FD-411 DOUBLE DENSITY/DOUBLE-SIDED
FLOPPY DISK SYSTEM

Users Manual

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PDP-11	RX02
RT-11	
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Section 1

INTRODUCTION

This manual contains all the information necessary to install and operate the FD411 flexible disk system. Section 2 contains information on unpacking, installation and diskette care. It should be read carefully before any use of the unit is attempted.

The FD411 is a double-sided dual density flexible disk system compatible with Digital Equipment Corporation's LSI-11 computer family. It is a direct replacement for Digital's RXV-21 (the LSI-11 version of the RX02) disk system with the added feature that double-sided diskettes may be used, allowing twice the storage capacity. It provides double density data encoding allowing the storage of 512K bytes on a single-sided diskette or 1024K bytes on a double-sided diskette. The single-sided mode allows access to programs written on older single-sided systems (either single density or double density). When operated with single-sided media, there is no software or media difference with RX02/FD211 operation. Seek time is faster, however.

1.1 SYSTEM CONFIGURATION

All FD411 Systems are shipped with the following parts:

1	Controller and Formatter Card for LSI-11 (FC-203)
1	Bootstrap Loader Card (BL-220)
1	Dual Drive Chassis
1	Chassis Slides and Mounting Hardware
1	A/C Power Cord
1	FD-411 User Guide

The controller/formatter is fully contained on the FC-203 dual height card. The controller is connected to the drive chassis as shown below:
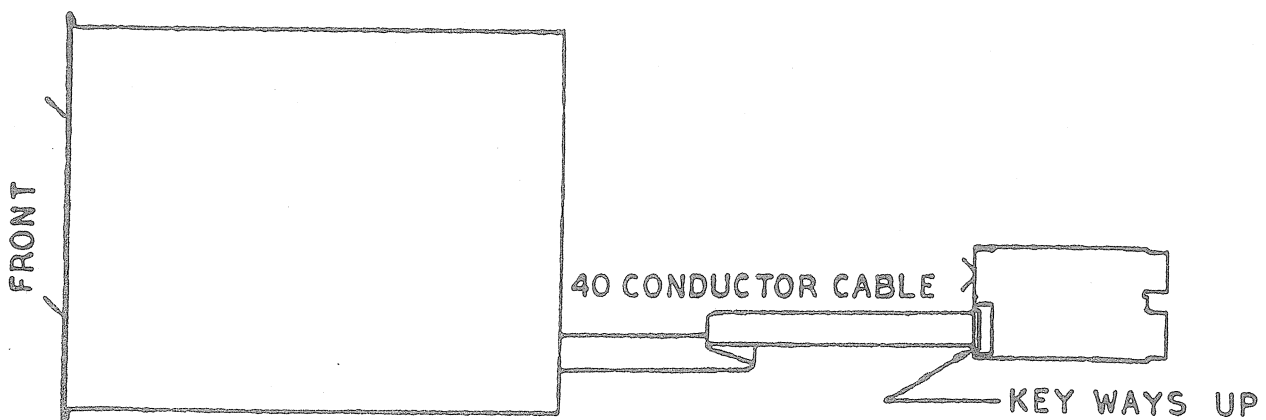
FIGURE 1-1
FD411 SYSTEM CONFIGURATION

1.2 CONTROLLER CARD

The controller card is based around a 2901 microprocessor which controls all reading and writing to the disk drives and emulates DEC's RXV21 (RX02) instruction set. In addition, it has the capability of completely formatting diskettes. It has the capability of operating with both single-sided and double-sided diskettes.

This card plugs into any dual slot in any LSI-11 backplane. A 40 conductor ribbon cable connects this card directly to each of two disk drives that are daisy-chained.

1.3 FD-411 DUAL DRIVE CHASSIS

This chassis holds two drives side by side, write protect switches, a circuit breaker, a power supply, and a fan.

1.3.1 ELECTRO-MECHANICAL

Each drive may be removed individually by removing the four machine screws that hold it in place.

Each drive has an activity LED mounted on its bezel which is lit whenever an I/O operation occurs.

1.3.2 POWER SUPPLIES

All systems have a power supply that generates +24 volts at 3 amps, -5 volts at 200 milliamps and +5 volts at 2 amps for the floppy disk drives.

1.4 SYSTEM COMPATIBILITY

The FD411 System is completely compatible with DEC's RX02 instruction set and runs with DEC supplied software or with most software designed to work with DEC's RX02 System.

1.5 MEDIA COMPATIBILITY

The FD411 is designed to operate with single-sided single density, single-sided double density, and double-sided double density diskettes. In single density mode, the FD411 is compatible with IBM's 3740 format. This allows interchange of media with RX01 (or FD-11) systems as well as the equipment of many other manufacturers who use this industry-standard format.

The single-sided double density mode of the FD411, while being interchangeable with RX02 (or FD211) systems, is a standard only to Digital Equipment Corporation. No other main-frame manufacturer uses this particular double density encoding at the present time.

The double-sided double density mode of the FD411 is not media compatible with any other system known of at this time. This mode allows twice the storage capacity by writing data according to DEC's RX02 double density format standard on both sides of a diskette.

1.5.1 DISKETTE

The flexible diskette consists of a flexible mylar disk coated with an oxide and encased in a plastic jacket. The jacket is lined with a fiber material that cleans the diskette as it rotates.

Care should be used in both selecting and handling these diskettes as described in Section 2.

1.5.2 SINGLE DENSITY FORMAT

The FD411 uses IBM's 3740 format in single density mode. In the IBM 3740 Data Entry System, each disk contains 77 tracks (0-76). Each track is divided into 26 sectors containing 128 data bytes. The organization of sectors on a track is determined logically (soft sectoring) rather than mechanically (hard sectoring). The principal characteristics of this format are shown below:
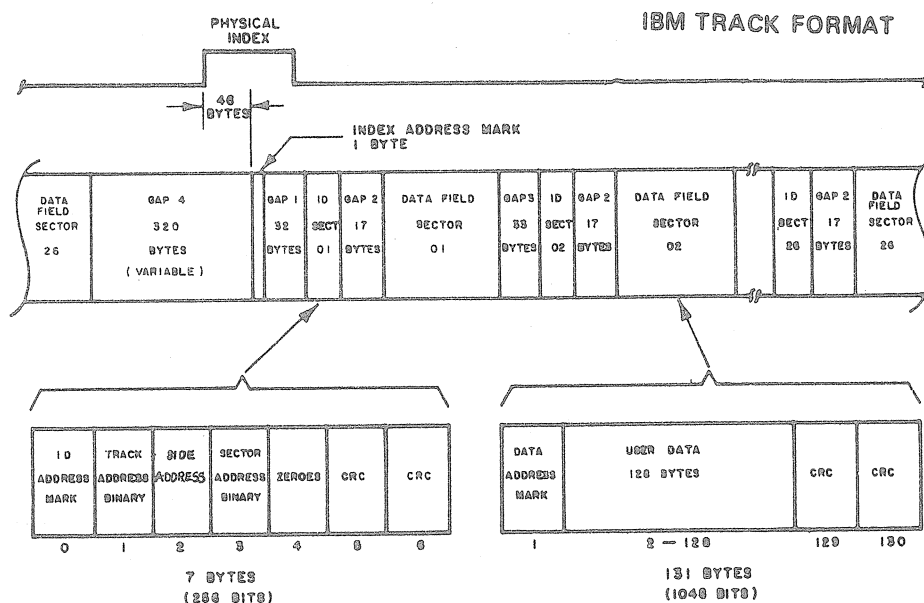
FIGURE 1-2

The headers, each 7 bytes long, identify the track and sector being read. During normal operation, these headers are not written over. On both read and write commands, these headers will be read to identify the sector number and verify the track address.

After a gap, the data field will either be read or written.

Single density data is written using the FM encoding. Four microsecond bit cells, as shown in Figure 1-3, always contain a clock bit and also contain a data bit if a "1" is present.

1.5.2 <u>SINGLE DENSITY FORMAT</u> (continued)
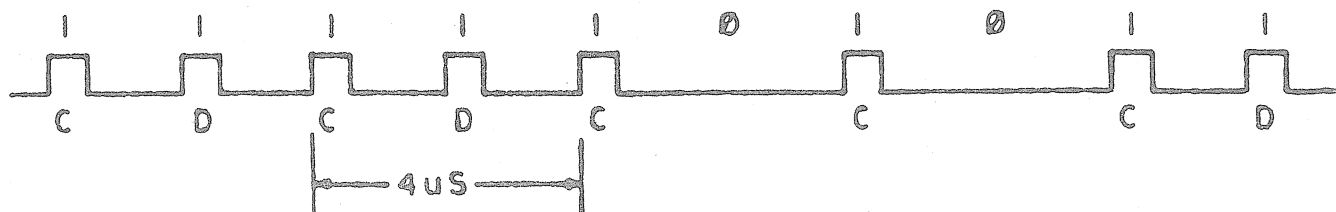
FIGURE 1-3

1.5.2 <u>DOUBLE DENSITY FORMAT</u>

The FD411 follows the same double density format selected by Digital Equipment
Corporation for use in its RX02 System on both single-sided and double-sided
media. This format is not compatible with IBM's double density format.

The double density format in the FD411 is actually the same as the single density
format except for the data fields. The exact same single density headers are used
so that a diskette may be used for either single or double density operation with-
out changing the headers. The principal characteristics of the double density
format are identical to those shown in Figure 1-2 except for the data field.
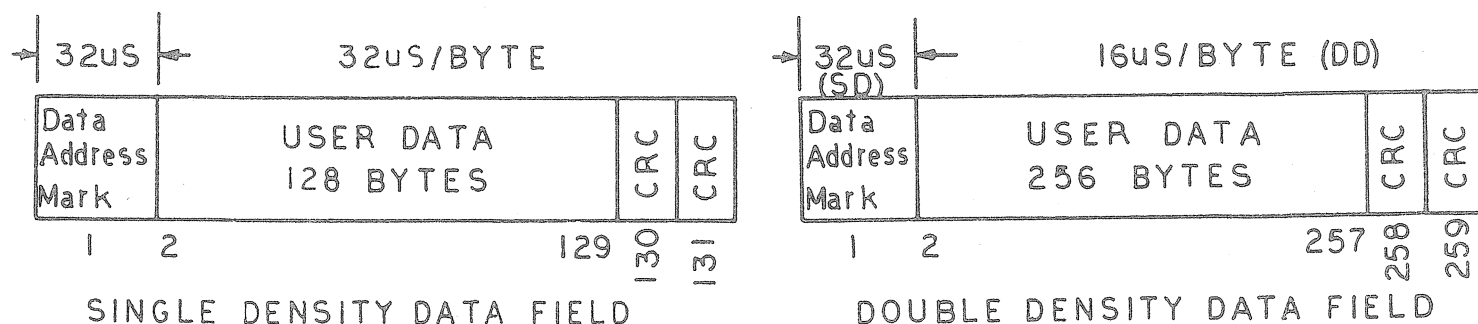
FIGURE 1-4

Figure 1-4 shows the data field format for double density as well as the single
density format for comparison. The data address mark, which is rewritten on
all write commands, designates the density of the data field. The table below
gives the different designations used in data address marks.

