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Author: Knud E. Hansen
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FDC 703

Reference Manual

Keywords: Floppy Disc Controller, FDC 703, FDD 703.

Abstracts: This paper describes the logical structure of the Floppy Disc Controller for the RC 3600 processor.

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The FDC 703 (Floppy Disc Controller) is an interface between FDD 703 Floppy Disc Drive and RC 3600. This Flexible Disc System provides the user with an on-line capacity of over 250K bytes. Off-line capacity is unlimited by use of the removable IBM compatible Diskette.

The FDC 703 is connected to the programmed transfer channel.

It should be noted that writing of check information and checking of this information during reading are included in the hardware of FDC 703.

The FDD 703 Floppy Disc Drive is composed of a drive mechanism, read/write head, head activator, and associated control circuits. It can write and read disc cartridges (diskettes) interchangeable from unit to unit; it enables data transfer rates at max. 30,875 8-bit bytes per sec., random access capability, and it can store up to 252,928 8-bit bytes on a single cartridge. The FDD 703 is full format compatible in accordance with the IBM 3740 Diskette System. Included in the FDD 703 is an interlock to prevent damage to a disc cartridge during loading or unloading.

Fig. 1.1 shows the physical structure of the disc system.

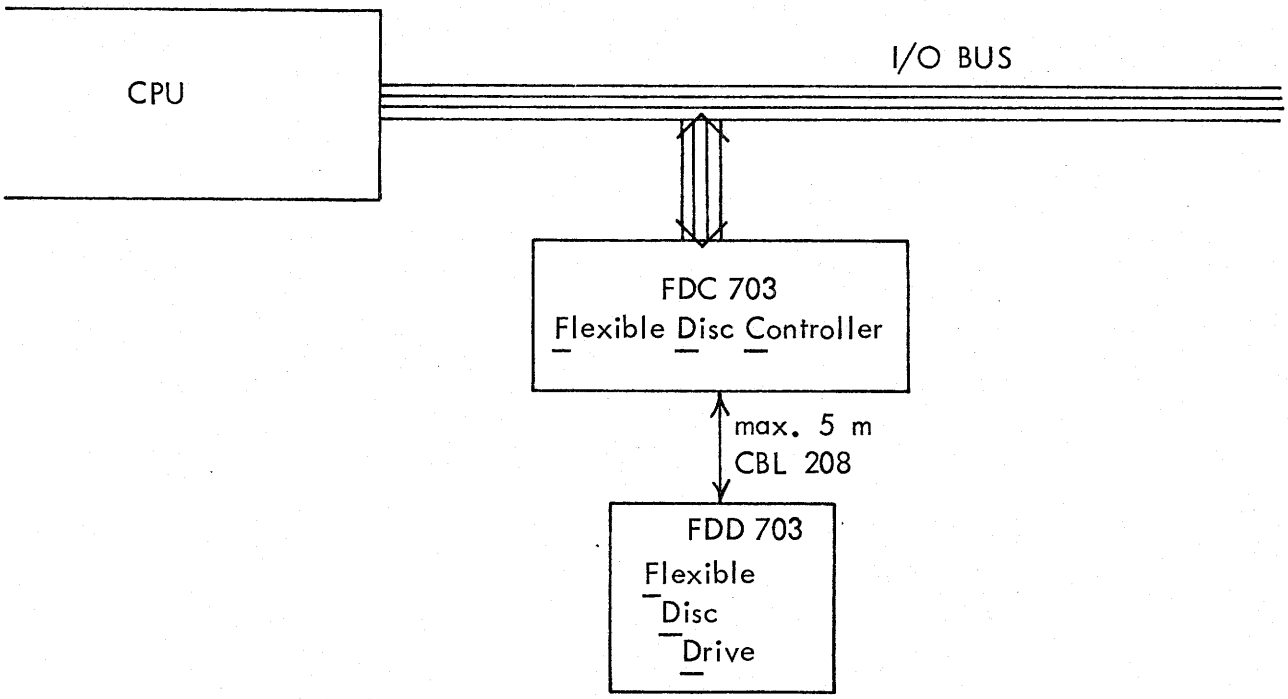


Fig. 1.1. Physical Structure of the Disc System.

Data Medium. 2.1

The data medium, the IBM formatted flexible disc cartridge - also called the diskette, used in the FDD 703 Floppy Disc Drive, is a flat disc composed of a Mylar substrate coated with a magnetic oxide. For protective purposes during handling, operation, and storage, the disc is encased in a flexible plastic envelope, eight inches square by one sixteenth inch thick. The disc itself rotates, during operation, inside this plastic envelope, which protects and cleans the surface.

The disc, 7.5 inches in diameter, has one hole for indexing.

