( ) Touch the ohmmeter probe to the round prong of the line cord. The ohmmeter should indicate zero ohms with Power switch S2 in either position.

( ) Disconnect the negative ohmmeter lead from the chassis and connect it to either flat prong of the line cord. Then touch the ohmmeter probe to the other flat prong. The ohmmeter should indicate infinity with Power switch S2 in one position (OFF) and 18 to 25 ohms with Power switch S2 in the other position (ON).

( ) Disconnect the negative ohmmeter lead from the line cord plug and reconnect it to the chassis.

( ) Set the ohmmeter to the R × 1000 range.

NOTE: If you do not obtain the correct indications in the three steps, interchange the meter leads and repeat the steps.

( ) Touch the ohmmeter probe to the positive (+) lead of capacitor C13. The ohmmeter should indicate 4000 ohms or higher. NOTE: It may take several seconds for the ohmmeter to reach the correct indication. This is due to the normal charging effect of capacitor C13.

( ) Set the ohmmeter to the R × 100 range.

( ) Touch the ohmmeter probe to the positive (+) lead of capacitor C15. The ohmmeter should indicate 500 ohms or higher.

( ) Disconnect the ohmmeter leads from the chassis.

This completes the "Primary Wiring Tests." If you obtained the correct indications in each of the above steps, proceed to "Voltage Tests." If any of the tests produced incorrect results, you must make the necessary corrections to obtain the correct results before you continue.

VOLTAGE TESTS

( ) Be sure POWER switch S2 on the rear panel is OFF (push down on the right side of the switch, as viewed from the rear of the chassis).

( ) Plug the line cord into the proper AC outlet.

( ) Connect the negative voltmeter lead to the chassis.

( ) Set the voltmeter to read +18-volts DC.

NOTES:

1. If you obtain the correct results in each of the following tests, proceed to "Final Assembly." If you do not obtain the correct results in any of the steps, refer to the "In Case of Difficulty" section of this Manual and correct the problem before you continue.

2. If you do not obtain the correct reading in the next step, immediately push POWER switch S2 to OFF and unplug the line cord.

3. When you turn the Plotter on, in the next step, the shaft of motor M1 may turn for a few seconds. This is normal.

( ) Touch the positive ohmmeter lead to the positive (+) lead of capacitor C13. Then push POWER switch S2 to ON. The voltmeter should indicate 12 to 18 volts. If you do not obtain the correct voltage indication, check the circuit board for an assembly error, such as an incorrectly installed diode or a solder bridge.

( ) Set the voltmeter to read +6 volts DC.

( ) Touch the positive voltmeter probe to the positive (+) lead of capacitor C15. The voltmeter should indicate 4.5 to 5.5 volts. If you do not obtain the correct voltage indication, check the circuit board for a solder bridge or an incorrectly installed integrated circuit (particularly U19 between the circuit board and the chassis).

( ) Push POWER switch S2 to OFF.

( ) Disconnect the voltmeter leads from the chassis and unplug the line cord.

This completes the "Voltage Tests."

FINAL ASSEMBLY

Refer to Pictorial 5-1 for the following steps.

( ) Position the carriage/drive assembly inside the chassis as shown in the Pictorial. Make sure the wires coming from the power transformer and solenoid are positioned between the transformer and the left side bracket as shown. Also make sure the twisted pair of wires coming from limit switch S1 is positioned between motors M1 and M2 and the right side bracket.

( ) Make sure there are no wires or cables pinched between the side brackets and the chassis. Then use 6-32 × 3/8″ hardware to secure the side brackets to the chassis at the four locations shown.

( ) Position the power transformer wires, the solenoid wires, and the LED cable coming from the circuit board as shown. Then refer to the inset drawing on the Pictorial and install a cable tie around these wires and the circuit board mounting stud at CC. Pull the cable tie only until it is snug. Then cut off the excess cable tie.

