
7, 8, 9	1	0	0	0
10,11,12	0	0	0	1
13,14,15	0	0	1	0
16,17,18	0	1	1	0
19,20,21	0	1	0	1
22,23,24	1	0	0	1
25,26,27	1	0	1	0

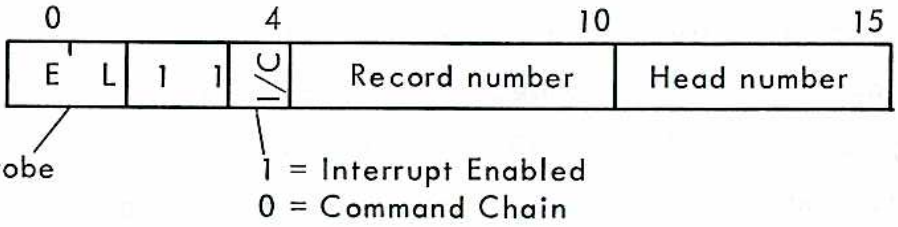
1.40 Error Status. Error Status bits may be set as follows:

- Not Operable Drive (status bit 15) is set if the selected disc drive is not operable.
- Throughput Error (status bit 14) is set if the CU is not able to access the addressed memory block within 100μsec.
- Parity Error (status bit 13) is set if the CRC check does not produce zero.
- Incorrect Length (status bit 12) is set if reading is not completed before the end of the track, or if the record length does not equal the specified length. Data equal to the shorter of the two lengths is transferred.
- Record Not Found (status bit 4) is set if the CU does not locate the addressed record.
- Flag Bad Track (status bit 2) is set if the Bad-Track Flag bit is set in the

ddressed record. This status bit causes an interrupt only if the Command-Word nterrupt Control bit is set.

.41 Verify A Record

COMMAND WORD



he Command Word (except bits 2,3) and the three Control Words are all identical o the Read-A-Record command.

his command is used to read a record from the currently-selected disc cylinder nd compare it word-for-word with a specified memory buffer. The disc record s not transferred to memory, and neither disc nor memory records are altered by he operation. The record number and head number are specified in the Command Word. The Command Word is obtained from memory following a CIO Start command, r following some other operation which specified Command Chaining. The equence of operation is:

- The Command Word is fetched from memory and the Verify-A-Record command is decoded.
- Three Control Words are fetched from memory.
- The CU reads the first block of data, both from the disc record and from the memory, and compares the two data.
- If Data Chaining was specified, the CU fetches the next two Control Words from memory; the CU then reads the next block of data from the same disc record and compares it with the new memory block data.
- When a Block-Length Control Word does not specify Data Chaining, the record is complete when that block has been read and compared with the memory block.
- If any error conditions are detected during the read and compare operation, the pertinent Error Status bits are set and an interrupt is sent to the CPU (either when the error occurs or at the completion of the operation).

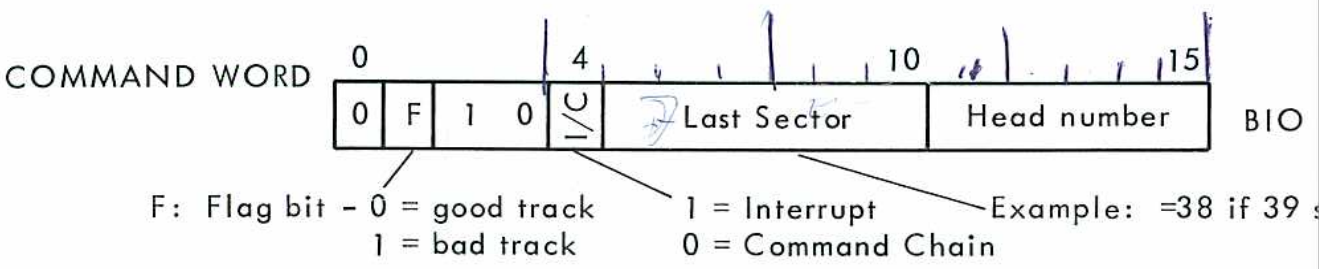
t the correct completion of the Verify operation (no errors):

- If the Interrupt/Command-Chain bit was set, the CU places its interrupt code on the BIEC lines to request an interrupt.
- If the Interrupt/Command-Chain bit was Zero, the CU adds 2 (word increment of 1) to the current Command/Control-Word address and fetches the next Command Word from memory.