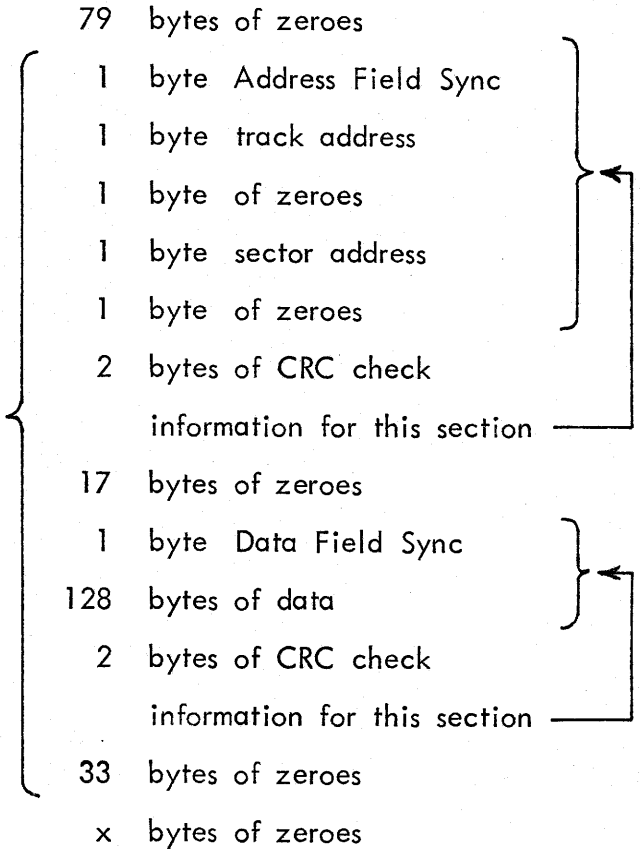
Fig. 2.1 shows the disc cartridge and disc configuration.

Through the read/write head opening, the read/write head is in direct contact with the disc surface.

Data Formats. 2.2

The disc is physically divided into 77 tracks. Each track is divided into 26 sectors. Each sector holds by definition one record of data. This sector recording format is shown below.

One track recording format:



The number of bytes in a sector are 188. The nominal time required for a sector is 6.08 msec.

The nominal numbers of bytes in a track are 5125. Due to tolerances on the disc speed, the number of x bytes may vary.

IBM Compatible Format. 2.2.1

Fig. 2.2 is a simplified summary of the compatible format. Complete details of the format are given in CDC Spec. 75270400.

The Index Gap (G1) with the FC/D7 Field Sync Byte (Address Mark) is present on disks as formatted by special initializing equipment (as received from the factory). However, if the disk is formatted by the 3740 equipment, the G1 and G1 gaps are combined resulting in 79 bytes of (00) Hex and a single FE/C7 Field Sync Byte (FE/C7 denotes data transitions of FE and clock transitions coded C7). This does not interfere with operation since the 3740 equipment does not utilize the G1 Field Sync Byte.

