SM-Z-89-37

Double-Density Disk Controller

Service Manual

ZENITH DATA SYSTEMS
SAINT JOSEPH, MICHIGAN 49085

585-8

Table of Contents

Specifications

The Z-89-37 Double-Density Disk Controller interfaces the Z-89/90 Computer with the Z-37 Floppy Disk.* The Controller will read and write to drives using SOFT-SECTORED DISKS as follows:

Double-Sided (H-17-4 drives):

96 tracks per inch
80 tracks per side
Single or double density

Single-Sided (H-17-1 drives):

48 tracks per inch
40 tracks
Single or double density

Required software is:

HDOS version 2.0 modified (or higher)
or
CP/M version 2.2.03 (or higher)

NOTICE: If a Z-87 Floppy Disk System is to be used with a Z-89 or Z-90 Computer, proceed to "Reconfiguration" and, if necessary, reprogram the drives in the Z-87 Floppy Disk.

*Cassette operation is not supported.

Reconfiguration

To reconfigure the system, choose the instructions below that fit the application and perform those steps.

TO CHANGE THE INTERNAL DRIVE...

To change the internal drive from handling hard-sectored diskettes to handling soft-sectored diskettes:

Refer to Figure 2-1 for the following steps.

- Open the cabinet shell.
- Unplug the short floppy cable from the H-88-1 Floppy Disk I/O circuit board and reconnect it to the top connector of the Z-89-37 Disk Controller.

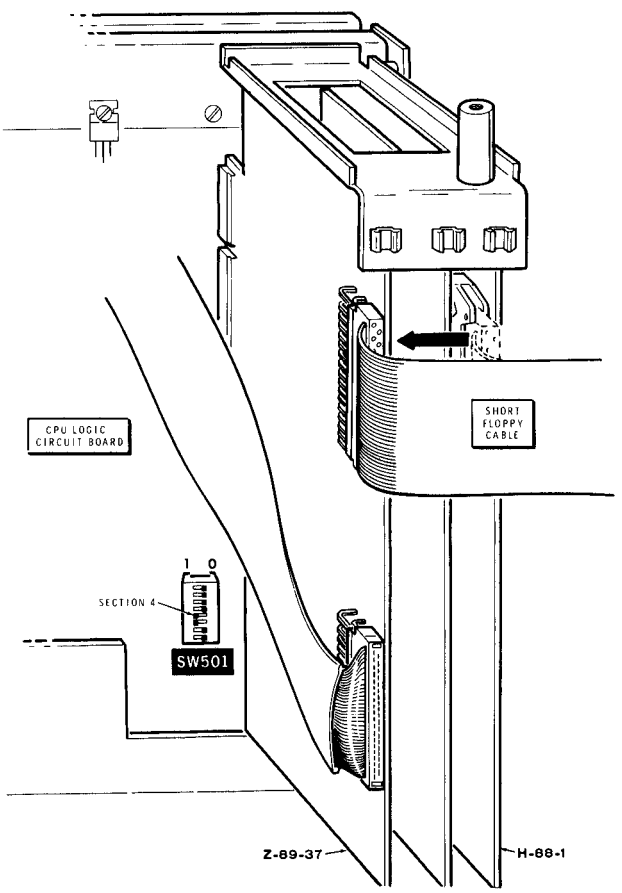


Figure 2-1

- Set switch SW501, section 4 (on the CPU logic circuit board) to 1. The Z-37 connected drives are now the primary drives and they are now numbered as shown in Figure 2-3 on Page 2-3. (NOTE: IF YOU REMOVE THE UNUSED H-88-1 FLOPPY DISK I/O CIRCUIT BOARD, YOU MUST CONNECT A 4700 OHM RESISTOR TO PLUG P512 BETWEEN PINS 1 AND 12. SEE FIGURE 2-2.)

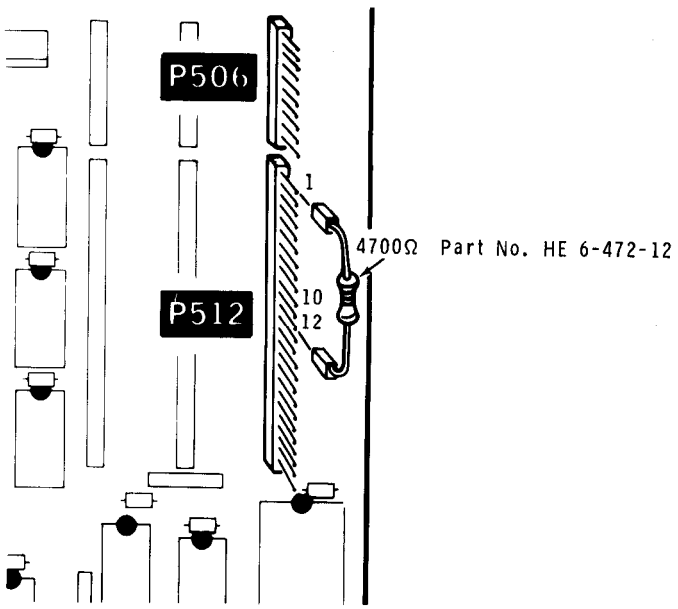


Figure 2-2

TO REARRANGE THE DRIVE NUMBERS...

Refer to the following chart and Figure 2-3, and select the configuration that fits your situation. Configuration E is normally used for transferring data and programs from hard-sectored disks to soft-sectored disks.

After you select the configuration you want, refer to Figure 2-4 on Page 2-4 to program any 48 TPI (H-17-1) drives, or Figure 2-5 on Page 2-5 to program any 96 TPI drives. [Figure 2-6 on Page 2-6 shows single-sided drives (H-17-1) programmed for connection to an H-88-1 Controller.] You can do this programming by physically interchanging preprogrammed drives, interchanging the programming modules, cutting the programming modules (if presently uncut); or by replacing the programming module with a properly set dip switch.

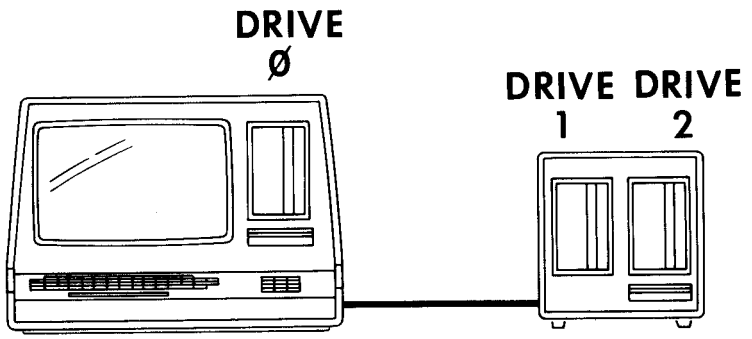


Figure 2-3

FLOPPY DISK CONTROLLER BOARD(S)		TYPES OF DRIVES: • 48 TPI (H-17-1) • 96 TPI (H-17-4)	Drive 0	Drive 1	Drive 2
A	H-88-1	48 TPI (H-17-1) only. Internal drive present	DS3	DS2	DS1
B	H-88-1	48 TPI (H-17-1) Internal drive absent	No drive installed	DS3	DS2
C	Z-89-37	Either* Internal drive present	DS1 (Z-89-37 jumper installed at J4)	DS2	DS3
D	Z-89-37	Either* Internal drive absent	No drive jnstalled (Z-89-37 jumper installed at J7)	DS1	DS2
E	H-88-1 & Z-89-37	Either* Internal drive present	DS3 [Drive 0 is 48 TPI (H-17-1) drive connected to H-88-1. Z-89-37 jumber installed at J6.]	DS1 (Drive 0 connected to Z-89-37)	DS2 (Drive connected Z-89-37)

* All drives connected to the Z-89-37 should be of the same type, either 48 TPI (H-17-1) or 96 TPI (H-17-4).

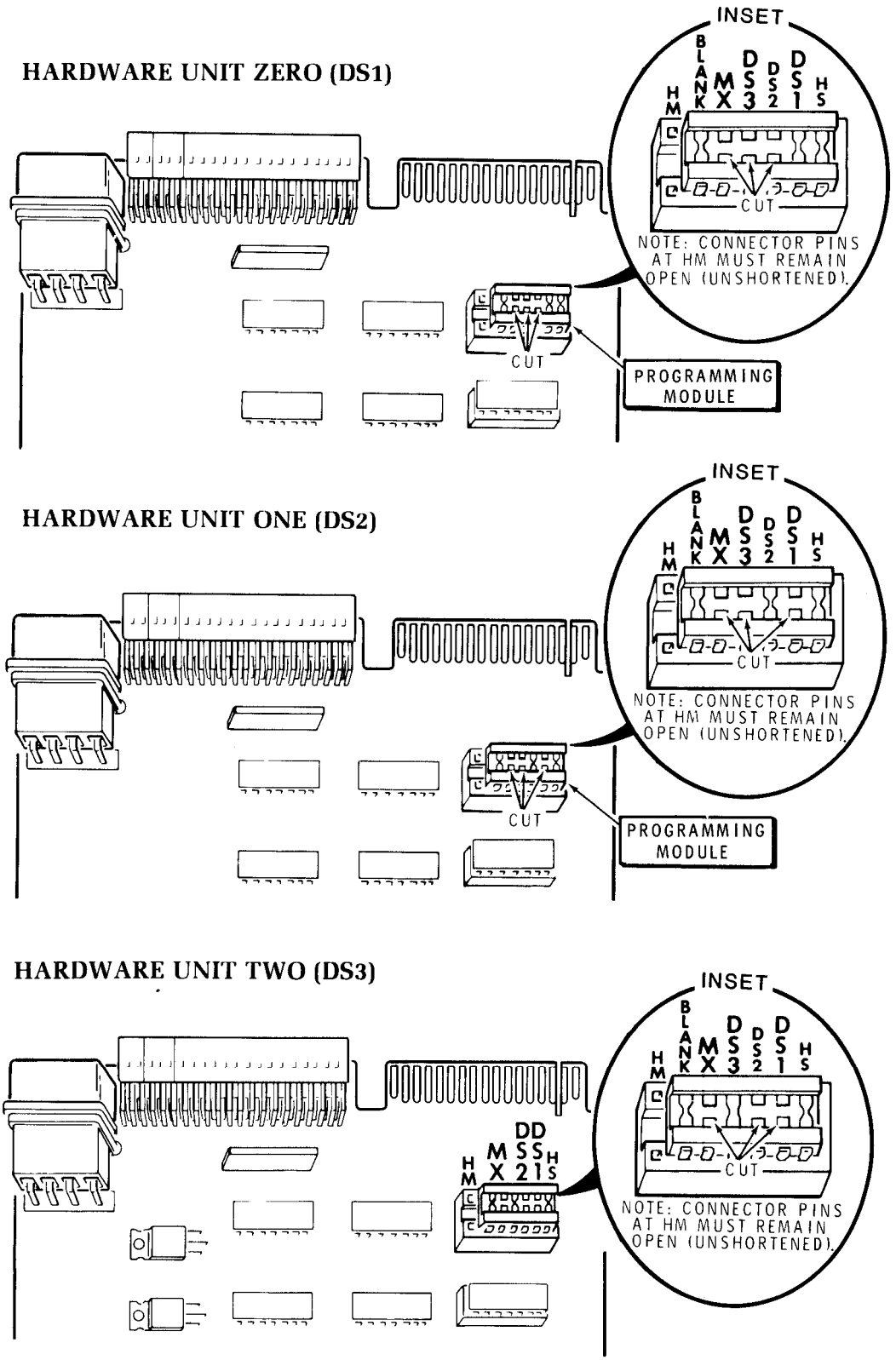
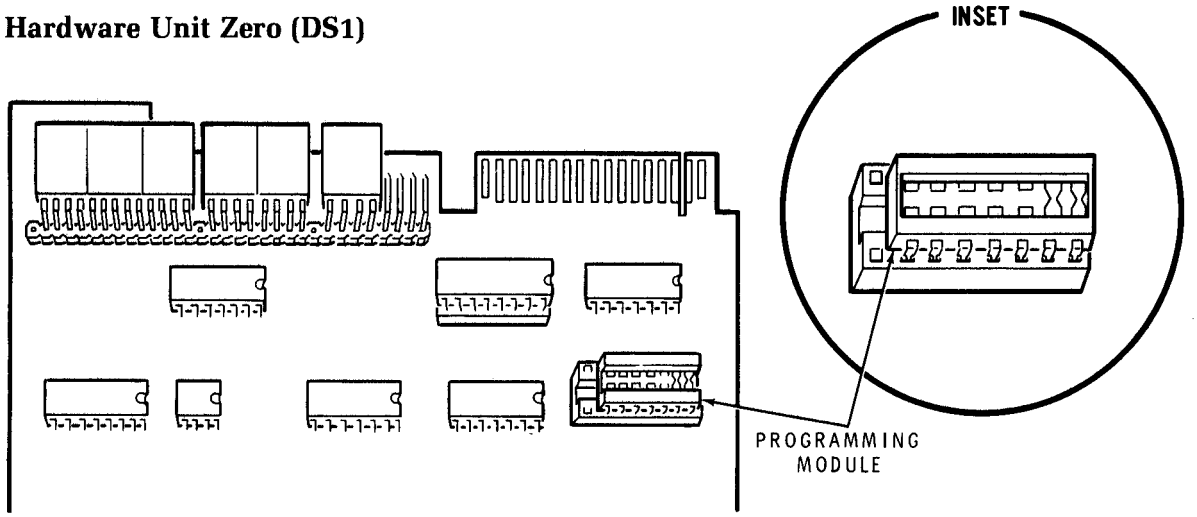
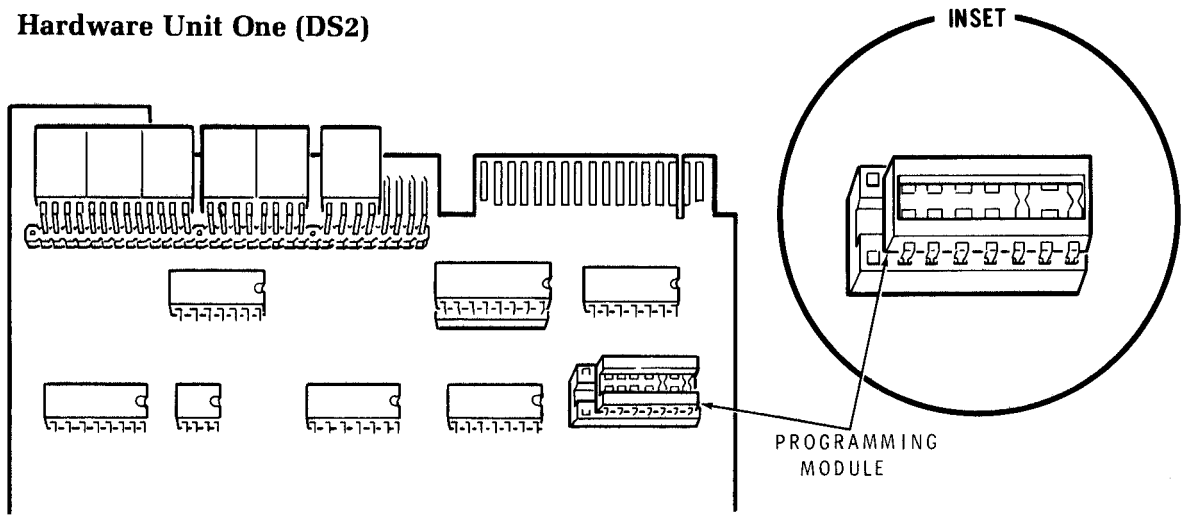


Figure 2-4
Single-sided drives (H-17-1) programmed for Z-89-37 Controller.