1.5.3 DOUBLE DENSITY FORMAT (continued)

MARK	DENSITY	DATA BYTE HEX	CLOCK BYTE HEX	STANDARD
DATA	SINGLE	F B	C 7	IBM 3740
	DOUBLE	F D	C 7	DEC
DELETED DATA	SINGLE	F 8	C 7	IBM 3740
	DOUBLE	F 9	C 7	DEC

FIGURE 1-5

The encoding technique used in double density is different from that used in single density. It is a variation on the MFM encoding technique used by IBM and other flexible disk manufacturers. The standard MFM encoding technique consists of two microsecond bit cells with clock bits only written when there are no data bits in either the present or previous cells. The data bits are written whenever a 1 is to be written. Figure 1-6 gives an example of this.
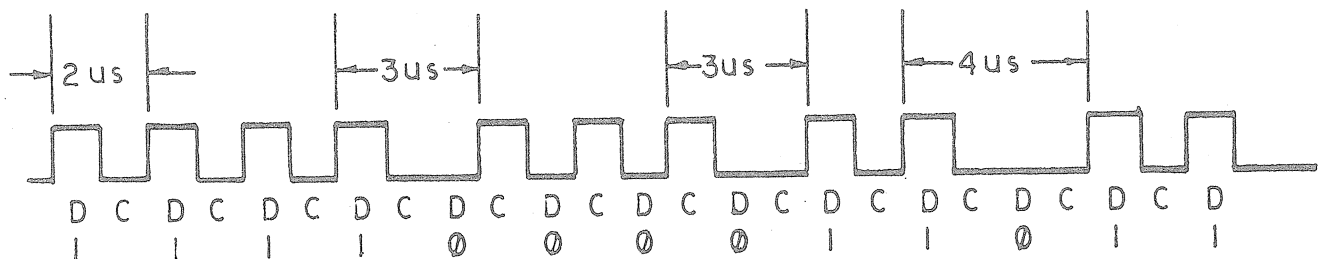
FIGURE 1-6

As can be seen from Figure 1-6, spacings of 2, 3 and 4 microseconds between flux changes are all possible. The fact that the address marks must be written with unique patterns so as to always be distinguishable from data for a soft-sectored controller presents a special problem here. A single density address mark will be detected unwittingly if an appropriate 2 bites of data is written in a double density data field. This danger is overcome by re-encoding a normal double density data pattern into a pattern with missing clocks. This is shown in Figure 1-7.

1.5.3 DOUBLE DENSITY FORMAT (continued)

WHENEVER $D_0 D_1 D_2 D_3 D_4 D_5$ APPEARS IN A DOUBLE DENSITY
$0\ 1\ 1\ 1\ 1\ 0$ DATA FIELD,

IT IS WRITTEN AS

$D_0\ C_1\ D_1\ C_2\ D_2\ C_3\ D_3\ C_4\ D_4\ C_5\ D_5$
$0\ 1\ 0\ 0\ 0\ 1\ 0\ 0\ 0\ 1\ 0$

FIGURE 1-7

When reading double density data fields, the controller checks for a missing
clock between 2 zero data cells, and if found, it substitutes in 2 ones for
the 2 zero data bits.

An understanding of the format differences between single and double density
described above will help the user understand the different format operations
available to the user, listed in Section 5 of this manual.

1.5.4 CYCLIC REDUNDANCY CHECK (CRC)

Every ID and data field on the track has a pair of CRC bytes appended to it.
These bytes, which are generated as the field is written, represent a cyclic
permutation of all the data bits in the field, from bit 0 of the address mark
to bit 7 of the last byte in the field (excluding the CRC bytes).

The cyclic permutation is the remainder that results from dividing the data
bits (represented as an algebraic polynomial) by a generator polynomial G(X).
The polynomial used in the 3740 format is

$$G(X) = X^{16} + X^{12} + X^5 + 1 \ .$$

1.6   SYSTEM SPECIFICATIONS

Capacity

Bytes per sector:	128 (single density); 256 (double density)
Sectors per track:	26
Tracks per diskette:	77 per side
Total bytes per diskette:	256,256 (single density);
	512,512 (double density);
	1,025,024 (double-sided, double density)

Access Time and Rates

Diskette to controller buffer:	32 µs/byte (SD); 16 µs/byte (DD)
Buffer to CPU:	16 µs/byte
Track to track:	3 ms
Seek settle time:	15 ms
Head load time:	35 ms
Rotational speed:	360 RPM +/- 2.5%
Average access (25 track seek and rotational latency):	174 ms

Recording Technique

Method:	FM (SD); MFM Modified (DD)
Maximum bit density	3200 BPI (SD),; 6400 BPI (DD), 6600 (DS,DD)
Track density:	48 TPI
Surfaces:	2

Reliability

Seek error rate:	1 in 10^6 seeks
Soft read error rate:	1 in 10^9 bits
Hard read error rate:	1 in 10^{12} bits

Environmental Restrictions

FD-411 operating range:	50 to 100 degrees F
FD-411 storage range:	32 to 150 degrees F
Diskette storage range:	50 to +125 degrees F
FD-411 humidity constraint:	10 to 80 percent without condensation

Section 2

INSTALLATION AND OPERATION

2.1 UNPACKING

The FD-411 is shipped with all items listed on Page 1-1. The container must be opened from the top (printing on side of box reading correctly). Remove the slides, hardware, manual, bootstrap loader card (BL-220), and controller card (FC-203) from the cut-out in the top section of the packaging. By then removing this top container piece, access is gained to the drive chassis.

2.2 RACK MOUNTING THE FD-411

The FD-411 may be mounted in standard 19" relay racks using the hardware provided. The hardware consists of:

1	cabinet slide (right side)
1	cabinet slide (left side)
2	T-bars (rear mounting brackets)
4	10-32 x 1/2 flat head screws
12	10-32 x 1/2 pan head screws
10	#10 lock washers
6	10-32 nuts
2	adjustable stops

Figure 2-1 shows the proper assembly and installation of the right side cabinet slide. Using the flat head screws A and B and nuts C and D, attach the T-bar to the cabinet slide such that the notches on the end of the T-bar are towards the cabinet slide. Leave the screws loose enough to allow the T-bar to slide freely. Install adjustable stop to T-bar using flat head screw I and nut J. Leave screw loose enough to allow the stop to slide.

Slide the T-bar to its shortest position. Attach the opposite end of the cabinet slide to the front of the relay rack using pan head screws and lock washers E and F (Figure 2-1). Extend the T-bar until it touches the rear of the relay rack, position the T-bar such that its uppermost hole will align with a hole in the rear of the relay rack using pan head screws and lock washers G and H. Tighten screws A and B. Finally, check screws E, F, G, and H for tightness. This procedure is the same for the left side cabinet slide.

Before sliding the FD-411 into the relay rack, be sure that the power and ribbon cables will not interfere with the installation. From the front of the rack, place the FD-411 onto the cabinet slide. Push it fully into the relay rack and adjust the location of the adjustable stops at the rear of the FD-411 and tighten screw I. Secure the FD-411 to the stop as shown in Figure 2-2 using the remaining pan head screw and lock washers.

FIG. 2-2

CABINET SLIDE
(RIGHT SIDE)

T-BAR
(REAR MTG BRACKET)