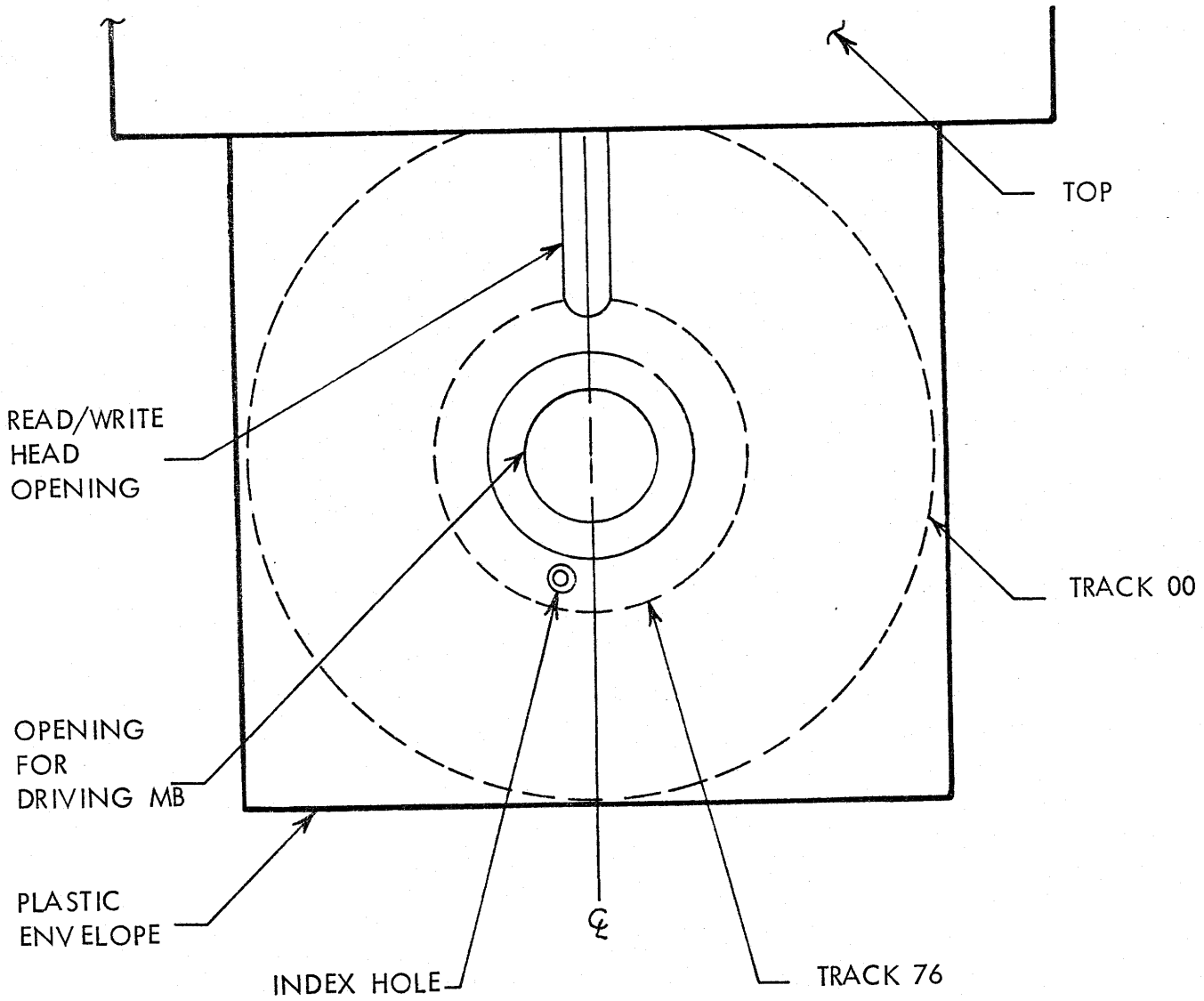


Fig. 2.1. Disc Cartridge and Disc Configuration.

Write Splices, points at which an update starts and ends during a write to a data field, occur 6 bytes ahead of the Field Sync Byte in the Address Gaps and 2 bits after the Polynomial Check Bytes (CRC) for the Data Field. The write operation comprises writing the last 6 bytes of zeroes in the Address Gap, a Field Sync Byte, 128 bytes of data and/or blanks, 2 CRC bytes, and 2 bits of zeroes.

In addition to providing the control logic with the required information to distinguish the beginning of Address Fields and Data Fields (missing clocks provide unique distinction from normal data), the Field Sync Bytes are used to uniquely identify Deleted Records and Defective Tracks. A Deleted Record has the normal FB/C7 Field Sync Byte at the end of the Address Gap replaced with an F8/C7 Field Sync Byte.

Polynomial Code Generation. 2.2.2

The polynomial codes recorded at the end of each field are the remainder (in each stage of the shift register) resulting from dividing the bits in the field being checked by the polynomial $X^{16} + X^{12} + X^5 + 1$. The field being checked extends from the first bit of the Field Sync Byte to the last bit in the Address or Data Field. During a write operation the required Polynomial Check Bytes are generated by: first setting all stages of the shift register to ones; then shifting the first bit of the Field Sync Byte and all subsequent bits through the last bit of the last byte of the field (exclusive of the 2 CRC bytes); after the last bit is shifted through the last stage of the register, the bits remaining in the 16 shift register stages are the 2 CRC bytes to be recorded.

When reading back, the checking operation consists of: first setting all stages of the shift register to ones; then shifting all bits starting with the first bit of the Field Sync Byte through the last bit of the second CRC byte through the register; after the last bit has been shifted through, a one present in any stage of the shift register indicates an error has occurred in the field or in the Field Sync Byte or the CRC Bytes (pre-

sumably the Field Sync Byte has already been confirmed as valid due to apriori information used to establish field synchronization).

Disc Drive. 2.3

The disc drive rotates the disc at 360 rpm., meaning that a full revolution of the disc takes 166.67 msec.

The time from power on until the drive is operable is approximately 2 sec.

After a power up, the position of the head is undefined, and the program should initially move the head to the outer track, track 00, before any other operation is initiated.

The time for a single track move is 20 msec. including settling time. This is defined as the time to move between any pair of adjacent tracks. Multiple track moves can be made at 10 msec. per step plus 10 msec. settling time.