( ) Position the cable coming from motor M2 and the wires coming from limit switch S2 as shown. Also be sure the wires are away from keyboard plug H3. Then install a cable tie around these wires and the circuit board mounting stud at CD. Pull the cable tie only until it is snug and cut off the excess tie.

( ) Sight between the circuit board and the platen and position the wires and cables away from the large vertically-mounted resistors that are mounted on the circuit board. These resistors become hot during normal operation.

( ) Refer to Detail 5-1A and install the pen holder and pen holder support onto the carriage as shown. NOTE: The pen holder will snap into place when you have it properly installed in the support.

( ) Carefully peel the backing paper from the blue and white label. Then press the label onto the inside of the chassis in the area shown. Be sure to refer to the numbers on this label in any communications you may have with the Heath Company about your kit.

Refer to Pictorial 5-2 for the following steps.

( ) Position the chassis as shown in the Pictorial.

( ) Loosen the hardware on pulley BB, if this has not already been done.

( ) Push the timing belt between the tabs of the carriage so the teeth in the belt are facing upward as shown.

( ) Position the timing belt around the belt drive pulley and pulley BB. Then slide the pulley toward the left until the belt is just snug and tighten the pulley hardware.

NOTE: When you install the limit switch stop tab in the next step, you may find it easier if you mark the timing belt (with a felt-tip marker or something similar). You can then move the belt to a more accessible position to install the stop tab.

( ) Turn the belt drive pulley in a clockwise direction until the carriage just touches the left side bracket. Then push the limit switch stop tab onto the timing belt as shown so it holds down the limit switch actuator. When you have the stop tab properly installed, limit switch S1 will close just before the carriage touches the left side bracket. Turn the belt drive pulley back and forth several times to make sure you have the stop tab properly installed.

( ) Use a cable tie to secure the cable coming from motor M1 and the wires coming from limit switch S1 to the right side bracket as shown. Pull the cable tie only until it is snug and cut off the excess tie.

( ) Position the wires coming from the limit switch so they do not interfere with or rub against the timing belt or belt drive pulley.

( ) Install a cable tie around the black wires coming from power transformer T1 and the wires coming from the solenoid. Cut off the excess tie.

( ) Push down on the Paper Load Button. If the left penlift arm rubs on the insulator paper (on the power transformer), mash down on the insulator as necessary to provide some clearance.

Refer to Pictorial 5-3 for the following steps.

( ) Position the case near the chassis assembly as shown in the Pictorial. Then push the socket on the end of the cable coming from the keyboard onto circuit board plug H3. Be sure the violet wire is at plug pin 1.

( ) Push the free end of the LED cable coming from the circuit board onto the leads of the LED at CR13. Be sure the black wire goes to the shorter LED lead. Also be sure to hold the LED in place in the case while you press the socket onto the leads (otherwise, you may push the LED out of the case).

( ) Position the case onto the chassis as shown. Be sure there are no wires or cable pinched between the case and the chassis. Then use four 6-32 × 3/8" screws to secure the case into place.

( ) Date and sign the FCC label. Carefully peel the backing paper from the label. Then press the label onto the bottom of the chassis in the area shown.

This completes the assembly of your Plotter. Proceed to "Installation."

INSTALLATION

To prepare your Plotter for operation, simply plug the line cord into a standard AC outlet (109 – 120 VAC, 55 – 65 Hz). For your protection, a 3-wire line cord is supplied to provide proper grounding. Do not use a cheater adaptor or attempt to defeat this ground circuit. To do so could expose you to hazardous operating conditions.

The only other connection required is a cable that connects between the parallel interface port on the back of the Plotter and the parallel port on your computer (see Pictorial 6-1). Ready-made cables that connect the Plotter to many popular computers are available from the Heath Company. Refer to a recent catalog for a listing of the cables that are available and their prices. A software-support package is also included with each cable to help you get the most out of your Plotter.

NOTE: Be sure your disk that contains the operating system (the disk you boot from) has been configured for parallel output. Consult your Operating System Manual for more information.