Hardware Unit Zero (DS1)



Hardware Unit One (DS2)



Hardware Unit Two (DS3)

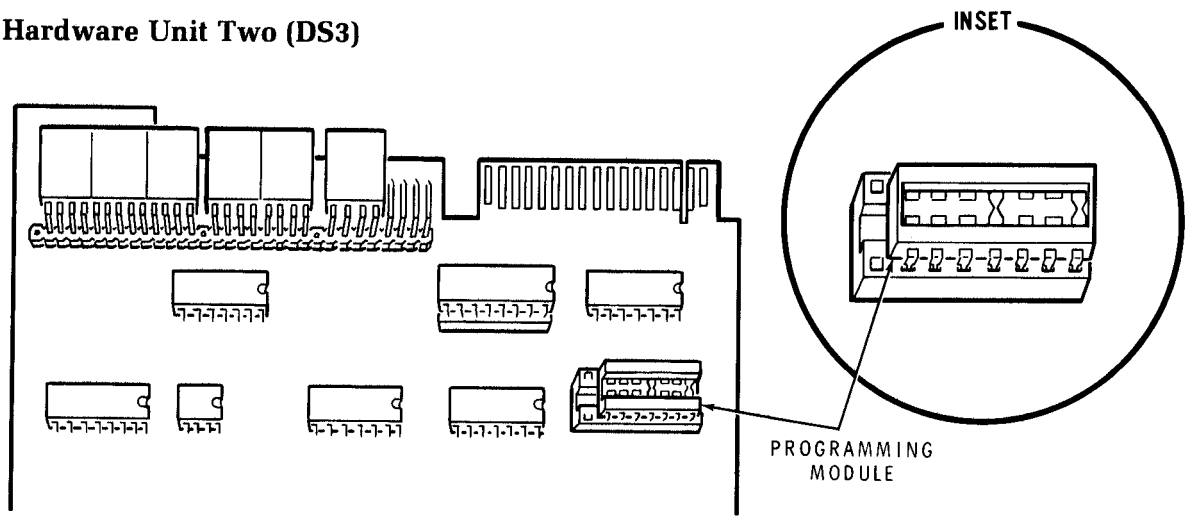
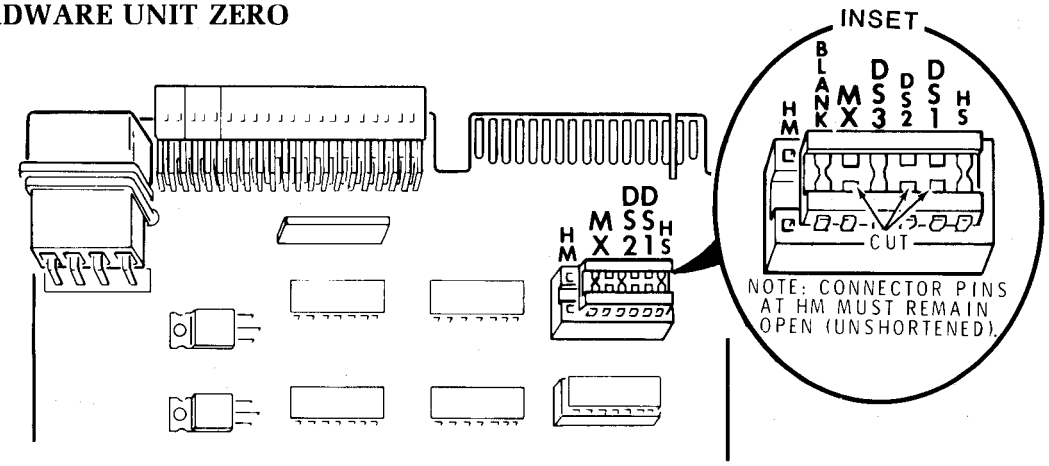
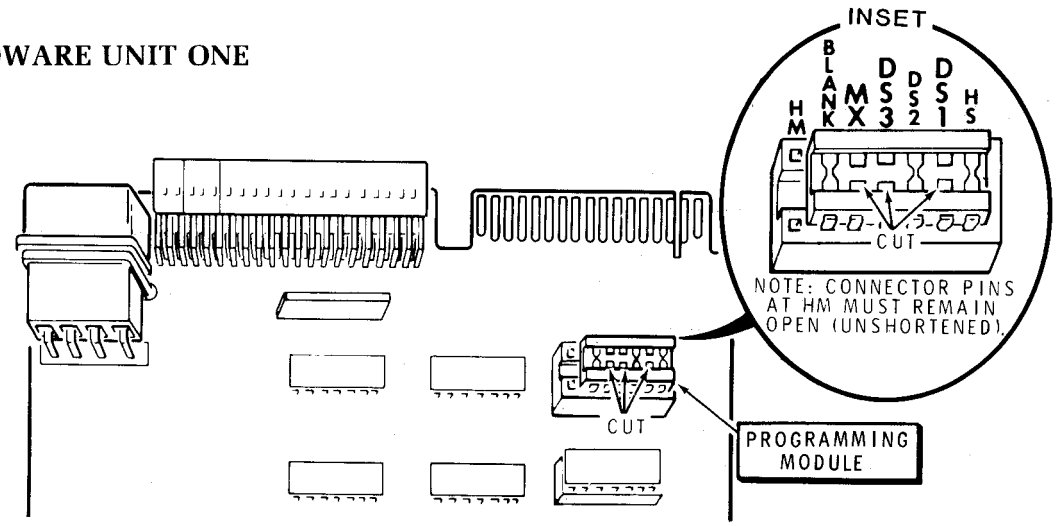


Figure 2-5
Double-sided drives (H-17-4) programmed for Z-89-37 Controller.

HARDWARE UNIT ZERO



HARDWARE UNIT ONE



HARDWARE UNIT TWO

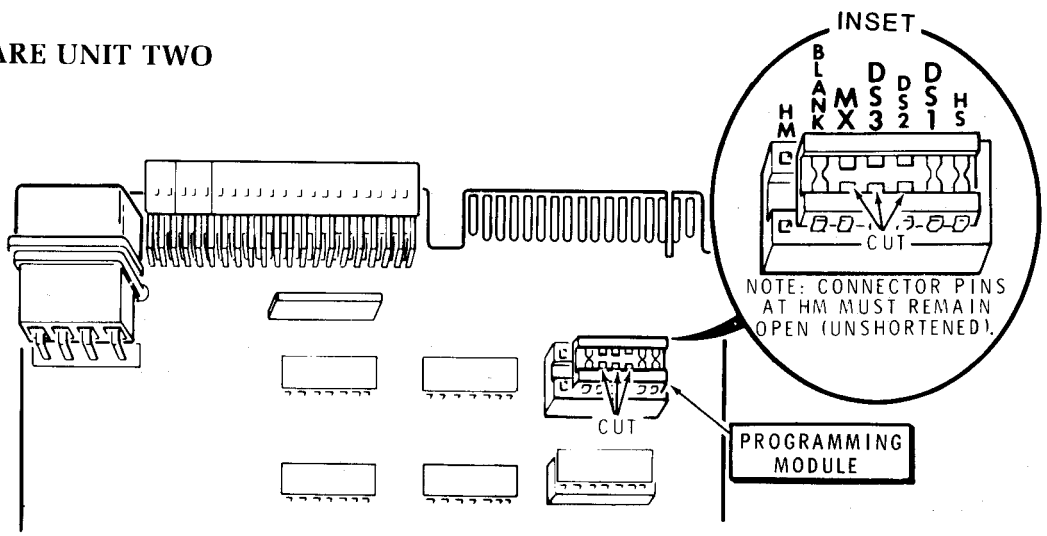


Figure 2-6
Single-sided drives (H-17-1) programmed for H-88-1 Controller.

PROGRAMMING MODULES

Refer to Figure 2-7 on Page 2-8 as you read the following information.

Use the following information for any special configurations that you may want.

Programming modules:

J1 & J2 — Select port 170 or 174. (Both jumpers must be at 170, or both jumpers must be at 174. 170 is normal.)

J3 — 0 = No precompensation; 1 = precompensation. (0 position is normal.) Use "0" only on Wangco drives. Otherwise, use "1."

We recommend that you do not use both 48 and 96 TPI drives in the same system, since the precompensation will be wrong for at least one of the drives. This can result in reduced data reliability. When precompensation is selected, it is factory pre-set to 300 nanoseconds.

J4 — J7 — Selects which drive is connected to plug P3. (Drive numbers are determined by how the drive programming modules are cut. See Figure 2-4 on Page 2-4).

J4 = DS1
J5 = DS2
J6 = DS3
J7 = DS4 (presently not supported)

Z-89-47

For a system to operate properly with the Z-89-37, the Z-89-47 I/O board should be installed at plugs P506 and P512. However, before the Z-89-47 will operate properly when plugged into plugs P506 and P512, a resistor must be added to the Z-89-47 circuit board.

To make the modification, use a 4700 Ω, 1/4-watt resistor (yellow-violet-red), HE 6-472-12; and slide a length of sleeving over the resistor. Solder the resistor between pins 1 and 12 of plug P2 on the foil side (not the component side) of the Z-89-47 circuit board as shown in Figure 2-2 on Page 2-2.

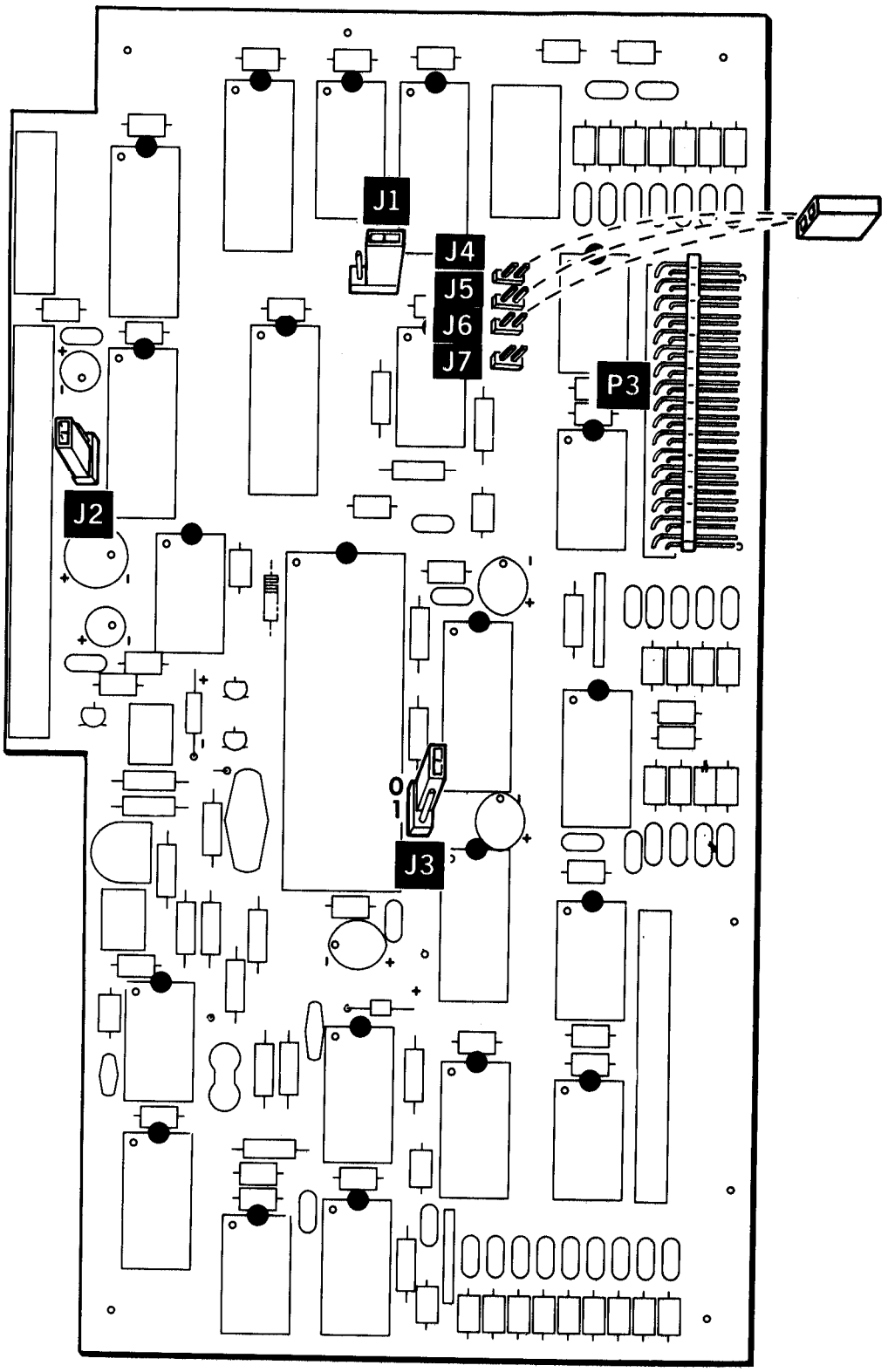


Figure 2-7

Z-89-37 Double-Density Disk Controller Board.
Part number HE 181-3614.