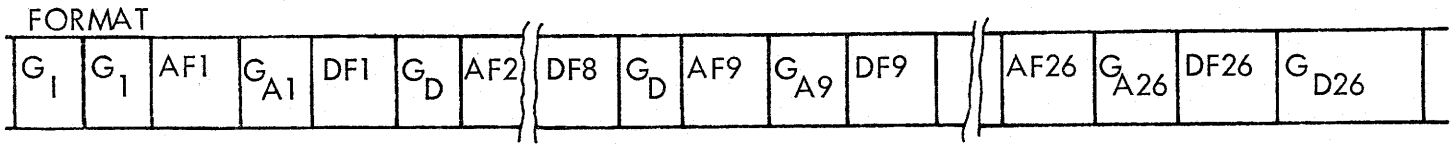
The random average positioning time is 260 msec. This is defined as the summation of the move times for all possible moves.

The maximum positioning time is 770 msec. This is defined as the time to move the head from track 00 to track 75 or from track 75 to 00 and includes settling time.

Loading of the read/write head is performed by software control.

The read/write can be loaded when the disk is fully installed and the front panel door is closed. Closing the front panel door activates the door interlock switch which completes the circuit to the head load solenoid. The head load settling time is 60 msec.

If more than four revolutions of the disk have occurred without any data transfer or head movements, hardware unloads the head from the disk surface, to cause minimum wear.



46B(00)H	DATA(FC)H CLOCK(D7)H
G1	

32B(00)H	DATA(FE)H CLOCK(C7)H
G1	

TT 00 SS 00 XX XX
BINARY TRACK - SEP. - SECTOR - SEP. - POLYNOMIAL CHECK BYTES
ADDRESS FIELD 4 + 2 B

17B(00)H	
GA (ADDRESS GAP)	

DATA(FB)H CLOCK(C7)H — TRACK 0 SECTORS 1-8; TRACKS 1-76 ALL SECTORS

DATA(F8)H CLOCK(C7)H — TRACKS 0-SECTORS 9-26

128 BYTES OF DATA OR BLANKS (40)H	XX XX POLYNOMIAL
DATA FIELD 128 + 2 B	

33B(00)H	DATA(FE)H CLOCK(C7)H
G1-25 (DATA GAP1-25)	

274B(00)H NOMINAL DISK SPEED DEPENDENT
G26 (DATA GAP26)

NOTES:

1. Recording Double Frequency -
   Zero - Clock transition only
   One - Clock and Data transition
2. Field Sync Byte (Address Mark) at end of gaps identified as if recording was two channel multiplexed NRZ1.
3. Track 0 ordinarily used for disk usage information such as write protect, logical sector length, defective tracks, etc.
4. Track 76 ordinarily used for CE Mode.
5. B = Bytes; ( )H = Hex Byte

A23606 Fig. 2.2. Compatible Format.

The number of tracks per disc is 77, and the number of sectors per track is 26, giving a total of 2002 sectors per disc. The number of data bytes per sector is 128 giving a total of 256,256K bytes per disc.

Data transfer rate within a byte is 30,825K bytes per sec.

Access time within a track is on an average slightly more than time for half a revolution of the disc, i.e. 84 msec.

List of Characteristics for FDD 703. 2.4

BPI	TK00	1836 BPI
	TK76	3268 BPI
RECORDING METHOD		FM
TPI		48 TPI
TRACK WIDTH		.014 IN
MAGNETIC HEAD		TUNNEL ERASE IN-CONTACT HEAD
HEAD MATERIALS		MU-METAL IN STAINLESS STEEL PAD
MEDIA		OXIDE ON .003 IN MYLAR
ROTATIONAL SPEED		360 RPM.
RELATIVE HEAD/MEDIA VELOCITY		TK00 - 136 IPS TK76 - 76 IPS
CAPACITY - PER DISK		3,208,128 BITS
PER TRACK		41,664 BITS (UNFORMATTED)
TRACKS		77
HEADS		1
TRANSFER RATE		249,984 BITS/SEC.

SEEK TIME - MIN.		20 MSEC.
	AVG.	260 MSEC.
	MAX.	770 MSEC.
	(10 MSEC./TRACK PLUS 10 MSEC. SETTLING)	
AVG. LATENCY TIME		83 MSEC.
MEDIA		CDC 9878 (AND OTHER IBM DISKETTE COMPATIBLE MEDIA)
COMPATIBILITY		IBM 3740 (MEDIA AND TRACK LOCATION)

POWER REQUIREMENTS

AC:	120V/60 HZ		0.7A START/0.5A RUN
	220V/50 HZ		0.35A START/0.25A RUN
DC:	+ 24V	2.0A	
	+ 5V	1.6A	
	- 5V	0.15A	

PHYSICAL DIMENSIONS

	W.O./FRONT PANEL	W/FRONT PANEL
HEIGHT	4.625 INCHES	4.97 INCHES
WIDTH	8.59 INCHES	8.78 INCHES
DEPTH	13.75 INCHES	14.00 INCHES
WEIGHT		12 LBS.