PARALLEL INTERFACE

NOTE: The following information is provided in the event an interface cable is not available for your particular computer. You should be able to use this information to modify one of the available cables to fit your computer.

Communication between your computer and the Plotter is via a 20-pin parallel interface port on the rear of the Plotter. If your computer is able to send ASCII (American Standard Code for Information Interchange) via a parallel interface to a printer, it can communicate with the Plotter.

The Plotter uses seven data bits, a data available STROBE line, an acknowledge (ACK) line, and a BUSY line. The DAV and ACK lines are active low. Pictorial 6-2 shows you how the pins of the interface port are numbered and the signal that is available at each pin. Be sure to connect each pin to the proper point in your computer.

This completes the "Installation." Proceed to "Operation."

OPERATION

Your Plotter can produce a wide range of statistical graphics for business, engineering, and science. Pictorial 7-1 shows you some of the Plotter's many capabilities.

The following sections provide you with information so you can create graphics to fit your own requirements.

GENERAL INFORMATION

Refer to Pictorial 7-2 and 7-3 as you read the following information.

The following paragraphs will familiarize you with the external parts of your Plotter.

Carriage Parts

Keyboard — Twelve keys that control Plotter movement.

Grip wheels — Move paper or Mylar on the X-axis.

Pen holder — Moves the pen on the Y-axis.

Platten — Antistatic platform on which the Plotter draws.

Keyboard Controls

PEN UP — Lifts the pen.

PEN DOWN — Lowers the pen.

POSITION (arrow) KEYS — Advance the pen forward, backwards, left, or right, depending upon the direction of the arrow. The pen will move at 45° angles when you press two adjacent position keys at the same time.

FAST — Accelerates the pen speed.

UPPER RIGHT — Moves the pen to the upper right location of the plotting area. You will also use this key when you load paper.

LOWER LEFT — Moves the pen to the lower left location of the plotting area (home position).

PAUSE — Suspends the plotting activity and moves the paper out to the full view position. You can use this key when you desire to change the pen.

SELF TEST — Activates a test plot program to test the Plotter's operation. Refer to the "In Case of Difficulty" section for more information about this key.

PEN DELAY — Causes a "pen drop" delay during Pen Up and Pen Down functions.

Rear Panel Controls

POWER SWITCH — Turns the Plotter On and Off.

FUSE — Contains a standard 630 mA fuse, which is available from the Heath Company or from some electronic stores. For your safety, unplug the line cord when you change the fuse.

USING YOUR PLOTTER

The following steps show you how to operate your Plotter.

Inserting the Pen

1. Be sure the Plotter is in the Idle mode, Pause mode, or off.

2. Remove the cap and test the pen on a piece of scrap paper to make sure the ink flows properly.

3. Refer to Pictorial 7-4 and insert a pen into the holder. Then rotate the pen 1/4-turn either clockwise or counterclockwise to lock the pen into position.

4. Be sure to remove the pen and replace the cap when you are finished using the Plotter.

Loading the Paper

1. Push the POWER switch on the rear panel to ON, if this has not already been done.

2. Press the UPPER RIGHT key. The pen will move to the upper right location of the plotting area.

3. Press down on the PAPER LOAD button while you slide the paper or Mylar under the grip wheels. Center the paper on the platen as you would when you load a typewriter. Slide the paper forward until its leading edge is aligned with the paper index mark (which is 1/4" past the grip wheels). See Pictorial 7-5.

4. Release the PAPER LOAD button. Make sure the paper stays flat on the platen.

Turning the Power On

1. Push the POWER switch on the rear panel to ON.

Operating the Plotter

1. When the pen and paper are in position, the Plotter is ready for operation. The "Programming" section, which follows, describes the commands you will use during operation.

2. If this is the first time you are using the Plotter, you may wish to check its operation. To do this, simply press the SELF TEST key. The Plotter will draw a test plot.