FIG. 2-1

A

B

C

D

G

H

I

J

J.
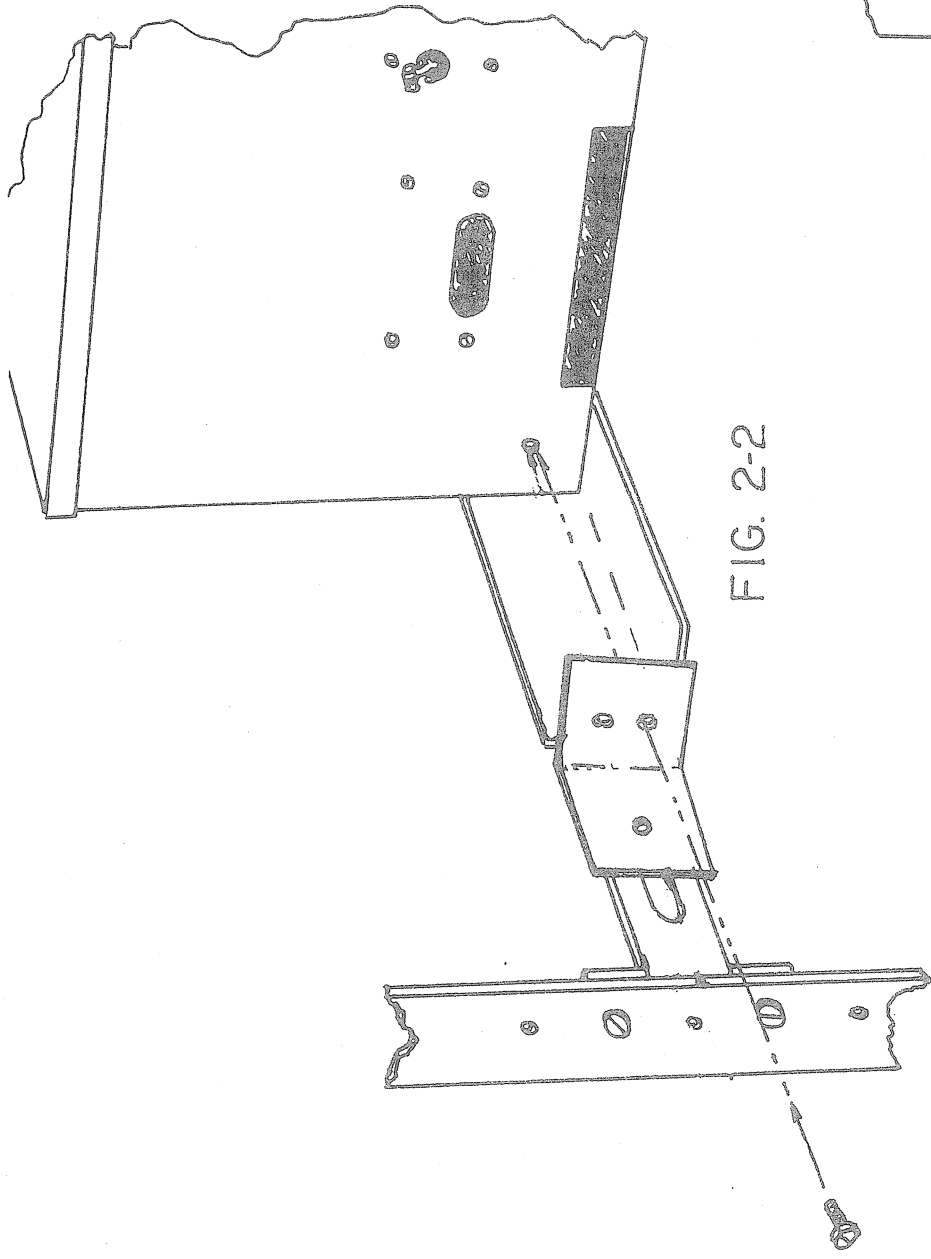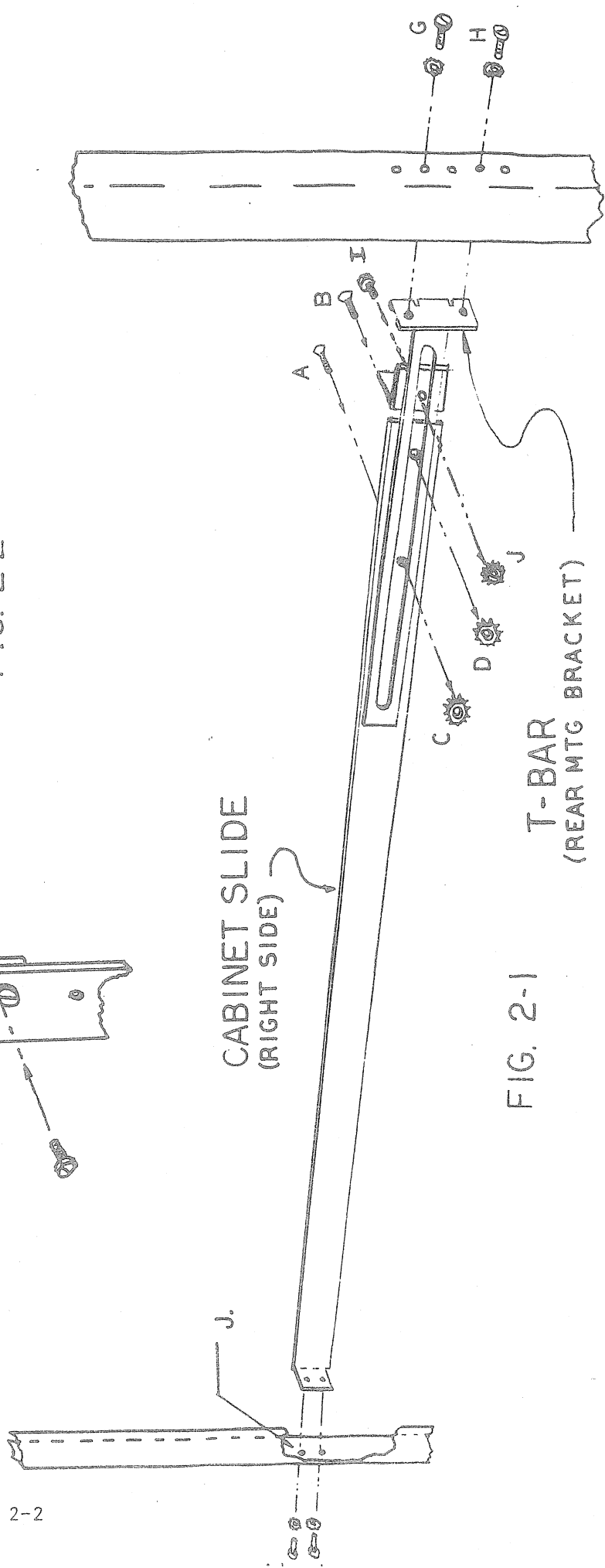
2.3 ELECTRICAL INSTALLATION

Next, the controller card should be installed. If a device address or interrupt
vector address different from the standard DEC assignment is desired, a request
must be made to CRDS for a new PROM set. In addition, any change in these assign-
ments necessitates a change in the system software. The DEC standard assignments
are given below:

Device Address:	777170
Interrupt Vector:	264

2.3.1 40-CONDUCTOR RIBBON CABLE

The 40-conductor grey ribbon cable should now be installed. The mating connector
and the header connector on the controller board are keyed so that the connector
may be inserted in only one way. The two key ways should face up when looking
at the component side of the controller card (see Figure 1-1).

2.3.2 CONTROLLER CARD INSTALLATION

The controller card can function in any Q-Bus slot after the processor as long as
interrupt and DMA continuity is maintained.

Because both interrupt and DMA priority is established by the distance from the
processor on a chain that runs along all LSI-11 backpanels, no unused slots
between the processor and the floppy disk controller card may exist. To deter-
mine the order that the priority chain follows on your particular backpanel,
consult the documentation supplied with your LSI-11 System. For the user's
convenience, a drawing of the priority chain of the most commonly used backplane,
DEC's H9270, is shown in Figure 2-3.

Option slots are designated numerically to show the order of priority. Notice
that the priority switchbacks down the cage.

VIEW FROM MODULE SIDE OF BACKPLANE

PROCESSOR (HIGHEST PRIORITY LOCATION)	PROCESSOR OR OPTION 1	1
OPTION 3	OPTION 2	2
OPTION 4	OPTION 5	3
OPTION 7 (LOWEST PRIORITY LOCATION)	OPTION 6	4

FIGURE 2-3

2.3.3 POWER CORD INSTALLATION

The line cord should now be installed. The female end of the cord goes in the oval hole (shown in Figure 2-2) in the rear of the cabinet.

2.4 DISKETTES

Diskettes must be treated with care to prolong diskette life and prevent damaging the sensitive recording surface. In addition we have found that not all of the media available is of good quality.

We strongly recommend that only the media listed below be used. This media has been extensively tested by Shugart, over many sample lots, and has been found to be of good quality. CRDS will only respond to complaints regarding the reliability of data stored on diskettes approved by Shugart.

	IBM	Dysan	Verbatim	Maxell
Single Density	Diskette 1	3740S	FD34-9000	FD-3200S
Double Density	-	3740D	FD34-8000	-
Double Sided, Double Density	-	3740/2D	DD34-4026	-

We recommend that the user use double-sided media in the FD411 except to transfer files from single-sided systems. Double-sided media is designed for use with the heads found in double-sided drives and will wear less than single-sided media in a double-sided system. The media is a critical factor in system reliability.

In most cases the media purchased will not have the appropriate headers or data fields preformatted on the disk (DEC and IBM double density formats are completely different). This problem can be overcome by formatting headers onto the disk as described in Section 3.4.5.2 and then writing data fields onto the disk by either of two methods, described in Sections 3.4.5.1 and 5.2.

2.4.1 DISKETTE CARE

The following rules should be observed in diskette handling:

    (1) Always return a diskette to its envelope after use.

    (2) Do not place any object on top of diskettes.

    (3) Observe the storage temperature and humidity specifications of the diskettes and preferably store them at operating conditions.

    (4) Do not write on labels on the jacket above diskette surface.

    (5) Do not touch the diskette through the oval read/write aperture.

    (6) Do not store diskettes in dusty areas.

    (7) Never clean the diskette.

    (8) Never expose to prolonged heat or sunlight.

    (9) Keep away from strong magnetic fields.

2.4.2 DISKETTE INSERTION AND EXTRACTION

The FD-411 is shipped with "shipping diskettes" inserted in the drive. These may be extracted by simply pressing the black button with the red LED. The door will pop up and the diskette will pop out. It may now be removed from the drive. Be sure to save these diskettes in case the unit is ever re-shipped.

Diskettes should be inserted into the FD-411 drives with the label up and facing the operator. The diskette should be inserted fully into the drive until it is stopped and a click is heard. The long black door handle may now be pressed down, locking the diskette in place.

Diskettes may be inserted or extracted with either the power on or off. They can not be removed while in use or anytime the red activity LED is on because of a door interlock.

2.5 INITIAL OPERATION AND CHECK-OUT

The following procedure should be used after installation is completed in order to check that the system is functioning properly:

(1) Switch the circuit breaker in the rear of the FD-411 to the up or "on" position.

(2) Place the enable/halt switch on the processor to the halt position and turn on the processor's power switch. The processor should print out an @ signifying it is in ODT mode (octal debugging technique).

(3) Place a scratch diskette in drive 0.

(4) Initialize the FD-411 by depositing the number 40000 in location 777170 (if the standard address assignment is used). This can be accomplished by typing 777170/. The processor will then print the contents of location 777170. Then type 40000 <CR>. Both drives should now calibrate themselves. First, unit 1 steps out 10 tracks and then steps in one track at a time until the drive indicates track 0 has been reached. This procedure is then repeated on unit 0.

At the completion of this procedure, the head on drive 0 is loaded and sector 1 of track 1 on unit 0 is read into the internal buffer on the controller card. This operation is indicated by the red activity LED on the button of the drives. First the LED on drive 1 will come on, and then the LED on drive 0. The LED on drive 0 will stay on for approximately 1/4 second after the read is completed.

If, after initializing the FD-411 controller, the red LED's do not flash on, there is a problem. The cabling should be checked as well as the power supplies.

(5) Read the contents of the FD-411 command and status register, location 777170 (if standard assignment is used). This can be accomplished by using the ODT monitor which allows examination of memory. The contents of this location should be 4040 (octal). Examining the next location, 777172, should yield the number 204 or 244. An explanation of what these bits mean can be found in Section 3.

(6) If the above procedures work without any problem, the system should
be ready for use. Diagnostics or an operating system may now be booted.
For more details on bootstrapping a system, see Section 4.

NOTE:
There have been occasional problems initializing the FD-411 during the
power-up sequence with some KD11F processors in use with H780 power
supplies (the supply used in 11/03 systems). This has been traced to
the BDCOK bus line. This signal should normally be asserted 3-10 ms
after the DC levels have stabilized. However, some H780 power supplies
have been seen to incorrectly assert their bus signal before the 3 ms
is complete. This problem can be fixed in two ways: (1) replace the
KD11F with a KD11HA. The KD11HA has its own wake-up circuit. or (2)
replace C37 on the H780 power supply with a capacitor twice its value.

2.6 SWITCH CONTROLS

The FD-411 contains two Write-Protect switches, and a circuit breaker as
described below.

2.6.1 WRITE-PROTECT SWITCHES

These Write-Protect switches are two-position toggle switches that send a
signal to the drive disabling the write current as well as to the controller
which aborts a write operation before it is attempted and returns a status bit
to the processor. These switches are very useful in protecting data from
accidental destruction.

There are no special provisions in the DEC software to handle a Write-Protect
violation condition. The error condition will cause the software to retry
the operation several times. If the write operation is really desired, there
is sometimes enough time to unprotect the disk before the retry counter runs
out. This usually works but could interfere with the write operation if the
switch exhibits too much contact bounce.

It should be noted that on the system disk, unexpected write operations often
occur. For example, under RT11, the USR may swap unexpectedly. The Write-
Protect feature must be used with care, and should be avoided on an RT-11
system device.

2.6.2 CIRCUIT BREAKER

The circuit breaker may be used as a switch to turn power on and off. It
is set at 4 amps for 120 volt systems and at 2 amps on 220 volt systems.

2.7 WRITE-PROTECT DETECTOR

In addition to the ability to write-protect diskettes by pressing a switch,
a photocell and LED detect the presence or absence of a write-protect hole
on the diskette. A diskette without a write-protect hole (standard IBM-
supplied diskettes) will not be write-protected. However, placing a hole in
the diskette as shown in Figure 2-4 will protect the diskette from being
inadvertently written on. Covering this hole with opaque tape will again
allow the disk to be written on. Diskettes will be write-protected if either
a write-protect hole exists or if the write-protect switch is in the "protect"
position. Avoid write-protecting an RT-11 system disk.

DISKETTE WRITE-PROTECTED

TAPE

FOLD OVER BACK
OF DISKETTE

DISKETTE WRITE-ENABLED

INDEX ACCESS HOLE

.125 ± .010

.075 RAD ± .005

.200 ± .010

WRITE-
PROTECT
HOLE
.150 Dia.