Description. 3.1

Program control of the disc drive is provided through all I/O transfer instructions. Busy and Done are controlled or sensed in I/O instructions with device code 61 (octal).

Interrupt disable is controlled by interrupt priority mask bit 7.

The clear function (F = 10) clears Busy and Done. Start (F = 01) clears Done, sets Busy, and if the status situation allows it, the operation indicated by the contents of the command register is executed, else the controller is left in the busy state. Start loads the head against the disc.

The Pulse function (F = 11) clears the device buffer immediately together with the Done flag.

The controller terminates all program initiated operations, that are executed, by clearing Busy and, if it was a time consuming operation, Done is set. The pulse function is to be used after a data transfer from device buffer to CPU.

The IORST instruction clears the Busy and Done flags together with the device buffer and all registers. The same operation is performed by power start-up.

Fig. 3.1 shows the data paths of the disc system.

Command Register. 3.2

The DOA instruction (see fig. 3.1 and 3.2) loads the contents of the specified AC into the command register.

The program starts a disc drive operation by executing an I/O instruction with modification S (F = 01, sets Busy and clears Done), and the actual

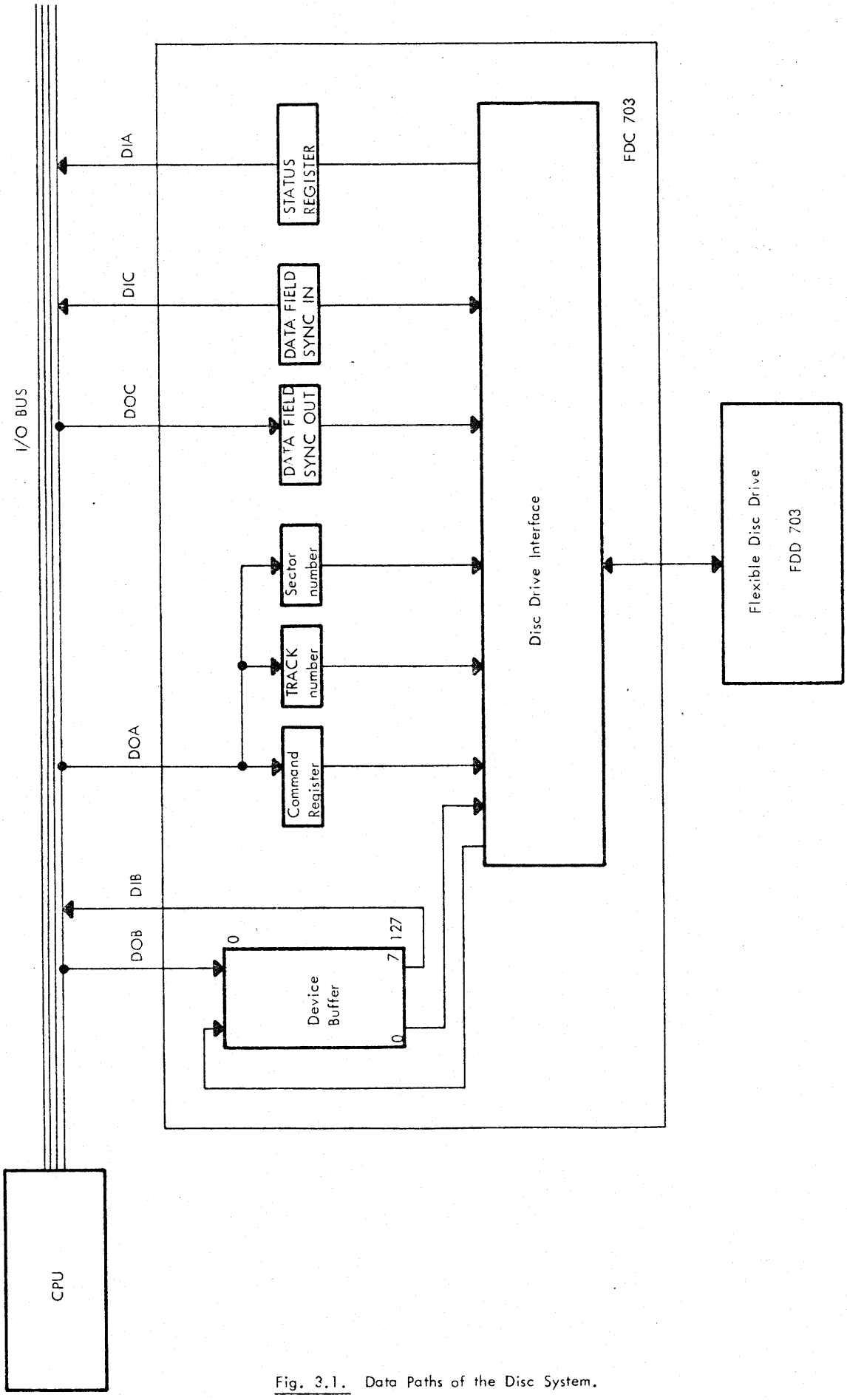
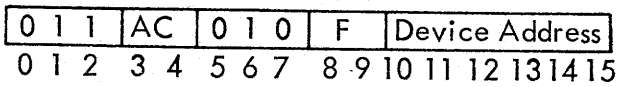


Fig. 3.1. Data Paths of the Disc System.

contents of the command register then specifies the type of operation to be executed.