Circuit Description

Refer to the Block Diagram (fold-out from Page 4-1) while you read the following Circuit Descriptions.

The board's function is to translate the instructions of the processor to the disk drives. Assume that the processor wants to write on disk drive number one. First, the processor sends the proper enabling and control signals over the control lines. These signals are made compatible with the 1797 disk controller by the control decoder and inverter. The controller then blocks all interrupts to the processor (except its own) by sending a "block interrupts" signal to the interrupt control ICs. This prevents another peripheral from interfering with the transfer of data between the processor and the disk drive. The controller also signals the buffer direction control IC to allow input from the processor to pass through the data buffer to the controller.

The interface control latch then starts the motor of disk drive number one by translating the drive control signals from the processor. The data from the processor is now sent over the data bus, through the 1797, the support logic and disk interface logic, and to drive number one over the disk serial data line (the support logic and disk interface logic help the 1797 disk controller communicate with the drive electronics). The support logic consists of ICs U8B, U13, U14A, and U15. The interface logic consists of U19, U20, U21, and U22. These are all explained below.

The read process is similar to the write process. First, the processor sends the proper enabling and control signals over the control lines, just as before (of course this time the signals enable the disk controller board to read instead of write). The signals are made compatible with the 1797 disk controller IC by the control decoder and inverter. The controller again blocks all interrupts to the processor (except its own) by sending a "block interrupts" signal to the interrupt control ICs, preventing another peripheral from interfering with the transfer of data. The controller also signals the buffer direction control IC to allow output to the processor to pass through the data buffer from the controller. The interface control latch then starts the motor of disk drive number one by translating the drive control signals from the processor. The data from the disk is now sent over the drive serial line, through the disk interface logic, the support logic and the 1797 disk controller, and to the processor via the data buffer and data bus.

The phase lock loop (PLL), which is part of the support logic, and the variable control oscillator (VCO) together track the frequency of data read from the disk. This tracking generates a read clock (RCLK) signal that tells the disk controller how fast to read the data. (The frequency of the incoming read data changes due to variations in the rotating speed of the disk and the position of the data on the disk.)

CONTROL LINES (P2)

Please refer to the Schematic Diagram (fold-in) while you read this description.

All of the disk control lines from the processor are input to U6 via plug P2, except for the processor system clock line, which is input to U5A via pin 13 of P2.

The control lines consist of address lines A0, A1, and A2, read line RD, write line WR, I/O DISK, I/O FLPY, and the reset line RESET. (Address line A2 is inverted by U5B when J1A is jumpered. J1A is jumpered in the standard operating mode, as is J2A. Otherwise A2 goes directly to U6.) The address lines access the 1797 disk controller's (U12) registers. The read and write lines, low when active, tell the controller which way the data buffer direction control should be set and whether the read or write lines to the disk driver electronics should be used. The I/O DISK and I/O FLPY lines enable the controller board and tell the board which block of memory in the processor is used for disk I/O. The I/O DISK line is used in the standard mode. In this mode the I/O memory block base address is 170 octal. I/O FLPY, when connected through jumper J2B, is used when the programmer wishes to designate another block of memory for disk I/O. The last control line, RESET, initializes the controller.

U1 DATA BUFFER AND U7B BUFFER DIRECTION CONTROL

The data buffer is a bidirectional, eight-bit buffer whose direction is controlled by U7B, the buffer direction control.

U2, U3, U4 INTERRUPT CONTROL

ICs U2 and U4 are taken from the processor CPU board. They are the processor's interrupt channels. They are relocated onto the disk controller board so that the disk controller can block all other interrupts to the processor except its own. U3 screens the interrupt signals to the processor under U11's direction. U3 turns the eight-bit interrupt to the processor into three-bit interrupt signals. The three-bit interrupt becomes part of an eight-bit data instruction via U2. U2 supplies five other hard wired bits.

For more information about U2 and U4, consult your processor's operation manual.

U5 OPEN COLLECTOR NAND GATES

There are four gates used on the IC, called A, B, C, and D. The gates invert the: processor system clock for use by the 1797, interrupt from the 1797 to the processor, and addressing information from the processor to all parts of the disk controller board.

U6 CONTROL DECODER AND INVERTER

U6 is a programmable logic array, designed to decode address and read and write conditions for the controller board. Using addresses A0, A1, and A2 it determines whether the board is being addressed, which register is being addressed, and whether the signal is a read enable or write enable signal.

The internal logic of U6, and most other ICs on the board, is shown in the "Semiconductor Identification Chart." All inputs and outputs of the IC are marked on the chart as they are on the Schematic.

U7A ADDRESS CONTROL LATCH

The address control latch helps call up the registers in the 1797 — either the track and sector registers or the C/S and data registers, depending on how data bit 0 is set on the interface control latch.

U8A RESET PULSE LATCH

The reset pulse from the processor does not meet the minimum reset pulse requirements of the 1797. To correct this, U8A lengthens the reset pulse to an interval sufficient to meet the 1797's specifications. U8A also supplies the reset signal to U16, part of the phase lock loop circuitry. U16 then resets the precompensation clock generator, U18.

U8B HEAD LOAD DELAY

U8B is a monostable multivibrator that delays the controller's response to commands. This allows the drive head to settle after it is selected.

U9 AND U10 DISK CONTROLLER CLOCK

U9 is a clock oscillator that runs at 16 MHz. The output of U9 is fed to U10. U10 divides U9's output by 16, producing a 1 MHz clock signal with a 50% duty cycle.

U11 INTERFACE CONTROL LATCH

The U11 is an octal type-D latch. It latches the high speed processor signals for the 1797 disk controller (U12) and interface control latch (U11). Some commands, such as MOTOR, go directly from the U11 to the disk drive interface ICs, U19, U20, and U21, rather than through the 1797.

U13 INPUT SIGNAL MULTIPLEXER

This IC multiplexes the control and data signals from the two disk interfaces into the disk controller board. The multiplexer switches between the two interface line groups, depending on which drive is selected and on which of jumpers J4, J5, J6, or J7 is set. The multiplexer isolates the two drive interfaces to prevent their interfering with each other.

U14 RAW READ LATCH

U14 lengthens the raw read pulse from the disk drive electronics to a size readable by the 1797 (U12).

U15 DRIVE BUFFER

U15 buffers the control and data signals to the two drive interfaces.

U16, U17, U18, Q1, AND Q2 PHASE LOCK LOOP TRACKING AND PRECOMPENSATION

U16 supplies U17 with either a pull-up (PU) or pull-down (PD) signal. This signal is then filtered by C29 and R13 and then called FC — frequency control. Voltage control oscillator U17 changes its frequency, higher with a PU signal and lower with a PD signal. The change in frequency produces a corresponding change in rotational speed of the disk.

Variable resistor R10 biases the PU and PD output at 1.4 volts (this means that PU/PD are 1.4 volts when the phase lock is inactive). This allows the phase lock to more quickly lock on to the data being read. Variable resistor R17 adjusts the VCO's center frequency to 2 MHz.

The VCO's output is divided down by U16. This signal then becomes the read clock (RCLK) signal, which is used by the 1797 to separate disk data and disk clock signals.

The U16 also strobes the early and late signals for data precompensation. These internally latched signals determine which phase of a four-phase clock generator, U18, will be used for the precompensation process. All phases are identical in pulse width (+ or −50 nsec). The phase delay time is set by R20.

Precompensation, used for 80-track double-density disk write operations, places data properly on the disk so that it can be read back with minimum error. (Error may be introduced by the shifting of old data as new data is written — as data is written, data adjacent to the new data is shifted over because of the nature of the magnetic medium of the disk.)

U18, precompensation clock generator, provides the clock signals needed for precompensation of write signals.

U19, U20, U21, AND U22 DISK DRIVE INTERFACE

The disk drive interface ICs buffer all signals to and from the disk drive electronics by means of open collector drivers.

U23 VOLTAGE REGULATOR

U23 supplies +5 V regulated to U17, isolating the U17 from the Z-89 +5 V power supply.

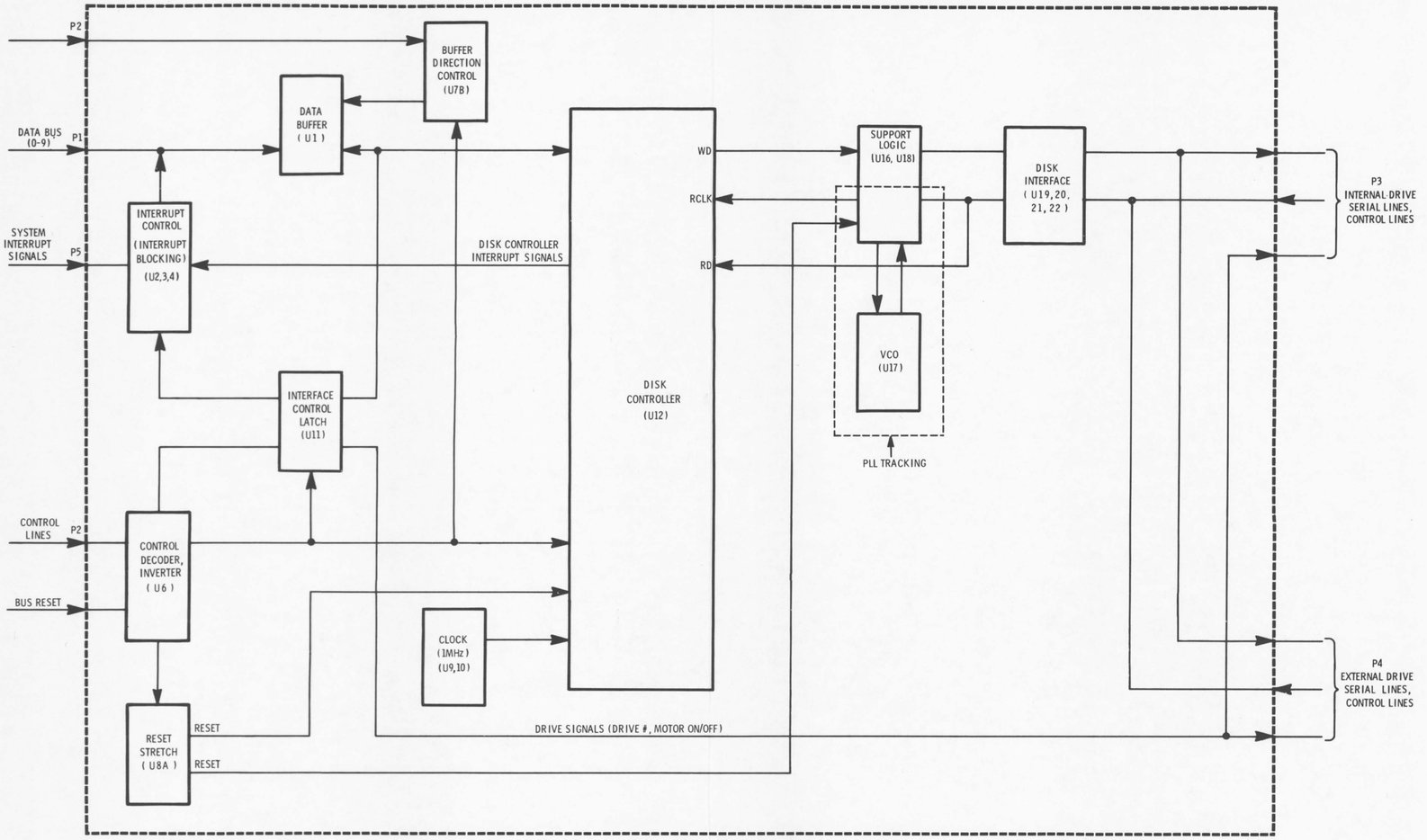
Diagnostic Routine

The diagnostic and conversion diskette supplied with the disk controller allows you to "check out" or troubleshoot your disk system and move software from the hard-sectored diskettes used by the single-density controller to the soft-sectored diskettes used by the double-density controller, Z-89-37.

The diagnostic routine is supplied on a 5.25-inch bootable diskette labeled "Soft Sectored." Customers also receive a diskette labeled "Hard Sectored." The only difference between these diskettes is the type of media and the addition of the hard-sectored to soft-sectored conversion routine on the hard-sectored diskette. Otherwise, the programs that the diskettes contain are identical. You can use either diskette to perform the diagnostics, but be sure to use the diskette labeled "Soft Sectored" only in disk drives that are connected to the Z-89-37 Controller. You can use the hard-sectored diskette in an H-17, H-77, or Z-87 with an H-88-1 (hard-sectored) floppy disk interface.

Those who have single-sided disk drives and are uncertain whether they have installed the Controller or disk drives correctly, should boot up the diskette labeled "Hard Sectored" in a hard-sectored disk drive connected to an H-88-1, single-density, floppy disk controller, and then run the diagnostics from the hard-sectored diskette.

To perform the diagnostics, you will need at least two blank, 5.25-inch, soft-sectored diskettes. It does not matter whether these soft-sectored diskettes are single or double density, nor whether they are signal or double sided.



BLOCK DIAGRAM

TO REARRANGE THE DRIVE NUMBERS...

Refer to the following chart and Figure 4-1, and select the configuration that fits your situation. Configuration E is normally used for transferring data and programs from hard-sectored disks to soft-sectored disks.

After you select the configuration you want, refer to Figure 4-2 on Page 4-3 to program any 48 TPI (H-17-1) drives, or Figure 4-3 on Page 4-4 to program any 96 TPI drives. [Figure 4-4 on Page 4-5 shows single-sided drives (H-17-1) programmed for connection to an H-88-1 Controller.] You can do this programming by physically interchanging preprogrammed drives, interchanging the programming modules, cutting the programming modules (if presently uncut); or by replacing the programming module with a properly set dip switch.