3. If the Plotter does not draw a test plot, make sure you have the pen and paper properly installed. Also make sure the Plotter is turned on. Refer to the "In Case of Difficulty" section if you still do not obtain the proper results.

4. Once you have confirmed that the Plotter is operating properly, you can reload paper and begin operation.

Turning the Power Off

1. Push the POWER switch on the rear panel to OFF when you are finished using the Plotter.

PROGRAMMING

Your tool for communicating with the Plotter is a set of organized instructions called a program. You are probably already familiar with the use of programs for your computer. The software that is available for this Plotter is user friendly and prompts you through each step. A variety of programs are available so you can expand the capabilities of your Plotter.

If you prefer to design your own software for the Plotter, study the information in this section in detail. We recommend that you use the BASIC language, although you can also use Pascal, Fortran, and many other languages.

The Plotter has a set of commands that are related to pen movement. Each command is described below through the use of examples. Programming examples are also provided at the end of this section.

Whether you design your own program or use prepackaged programs, you must be familiar with the plotting area of the Plotter. The Coordinate System is described next.

PEN MOVEMENT AND THE COORDINATE SYSTEM

This Plotter uses a Cartesian Coordinate System, which breaks the plotting area up into thousands of plotter units. These plotter units are points along the X (horizontal) and Y (vertical) axis.

Just as you use latitude and longitude coordinates to locate a location on a map, you can use X and Y coordinates to locate individual plotter units.

The X and Y coordinates express the plotter unit distance from the home position (0,0). When you reference the coordinates, the X-axis position is given first, followed by the Y-axis position. Point (250,500), for example, is located 250 units to the right of (0,0) on the X axis and 500 units above (0,0) on the Y axis.

On a standard 8-1/2″ × 11″ page with 1/2″ margins, the plotting surface is 7.35″ × 10″. Since the plotter units are 0.004″ apart, there are 1838 plotting units along the Y axis and 2500 plotting units along the X axis. See Pictorial 7-6.

To move the pen, you must assign a plotter unit designation. The pen will proceed from one point to the next point in the order you program them. This drawing process is similar to the "follow the dot" pictures you may have done as a child. After you load the paper, the Plotter uses plotter unit (2500,1838) as its starting point, unless you specify otherwise.

It may seem tedious to assign coordinates to every single point in a graph or drawing. Fortunately, the Plotter has several pen movement commands, such as MOVE and DRAW RELATIVE, that eliminate the need to always specify actual coordinates.

This Plotter has a memory capacity that extends well beyond its physical plotting area (1838 × 2500 units) as shown in Pictorial 7-7. The memory limits are plus (+) 32,768 units along the X and Y axes. Not only do the plotter units extend 32,768 to the right on the X axis and 32,768 up on the Y axis; but if you enter negative (−) numbers, the plotter units extend 32,768 to the left on the X axis and 32,768 down on the Y axis. Actually, the physical plotting area is a small portion of a 65,536 × 65,536 unit-addressable area.

If you program points that are outside of the Plotter's physical plotting area, the pen will lift when it reaches the outer limits of its boundaries. The Plotter keeps track of the program, however, and resumes pen operation once the coordinates fall back within its physical plotting area.

Since the memory extends beyond the physical plotting area, you can store the layout of a large drawing in memory, and then draw the layout in sections.

In addition, the Plotter accommodates long rolls of paper (8-1/2″ wide) and allows the paper to move along the X-axis past 11″ up to 121″. The memory is large enough to meet complex needs that you may have in the future.

PROGRAMMING INSTRUCTIONS

You will enter commands by typing abbreviated command symbols followed by either text (alphanumeric characters), plotter units, or coordinates. To use the Move Absolute command, for example, you would type:

MA x,y; (for example: MA 500,500;)

When you specify plotter units or coordinates, you must give the X unit first followed by the Y unit. These coordinates and plotter units must be within ± 32,786. The semicolon at the end of the command line tells the Plotter that the command is finished.