If the start instruction is a DOAS, then the command register is loaded before the operation is executed.

DOA-Instruction.



AC:

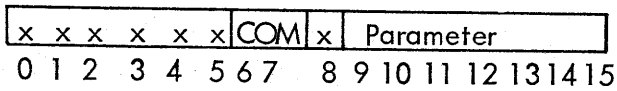


Fig. 3.2. The Data Out A instruction (x = not used).

The parameter field, bits (9 : 15), specifies for read/write operations the sector number (1 to 26) on the selected track, and the track number (0 to 76) for a track search operation.

In the case of a recalibration operation this field is dummy.

The command field, bits (6 : 7) specifies the command to be executed.

The possible commands are listed in fig. 3.3.

Command Code	Mnemonic
0	READ ONE SECTOR
1	WRITE ONE SECTOR
2	RECALIBRATION
3	TRACK SEARCH

Fig. 3.3. Command Table.

x x x x x x	0 0	x	SECTOR NUMBER
0 1 2 3 4 5 6 7	8 9	10	11 12 13 14 15

Fig. 3.4. READ ONE SECTOR (x = not used).

The disc controller normally terminates the execution of this command by setting Done.

The command is never rejected, but if the status of the disc drive is LOCAL, the command is terminated immediately .

The effect of this command is, if the necessary settling time for the head has gone (10 msec. after last track move and 60 msec. after head loading) - or the hardware waits until the settling time is terminated - that FDC 703 starts to monitor the serial data from the diskette to look after an ADDRESS FIELD SYNC byte.

When such a byte is found, the following address block is read.

The track number in the address block is compared with the contents of the track counter, if not equal, the status bit POSITION ERROR (bit 12) is set.

The sector number in the address block is compared with the wanted sector number. If not equal, the hardware in FDC 702 goes to look after next Address Field Sync byte and the track examine procedure above is repeated. When the correct sector number is found, the cyclic polynomial check characters for this block are checked. If a CRC error is found, the status bit ADDRESS FIELD ERROR (bit 3) is set; but reading from the diskette continues.

When the head reaches the Data Field Sync byte, this byte is loaded into the input C-register. The following 128 data bytes are loaded into the device buffer byte by byte. When this data block is read from the

diskette, the cyclic polynomial check characters following the data bytes are checked. If a CRC error is found, the status bit PARITY ERROR (bit 10) is set. The command is terminated by setting done.

If during a READ command, no correct sector number is found, the command is terminated by setting done after four revolutions of the diskette. This situation is indicated by setting the status bit TIME OUT (bit 14).

Every Read Command will reset the Device buffer before operation is initiated.

WRITE ONE SECTOR Command. 3.2.2

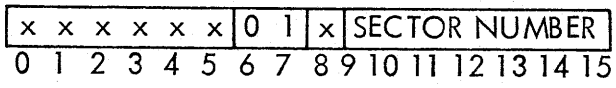


Fig. 3.5. WRITE ONE SECTOR (x = not used).

The effect of this command is, if the necessary time for the read/write head has gone (10 msec. after last track move and 60 msec. after head loading) - or the hardware waits until this time has elapsed - the FDC 703 starts to monitor the serial data from diskette to look after an Address Field Sync byte.

When such a byte is found, the following address block is read.

The track number in the address block is compared with the contents of the track counter; if not equal, the status bit POSITION ERROR (bit 12) is set.

The sector number in the address block is compared with the wanted sector number. If not equal, the hardware in FDC 703 goes to look after next Address Field Sync byte and the track examine procedure above is repeated. When the correct sector number is found, the cyclic polynomial check characters for this block are checked, and the state of the Write Protection switch is tested.

If a CRC error is found, the command is terminated by setting Done; this situation is indicated by setting status bit ADDRESS FIELD ERROR (bit 3).

If Write Protection is selected, the command is terminated by setting Done; this situation is indicated by status bit WRITE PROTECTION (bit 5).

If the CRC check mentioned above is OK, and Write Protection is not selected, the reading from diskette continues until 6 bytes before the Data Field Sync byte. These 6 bytes are written by hardware as all zeroes, then the Data Field Sync byte taken from the output C-register is written on the diskette.