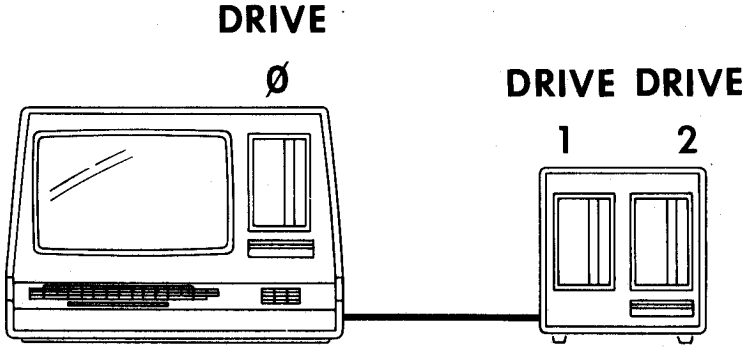
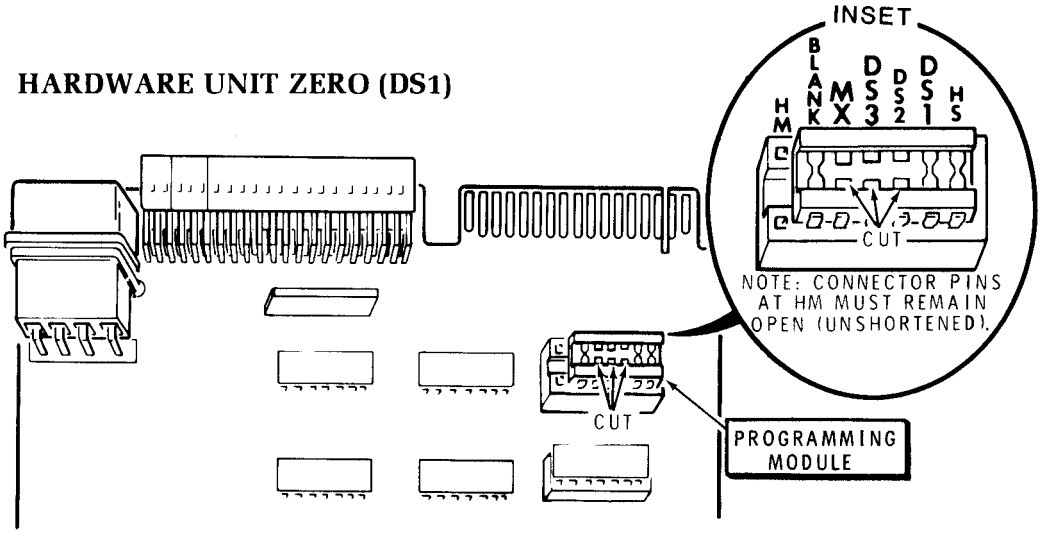


Figure 4-1

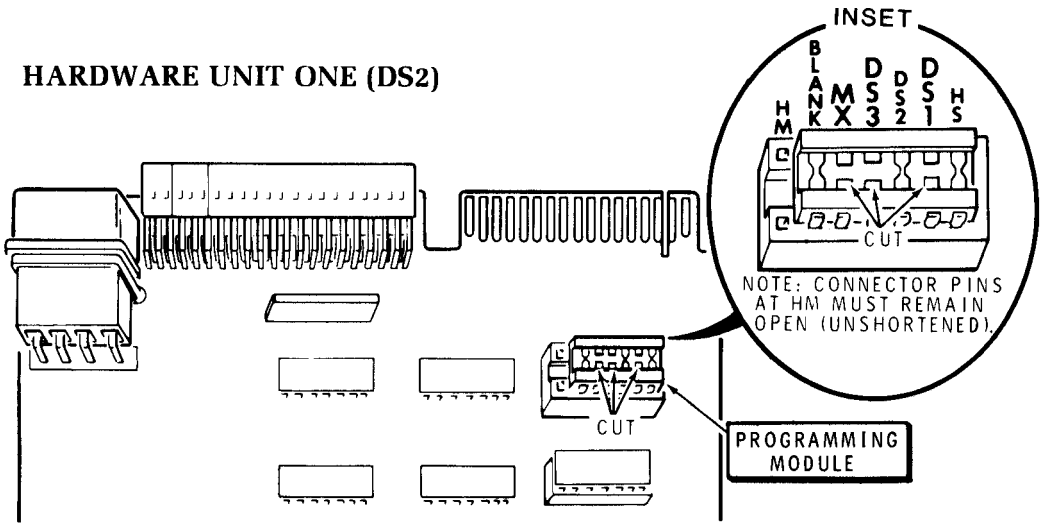
FLOPPY DISK CONTROLLER BOARD(S)		TYPES OF DRIVES: • 48 TPI (H-17-1) • 96 TPI (H-17-4)	Drive 0	Drive 1	Drive 2
A	H-88-1	48 TPI (H-17-1) only. Internal drive present	DS3	DS2	DS1
B	H-88-1	48 TPI (H-17-1) Internal drive absent	No drive installed	DS3	DS2
C	Z-89-37	Either* Internal drive present	DS1 (Z-89-37 jumper installed at J4)	DS2	DS3
D	Z-89-37	Either* Internal drive absent	No drive installed (Z-89-37 jumper installed at J7)	DS1	DS2
E	H-88-1 & Z-89-37	Either* Internal drive present	DS3 [Drive 0 is 48 TPI (H-17-1) drive connected to H-88-1. Z-89-37 jumper installed at J6.]	DS1 (Drive 0 connected to Z-89-37)	DS2 (Drive connected Z-89-37)

* All drives connected to the Z-89-37 should be of the same type, either 48 TPI (H-17-1) or 96 TPI (H-17-4).

HARDWARE UNIT ZERO (DS1)



HARDWARE UNIT ONE (DS2)



HARDWARE UNIT TWO (DS3)

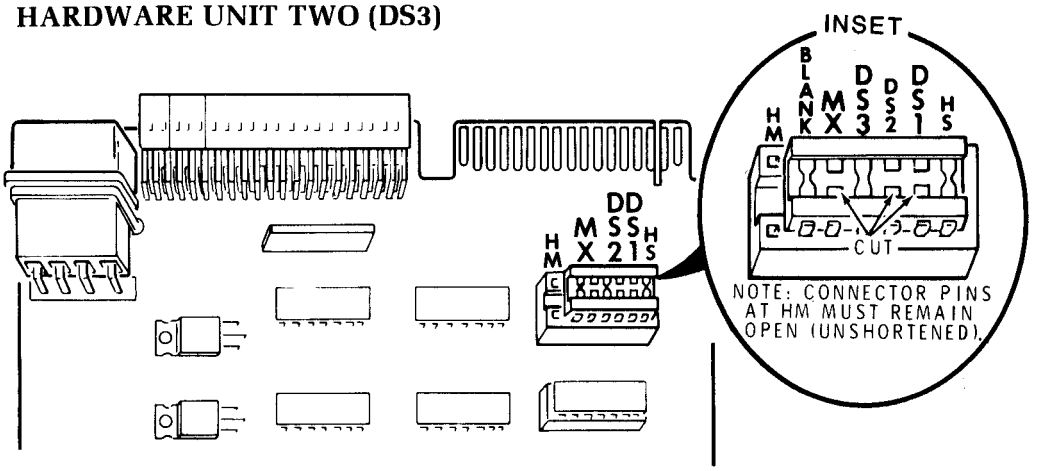
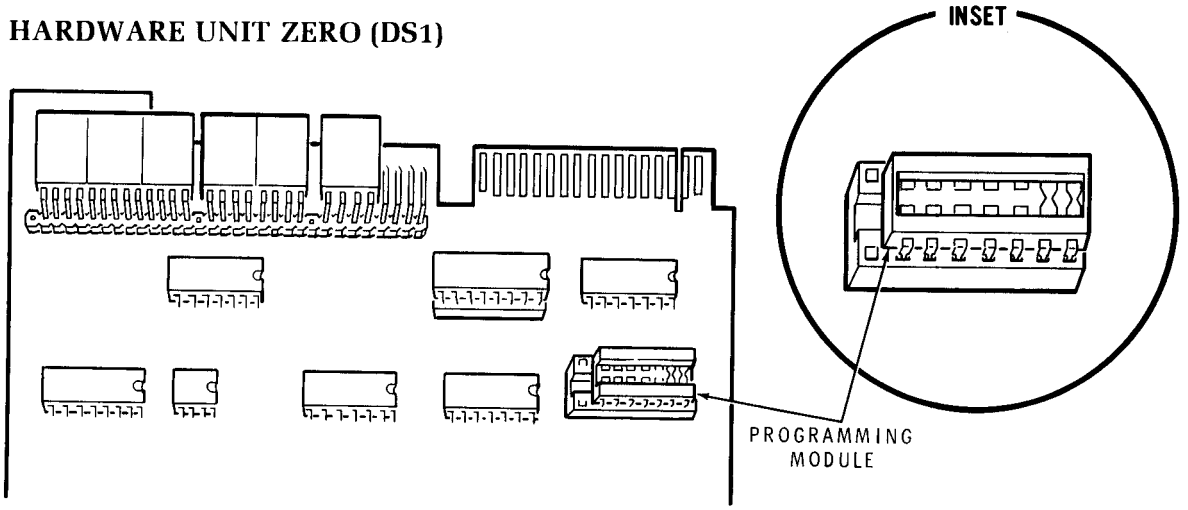
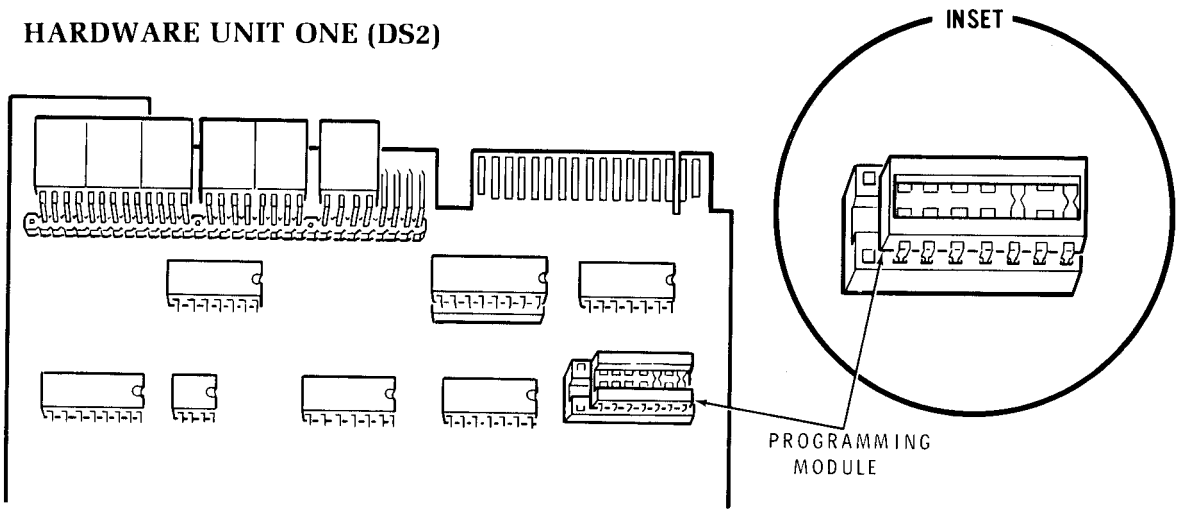


Figure 4-2
Single-sided drives (H-17-1) programmed for Z-89-37 Controller.

HARDWARE UNIT ZERO (DS1)



HARDWARE UNIT ONE (DS2)



HARDWARE UNIT TWO (DS3)