When you are drawing a series of lines (Draw Absolute, Move Absolute, Draw Relative, Move Relative, Point, and Line), or making several moves of the same command, there is no need to enter separate command lines. Simply enter the command followed by the plotter units or coordinates in the order you desire. Separate each set of numbers with a comma and enter a semicolon when you complete the series. To draw a series of lines from point to point using the Draw Absolute commands, for example, you would type:

DA x_1,y_1,x_2,y_2,x_3,y_3...x_n,y_n;

The Print Statement

A print statement enables your computer to communicate with the Plotter. A print statement, which is identical to those you use with a printer, must preceed all plotter commands or the plotter will not receive the command. An example of the print statement for a typical computer is shown below. Note that the plotter command is enclosed in quotation marks.

LPRINT "MA 500,500;"

Print statement formats vary from one computer to another. The correct print statement for your computer is described on the software disc that has been prepared specifically for your computer. Refer to item 5 of the "Programmer's Tutorial."

Default Values

Your Plotter is preprogrammed with settings for certain commands. These settings are called "default values." Unless you specify different numbers, the Plotter will automatically use the default values listed below:

Pen Up:	Pen in up position.
Pen Position:	2500,1838.
Character Size:	1 (20 plotter units high).
Character Rotation:	0 (characters print on positive X axis).
Pen Speed:	5.7 inches per second.
Paper Length:	11″ with 1/2″ margins.
Text Delimiter:	;

PLOTTER COMMANDS

Refer to Pictorial 7-8 as you read the following information.

Move Absolute(MA)

Function: Moves the raised pen to a specified point.

Enter: MA x,y;

Example: MA 500,500;

The raised pen moves from its current position to point (500,500).

Draw Absolute(DA)

Function: Moves the lowered pen to a specified point.

Enter: DA x,y;

Example: DA 500,500;

The lowered pen draws a line from its current position to point (500,500).

Move Relative(MR)

Function: Moves the raised pen from its current position to another point according to the amount of units specified. Positive numbers will move the pen right (▶) along the X axis and up (▲) along the Y axis. Negative (−) numbers will move the pen left (◀) along the X axis and down (▼) along the Y axis.

Enter: MR x,y;

Example: MR 20, − 20;

The raised pen moves from its current position to a point that is 20 units to the right and 20 units down.

Draw Relative(DR)

Function: Moves the lowered pen from its current position to another point according to the amount of units specified. Positive numbers will move the pen right (▶) along the X axis and up (▲) along the Y axis. Negative (−) numbers will move the pen left (◀) along the X axis and down (▼) along the Y axis.

Enter: DR x,y;

Example: DR 20, − 20;

The lowered pen draws a line from its current position to a point that is 20 units to the right and 20 units down.

Refer to Pictorial 7-9 as you read the following information.

Line(LN)

Function: Draws a line between two sets of coordinates.

Enter: LN x_1,y_1,x_2,y_2;

Examples: LN 20,30,200,300
Draws a line from point (20,30) to point (200,300).

LN 20,30,200,300,44,80,76,503;
Draws a line from point (20,30) to point (200,300) and draws another line from point (44,80) to point (76,503).

Point(PT)

Function: Moves the pen from its current position to a specified plotter unit and makes a point mark.

Enter: PT x,y;

Example: PT 600,600;

The pen makes a point at plotter unit (600,600).

Pen UP(PU)

Function: Raises the pen.

Enter: PU;

Pen Down(PD)

Function: Lowers the pen.

Enter: PD;

The pen will return to the up position after 10 seconds if no instructions are received from either the computer or the Plotter keyboard. This feature prevents ink from bleeding out of the pen onto the plotting surface.

Reset(RE)

Function: Reinitializes the plotter. All settings return to the default values.

Enter: RE;

Home(HO)

Function: Returns the pen to the home position (0,0) at the lower left corner of the plotting area.