From this point the 128 bytes in the device buffer are written byte by byte. After this data block is written on the diskette, two bytes more are written, the cyclic polynomial check characters generated by hardware in FDC 703. The command is terminated by setting done.

If during a Write command, no correct sector number is found, the command is terminated by setting done after four revolutions of the diskette. This situation is indicated by setting the status bit TIME OUT (bit 14).

If during a Write command, hardware Error (see description of status bits in section 3.7) occurs, the TIME OUT situation above will terminate the command by setting done. The status bit HARDWARE ERROR (bit 0) is set.

The command is never rejected, but if the status of the disc drive is LOCAL, the command is terminated immediately .

RECALIBRATION. 3.2.3

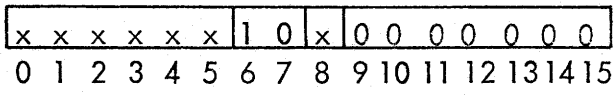


Fig. 3.6. RECALIBRATION (x = not used).

The effect of this command in FDC 703 is, that Step Out pulses (duration 10 ms.) are supplied to the head, until the head is positioned over track 00, the outer track. The track-counter is reset, and the command is terminated by setting done.

If the head is positioned over track 00 before executing this command, no step out pulses are supplied to the head, and the command is terminated after 10 ms. by setting done.

This command should be issued before operation after powering up.

This command should also be issued, if a Position Error is found during executing one of the data commands.
If FDC 703 is in LOCAL state , the command is terminated immediately .

TRACK SEARCH. 3.2.4

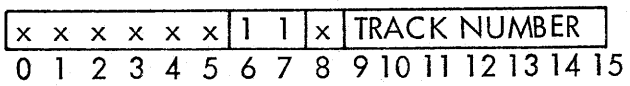


Fig. 3.7. TRACK SEARCH (x = not used).

When this command is started in FDC 703, the delivered number for wanted track is compared with the contents of the track counter (CUR TRACK).

If wanted track number is greater than CUR TRACK, step in pulses (10 msec.) are supplied to the head move drive, and the track counter is incremented by each step in pulse, until wanted track number is

equal to the contents of the track counter. If wanted track number is lesser than CUR TRACK, step out pulses (10 msec.) are supplied to the head move drive, and the track counter, and the track counter is decremented by each step out pulse, until wanted track number is equal to the contents of the track counter.

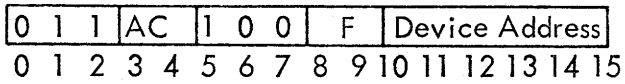
When wanted track is equal to CUR TRACK, the command is terminated by setting done.

If FDC 703 is in LOCAL state , the command is terminated immediately .

Write Data Instruction. 3.3

The DOB instruction (see fig. 3.1 and 3.8) loads the contents of the specified AC into the device buffer.

DOB-Instruction.



AC:

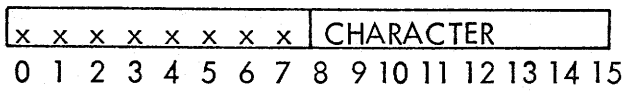


Fig. 3.8. DOB-instruction (x = not used).

The character field in the specified AC contains the character to be loaded into the device buffer.

If more than 128 bytes are loaded into the device buffer when executed, the transferred character will be lost.

Read Data Instruction. 3.4

The DIB instruction (see fig. 3.1 and 3.9) loads one character from the device buffer into the specified AC.

DIB-Instruction.

0	1	1	AC				0	1	1	F	Device Address				
0	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15

AC:

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

Fig. 3.9. DIB-instruction (x = not used).

After the instruction has been executed, the selected AC contains the character read from the device buffer as shown in fig. 3.9.

If the device buffer is empty when executed, the transferred character makes no sense.

Write Data Field Sync Instruction. 3.5

The DOC-instruction (see fig. 3.1 and 3.10) loads the contents of the specified AC into the Data Field Sync output register.

DOC-Instruction.

0	1	1	AC				1	1	0	F	Device Address				
0	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15

AC:

x	x	x	x	x	x	x	x	Data Field Char.							
0	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15

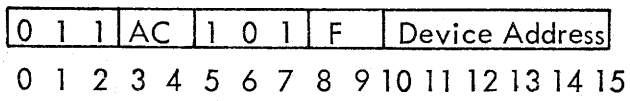
Fig. 3.10. DOC-instruction (x = not used).

The character field in the specified AC contains the character to be loaded into the Data Field Sync output register.

Read Data Field Instruction. 3.6

The DIC-instruction (see fig. 3.1 and 3.11) loads the contents of the Data Field Sync input register and the contents of the track counter into the specified AC.

DIC-Instruction.