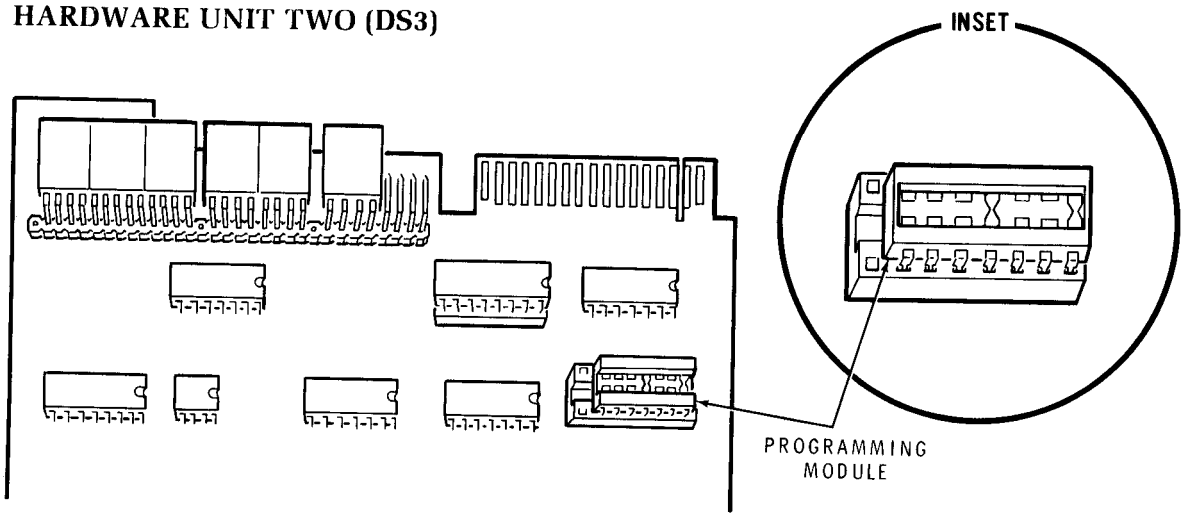
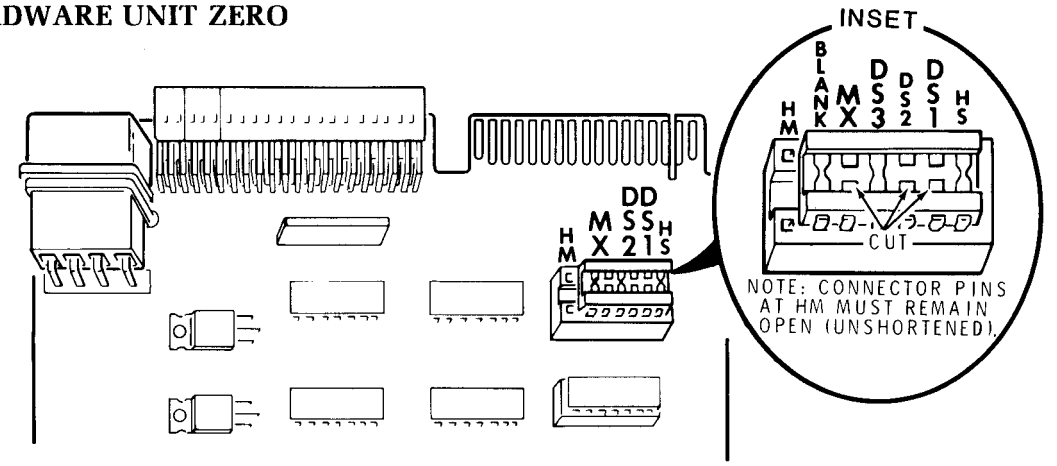
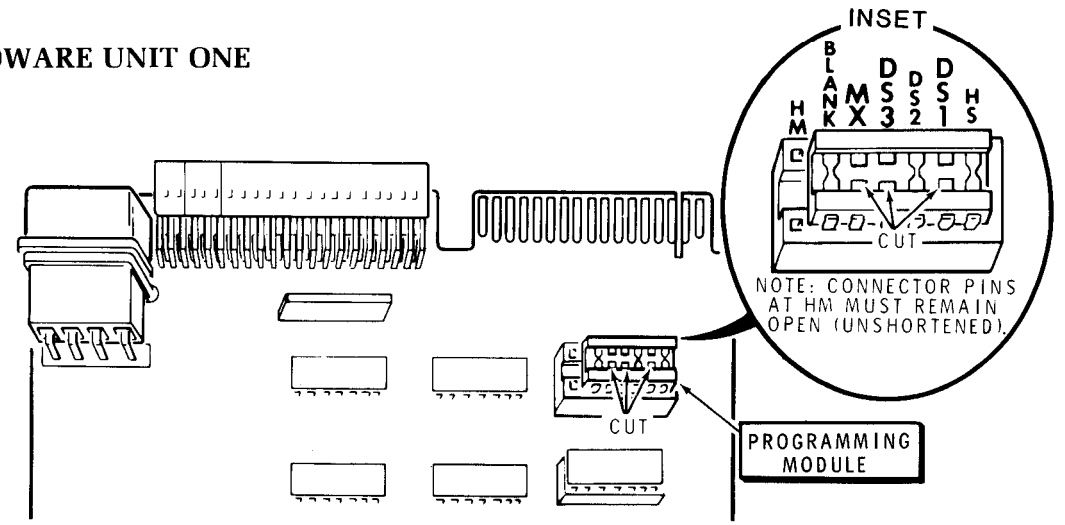


Figure 4-3
Double-sided drives (H-17-4) programmed for Z-89-37 Controller.

HARDWARE UNIT ZERO



HARDWARE UNIT ONE



HARDWARE UNIT TWO

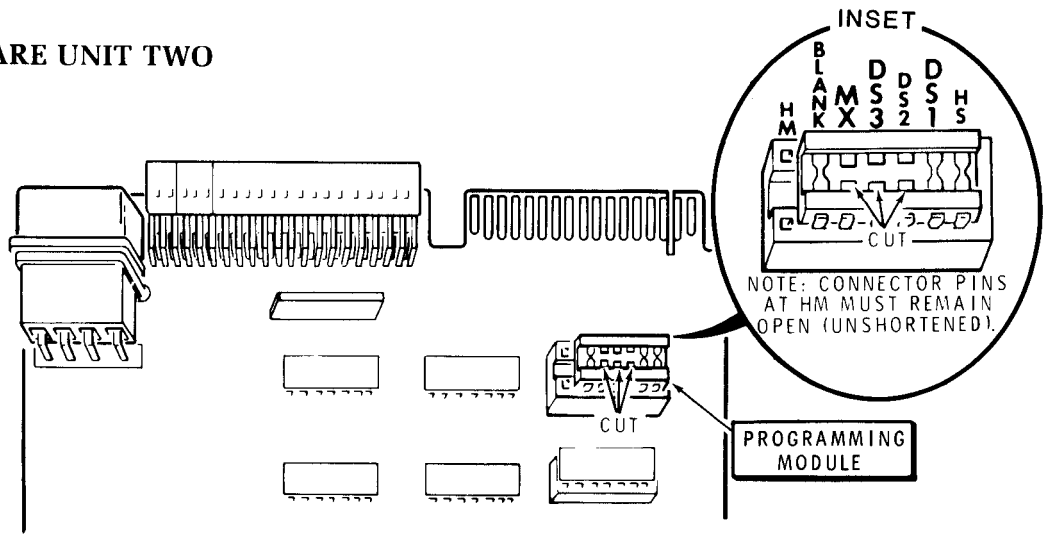


Figure 4-4
Single-sided drives (H-17-1) programmed for H-88-1 Controller.

STARTING THE DIAGNOSTIC PROGRAMS

To start the diagnostic programs, boot up the system using either the hard- or soft-sectored Diagnostic and Conversion Utilities diskette. The part number for the hard-sectored diskette is HE 890-156. The part number for the soft-sectored diskette is HE 890-157.

Greater centering accuracy is required when you are using 96 TPI drives. Therefore, it is imperative that the diskettes you use with your high capacity 5-1/4" floppy disk system have factory-installed mylar hub reinforcing rings. All of the diskettes supplied by Zenith Data Systems have these rings, as well as Verbatim **Datalife** diskettes and several other brands. **Do not** use any diskettes that do not have these rings.

The following procedure outlines how you should boot up your Computer.

1. Turn on the power to the Computer. You will hear one or two beeps and see an H: in the upper left-hand corner of the screen.

2. Insert the Diagnostic and Conversion Utilities diskette into the drive.

   - Soft-sectored disk goes into drive 0 if you are using only the Z-37 (or comparable drives outside your Computer) and no drive in your Computer.

   - Hard-sectored disk goes into drive 2 if you are using the Z-89-37 controller board with a Z-89 Computer, and drive 2 is connected to a hard-sectored floppy disk interface (H-88-1). Or, use drive 2 if you are using the H-88-1 interface board with a Z-90-82 Computer.

   - For all others, refer to "Reconfiguration" on Page 2-1. Define drive 0 and insert the soft-sectored disk.

3. Close the drive door.

4. Type the letter B and press the RETURN key. The terminal will display:

```
H: Boot
```

You will hear some clicking noises from the disk drive. This is normal. You will hear such noises whenever the Computer is reading from or writing to the diskette. The clicks will continue for about 15 seconds. Then the terminal will display the diagnostic program's main menu, as follows:

```
Zenith Data Systems Z-37 Support System

Enter the number corresponding to the type of program
you wish to run.

1. Disk Controller Checkout

2. General Drive/Controller Diagnostic

3. Detailed Drive Diagnostic

Your Choice ->
```

From this main menu, you can select any diagnostic or conversion utility. To select an option, simply type the number which corresponds to the option. When you are finished running any of these options, the system will return you to this diagnostic program's main menu.

Whenever the main menu is displayed, you can safely remove all diskettes and turn off the power.

DISK CONTROLLER CHECKOUT

The Disk Controller Checkout is used to verify the operation of the Z-89-37 disk controller circuit board. This diagnostic program turns on the disk drive motors, loads the disk drive read/write heads as a program would if it were trying to read from or write to the disk, and then tries to position and reposition the read/write head. If the program can successfully complete all these tests, it will print a message which indicates that the controller works properly. If the program cannot successfully complete any test, it will print an error message which tells you how to correct the problem.

The Disk Controller Checkout diagnostic will refer to various drive numbers. These numbers are the drive hardware unit numbers, and they range from 0 (zero) through 2. Pay close attention to which number the program associates with a drive as it activates it. This "drive hardware unit number" will be referred to frequently throughout these diagnostics.

To run the Disk Controller Checkout, select diagnostic program's main menu option 2. The system will print:

```
Detailed Controller Checkout.

This program  attempts to verify the operation
of the Z-37 disk controller board.

Please answer the following questions with 'Y'
For YES and 'N' for NO, by looking at your
Disk Drivers and verifying proper operation.

Are All Drive Motors Turning?
```

To respond, open the doors of the drives on your Z-37(s). On the right-hand side of the drive, about two inches back from the drive door, is a metal cylinder which measures about an inch in diameter. Make sure this cylinder is turning in each of the drives in your Z-37(s). It does not matter whether this cylinder is turning in any drives connected to an H-88-1 hard-sectored controller.

If all the cylinders are turning, respond Y. Otherwise, respond N and turn to Page 4-13 for an explanation of the message you receive.

If you have responded Y to the preceding question, the program will print:

```
Selecting Drive Zero.

If this is a non-existent drive for your system,
Answer 'Y' to the following question.

Is Drive Select Light On and Head Loaded?
```

Note that this "Drive Zero" is the drive which you normally use to boot up.

To respond to this question, check to make sure the red light on drive 0 is glowing. If it is, enter Y. Otherwise, enter N and turn to Page 4-13 for an explanation of the message you receive.

If you have responded Y to the preceding question, the system will print:

```
Selecting Drive One.

If this is a non-existent drive for your system,
Answer 'Y' to the following question.

Is Drive Select Light On and Head Loaded?
```

To respond to this question, check to make sure the red light on drive 1 is glowing. If it is, enter Y. Otherwise, enter N and turn to Page 4-13 for an explanation of the message you receive.

The program will continue to activate the drives in this way for drive 2. In general, you should respond Y if the drive exists and the red light glows, and N only if the drive exists but the drive light does not come on.

If all the drive motors work properly and the program was able to successfully select all the drives, the system will now print:

```
Attempting to verify the operation of the
Head positioning system. Please stand by...
```

The program will now attempt to position and reposition the disk drive read/write head, much as it would as if it were reading from or writing to a diskette. If this test is successful, the program will print:

```
Controller appears to be ok. Please continue
on to selection 3 or 4 to make further checks.
```

If you do not receive this message, refer to the error messages on Page 4-10 for an explanation of the error message you receive.

DISK CONTROLLER CHECKOUT ERROR MESSAGES

Prompt: `Are All Drive Motors Turning?`

If they are not turning, be sure that power is applied to the unit, and the cables are plugged in correctly. Then repeat this test.

First, check to make sure that the power to the drive is on. If the power is on, check the connection of the ribbon cable on the controller circuit board (this is the third circuit board to the immediate left of the disk drive). If the ribbon cable is connected correctly, compare the jumper selection on the controller with the section selections given in "Reconfiguration" on Page 2-1. Then repeat the test.

Prompt: `Is Drive Select Light On and Head Loaded?`

If not, be sure that the drives are jumpered for the proper drive select, and that inboard drive jumper is in the proper position. Then repeat this test.

Check the drive jumpers on the disk controller board against the settings given in "Reconfiguration" on Page 2-1. Then repeat the test.

Prompt:
```
Attempting to verify the operation of the
Head positioning system. Please stand by...
```

If there is no track indication, check the head movement and indicator operation.

GENERAL DRIVE/CONTROLLER DIAGNOSTIC

The General Drive/Controller Diagnostic, or TEST, is a diagnostic utility used to test soft-sectored 5.25-inch diskettes and 5.25-inch disk drives. TEST verifies the drive rotational speed, drive step rate, read/write mechanism, and the quality of the recording surface of the diskette used for the tests.

You must format the diskette which you use to perform the TEST diagnostics specifically for these diagnostics, using the TEST F (format disk) option, before you run tests. Furthermore, the disk which you use to perform the diagnostics must not have been used with any other drive diagnostics. After you use the diskette to perform TEST tests, use an operating system disk formatting program (CP/M FORMAT or HDOS INIT) before you actually use the diskette for data or program storage.

The amount of time you need to run the tests varies with the number of sides and the density of the media under test. It will take about two hours to run all tests using a single-sided, single-density diskette. It will take about four and a half hours to run all tests using a double-sided, double-density diskette.

Initiating the General Drive/Controller Diagnostic

To run TEST, boot up using the Diagnostic and Conversion Utilities diskette and then select menu option 3.

TEST will explain itself and ask whether you want to proceed. If you type YES and press RETURN, the program will continue. If you type NO and press RETURN, TEST will return you to the diagnostic programs main menu.

If you have chosen to proceed, the program will dismount the disks and print the following message:

```
REMOVE THE DISK(S). HIT RETURN WHEN READY:
```

At this point, you should remove all disks and press RETURN.

TEST will now ask for the hardware unit number of the drive you want tested. For example:

```
WHICH DRIVE (0/1/2)?
```

At this prompt, enter the hardware unit number of the drive which you want to test and press RETURN. If this is your first time through the test, we recommend that you test drive 0. After you have selected a drive number between 0 and 2, TEST will print the following menu:

```
FUNCTIONS AVAILABLE:

T - DISPLAY DRIVE ROTATION SPEED
D - GENERAL DRIVE CHECKOUT
M - MEDIA CHECK (SECTOR VALIDITY)
S - PERFORM SEEK TIME CHECKOUT
U - SELECT ANOTHER DRIVE UNIT
E - EXIT TO BOOT PROGRAM
A - ALIGN DRIVE HEAD
F - FORMAT DISK

CTRL-C CANCELS THE TEST IN PROGRESS.
 OPTION:
```

To start any test, type the letter which precedes the name of the test in the TEST menu and then press RETURN. Since you must format the diskette before performing any tests, select menu option F and press RETURN.

Available Tests and Options

The following sections describe the various tests and the options available. To end any test or menu option early, hold down the CTRL key and simultaneously type the letter C.

F — FORMAT DISK SURFACE

The Format Disk Surface option prepares a soft-sectored blank diskette for use with the TEST diagnostics. Use the Format Disk Surface option with any diskette which has not previously been formatted for TEST.