Enter: HO;

Page Length(PL)

Function: Sets the page length. The minimum setting should be more than 1 (1″), since the Plotter automatically sets 1/2″ margins at the top and bottom of the page. The maximum setting is 121 (121″).

Enter: PL n;

Example: PL 16;

Page length is 16″ with 1/2″ margins at the top and bottom of the page.

Velocity Setting(VS)

Function: Changes the speed of the pen and paper movement. The slowest rate is 1.4″ per second, which causes the drawing to be made at 1.4″ per second. The fastest rate is 6″ per second, which causes the drawing to be made at 6″ per second. Speed settings range from 0 to 15, where VS15 is 6" per second and VS0 is 1.4″ per second.

Enter: VS n;

Example: VS 6;

Drawing is made at 2.62″ per second.

The velocity settings and corresponding pen speeds are listed below:

Velocity Setting (VS)	Maximum Pen Speed (inches/second)
0	1.40
1	1.55
2	1.70
3	1.89
4	2.13
5	2.35
6	2.62
7	2.92
9	3.65
10	4.13
11	4.61
12	5.06
13	5.46
14	5.72
15	6.00

Text(TX)

Function: Draws alphanumeric characters (numerals, letters, punctuation marks, symbols) at the current pen position. If text is required in a specified position, the pen must be moved to the position with the proper command.

Characters to be drawn are indicated by enclosing them within text delimiters. The default text delimiter is a semicolon (;). You can choose a different text delimiter by using the Text Delimiter command (TD) explained next.

Enter: TX;a,b,c,d...x;

Example: TX;Heath;

Draws Heath starting at the current pen position as shown in Pictorial 7-10.

Refer to Pictorial 7-11 as you read the following information.

Text Delimiter(TD)

Function: Changes the text delimiter.

Enter: TDc;

When you enter this command, the character immediately following the TD becomes the text delimiter. If you place a space after TD, the space becomes the text delimiter.

Example: TD';

The single quote (') becomes the new text delimiter. If you use the example from the Text command, you would enter:

TX'Heath';

Character Size(CS)

Function: Specifies the size of the alphanumeric characters to be drawn. The basic size is 1 (20 plotter units high and 12 to 16 plotter units wide, 0.08″ × 0.048″ – 0.064″). Spaces between the characters vary from 6 to 10 units (0.024″ to 0.04″). The maximum character height is 255 (5100 plotter units high, 20.4″). At 255, the character size exceeds the plotting surface.

Enter: CS n;

Example: CS5;
TX'Heath';

The text, Heath, is drawn at a height 5 times the basic size (100 plotter units high, 0.4″). You should enter the character size (which is CS5 in this example) before you enter the text command. If you do not enter the character size, the Plotter uses the size that was specified previously.

All characters reside in a basic 22- × 20-unit grid (22 along X and 22 along Y). The actual size and spacing may be calculated by the following formulas:

Height = (0.004″) × (20) × (character size setting)

Length = (0.004″) × (22) × (character size setting)

You can calculate the length of a string of characters by multiplying the calculated length of a single character by the number of characters.

Mark(MK)

Function: Draws a specified character around the current pen position. This command is similar to the TX command except that the pen returns to the original coordinate position after it draws the character. This command is useful for labeling points on a graph. Like TX, Mark uses text delimiters to indicate the character to be drawn.

Example: MK'A';

Draws a letter A around the current cursor pen position.

Refer to Pictorial 7-12 as you read the following information.

Rotation(RO)

Function: Sets the angle at which the alphanumeric characters are to be drawn. The four available settings are:

0° — Characters read upright along the X axis (default setting)

90° — Characters read upright along the Y axis.

180° — Characters read upside-down along the X axis.

270° — Characters read upside-down along the Y axis.

Example:
RO 90;
TX'Heath'

The text Heath is drawn upright along the Y axis.

NOTE: The current rotate command remains in effect until you change it with a new RO command.