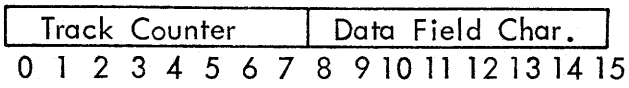


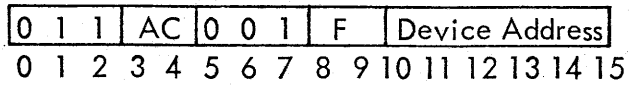
Fig. 3.11. DIC-instruction.

After the instruction has been executed, the selected AC contains the contents of the track counter and the contents of the Data Field Sync input register as shown in fig. 3.11.

STATUS Register. 3.7

The DIA-instruction (see fig. 3.1 and 3.12) transfers the current state of the controller into the specified AC. In addition it clears the status register.

DIA-Instruction.



AC:

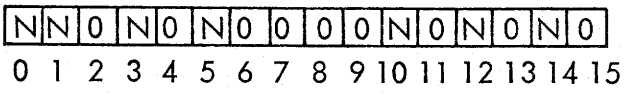


Fig. 3.12. DIA-instruction (N = status bit).

The status bits are listed in fig. 3.13.

The status bits are flag signals, and the mnemonics refer to the active onestate.

In the following the meaning of each status bit is explained in detail.

Updating of the status register is performed automatically by the controller.

Bit No.	Mnemonic
0	HARDWARE ERROR
1	LOCAL
2	0
3	ADDRESS FIELD ERROR
4	0
5	WRITE PROTECTION
6	0
7	0
8	0
9	0
10	PARITY ERROR
11	0
12	POSITION ERROR
13	0
14	TIME OUT
15	0

Fig. 3.13
Status bit allocation

HARDWARE ERROR. 3.7.1

Indicates one or more of the following fault conditions:

a. Write Enable to the Disc Drive without head loaded.

b. Incorrect data rate.

LOCAL. 3.7.2

Indicates that the disc drive is or has been in off-line mode, i.e. the cartridge door is or has been open.

Furthermore it indicates that a diskette is not loaded into the drive.

This status bit is also set after powering up.

ADDRESS FIELD ERROR. 3.7.3

Indicates that the polynominal check characters in the address section of the wanted sector was in error.

WRITE PROTECTION. 3.7.4

This status bit simply follows the Write Protection Switch on the Front Panel.

PARITY ERROR. 3.7.5

Indicates that a CRC error is found during reading the data part of a sector.

POSITION ERROR. 3.7.6

If during reading the address part of the wanted sector, the track number read from the diskette does not correspond to the number selected during a TRACK SEARCH command, this status bit is set.

TIME OUT. 3.7.7

Indicates that no correct sector number is found before four revolutions of the diskette has elapsed after starting a READ (or WRITE) command.

OPERATOR CONTROLS 4

Diskette Removal. 4.1

Open Disc Door; this causes rotation to stop, and disengages spindle.

Remove the diskette from Disc Drive and put it in its storage envelope.

Remember that the door can be opened both when FDC 703 is performing a command or not. When the door is opened the status bit LOCAL is set.

Diskette Loading. 4.2

Remove the diskette from storage envelope. Carefully slide diskette into Disc Drive, until jacket is solidly seated against stops.

Carefully close unit door. Ensure that jacket is properly seated, spindle has engaged diskette, and door is closed and latched.

Protect the empty envelope from liquids, dust, and metallic materials.

When the door is closed, FDC 703 starts to monitor the distance between the index hole pulses (one per revolution of the diskette) to indicate when the diskette rotates with nominal speed. This detection takes about 2 sec. (15 revolutions). When the speed of the diskette is nominal, the controller is able to accept commands.

Remember that the head position is undefined after the load procedure above.

Switches. 4.3

The only operator control is the WRITE PROtection switch.

This switch is connected to a Flip-Flop in FDC 703; the state of this Flip-Flop is alternated every time the operator pushes the WRITE PRO switch.

When this Flip-Flop is in the Write Protection state, all write operations are inhibited, as described in section 3.2.2.

After power up and after FDC 703 has been in LOCAL mode, FDC 703 is forced into write protection mode.

Indicators. 4.4

In the WRITE PRO switch is placed a lamp, lighting when FDC 703 is in write protection mode.

Technical Specifications. 5.1

The FDC 703 Floppy Disc Drive Controller is designed for use in RC modular system CHS 701.

In addition to the normal + 5V power supply, both - 12V and + 24V power supplies must be present in the CHS 701.

Power consumption for one FDC 703 incl. FDD 703:

From the + 5V bus:	6.0 A.
- - - 12V bus:	50 mA.
- - + 24V bus:	2.0 A.

Ambient temperature and humidity range:

0-45°C.

20-80% RH without condensation