The format option begins by instructing you to insert a diskette. For example:

```
Insert a diskette into unit ?.
Press the RETURN key to format the diskette.
```

At this point, insert a soft-sectored diskette into the drive whose hardware number the program substituted for ? in the sample message given above. When you have inserted the diskette, press RETURN. Be sure the diskette you insert is either blank or does not contain any valuable information, since the format option destroys all information on the diskette which it formats.

When you have inserted a soft-sectored diskette and pressed RETURN, the system will print:

```
Double Density <YES> ?
```

If you want the formatted diskette to be double-bit density, simply press RETURN; if you want the formatted diskette to be single-bit density, type NO and press RETURN. The system will then print:

```
Double Sided <YES> ?
```

To create a double-sided diskette (if you have drives that handle double-sided diskettes), simply press RETURN. If you want to create a single-sided diskette, enter NO and press RETURN. The system will then print:

```
80 Tracks <YES> ?
```

To create a double-track density diskette (80 tracks instead of 40 — again, you **must** have the proper drives), press RETURN. To create a single-track density diskette (40 tracks), enter NO and press RETURN.

When you have responded to the message which asks how many tracks you want on the formatted disk, TEST will begin to format the tracks on the blank diskette. TEST will print one asterisk for each track it has formatted. When it has finished formatting the disk, the system will print:

```
Disk Formatted. CTRL-C to continue diagnostics.
Otherwise, Insert a diskette into unit ?.
Press the RETURN key to format the diskette.
```

If you want to format more diskettes at this point, insert another blank, soft-sectored diskette and press RETURN. If you do not want to format more diskettes, type the CTRL and C keys simultaneously. This will return you to the TEST main menu.

T — DRIVE SPEED

The drive speed test checks the rotational speed of your drive. During this test, the screen will display the relative rotational speed of the drive under test. A series of decimal numbers, which should be close to 1.000, will scroll up the screen, updating as they scroll. The rotational speed tolerance is one percent. The final value may safely range anywhere from 0.990 to 1.010. Do not adjust the speed unless it is out of tolerance. Allow this test to run for about 30 seconds; then type CTRL-C.

If there are any numbers displayed on the terminal which are less than 0.990 or greater than 1.010, restart the test and carefully adjust the speed adjustment control on the drive with a small screwdriver until the number is within tolerance. The speed adjustment control may be extremely sensitive, so if an adjustment is necessary, do not turn it far in either direction.

You may wish to perform this test periodically, depending on how heavily your drive is used. The linear servo loop which regulates the drive rotational speed makes this speed stable. But as the drive bearings wear, the speed may change slightly. Fluctuations within the tolerance are normal and may be attributed to variations in temperature and humidity.

D — GENERAL DRIVE CHECKOUT

The purpose of the General Drive Checkout is to verify that your system is reading from and writing to the diskette properly. Each sector on the diskette is written to and read from a number of times. Various patterns are written on the diskette to allow testing of the head seek mechanism and the read/write head itself. The test is repeated three times. Do not be alarmed if this test seems to take an abnormally long time to finish. It is a very thorough test, and requires from 45 minutes to an hour and a half to complete. The duration of the test will depend on the type of media you use for the test. Run this test again only if you encounter problems.

While each pass is being executed, the program will print the letters "ABCDEFG," one after the other, at intervals of a few minutes. These letters indicate the various phases of the test and give you an idea of how far it has progressed.

TEST will print an "END OF PASS" message at the end of each pass. There are two possibilities. If everything proceeds normally, the output for the pass will read:

```
ABCDEFG END OF PASS n
```

However, if the test discovers any problems on the current pass, the output will include the number of "hard" (h) and "soft" (s) errors, as follows:

```
ABCDE hhh/sss FG END OF PASS n
```

In this example, test E has errors. The tests corresponding to each letter are:

A = Write all zeroes
B = Read all zeroes
C = Write all ones
D = Read all ones
E = Write identification pattern
F = Read identification pattern
G = Random read/write test

The number of "hard" and "soft" errors is indicated by the numbers "hhh" and "sss," respectively. Let the test run through all three passes, even if it discovers errors.

Soft errors usually indicate that the disk drive temporarily had difficulty reading from or writing to the diskette. The difficulty may occur because of dust, noise, static electricity, etc. Soft errors are nothing to be concerned about; you may correct them by simply repeating the failed process.

If after performing ten retries (in an attempt to correct a soft error) the program still cannot perform the read or write operation, TEST reclassifies the soft error as a hard error. Hard errors are caused by malfunctions in the electronic or electro-mechanical hardware and/or defective diskettes.

If you have hard errors, the best approach is to exit this program (type E at the option menu), format another blank diskette, and repeat the entire TEST procedure. If this approach is successful, it is probably because the first diskette had one or more bad sectors, possibly caused by dust. If replacing the diskette corrects the hard errors, continue through the other TEST options and then use "Switch" to restart TEST. Then insert the bad diskette and perform "Media Check" in order to identify bad sectors. If the diskette contains bad sectors, put it aside. Do not use a defective diskette to store data or programs.

Hard errors on the inside (high numbered) tracks will usually result if you use double-bit density, double-sided, 80-track operation with diskettes not certified for such use.

If you are getting both hard and soft errors, and "Media Check" finds nothing wrong with the "bad" disk, you may have hardware problems.

If changing the diskette does not correct the problem, or if you do suspect that you have hardware problems, refer to the "In Case of Difficulty" section, Page 5-5.

M — MEDIA CHECK

The Media Check will examine the diskette under test for defects in the magnetic oxide recording medium. If you had any hard or soft errors during the General Drive Checkout, defects in the diskette medium could be the cause. If the Media Check finds any bad sectors, the bad sector numbers will be listed at the end of the test. Run this test on all new diskettes to confirm the quality of the medium.

The Media Check will take anywhere from 20 to 45 minutes. At the end of the test, the following message will be printed:

```
nnnn BAD SECTORS LOCATED
```

The number "nnnn", which can range from 0000 to 2879, tells how many of the sectors on the diskette under test are defective. The numbers of any bad sectors will also be listed. Record the numbers for future reference. If the Media Check discovers a bad sector, put the diskette which contains the bad sector aside. Do not use it to store data or programs. However, disks which have errors in double-density or double-sided use may still be suitable for single-density or single-sided use.

S — SEEK TIME

This test will vary the track seek time of your drive in order to determine its highest reliable speed. The drive assemblies are guaranteed to perform reliably at a seek time of 30 milliseconds per track.

The maximum seek speed may change as the drive unit becomes "broken in." If frequent read errors occur with one of your drives, you should re-run TEST to check for possible changes in the drive speed.

The first speed to be tested is 30 milliseconds per track. The program will attempt faster step rates of 20, 12, and 6 milliseconds until it has determined your drive's fastest reliable seek time. As it tests, the program will print what speed it is attempting. For each successful pass, TEST will print the message "OK!" to indicate that the drive performs reliably at that speed.

When the seek time test is complete, the message "Drive performs reliably at nn milliseconds per track" will be printed, where "nn" is the optimum seek time of your drive. Record this number for future reference.

Note that if TEST attempts a pass at 6 milliseconds per track, it may not print the "Drive performs reliably..." message, but instead may simply stop execution. If the test attempts a speed of 6 milliseconds per track but fails to print the "Drive performs reliably..." message, then the fastest reliable seek time is 12 milliseconds per track. If the test stops executing without printing any message, type CTRL-C before you proceed to the next test.

You will probably want to perform this test on your other drives in order to determine the seek speed for all drives in the system. To do this, use the "Switch" TEST menu option to change the drive to be tested; then run the seek time test again. Set your operating system seek speed to that of the slowest drive in your system unless it has the ability to use different speeds for different drives.

A — ALIGN

NOTE: This procedure is for authorized service personnel only. Unauthorized use may void your drive warranty.

The Align menu option is used to align the disk drive read/write head. To use this option you will need an alignment diskette and a dual-trace oscilloscope with algebraic add. This option causes the disk drive read/write head to select a track on the disk which you specify. The drive will continue to select the track while you adjust the alignment. You can then respecify track numbers, continuing this procedure until the tracks on the alignment diskette produce the desired displays on the oscilloscope. **Be sure to read the disk drive manufacturer's instructions and the alignment disk manufacturer's instructions before using this program.**

To use the Align option, enter A and press RETURN when the TEST menu is displayed. The program will print:

```
          Radial head alignment:
WARNING -- Check your manual before proceeding
Insert the ALIGNMENT diskette in drive ?
Hit return when ready?
```

The program will have substituted the hardware number of the drive you have been testing for the ? in the sample message given above.

To begin the alignment procedure, insert the alignment diskette into the drive whose hardware configuration number appears in the message and press RETURN. The program will print:

```
Enter track number <0>
```

At this point, enter the first track number (as directed by the manual provided with the alignment disk) and press RETURN. The system will then print,

```
Enter side number <0>
```

Enter the side number (as per the directions provided with the alignment disk and/or disk drives) and press RETURN. The system will print:

```
CTRL-C -- request another track
CTRL-C -- return to menu
```

This message instructs you to type CTRL-C once to change the track number which you entered above, or type CTRL-C twice in succession to return to the TEST menu.

You will probably need to change the track number at least twice, but this will vary, and you should follow the alignment disk and disk drive manufacturer's instructions. To change the current track number, type CTRL-C once. The program will print:

```
Enter track number <0>
```

Now enter the new track number and press RETURN. The system will again print:

```
CTRL-C -- request another track
CTRL-C -- return to menu
```

When you have selected all tracks designated in the manufacturer's instructions, and achieved the desired oscilloscope displays for all designated tracks, type CTRL-C twice in succession to return to the TEST menu.

U — SWITCH

This procedure will restart TEST, thereby enabling you to select another drive unit to be tested, or to insert a new diskette. After you have typed U and pressed RETURN, TEST will restart itself. When you are asked which drive you want to test, enter the hardware number of the drive you want to test. You can change the diskette when you are asked to insert the diskette you wish to use for this test. If you are inserting a new diskette, be sure to use TEST menu option F to format the diskette before you perform tests.

Note that using "Switch" will enable you to alternate among your drives for as long as you wish to test them.

E — EXIT

To exit TEST, type E and press RETURN. This will return you to the diagnostic program's main menu.

Service

RECALIBRATION

You will need the following equipment to calibrate your Disk Controller Board:

- A Digital Voltmeter (DVM) with 3-1/2 digit readout.
- A calibrated oscilloscope with sweep speeds of 100 ns/cm and 200 ns/cm, and an operating scale of 5 V peak-to-peak.
- A Frequency Counter capable of measuring 2.00 MHz. (Optional, but preferred).
- HDOS 2.0 modified with INIT or CP/M 2.2.03 with FORMAT software.

If you cannot obtain the proper results in the following steps, refer to the "In Case of Difficulty" section of this manual and correct any difficulties before proceeding.

Refer to Figure 5-1 (Page 5-3) when you perform the "Recalibration."

VCO BIAS ADJUSTMENT

Warm up the Computer for a minimum of 15 minutes with the lid closed.

Connect your DVM to test point 1 on the H-/Z-89-37 board; connect the negative lead to ground and the positive lead to test point 1. The reading should be 1.38 to 1.42 V (this is the VCO bias voltage). If you do not obtain the proper voltage, adjust control R10.

Disconnect the DVM.

VCO CENTER FREQUENCY ADJUSTMENT (WITH FREQUENCY COUNTER)

This is the preferred method of adjusting the VCO's center frequency.

Connect the frequency counter to test point 2 on the board. Set the counter to the 100 ms time base. The counter should read from 1975 to 2025 kHz. If it does not, adjust control R17.

Disconnect the counter.

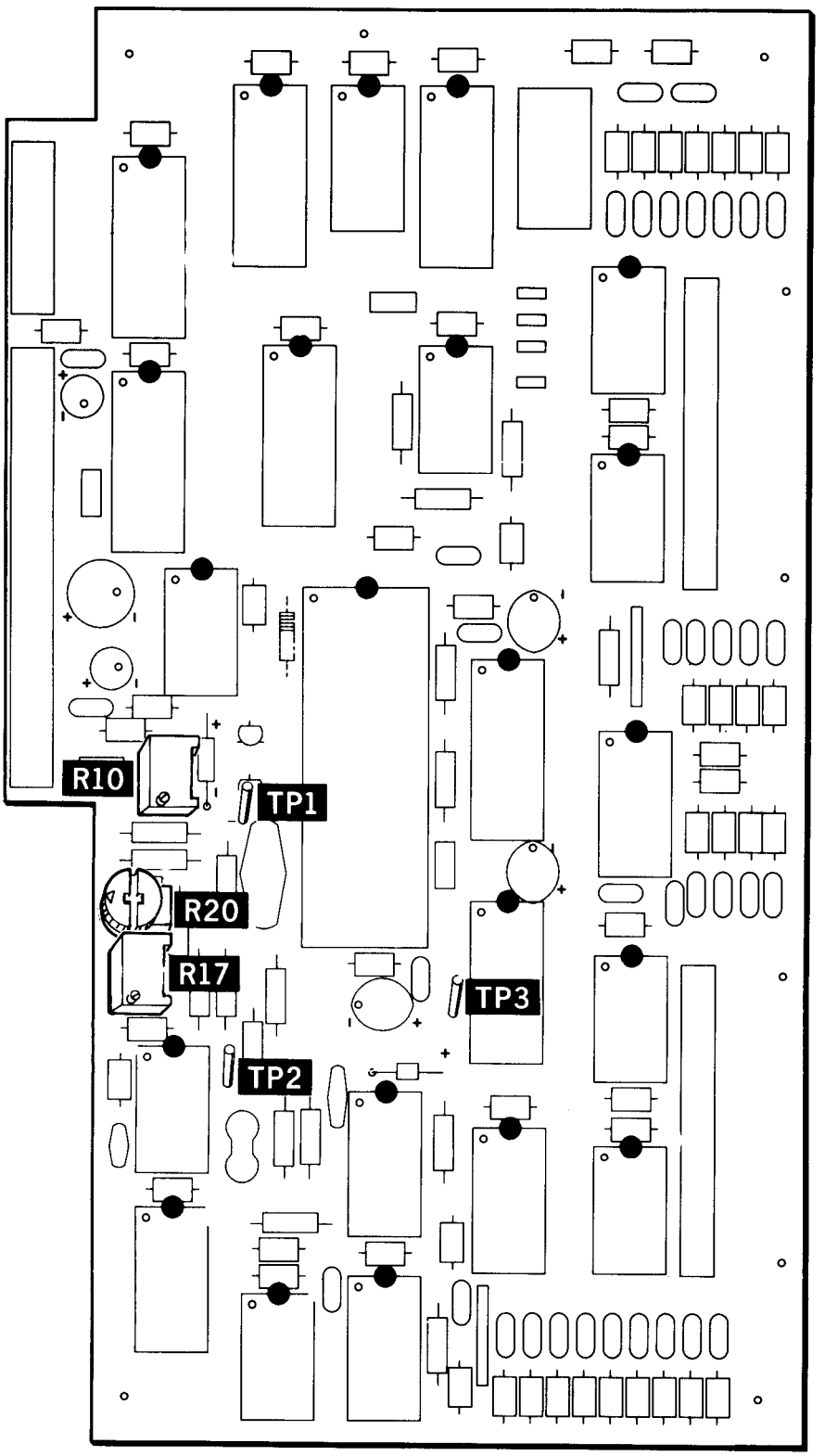


Figure 5-1

Z-89-37. Part number HE 181-3614

VCO CENTER FREQUENCY ADJUSTMENT (WITH OSCILLOSCOPE)

Connect the oscilloscope's input lead to test point 2.