.150 ± .005

6.250 ± .010

6.175 ± .005

WRITE-PROTECT
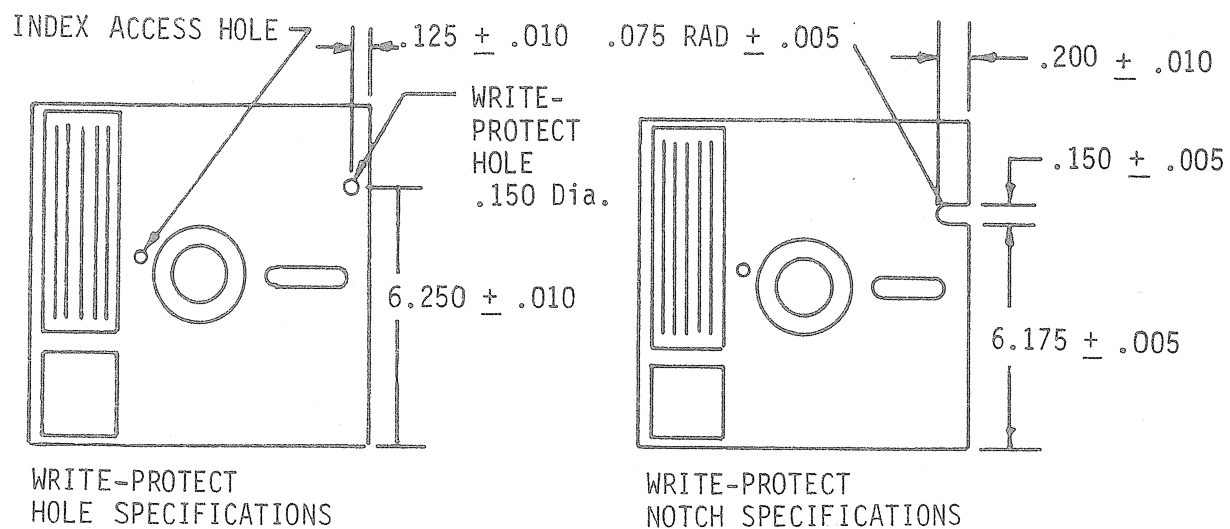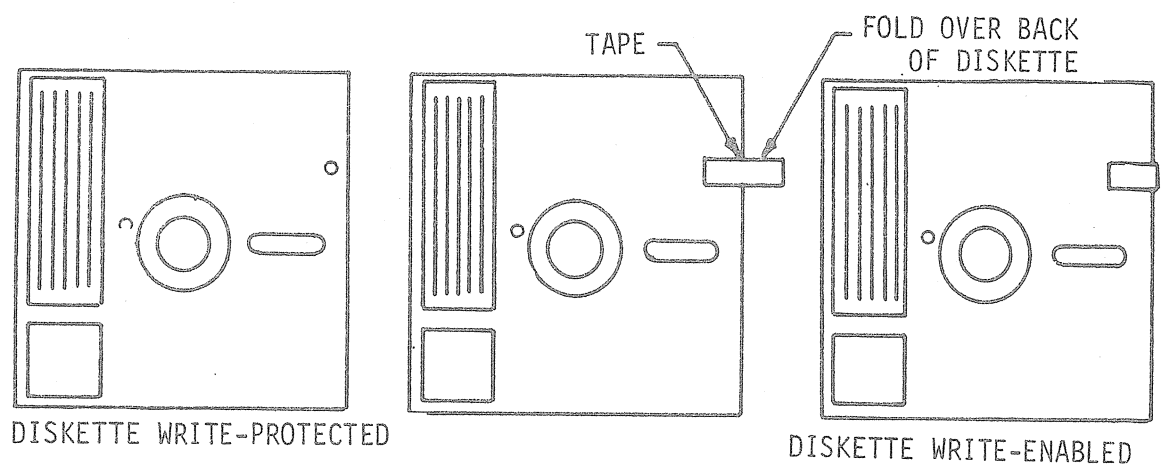HOLE SPECIFICATIONS

WRITE-PROTECT
NOTCH SPECIFICATIONS

FIGURE 2-4

Section 3

STANDARD INSTRUCTION SET

3.1 GENERAL

The FD-411 emulates DEC's RX02 instruction set with the exception of an additional control bit that selects the second side of a double-sided diskette. In general, this bit does not interfere with emulation of the RX02 instruction set with single-sided diskettes.

Program control of the FD-411 is accomplished by the proper manipulation of two device registers in the FD-411. The first of these two registers, the RXCS, serves to pass control information from the CPU to the FD-411 and to report status and error information from the FD-411 to the CPU. The second register, the RXDB, transfers additional control and status information between the CPU and the FD-411. The information that is present in the RXDB at any given time is a function of the FD-411 operation that is in progress at that time.

Data transfers both to and from the diskette are always one complete sector (128 single density or 256 double density eight-bit bytes) per transfer command. Partial sector transfers are not accommodated by the FD-411.

The FD-411 contains a read/write data buffer of 256 bytes. During write operations, this buffer is first loaded under a DMA command (fill) and then a write command is issued which transfers the contents of the buffer to the diskette. During read operations the read instruction is issued and the information from the proper sector and track is read into the buffer. After the buffer is full, the contents of the buffer are read out by a DMA command (EMPTY).

3.2 REGISTER AND VECTOR ADDRESSES

The normal address assignments for the FD-411 device registers and the interrupt vector address are as follows:

Function	Address
RXCS	777170
RXDB	777172
Interrupt Vector	264

3.3 FD-411 REGISTER DESCRIPTION

The two registers listed above are used to transfer both command and status information between the CPU and the FD-411. The first of these registers is used to initiate commands and indicate certain status information. The second of these registers has five different uses; which one it serves is determined by the protocol of the operation being performed. These five functions are: (1) to transfer the sector address for a read or write operation, (2) to transfer the track address for a read or write operation, (3) to indicate certain common error conditions, (4) to transfer the word count for a DMA command, and (5) to transfer the starting address of a DMA command.

3.3.1   RXCS COMMAND AND STATUS REGISTER (777170)

Commands to the FD-411 are initiated by loading this register with the proper
function code accompanied by the "Go" bit provided that the FD-411 is not busy
when the command is issued. The operation codes and bit assignments for the RSCS
are shown below. Bits designated W are write only, bits designated R are read
only, and bits designated R/W can be both written and read by the CPU.
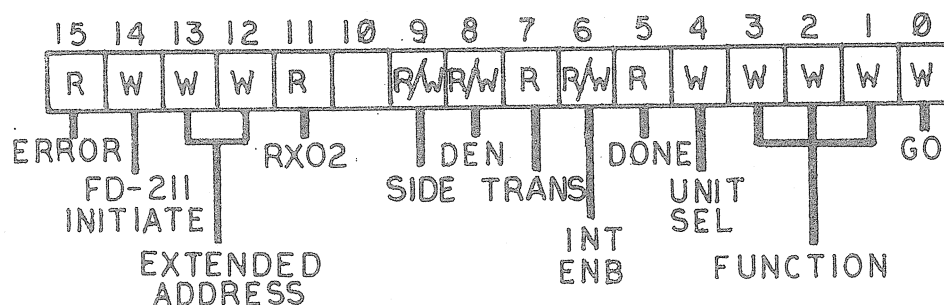
FIGURE 3-1
RXCS BIT ASSIGNMENTS AND FUNCTION CODES

Binary Function Code

000	Fill Buffer
001	Empty Buffer
010	Write a Sector
011	Read a Sector
100	Format Functions
101	Read Status
110	Write Deleted Data Sector
111	Read the Error Register

Description of Bit Assignments for RXCS

Bit Number	Function
0	Go bit. Initiates the selected operation in the FD-411.
1-3	Function Code. These three bits select the operation to be performed by the FD-411.
4	Unit Select Bit. Selects which of two disk drives is to execute the selected operation.
5	Done Bit. Indicates the completion of an operation. If Interrupt Enable is set when Done is asserted, a program interrupt will occur.
6	Interrupt Enable. When this bit is set, the FD-411 will cause a program interrupt upon the completion of an operation.
7	Transfer Request Bit. This bit indicates to the CPU that the FD-411 requires data from the CPU.
8	Density. This bit determines the density of the function to be executed when a command is given. It is valid only when Done is set, at which time it indicates the density of the last command executed.
9	Side. This bit determines which side of a double-sided diskette is to be accessed. This bit should be set to 0 when a command is executed on a single-sided diskette.
10	Not used at the present time.
11	RX02. This bit indicates that a FD-411, DMA Dual Density System is on-line. It is valid at all times.
12-13	Extended Address. These bits determine on a DMA command the higher order address bits of the starting address. These bits allow expansion above the normal 32K addressing to 128K for this peripheral. These bits are used with the LSI-11/23.

3.3.1 <u>RXCS COMMAND AND STATUS REGISTER (777170)</u> (continued)

Description of Bit Assignments for RXCS

Bit Number	Function

14   <u>FD-411 Initialize</u>. The FD-411 can be selectively initialized by setting this bit in the RXCS. Other devices connected to the system bus are not affected. The effects of setting this bit are the same as a bus init signal. The FD-411 will:

      (a) Reset Done bit.

      (b) Move the head of drive 1 to track 0
           (LED on drive will flash)

      (c) Move the head of drive 0 to track 0
           (LED on drive will flash)

      (d) FD-411 clears the error and status register

      (e) FD-411 sets Initialize Done.

      (f) FD-411 sets RXES bit 7 (DRV RDY) if drive 0 is ready

      (g) Sector 1 of track 1 of side 0 of the diskette on drive 0 is read into the buffer.

15   <u>Error</u>. This bit indicates an error of some type occurred during a command. It is cleared by a new command or an initialize.

3.3.2   <u>RXDB REGISTER (777172)</u>

As mentioned in paragraph 3.3, this register has five distinct functions determined by the protocol of the operation. Section 3.4 details this protocol. The RXDB can be read only when the FD-411 is not executing a command, the RXDB can be written only when the TR (transfer) bit (RXCS Bit 7) is set.