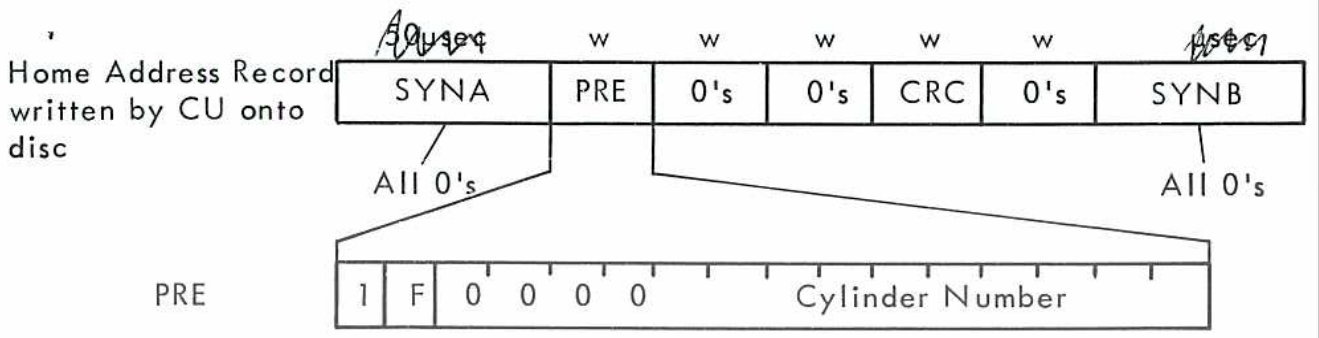
Error Status bits may be set as follows:

- Not Operable Drive (status bit 15) same as for Read.
- Throughput Error (status bit 14) same as for Read.
- Incorrect Length (status bit 12) same as for Read.
- Record Not Found (status bit 4) same as for Read.
- Flag Bad Track (status bit 2) same as for Read.
- Parity Error (status bit 13) is set if the CRC check does not produce zero, or if the data comparison is incorrect. Bit 13 is also set if the memory record is shorter than the disc record, unless the remaining data is exactly equal to the data already compared and the total length is correct; in this last case, bit 13 is not set, but bits 12 and 14 are set.

1.42 Write Home Address



w = 16-bit word



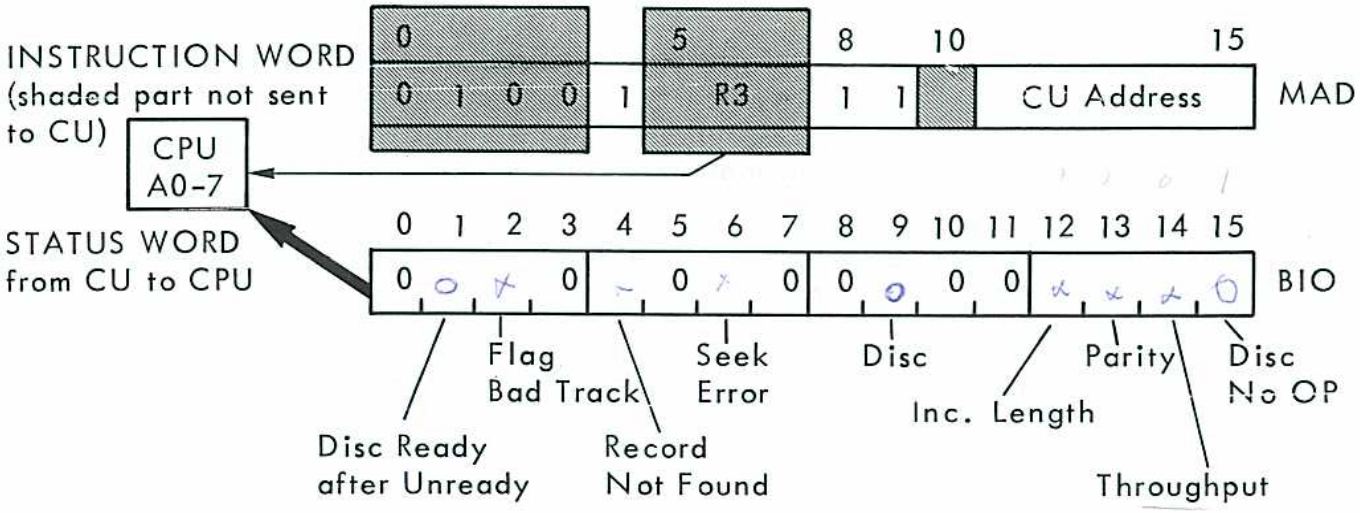
This command is used to write the Home Address record followed by alternate sector Address Marks and "all zeros" sectors onto the currently-selected disc cylinder. All sectors on a track have the same length (specified by the Control Word). The head number specified in the Command Word selects the track to be written. The Command Word and Control Word are obtained from memory following a CIO-Start command, or following some other operation which specified Command Chaining. Following this command, Write operations can be interleaved, with two revolutions minimum to write all sectors. It is not possible to write on a disc where sector address marks were not written by means of this command. The sequence of operation is:

- The Command Word is fetched and Write Home Address is decoded.
- One Control Word is fetched from memory.
- The CU writes the Home Address record on the selected disc, synchronized on the disc Index pulse. The Flag bit is set in the Preamble according to the Command-Word. The cylinder number is obtained from a CU register.
- Following the Home Address, the CU writes alternately sector Address Marks and all-zeros sectors. The same Control Word is fetched from memory for each sector written because the sector word length is counted down each time.
- If the addressed drive is not operable, the CU sets Not Operable Drive (status bit 15) and sends an interrupt to the CPU.
- If: (Last Sector + 1) . Length > track capacity, the CU sets Incorrect Length (status bit 12) and sends an interrupt to the CPU.

At the correct completion of the operation (no errors):

- If Interrupt Enable was specified, the CU sends an interrupt to the CPU on the BIEC lines.
- If Command-Chaining was specified, the CU adds 2 (word increment of 1) to the current Command/Control-Word address and fetches the next Command Word from memory.

1.43 Send Status (SST)



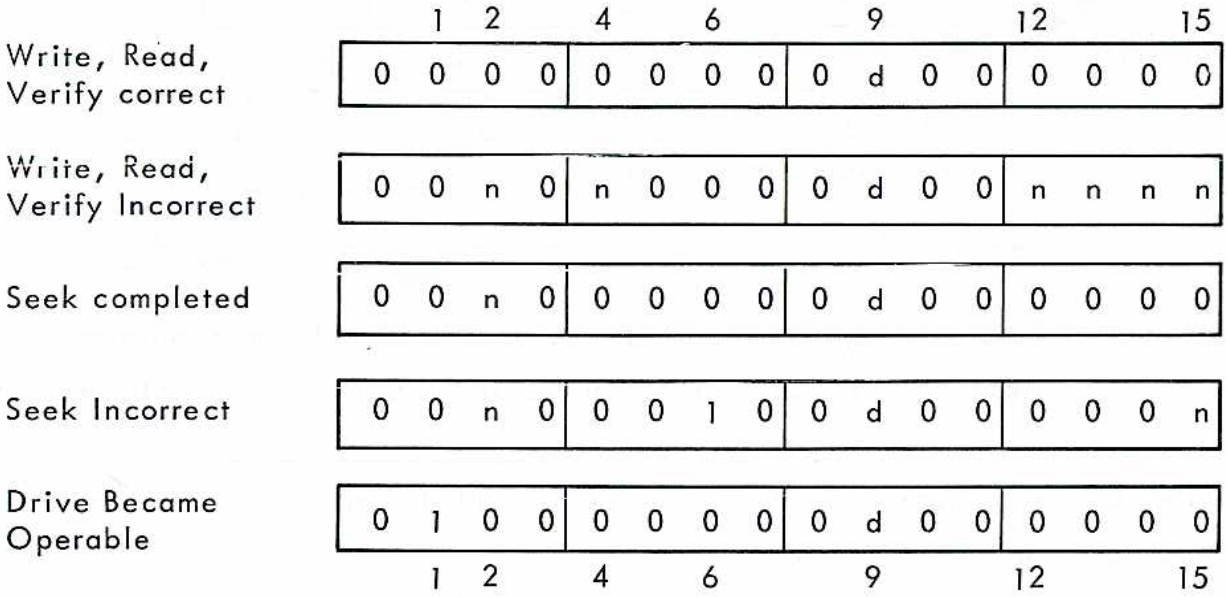
The SST instruction is used to transfer the CU status word to the CPU accumulator specified by the R3 field. SST is accepted by the CU if the CU is in Wait-Status state.