Set the oscilloscope's sweep to 500 ns/cm. The period of the square wave displayed on the screen should be 493 to 506 ns. If it is not, adjust R17. See Figure 5-2.

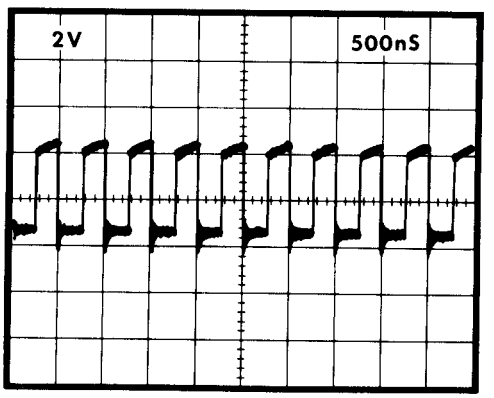


Figure 5-2

Disconnect the oscilloscope.

PRECOMPOSITION ADJUSTMENT

Connect the oscilloscope to test point 3.

Set the oscilloscope's sweep to 100 ns/cm.

Using your system's software (INIT in HDOS and FORMAT in CP/M), write on the disk in double-density mode. The period of the pulse displayed on the screen should be 300 to 350 ns. If it is not, adjust control R20. See Figure 5-3.

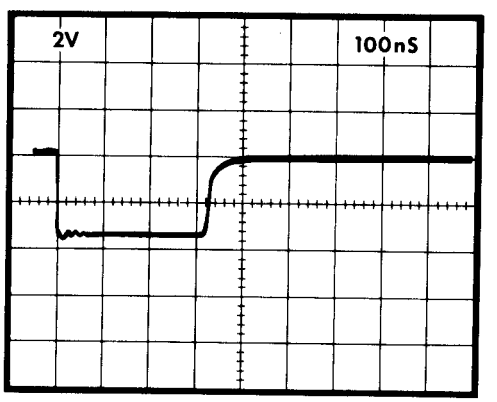


Figure 5-3

Disconnect the oscilloscope.

This completes the calibration of your disk controller board.

IN CASE OF DIFFICULTY

If your system does not operate properly, make the following checks.

PROBLEM	POSSIBLE CAUSE
Drive access light does not turn on when disk is booted.	1. Check for proper connections of floppy cable inside Computer. 2. Check for proper connections of rear panel extension cable inside Computer. 3. Be sure Z-37 or Z-87 is turned on. 4. Check positions of J1 and J2 on Z-89-37 circuit board. 5. Check U550 for correct part and installation.
Drive access light turns on but drive makes an unusual clicking sound.	1. Check positions of J4 through J9 on Z-89-37 circuit board.
All disk access lights turn on and remain on.	1. A cable is connected with marked edge on the wrong side.
Two drives turn on when a boot operation is selected.	1. Two drives have their disk selection jumpers programmed the same.
Computer only beeps once when turned on.	1. OFF LINE key in down position. Should be up. 2. U550, U516, or U518 installed incorrectly. 3. 3" jumper wire installed incorrectly. 4. 16-conductor cable with plugs installed incorrectly.
Computer will not accept boot command, returns to H: prompt, or starts to boot but does not return to H: prompt without reset.	1. Be sure disk is installed in selected drive before boot command is given. 2. If H-88-1 disk I/O is not installed, check for proper installation of the 4700 Ω resistor with connectors.

DECIMAL TO OCTAL TO HEX TO ASCII CONVERSION

I

DEC	OCT	HEX	ASCII
0	000	00	NUL
1	001	01	SOH
2	002	02	STX
3	003	03	ETX
4	004	04	EOT
5	005	05	ENQ
6	006	06	ACK
7	007	07	BEL
8	010	08	BS
9	011	09	HT
10	012	0A	LF
11	013	0B	VT
12	014	0C	FF
13	015	0D	CR
14	016	0E	SO
15	017	0F	SI
16	020	10	DLE
17	021	11	DC1
18	022	12	DC2
19	023	13	DC3
20	024	14	DC4
21	025	15	NAK
22	026	16	SYN
23	027	17	ETB
24	030	18	CAN
25	031	19	EM
26	032	1A	SUB
27	033	1B	ESC
28	034	1C	FS
29	035	1D	GS
30	036	1E	RS
31	037	1F	US

II

DEC	OCT	HEX	ASCII
32	040	20	SPACE
33	041	21	!
34	042	22	"
35	043	23	#
36	044	24	$
37	045	25	%
38	046	26	&
39	047	27	'
40	050	28	(
41	051	29	)
42	052	2A	*
43	053	2B	+
44	054	2C	,
45	055	2D	-
46	056	2E	PERIOD
47	057	2F	/
48	060	30	0
49	061	31	1
50	062	32	2
51	063	33	3
52	064	34	4
53	065	35	5
54	066	36	6
55	067	37	7
56	070	38	8
57	071	39	9
58	072	3A	:
59	073	3B	;
60	074	3C	<
61	075	3D	=
62	076	3E	>
63	077	3F	?

III

DEC	OCT	HEX	ASCII
64	100	40	@
65	101	41	A
66	102	42	B
67	103	43	C
68	104	44	D
69	105	45	E
70	106	46	F
71	107	47	G
72	110	48	H
73	111	49	I
74	112	4A	J
75	113	4B	K
76	114	4C	L
77	115	4D	M
78	116	4E	N
79	117	4F	O
80	120	50	P
81	121	51	Q
82	122	52	R
83	123	53	S
84	124	54	T
85	125	55	U
86	126	56	V
87	127	57	W
88	130	58	X
89	131	59	Y
90	132	5A	Z
91	133	5B	[
92	134	5C	\
93	135	5D	]
94	136	5E	^
95	137	5F	_

IV

DEC	OCT	HEX	ASCII
96	140	60	`
97	141	61	a
98	142	62	b
99	143	63	c
100	144	64	d
101	145	65	e
102	146	66	f
103	147	67	g
104	150	68	h
105	151	69	i
106	152	6A	j
107	153	6B	k
108	154	6C	l
109	155	6D	m
110	156	6E	n
111	157	6F	o
112	160	70	p
113	161	71	q
114	162	72	r
115	163	73	s
116	164	74	t
117	165	75	u
118	166	76	v
119	167	77	w
120	170	78	x
121	171	79	y
122	172	7A	z
123	173	7B	{
124	174	7C	|
125	175	7D	}
126	176	7E	~
127	177	7F	DELETE

Replacement Parts List

(Double-density disk controller circuit board part number HE 181-3614.)

CIRCUIT Comp. No.	PART NUMBER	DESCRIPTION
RESISTORS		
R1	HE 6-102-12	1000 Ω, 1/4-watt
R2	HE 6-103-12	10 kΩ, 1/4-watt
R3	HE 6-103-12	10 kΩ, 1/4-watt
R4	HE 6-102-12	1000 Ω, 1/4-watt
R5	HE 6-102-12	1000 Ω, 1/4-watt
R6	HE 6-104-12	100 kΩ, 1/4-watt
R7	HE 6-103-12	10 kΩ, 1/4-watt
R8	HE 6-102-12	1000 Ω, 1/4-watt
R9	HE 6-103-12	10 kΩ, 1/4-watt
R10	HE 10-1180	100 kΩ control
R11	HE 6-473-12	47 kΩ, 1/4-watt
R12	HE 6-473-12	47 kΩ, 1/4-watt
R13	HE 6-680-12	68 Ω, 1/4-watt
R14	Not Used	
R15	Not Used	
R16	HE 6-2002-12	20 kΩ, 1/4-watt
R17	HE 10-1154	10 kΩ, 1/2-watt control
R18	HE 6-1002-12	10 kΩ, 1/4-watt
R19	HE 6-222-12	2200 Ω, 1/4-watt
R20	HE 10-1138	10 kΩ, 3/4-watt control
R21	HE 6-124-12	120 kΩ, 1/4-watt
R22	HE 6-332-12	3300 Ω, 1/4-watt
INDUCTORS		
L1-L7	HE 235-192	35 μH, RF Choke
L8	HE 235-230	7 μH, Ferrite Core
L9	Not Used	
L10-L37	HE 235-230	7 μH, Ferrite Core

CIRCUIT Comp No.	PART NUMBER	DESCRIPTION
INTEGRATED CIRCUITS		
See the "Semiconductor Identification Charts."		
CAPACITORS		
C1-C16	HE 21-769	.01 μF ceramic
C17	HE 25-911	22 μF electrolytic
C18	HE 21-769	.01 μF ceramic
C19	HE 25-911	22 μF electrolytic
C20	HE 21-769	.01 μF ceramic
C21	HE 21-141	.0033 μF ceramic
C22	HE 21-769	.01 μF ceramic
C23	HE 21-769	.01 μF ceramic
C24	HE 21-769	.01 μF ceramic
C25	HE 21-769	.01 μF ceramic
C26	HE 21-769	.01 μF ceramic
C27	HE 20-96	36 pF mica
C28	HE 21-769	.01 μF ceramic
C29	HE 27-217	.68 μF Mylar*
C30	HE 21-192	.1 μF ceramic
C31	HE 25-195	2.2 μF tantalum
C32	HE 21-744	82 pF ceramic
C33	HE 21-192	.1 μF ceramic
C34	HE 21-769	.01 μF ceramic
C35	HE 25-197	1 μF tantalum
C36-C63	HE 21-773	470 pF ceramic
C64	HE 25-883	47 μF electrolytic
C65-C66	HE 25-841	4.7 μF tantalum
C67	HE 21-769	.01 μF ceramic
C68	HE 25-841	4.7 μF tantalum
C69	HE 21-769	.01 μF ceramic

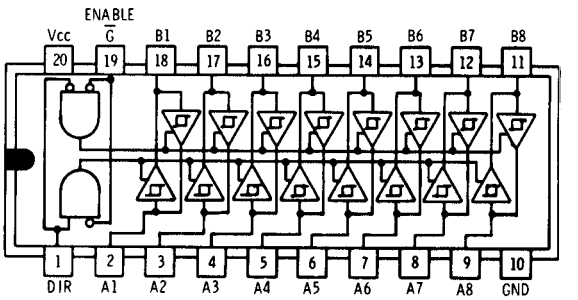
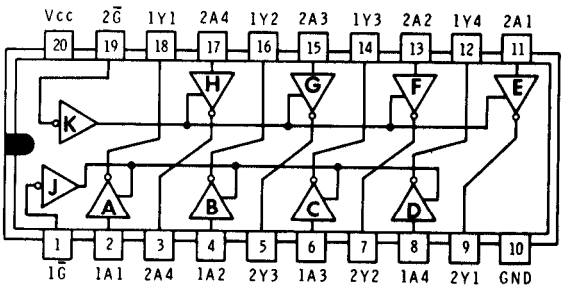
*DuPont Registered Trademark

MISCELLANEOUS

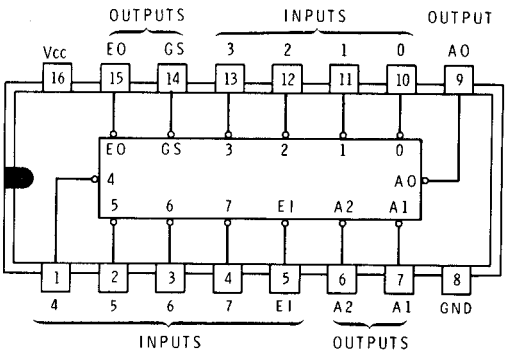
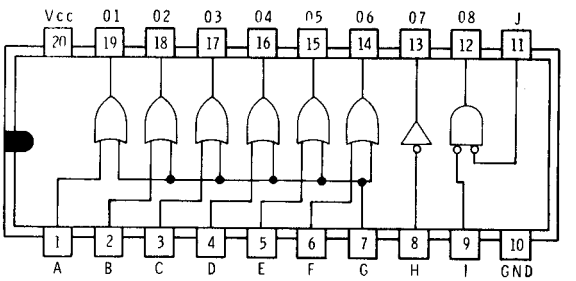
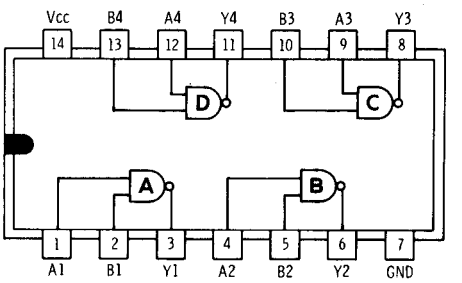
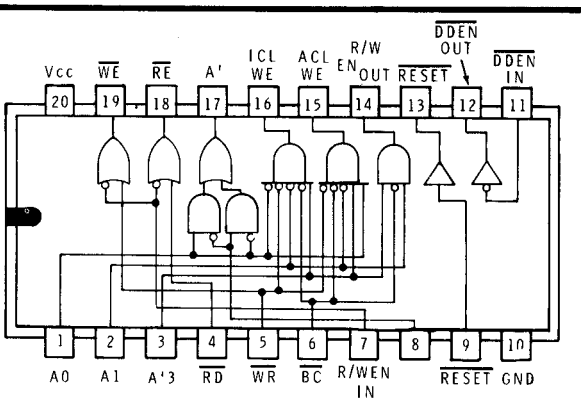
PART NUMBER	DESCRIPTION
HE 181-3614	89-37 controller board
HE 134-1158	16 conductor cable with plug
HE 134-1074	Floppy cable
HE 134-1163	Extension cable