3.3.2.1 <u>SECTOR ADDRESS REGISTER</u>

This register indicates which of 26 sectors, numbered 1 through 26 (32 octal), are to be used in a read or write command.
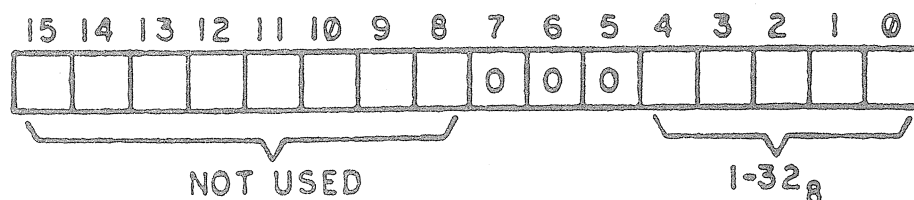
FIGURE 3-3
SECTOR ADDRESS FORMAT

3-4

3.3.2.2 TRACK ADDRESS REGISTER

This register indicates which of 77 tracks, numbered 0 through 76 (114 octal), are to be used in a read or write operation.

```
 15  14  13  12  11  10   9   8   7   6   5   4   3   2   1   0
┌───┬───┬───┬───┬───┬───┬───┬───┬───┬───┬───┬───┬───┬───┬───┬───┐
│   │   │   │   │   │   │   │   │ 0 │   │   │   │   │   │   │   │
└───┴───┴───┴───┴───┴───┴───┴───┴───┴───┴───┴───┴───┴───┴───┴───┘
            └──────────┬──────────┘       └─────────┬─────────┘
               NOT USED                        0·114₈
```
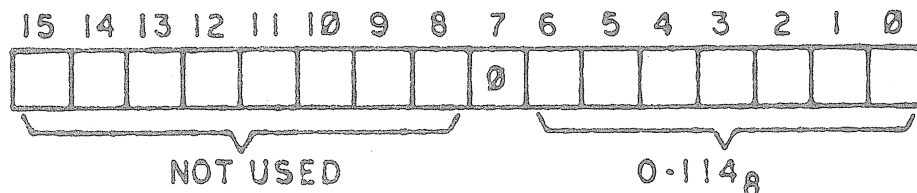
FIGURE 3-4
TRACK ADDRESS FORMAT

3.3.2.3 ERROR AND STATUS REGISTER

This register contains certain error and status flags for the drive selected by the unit select bit. It is always available at the completion of an operation and may also be read by the read status function.

```
 15  14  13  12  11  10   9   8   7   6   5   4   3   2   1   0
┌───┬───┬───┬───┬───┬───┬───┬───┬───┬───┬───┬───┬───┬───┬───┬───┐
│   │   │   │   │NXM│WC │   │UNIT│DRV│DD │DRV│DEN│ X │ID │DS │CRC│
│   │   │   │   │   │OVFL│  │SEL│RDY│   │DEN│ERR│   │   │   │   │
└───┴───┴───┴───┴───┴───┴───┴───┴───┴───┴───┴───┴───┴───┴───┴───┘
   └──────────┬──────────┘   │
       NOT USED          NOT USED
```
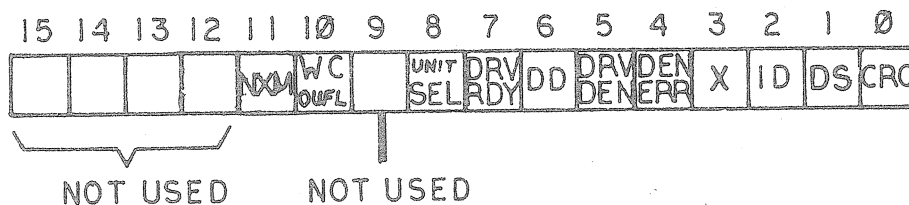
FIGURE 3-5
ERROR AND STATUS FORMAT

3.3.2.3 ERROR AND STATUS REGISTER   (continued)

Bit No.	Code	Description
0	CRC	A cyclic redundancy error has occurred in a read operation.
1	DS	Double-sided - This bit, when set, indicates that a double-sided diskette is installed in the selected drive. THIS BIT IS VALID ONLY AFTER A READ STATUS COMMAND.
2	ID	Initialize Done - indicates that an initialization took place. This can be caused by a power failure, programming or a bus signal.
3	X	Not used.
	DEN EER	Density error. Indicates that the density of a read or write command was different than the density of the diskette in the selected drive. The read or write operation is terminated.
5	DRV DEN	This bit indicates the density of the diskette in the drive selected by a read or write operation.
6	DD	A deleted data mark was found during a read or the last command issued was a write deleted data command.
7	DRV RDY	This bit indicates that the selected drive is ready and has a diskette installed correctly. It is only valid when retrieved after a read status function or after an initialize when it indicates the status of drive 0.
8	UNIT SEL	This bit indicates which drive was selected by the last read or write operation.
9		Not used.
10	WC OVFL	Wordcount overflow indicates that the wordcount specified by a fill or empty command was greater than sector size for the density selected. The operation is terminated.
11	NXM	Non-existent memory error. This bit is set if during a DMA transfer, the controller did not receive a reply when it attempted to read or write memory. The operation is terminated.

3.3.2.4 WORD COUNT REGISTER

This register indicates how many words are to be transferred in a Fill Buffer or Empty Buffer operation. The maximum word count is 128_{10} for a double density sector, and 64_{10} for a single density sector. This write-only register is loaded with the actual word count and not the 2's complement.
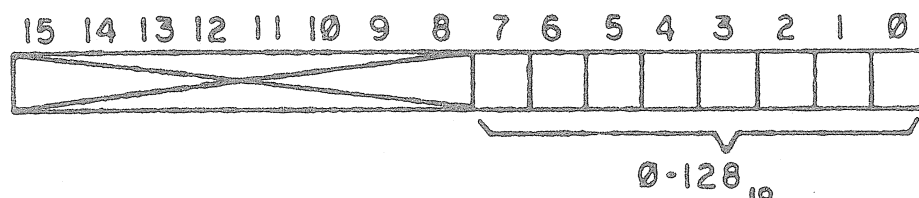

FIGURE 3-6
WORD COUNT FORMAT

3.3.2.5 BUS ADDRESS REGISTER

This 16-bit, write-only register indicates the starting bus address of data transferred during Fill Buffer, Empty Buffer, and Read Error Register operations.
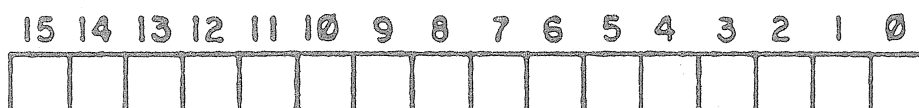

FIGURE 3-7
BUS ADDRESS FORMAT

3.4 COMMAND FUNCTIONS AND THEIR PROTOCOL

The function codes listed in Figure 3-1 are described in detail below. The specified protocol of each function must be observed or data loss may result.

3.4.1 FILL BUFFER FUNCTION (000)

This function is used to fill the FD-411 internal buffer with data from the memory. The contents of the buffer are usually written onto the disk after completion of this operation. The following procedure is used in executing this function:

   (1)   Store function code 000 and the Go bit into the RXCS (777170).

   (2)   Check that the TR bit in the RXCS is on.

   (3)   Deposit the wordcount in the RXDB register (777172).
This number will be 100 (octal) for a full single density sector and 200 (octal) for a full double density sector. Wordcounts less than these numbers are permissable for partial sector transfers. The remainder of the buffer will be set to 0.

   (4)   Again, check that the TR bit in the RXCS is on.

   (5)   Deposit the starting address in the RXDB register.
This address may be anywhere in the 30K memory address range of the LSI-11. For addressing above 32K, set the extended address bits in the RXCS during step 1 (see Section 3.3.1).

   (6)   The controller will perform DMA read operations on memory to obtain up to 128 16-bit words of memory (double density) or up to 64 words (single density).

   (7)   The Done bit will then be set and the function is complete.

3.4.2 EMPTY BUFFER ROUTINE (001)

This function is used to empty the FD-411 internal buffer into the CPU.

This function is usually performed after the completion of a read operation. The following procedure is used in executing this function.

   (1)   Store function code 001 and the Go bit into RXCS.

   (2)   Check that the TR bit in the RXCS is on.

   (3)   Deposit the wordcount in the RXDB register (777172).
This number will be 100 (octal) for a full single density sector and 200 (octal) for a full double density sector. Wordcounts less than these numbers are permissable for partial sector transfers.

   (4)   Again, check that the TR bit in the RXCS is on.

   (5)   Deposit the starting address in the RXDB register. This address may be anywhere in the 30K memory address range of the LSI-11. For addressing above 32K, set the extended address bits in the RXCS during step 1 (see Section 3.3.1).

   (6)   The controller will perform DMA write operations on memory to unload up to 128 16-bit words (double density) or up to 64 words (single density).

   (7)   The Done bit will then be set and the operation is complete.

3.4.3 WRITE SECTOR FUNCTION (010)

This function is used to write the contents of the FD-411's internal buffer onto the disk. The following procedure is used in executing this instruction.

(1) Store function code 010 and the Go bit into RXCS. The setting of the density bit will determine if a single or double density operation is to be performed.

(2) Check that the TR bit in the RXCS is on.

(3) Now transfer the sector address to the FD-411 via the RXDB.

(4) Check that the TR bit in the RXCS is on.

(5) Now transfer the track address to the FD-411 via the RXDB.

(6) A write operation will now occur if no error conditions appear. Write protection is sensed and the operation terminated if set. Any track seeking required now takes place. If the head of the selected unit was loaded at the time the operation was initiated, then there can be no danger of a density error and the write operation is performed. If the head was unloaded at the time the operation was initiated, the diskette may have been changed. The controller, therefore, performs a quick density check of the next sector to come, lasting on the average only 4 to 5 milliseconds. If the density of the operation agrees with the density of the diskette, the write operation is performed.

(7) On completion of the operation, the Done bit will be set and the RXDB will contain the error and status register.

3.4.4 READ SECTOR FUNCTION (011)

This function is used to read a diskette sector into the FD-411's internal buffer. The procedure followed by this function is identical to that of the write sector function described in the previous paragraph. After waiting for the TR bit each time, the sector address and then the track address are deposited into the RXDB, location 777172. The function is then executed.

3.4.5 FORMAT FUNCTION (100)

Two separate and distinct format functions are provided with the FD-411 system.

3.4.5.1 FORMAT DATA FIELDS

The first of these is identical to DEC's "Set Media Density" operation. It rewrites the data fields of all sectors on a diskette with either single or double density marks, as specified by bit 8 (density bit) in the command register. These marks are in fact always rewritten during any write operation but the write operation does not allow the user to write a mark with a density different from other marks on the diskette (see write function, Section 3.4.3). This is to prevent diverse densities on one diskette.

3.4.5.1 FORMAT DATA FIELDS (continued)

Therefore, in order to change the density of a diskette, all data field marks
must be rewritten to the new density. This operation will destroy all data on
the diskette, leaving data fields of all zeros. The location of these data
field marks is shown in Figure 1-2.

The format function can be performed by using the format command under RT-11
(see Section 5) or directly through the use of ODT. This is done by the
following sequence of operations:

    (1) Store function code 100, the Go bit, the density bit (0 for
         single density, 1 for double density) and the unit select bit
         into RXCS. The possible combinations of bits are listed below.

Format	Code
Unit 0, single density	11
Unit 0, double density	411
Unit 1, single density	31
Unit 1, double density	431

    (2) Wait for the trans bit to be set.

    (3) Deposit the key word 111 (octal) into the RXDB. This key word
         is to help prevent accidental initiation of this function.

    (4) The FD-411 will start the selected drive at side 0, track 0,
         sector 1, and rewrite all sectors through side 1, track 76,
         sector 26. If the operation is interrupted at any time during
         the 50 seconds needed to complete this operation, the operation
         must be restarted and allowed to complete, otherwise an "illegal"
         diskette has been created. Single-sided media needs 25 seconds
         to complete. One side is done at a time.

    (5) If the operation does not complete normally, and ends with the
         error flag on, a difficulty was encountered in reading the headers
         of the sectors. This may be due to defective media. The user
         may attempt to rewrite these headers using the instructions given
         in Section 3.4.5.2.