- If no CU recognizes the address code on MAD11-15, the CPU condition register is set to 3 (CR=11).
- If the command is not accepted by the CU, the CPU condition register is set to one (CR=01), the register specified by R3 becomes non-significant, and nothing happens in the CU.
- If the command is accepted, the condition register is reset (CR=00), the status word is transferred to the CPU register specified by R3, status is reset in the CU, and the CU switches to Inactive state.

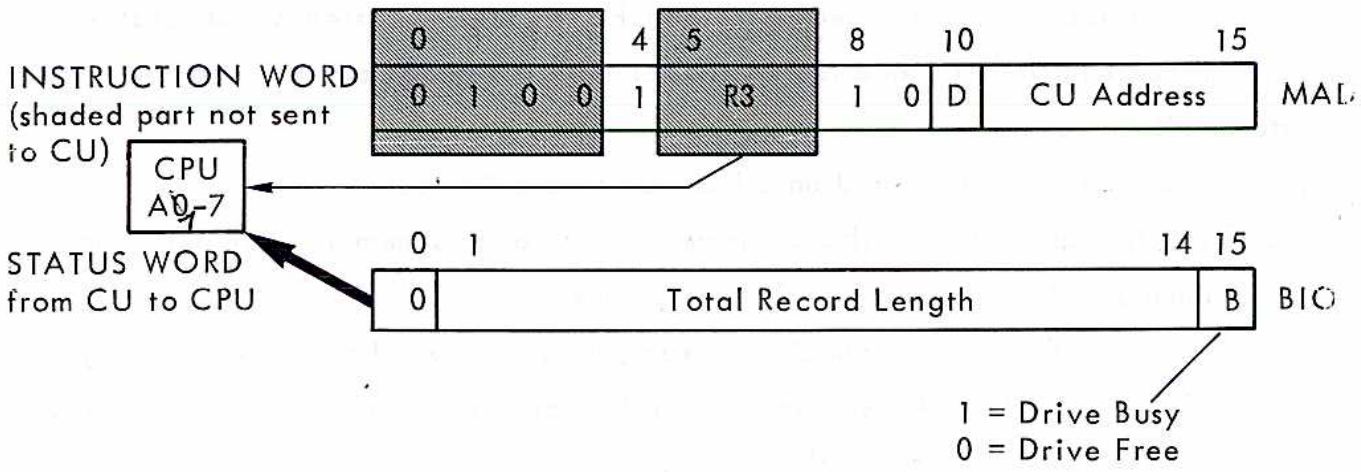
The status bits have the following meanings:

- 15: command attempted on a Non-Operable Drive.
- 14 Throughput Error: the CU is not able to access memory within 100μsec during Write, Read, or Verify operations
- 13 Parity Error: CRC check incorrect, or Verify word comparison wrong.
- 12 Incorrect Length: specified record length different from actual length, or Read or Write not finished before end of the track.
- 9 Disc Drive: Zero = disc 0; One = disc 1.
- 6 Seek Error: during Seek operation, the drive cannot reach the addressed cylinder, or a cylinder number comparison is incorrect at the completion of the Seek.

- 4 Record Not Found: addressed record not found during Write, Read, or Verify.
- 2: Flag Bad Track bit is set in the Home Address record of the addressed track.
- 1: Drive Ready after being inoperable.



1.44 Test Status (TST)



This command is used before an I/O operation to test if a disc drive is busy, or following a Read operation to obtain the total length of the record that was read. The TST command is always accepted by the CU. Upon receipt of this command, the CU puts the drive status and the record length on the BIO lines, as shown above.