Semiconductor Identification Chart

INTEGRATED CIRCUITS

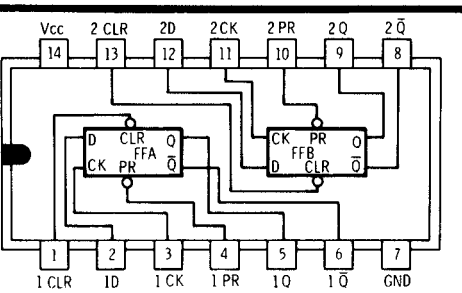
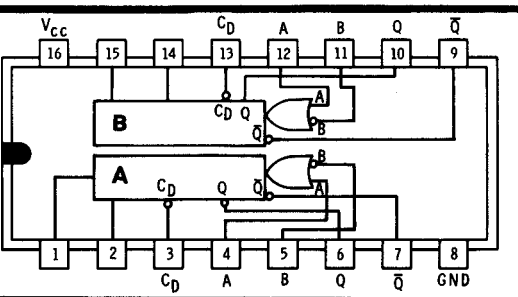
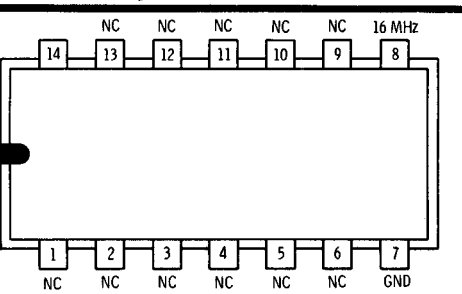
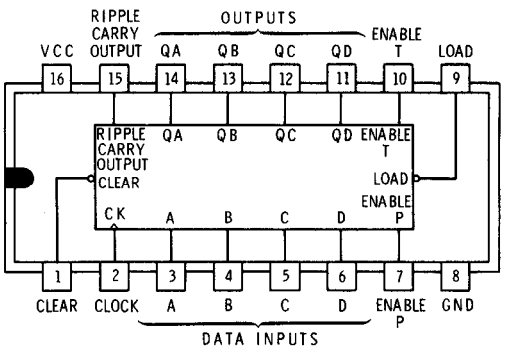
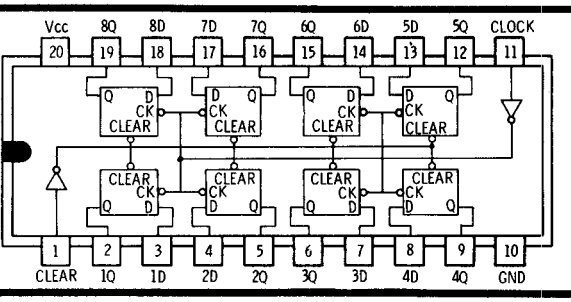
COMPONENT NUMBER	PART NUMBER	MAY BE REPLACED WITH	IDENTIFICATION
U1	HE 443-885	74LS245	
U2	HE 443-754	74LS240	

Integrated Circuits (Cont'd.)

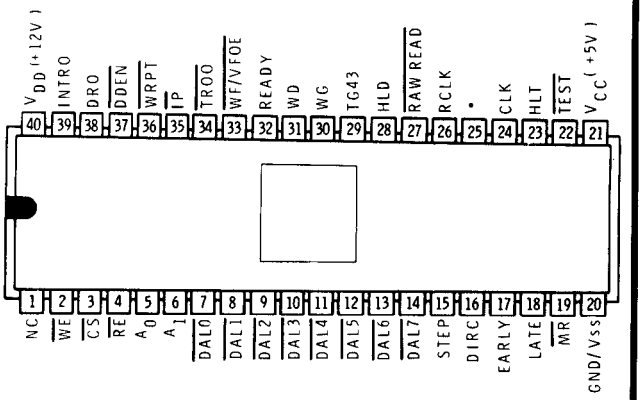
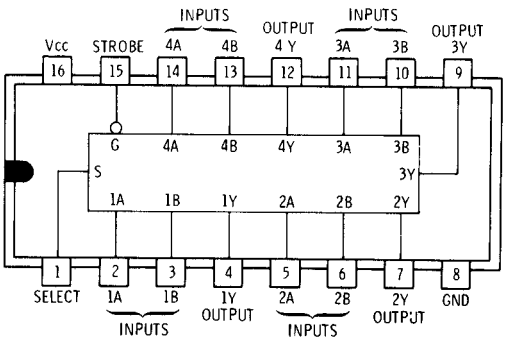
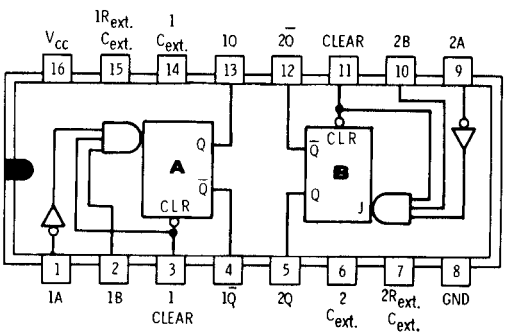
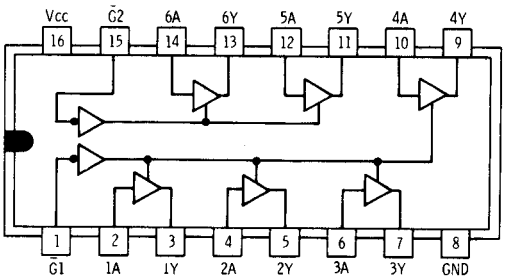
COMPONENT NUMBER	PART NUMBER	MAY BE REPLACED WITH	IDENTIFICATION
U3	HE 443-912	74LS148	
U4	HE 444-81	*	
U5	HE 443-745	74LS03P	
U6	HE 444-82	*	

*Only available from Heath Co.

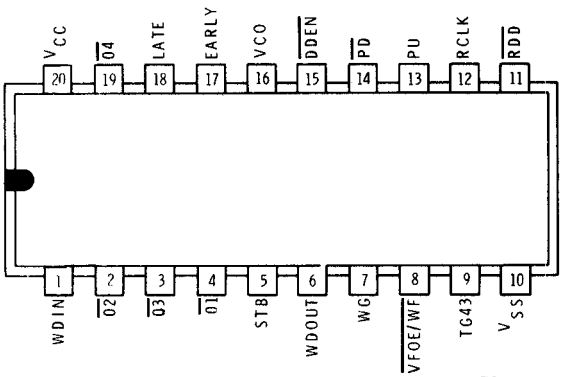
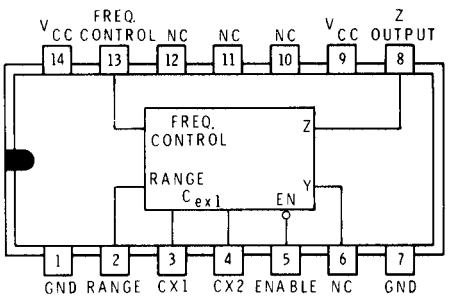
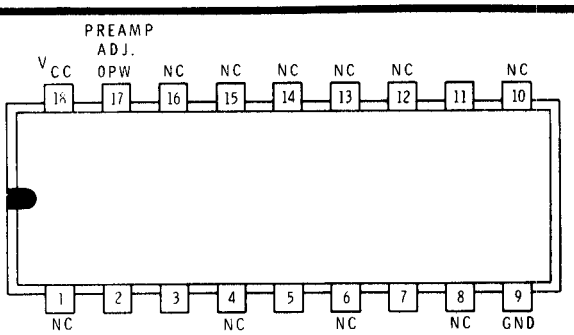
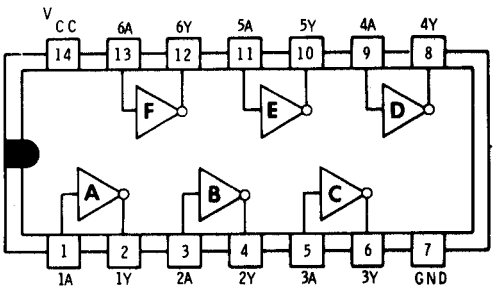
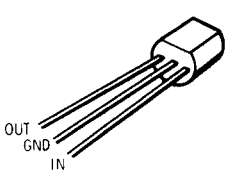
Integrated Circuits (Cont'd.)

COMPONENT NUMBER	PART NUMBER	MAY BE REPLACED WITH	IDENTIFICATION
U7	HE 443-730	74LS74	
U8	HE 443-727	96L02	
U9	HE 150-107	LOCO II 16 MHz Osc.	
U10	HE 443-757	74LS161	
U11	HE 443-805	74LS273	

Integrated Circuits (Cont'd.)

COMPONENT NUMBER	PART NUMBER	MAY BE REPLACED WITH	IDENTIFICATION
U12	HE 443-997	WD1797-02	
U13	HE 443-799	74LS157	
U14	HE 443-90	74123N	
U15	HE 443-857	74LS367	

Integrated Circuits (Cont'd)

COMPONENT NUMBER	PART NUMBER	MAY BE REPLACED WITH	IDENTIFICATION
U16	HE 443-998	WD1691	
U17	HE 443-999	74LS624	
U18	HE 443-1000	WD2143-03	
U19, U20, U21, U22	HE 443-73	7416N	
U23	HE 442-627	78L05	

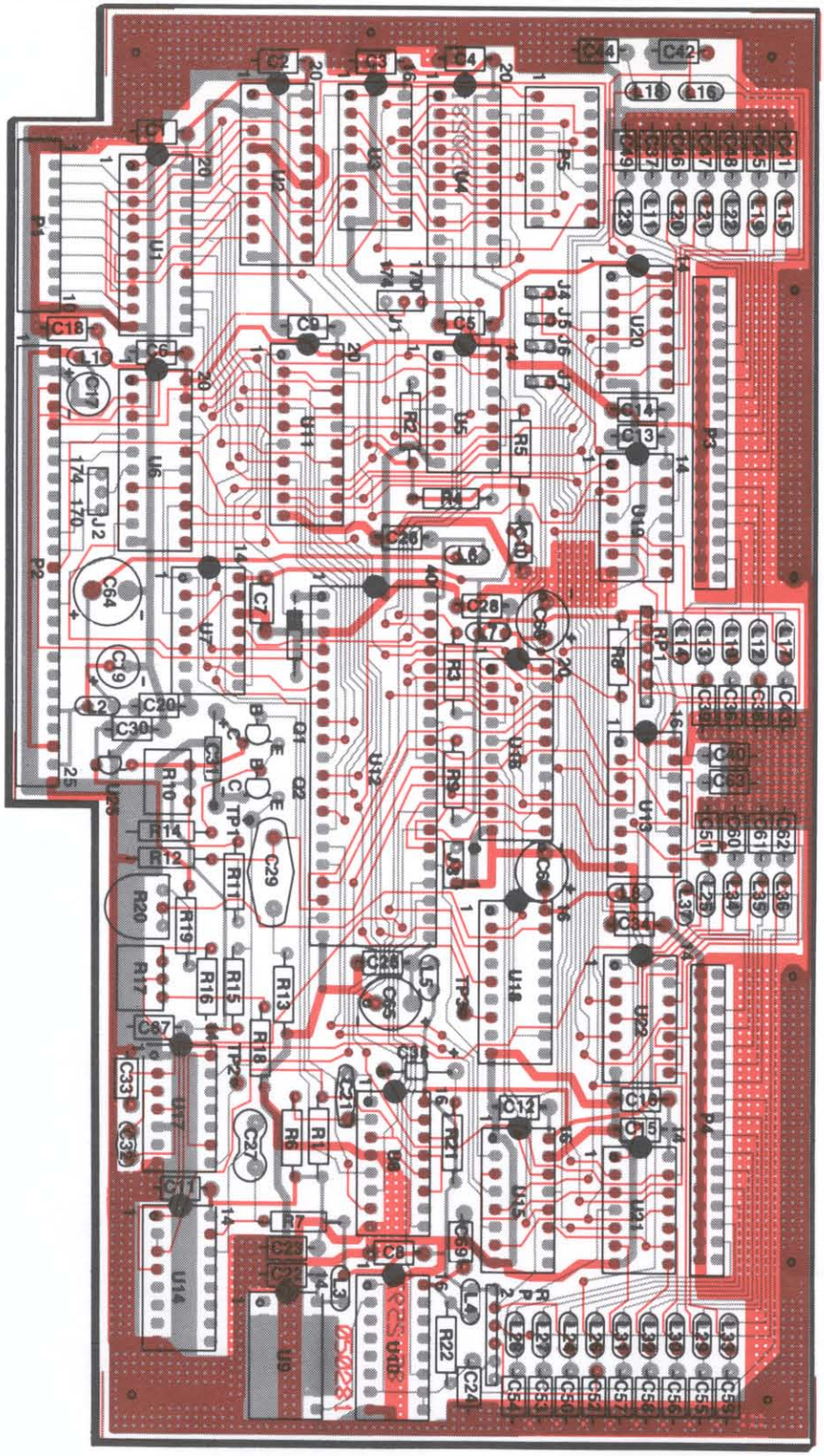
Circuit Board X-Ray View

NOTE: To find the PART NUMBER of a component for the purpose of ordering a replacement part:

A. Find the circuit component number (C101, C104, etc.) on the X-Ray View.

B. Locate the same number in the "Circuit Component Number" columns of the "Replacement Parts List."

C. Adjacent to the circuit component number, you will find the PART NUMBER and DESCRIPTION which must be supplied when you order a replacement part.



Z-89-37 DOUBLE-DENSITY DISK CONTROLLER BOARD

Part number HE 181-3614. Shown from the component side.