    (6) If the operation completes successfully, the Done bit will be set
         and no error condition will be flagged.

3.4.5.2 FORMAT HEADERS

Although it is possible to buy diskettes preformatted with the standard IBM 3740
headers, these diskettes are intended for single density, not double density
operation. These diskettes have not been certified for double density, and in
some cases they lack the superior oxide coating that diskette manufacturers place
on double density media. It is therefore suggested that the user purchase
double-density certified media. Because no other mainframe manufacturer besides
DEC uses a single density header format for double density operation at the pres-
ent time, diskette suppliers do not supply double density media with formats
compatible with the FD-411 and the RX02.

3.4.5.2 FORMAT HEADERS (continued)

In case of the RX02, this media is unusable. However, the FD-411 provides a
function to write headers. These headers are never written by the RX02 and
only written by the FD-411 during this format operation.

This format function cannot be activated from RT-11 but can easily be activated
through ODT.

    (1)   Store the function code 100, the Go bit and the unit select bit
         into RXCS.

             Format the headers of the diskette in unit 0:   11
             Format the headers of the diskette in unit 1:   31

         This is accomplished by typing 777170/ and after the LSI-11 states
         the contents, type 11 (or 31) <CR>.

    (2)   The key word is now used to avoid accidental initiation of this
         function. It also differentiates this function from the format
         data fields function.

             Please note that the keyword is different from
             the FD-211's keyword. Use of the FD-211 keyword
             will cause a halt and error indication.

         The keyword is 4111 (octal) and should be deposited in the RXDB.
         Type 777172/ and after the LSI-11 gives the contents, type 4111 <CR>.

    (3)   This operation takes approximately 50 seconds for double-sided
         diskettes to complete. If interrupted, it must be reinitiated
         or an "illegal" diskette will have been created. This routine
         does not format the data fields. At the completion of this function
         the user must write either single or double density data fields
         using the other format function described in Section 3.4.5.1. The
         disk is unusable until this is accomplished.

3.4.6 READ STATUS FUNCTION (101)

When this function is executed the error and status register will be loaded into
the RXDB. This register will contain the same status generated from the last
operation except that bit 7 will now indicate whether the drive selected by the
unit select bit is ready or not. If a double-sided diskette is inserted in the
selected drive, bit 3 of the RXES will be set.

3.4.7 WRITE SECTOR WITH DELETED DATA FUNCTION (110)

This function is identical to the write sector function described in paragraph
3.4.3 except that a deleted data marks is written just before the start of the
data field.

3.4.8 READ ERROR CODE (111)

This function is used after an error occurs to determine the exact nature of the error and the contents of certain registers at the time the error occurred. It is initiated by the following sequence:

   (1)   Deposit the Go bit and the function code 111 (17) into the RXCS.

   (2)   Wait for the trans bit in the RXCS to set.

   (3)   Deposit the starting address of an unused three-word block in memory into the RXDB.

   (4)   The FD-411 will now DMA the following words into memory (LSB = least significant byte, MSB = most significant byte):

Definitive error code	Word 0, LSB
Word count register	Word 0, MSB
Current track address of drive 0	Word 1, LSB
Current track address of drive 1	Word 1, MSB
Target track of command	Word 2, LSB
Target sector of command	Word 2, MSB

It should be noted that the word count register is only valid after DMA commands and that the target track and sector registers are only valid after disk I/O commands.

The definitive error codes given by the FD-411 are defined below:

Octal Code	Error Code Meaning
0010	Drive 0 failed to see home on Initialize.
0020	Drive 1 failed to see home on Initialize.
0100	Write protect violation attempted.
0120	A preample could not be found or no ID mark found within allowable time span.
0150	The header track address of a good header does not compare with the desired track.
0160	Too many tries for header identification routine. Incorrect side or other information was read.
0170	Data AM not found in allotted time.
0200	CRC error on reading the sector from the disk.
0230	Word count overflow.
0240	Density error.
0250	Wrong key word for set media density command.

Section 4

SPECIAL FUNCTIONS: BOOTSTRAP AND SELF-TEST

4.1 BL-220 BOOTSTRAP CARD

A separate bootstrap card is supplied with the FD-411. This card, the BL-220, consists of a 256-word bootstrap that starts at location 773000 and ends at location 773776. The bootstrap program includes a four-second memory test along with the ability to boot RX01's, RX02's and RL01's.

The BL-220 also has three resistor terminator packs that will improve signal propagation along the Q-Bus. If there already is a terminator on the system, these three resistor packs should be removed from their socket.

The BL-220 contains bootstraps for the following devices:

Mnemonic	Device	
DLn	HD-11 or RL01	Will bootstrap any of four units
DYn	FD211 or RX02	Will bootstrap floppy disks in either unit 0 or 1.
DXn	FD11 or RX01	Will bootstrap floppy disks (single density, programmed-controlled) in either unit 0 or 1.

To use this bootstrap, start execution of the LSI-11 at location 773000. This may be done by either typing 773000G to ODT or by doing an INIT on a processor strapped for power-up mode 2.

The console monitor will then type an asterisk. Any of the three mnemonics above may then be typed in, followed by a carriage return. The lowercase letter n above is used to denote the unit number.

It should be noted that the ROM program performs a memory test prior to printing the asterisk. Another note: The DX and DY mnemonics lead to identical entry points; in actuality, RX01's are distinguished from RX02's by the 'RX02 bit' (bit 11) of its CSR (777172).

4.2 SELF-TEST FUNCTION

This function may be used to both diagnose problems with the FD-411 system as well as certify that all sectors of a particular diskette are readable. When initiated this function starts reading each sector of the diskette starting with side 0, track 0, sector 1 and ending with side 1, track 76, sector 26. If at any time a CRC or other error is encountered, this microcode routine will halt with the error and done bits set. If no error is found, a halt occurs after reading track 76, sector 26 and the done bit is set. The function is initiated in the following manner. The function operates with both single and double-sided media.

4.2   SELF-TEST FUNCTION   (continued)

(1)   Store function code 100, the Go bit, the density bit (0 for
single density, 1 for double density) and the unit select
bit into RXCS.   The possible combinations of bits are listed
below.

Format	Code
Unit 0, single density	11
Unit 0, double density	411
Unit 1, single density	31
Unit 1, double density	431

(2)   Wait for the trans bit to be set.

(3)   Deposit the keyword 2111 (octal) into the RXDB.

(4)   The FD-411 will start the selected drive at side 0, track 0,
sector 1 and read all sectors through track 76, sector 26
(side 0 if single-sided, side 1 if double-sided).

(5)   If the operation does not complete normally, and ends with
the error flag on, a difficulty was encountered in reading the
disk. This may be due to defective media.

(6)   If the operation completes successfully, the Done bit will be
set and no error condition will be flagged.

USE OF THE FD-411 WITH RT-11

The introduction of new products in the computer industry often brings questions from users on compatibility with previous equipment, software, and media. This product is no exception.

The FD-411 is identical to the FD-211 (and the RX02) when used with single-sided media or when only one side of a double-sided diskette is used. A change must be made to DEC's DY handler when both sides of double-sided media are to be used.

The FD-411 and FD211 (and RX02) are compatible with single density media but have a different instruction set than their predecessor, the FD-11 (and RX01). This has led to much confusion. The FD-411 and FD-211 allow the user access to all of his old single density programs, the ability to store twice as much data in double density mode, and the use of DMA to transfer data to and from the disk.

The FD-411 and FD-211 do, however, require a different handler than the single density systems. This handler utilizes DMA to transfer data rather than using program controlled data transfers. This handler is available in RT-11-V03B and later software revisions. From the point of view of the operating system, the FD-411 or FD-211 is a new device designated "DY". The single density system designation for floppy disk is "DX".

The DY handler does have one unusual feature. It will read both single and double density and both single and doubled-sided disks without any need for the user to tell the system which density or how many sided disk it is using. A difference in the format of the diskette's data field automatically informs the handler of the density of the disk. The displaced index hole in double-sided media lets the user know that the diskette is double-sided. All diskettes, single or double density, single or double-sided, are designated "DY".

5.1 GENERATION OF DOUBLE-SIDED/DY-BASED RT-11 SYSTEM DISKS

The user may boot his double density single-sided, RT-11 V03B system disks without any changes. In order to access the second side of double-sided media, however, the user must do a SYSGEN on RT-11 V03B with a revised DY handler. The handler supplied with RT-11 V03B in fact includes conditional code to access the second side of a diskette but this code is not normally assembled. The code was apparently not tested because it does contain errors. CRDS has supplied a handler with these errors corrected and conditions set appropriately.

A SYSGEN can be performed with this new DY handler to create RT-11 system diskettes with double-sided capability.

Be sure that the monitor file (i.e., DYMNFB) is located on the first half of the diskette. Otherwise, the system's bootstrap routine will not locate the monitor file unless further modifications are made.

5.2 USING THE FORTMAT COMMAND UNDER RT-11

In order to format the data fields of a diskette, an RT-11 utility program
called FORMAT may be used. However, this program will not format headers and
this is required for most double-density or double-sided media. Refer to
Section 3.4.5.2 to do this from ODT. A CRDS program called FRMTDY is easiest
to use and this is described in Section 5.3. In any case, the FORMAT program
may be used with either single or double-sided media. The microcode in the
FD-411 controller automatically checks for double-sided media and formats the
second side, if found.

5.3 FRMTDY - CRDS FORMAT PROGRAM

This program will do a complete format operation on single or double-sided
media. The program inquires which drive the user wishes to format and the
density. The program does not require the user to specify single or double-
sided media, this is taken care of automatically. The program is executed
by simply typing:

          .R   FRMTDY

Section 6

MAINTENANCE

This section contains the basic maintenance information on the FD-411 needed to service the system by spare parts. It is suggested that only large volume users of the FD-411 attempt to service the system to the component level. It is far better for the majority of users to swap out either a card or a drive in the event of a failure. We have included here the diagnostic and maintenance procedures necessary to do this.

6.1 PREVENTIVE MAINTENANCE

Though the cards and other electronics require no preventive maintenance, all mechanical devices do. Preventive maintenance of the disk drive, however, is minimal due to the efficient design, reliability, and manner in which the unit is operated.

6.1.1 VISUAL INSPECTION

During normal operating conditions, periodically inspect the unit for signs of dirt, wear, or loose latching hardware on the handle. When servicing the unit, check all areas for signs of loose connections, abnormal wear, and dirt accumulation on the flexible disk guide.

6.1.2 CLEANLINESS

A clean disk drive, externally and internally, will extend the operating life of the equipment and enhance the appearance. The importance of periodic visual inspection and normal cleanliness of the unit cannot be over-emphasized.

6.1.3 ROUTINE MAINTENANCE SCHEDULE

A systematic routine operating check is recommended. The checks should be performed in accordance with Figure 6-1.

FIGURE 6-1
ROUTINE MAINTENANCE SCHEDULE

UNIT	FREQ MONTHS	CLEAN	OBSERVE
Read/Write Head	12	Clean Read/Write Head ONLY IF NECESSARY	Oxide build up
Stepper Motor and Lead Screw	12 12	Clean off all oil, dust, and dirt	Inspect for nicks and burrs
Belt	12		Frayed or weakened areas
Base	12	Clean base	Inspect for loose screws, connectors, and switches
Read/Write Head	12		Check for proper alignment

6.2   DIAGNOSING THE PROBLEM

There are really only two basic elements in the FD-411: the controller card and
the drives. It is most important to isolate the problem to one of these two
elements. The only other possible problems are the power supply, switches, and
cabling. The following procedures may be used to isolate a problem.

First refer to Section 6.2.1. This section lists some common problems with
FD-411 systems. If this does not help, check the power supply (Section 6.2.2)
and run the diagnostics (Sections 6.2.3 and 6.2.4).

6.2.1   COMMON PROBLEMS

Problem	Possible Cause	Remedy
LED on drive "0" stays on, run LED is off, no terminal response (when booting)	No disk in drive "0" DMA chain broken No double density boot on diskette	Insert Diskette Check card placement Replace diskette
Processor is in ODT, run LED is off, LED's on drives flash once (when booting)	Interrupt chain broken Halt/Enable switch in halt position Processor is not strapped to come up in mode 2	Check card placement Switch to run See Section 4.2
Many retries on a write	Diskette is write protected Bad diskette (headers not readable) Head dirty Worn load pad	Write enable the diskette Try a /K in DUP Check, clean Check, replace
Many retries on a read	Bad Diskette Head dirty Worn load pad	Try a /K in DUP Check, clean, Check, replace

6.2.2   POWER SUPPLY

The FD-411 power supply provides three voltage levels: +24 volts, +5 volts, and
-5 volts. These voltages are bussed by yellow, orange, and blue wires respectively.
Green wire is used for ground. The outputs of the supply are marked and may be
easily tested with a voltmeter. Below each output is a pot which adjusts the volt-
ages. If the voltages are off more than 5%, try to bring them back into spec with
these pots.

To replace the power supply, it is easiest to disconnect the power connectors at
the drive and the AC terminal block, thereby removing the supply with the harness.
CRDS provides spare power supplies with the harness attached making replacement
easier.

6.2.3 FD-411 DIAGNOSTIC

Several useful diagnostics are available to the user. The simplest one is built
into the microcode of the FC-203 controller. Place a good diskette into drive 0
and init the system with the halt switch in the halt mode. Examine location 777170
using ODT. If the error bit, bit 15 is set, the nature of the error can be deter-
mined by looking at location 777172 for simple errors, and performing the read
error code function for other errors as described in Section 3.4.8.

For problems that are not solid, the self-test function as described in Section 4.4
should be performed. Try to isolate the problem to a single drive or the media.

For more difficult problems, the DEC diagnostic ZRXDA is suggested.

6.2.4 ZRXDA DIAGNOSTIC

This diagnostic will provide a thorough test of the FD-411 system. The diagnostic
may be loaded from diskette only when the line time clock is disabled. This may
be done with a front panel switch on the PDP-11/03. On the PDP-11/03-L, the
BDV11A, which is provided with all systems, automatically disables the line time
clock.

The diagnostic provides many modes selectable by the user, in which to test the
FD-411. This diagnostic is especially useful for testing data reliability.

If double-sided media is to be used under test, the user may take advantage of
the "future expansion" option available on this DEC diagnostic. Although DEC
is not providing double-sided disk systems at this time (March 1980), allowance
for their use was made in this diagnostic. CRDS's implementation of the double-
sided selection bit is compatible with this.

The diagnostic allows the user to test up to four "units". These "units" are
specified as either drive 0 or drive 1 and as "future expansion 0" or "future
expansion 1". Up to four "units" may be tested at one time, allowing full
testing of both drives, both sides. Testing of two controllers at one time
(different device registers and interrupt vectors) is not permitted.

In addition to specifying the side desired when the future expansion question
is asked for each unit, a "yes" response must be given to the "future expansion"
question asked in the software parameter section.

The correct sequence for full testing of a dual-drive double-sided FD-411 is
given in Figure 6-2.

120, 160, or 200 (CRC) errors are often caused by defective media, drive or
read/write circuitry on the controller card. Try to isolate the problem to
either the media or a single drive. Other error messages usually indicate a
faulty controller card.

```
CZRXDAO
L-CLK  (L)  N ?
P-CLK  (L)  N ?
LSI  (L)  N ?  Y
LPT  (L)  N ?
MEM  (K)  (D)   16 ?

TYPE 2 CHAR 4 SECONDS APART
DS-B>STA/FLAGS:ISR

# UNITS  (D)   ?  4

UNIT 1
RX ADDRESS  (O)   177170 ?
VECTOR ADDRESS  (O)   264 ?
DRIVE #  (O)   0 ?
EXPANSION-TYPE  <CR>  (O)   0 ?

UNIT 2
RX ADDRESS  (O)   177170 ?
VECTOR ADDRESS  (O)   264 ?
DRIVE #  (O)   0 ? 1
EXPANSION-TYPE  <CR>  (O)   0 ?

UNIT 3
RX ADDRESS  (O)   177170 ?
VECTOR ADDRESS  (O)   264 ?
DRIVE #  (O)   1 ? 0
EXPANSION-TYPE  <CR>  (O)   0 ? 1

UNIT 4
RX ADDRESS  (O)   177170 ?
VECTOR ADDRESS  (O)   264 ?
DRIVE #  (O)   0 ? 1
EXPANSION-TYPE  <CR>  (O)   1 ? 1

CHANGE SW  (L)   ? Y

TEST SETUP HELP   (L)  N ?
EXERCISE #  (0-6)  (O)   5 ? 0
DATA PATTERN #  (0-6)  (O)   6 ? 0
TRACK SEQUENCE #  (0-6)  (O)   1 ? 0
IS TEST TO RUN IN DOUBLE DENSITY   (L)  Y ?
IS TEST TO RUN IN DELETED DATA MODE   (L)  N ?
ANY PROGRAM CONTROL FLAGS   (L)  N ?
MODIFY TRACK ADDRESS LIMITS   (L)  Y ?
    OUTER DIAMETER ADR #   (D)   70 ? 0
    INNER DIAMETER ADR #   (D)   76 ?
MODIFY SECTOR ADDRESS LIMITS   (L)  N ?
FUTURE EXPANSION TYPE  <CR>   (L)  N ? Y
```

FIGURE 6-2

6.2.5 DRIVE REPLACEMENT

Problems with a single drive in a dual drive system usually indicate a problem in
the failing drive, rather than the controller. If the problem can be isolated
to one drive, the drive should be removed for repair or replacement. The remain-
ing drive can be configureed to respond as drive 0 or drive 1 (see Section 6.2.5.1).
Follow the procedure outlined below to remove drives:

(1) Remove the 50-pin ribbon cable edge connector from the drive.

(2) Unplug the 3-terminal AC power connector from the drive.

(3) Unplug the 6-terminal DC power connector from the drive.

(4) Remove the two screws that hold the drive in place from the
     bottom of the unit.

(5) Remove the two screws that hold the drive in place from the
     side of the unit.

(6) Slide the unit backwards one inch so that the write-protect switch
     clears its hold in the front panel.

(7) Remove the drive by pulling it up out of the chassis.

(8) A replacement drive may be installed by reversing the above pro-
     cedures. The proper jumper configuration of such a drive is given
     below.

6.2.5.1 DRIVE CONFIGURATION

The Shugart SA-850R drive contains a PC card with silk screen designations for
various jumpers. There are differences between the jumper configuration in
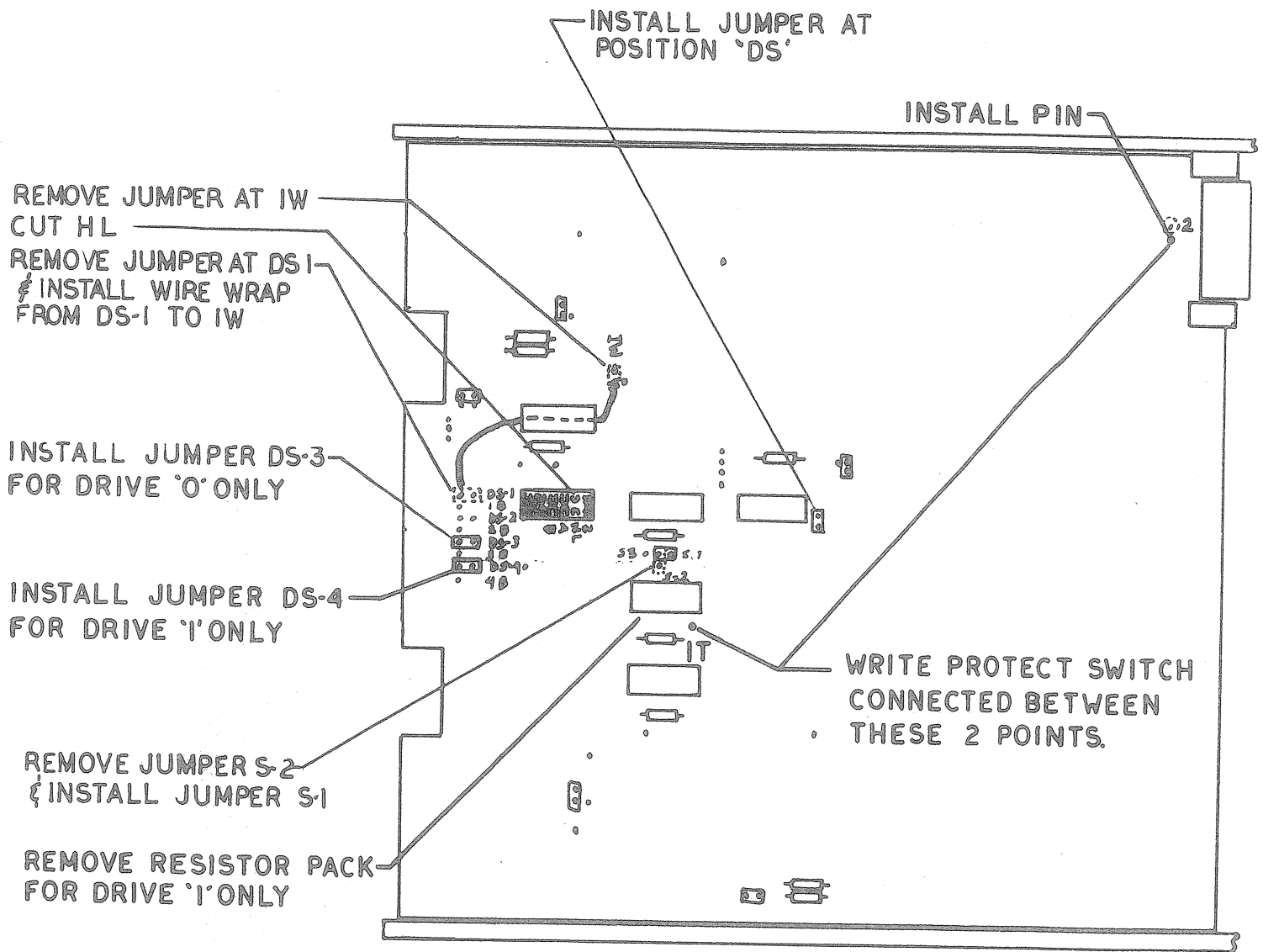the FD-411 and the standard configurations used by Shugart and these are shown
in Figure 6-3.

FIGURE 6-3

6.2.6 FC-203 CONTROLLER CARD REPLACEMENT

The controller card consists of a 6 MHz bipolar bit slice microprocessor that controls almost all functions performed by the controller. DMA bus cycles, reading and writing of the disk, and RX02 instruction set emulations are handled by this processor. The few functions in hard logic include DMA grant arbitration, interrupt acknowledge arbitration, and the phase-locked loop, used to track data from the disk on read operations.

The phase-locked loop is the only analog circuitry on the board and contains an inductor and capacitor to isolate the VCO chip from the digital logic. The effective isolation may be checked by placing a scope on Z45 pin 16, AC coupled. There should be less than 30 millivolts of noise. Other checks that may be made on this circuitry are listed below. These checks should be performed when the reliability of reading data is in questions.

(1) Check the single density bit cell divider one-shot at Test Point 5 (Z44 pin 12). During read operations, this one-shot will be triggered and using a scope set on negative-edge triggering, the one-shot should stay low for 1000 +/- 70 nanoseconds.

(2) Check the double density bit cell divider one-shot at Test Point 6 (Z44 pin 4). During read operations this one-shot will be triggered and using a scope set on negative-edge triggering, the one-shot should stay low for 500 +/- 20 nanoseconds.

(3) Check the voltage level of Test Point 2 (Z45 pin 2) with a digital voltmeter while the FD-411 is idle. It should read 3.0 +/- 0.3 volts DC.

The FC-203 controller card should be swapped first when trying to isolate any problem that does not appear to be drive dependent or media dependent, or if it fails any of the above tests. Turn off the power, remove the card, and inspect it for contaminated gold fingers or any contaminants that might have caused a short. If the card is still not working, it should be returned to CRDS.

RETURNING MATERIAL

IN THE EVENT THAT IT BECOMES NECESSARY FOR YOU TO RETURN MATERIAL
TO CHARLES RIVER DATA SYSTEMS, PLEASE:

1. Phone the factory in advance of your return.

   When you call, please have available:

   a. A description of the problem or reason for
      the return.

   b. The serial number of the unit.

   c. Your original purchase order number, CRDS
      invoice number, or shipping memo number.

2. Obtain a Return Authorization (RA) Number from CRDS.

3. Show the RA Number on all packages shipped to CRDS.

   Parcels which are not marked with an RA Number may be
   refused at the factory. You should reference this
   number in all communications concerning the returned
   goods.

4. Enclose a description of the problem or any other
   information which may help in expediting repair of
   the unit.

Please note that a new purchase order number will be required whether
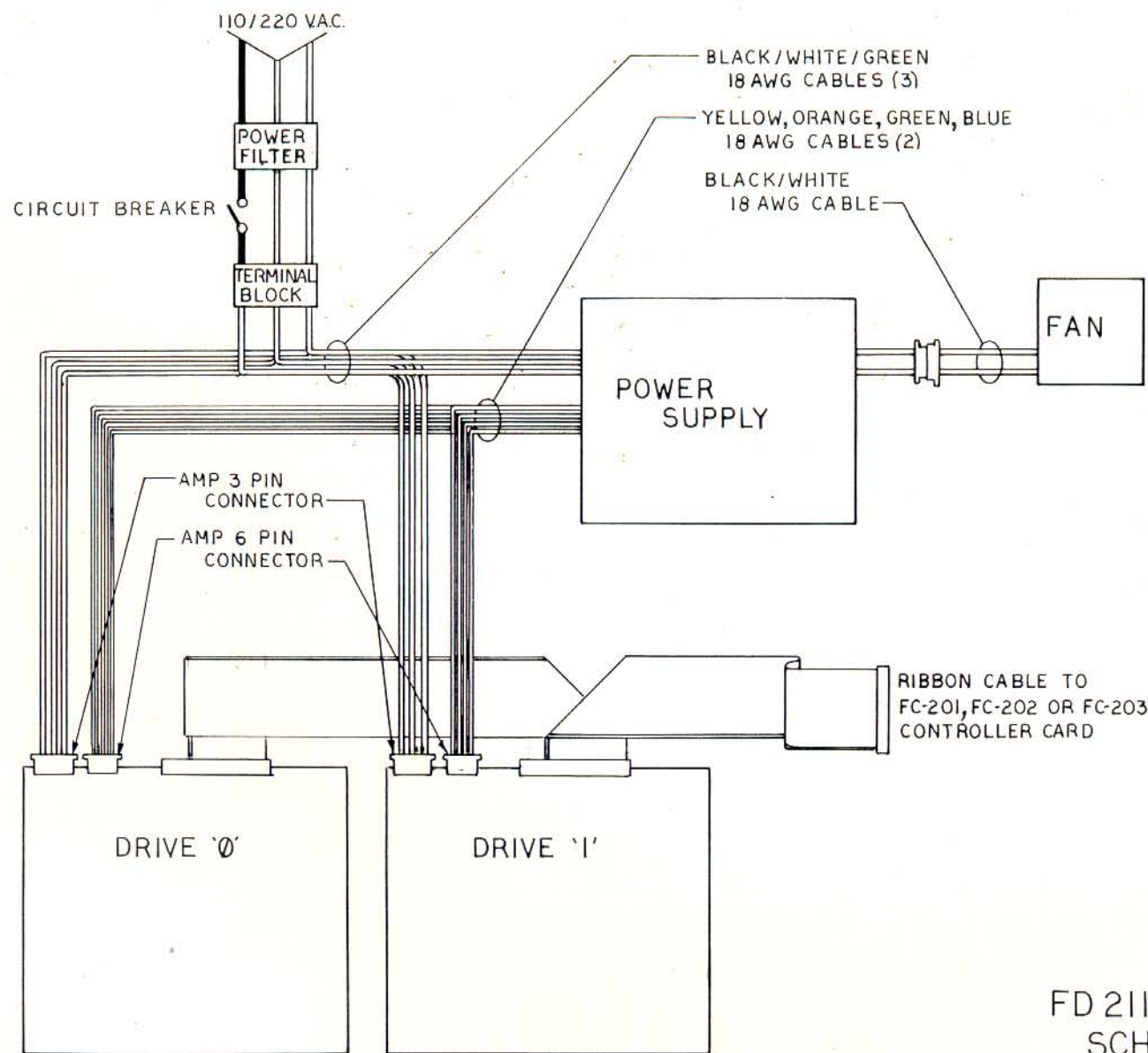the unit is in warranty or out of warranty.

WARRANTY

CHARLES RIVER DATA SYSTEMS, INC.

All equipment purchased directly from CRDS, its authorized representatives
and/or franchised distributors is warranted on "return-to-factory" basis
against defects in workmanship and materials under normal and proper use
in its unmodified condition for a period of ninety (90) days from date
of initial shipment. As a condition of this warranty, Customer must
(a) obtain a CRDS Return Authorization (RA) Number, (b) ship the equip-
ment (or sub-assembly) to the designated CRDS repair point, transportation
prepaid, and (c) include with the returned equipment (or sub-assembly)
a WRITTEN description of the claimed defect. Transportation charges for
the return to Customer of in-warranty repaired equipment (or sub-assembly)
shall be paid by CRDS within the fifty (50) United States, District of
Columbia, and Canada. Returns to customer of out-of-warranty repaired
equipment (or sub-assembly) shall be "Transportation Collect". If CRDS
determines that the equipment (or sub-assembly) returned to it for warranty
correction is not defective as herein defined, Customer shall pay CRDS all
costs of handling and transportation. All repaired or replaced equipment
shall be returned only to Customer and not to third parties to whom Cus-
tomer may have sold, leased or otherwise transferred the equipment. The
warranties provided herein are exclusive to the Customer only.

Charles River Data Systems, Inc., hereby warranties all equipments (or
sub-assemblies) of first party manufacturers and/or their authorized,
franchised representatives and distributors against defects in workmanship
and materials, only to the full limits and extent that such items are
warranted to CRDS.

This warranty is expressed in lieu of all other merchantability warranties
expressed or implied (including the implied warranty of fitness for a
particular purpose) and of all other obligations or liabilities on CRDS's
part, and CRDS neither assumes nor authorizes any other person to assume
any other liabilities in connection with the sale of the said article.

110/220 V.A.C.

POWER FILTER

CIRCUIT BREAKER

TERMINAL BLOCK

BLACK/WHITE/GREEN
18 AWG CABLES (3)

YELLOW, ORANGE, GREEN, BLUE
18 AWG CABLES (2)

BLACK/WHITE
18 AWG CABLE

FAN

POWER SUPPLY

AMP 3 PIN CONNECTOR

AMP 6 PIN CONNECTOR

RIBBON CABLE TO
FC-201, FC-202 OR FC-203
CONTROLLER CARD

DRIVE '∅'

DRIVE 'I'

VOLTAGE-COLOR CODE	
+24	YELLOW
+5	ORANGE
GND	GREEN
−5	BLUE
110/220 HOT	BLACK
110 NEUTRAL 220 HOT	WHITE

FD 211/311/411 WIRING
SCHEMATIC

BL-220 BOOTSTRAP AND TERMINATOR CARD AND FC-203 FLOPPY CONTROLLER

FC-203.
The FC-203 controller card (unlike the FC-201 and FC-202) has no bootstrap or jumper options. The BL-220 is used to bootstrap.

BL-220.
This card has bootstraps for RX01 and RX02 compatible floppy drives, RL01 hard disk compatible drives and a quick memory test which runs each time the system is rebooted. This board also terminates the Q-bus.

The only selectable option is to remove the bus terminating resistors. They are the DIP resistor networks in sockets Z4, Z8 and Z12. Termination is necessary when a total of 20 AC bus loads is surpassed. That is typically 10 to 15 boards. The termination resistors should only be removed if there is another terminator board present on the bus.

When the BL-220 is used, all other boards that have a bootstrap at the standard address of 773000 must be disabled (i.e., the FC-201 or FC-202).

The BL-220 must always be installed in the last slot of the card cage unless you have removed its terminating resistor networks.

OPERATION:
When the system boots, the memory test will execute for about 5 seconds. An asterisk will be displayed at the end of a successful memory test (the system halts at address 173056 or 173102 when a memory error accurs). The selected device then can be booted using these commands:

a.	DY0<CR>	NOTE:	These commands expect the RX2CS status
b.	DY1<CR>		registor at 777170.
c.	DX0<CR>	NOTE:	These commands expect the RXCS status
d.	DX1<CR>		registor at 777170
e.	DL0<CR>	NOTE:	These commands expect the RLCS status
f.	DL1<CR>		registor at 774400.
g.	DL2<CR>		
h.	DL3<CR>		
i.	SP<CR>	NOTE:	This command expects the HD-11(T) status
			registor at 774400.

Note: <CR> means the "return" key.

Note: SP is used to boot the special programs that only reside on the CRDS HD-11(T).

Note: Halting at one of the following addresses during the execution of the bootstrap means:
173102 = Bad memory data (memory chip)
173056 = Memory address error (address decode logic)
173334 = No special program on CRDS' HD-11 (In responce to SP boot)
173464 = Error bit set in the CSR of the boot device
173666 = No bootstrap program on the selected boot device