Axis X(AX)

Function: Draws a line along the positive X axis with ticks spaced at a specified distance. Since the line is drawn from the current pen position, you must use the proper command to move the pen to the point where you wish to start.

Enter: AX n,t_s,t_1;

n = The length of the X axis.
Minimum length is 1 plotter unit.
Maximum length is 32,767 units.

t_s = The distance between ticks.
Minimum distance is 1 plotter unit.
Maximum distance is 32,767 units.

t_1 = The length of the ticks.
Minimum length is 1 plotter unit.
Maximum length is 255 units.

Example: AX 1000,100,20;

Draws a line along the positive X axis which is 1000 units (4″) long from the current pen position. The ticks are at 100 units (0.4″) intervals and are 20 units (0.08″) long.

Axis Y(AY)

Function: Similar to the AX command, except the line with the ticks is drawn along the positive Y axis.

Enter: AY n,t_s,t_1;

Example: AY 1000,100,20;

Draws a line along the positive Y axis from the current pen position. The line is 1000 units (4″) long with ticks are at 100 units (0.4″) intervals and 20 units (0.08″) long.

PROGRAMMING EXAMPLES

Refer to Pictorial 7-13 as you read the following information.

This section of the Manual contains examples to help you plan and design your own programs. If you wish to learn more about programs, we recommend that you take a course in BASIC. The Heathkit Model EC-1110 Microsoft BASIC Programming Course is an excellent home-study course.

For the following examples, assume that the Plotter is connected to a Heathkit Computer. These examples use Microsoft BASIC to communicate with the Plotter and the computer uses the same LPRINT statement required for a printer as shown below:

```
LPRINT "MA 500,500;"
```

Sends a print command to the plotter.

Example 1

This example draws both X and Y axes that are 4 inches long (1000 plotter units).

```
10 LPRINT "MA 500,500;"
20 LPRINT "DA 1500,500;"
30 LPRINT "MA 500,500;"
40 LPRINT "DA 500,1500;"
50 END
```

Example 2

This example draws four tick marks on both the X and Y axes.

```
10 LPRINT "LN 750,500,750,550,1000,500,1000,550;"
20 LPRINT "LN 1250,500,1250,550,1500,500,1500,550;"
30 LPRINT "LN 500,750,550,750,500,1000,550,1000;"
40 LPRINT "LN 500,1250,550,1250,500,1500,550,1500;"
50 END
```

Example 3

This example draws four points within the graph.

```
10 LPRINT "PT 750,750;PT 1000,1250;PT 1250,1000;PT 1500,1500;"
20 END
```

Example 4

This example draws a continuous line that connects the points created in Example 3.

```
10 LPRINT "MA 500,500;"
20 LPRINT "DA 750,750,1000,1250,1250,1000,1500,1500;"
30 END
```

Example 5

This example labels the X axis as YEAR and the tick marks as 1980 through 1983.

```
10 LPRINT "RO 0;CS 1;MA 730,420;TX;80;MA 980,420;TX;81;"
20 LPRINT "MA 1230,420;TX;82;MA 1480,420;TX;83;"
30 LPRINT "MA 910,350;CS 2;TX;YEAR;"
40 LPRINT "CS 1; MA 420,735;TX;1;MA 420,985;TX;2;"
50 LPRINT "MA 420,1235;TX;3;MA 420,1485;TX;4;"
60 LPRINT "MA 350,690;RO 90;CS 2;TX;DOLLARS(100,000);"
70 END
```

Example 6

This example draws specified characters at the points created in Example 3.

```
10 LPRINT "MA 500,500;RO 0;"
20 LPRINT "DR 250,250;CS 1;MK;A;DR 250,500;MK;B;"
30 LPRINT "DR 250,-250;MK;C;DR 250,500;MK;D;"
40 END
```

Example 7

This example is an interactive program that draws and labels the X and Y axes. The program will ask you to enter your sales figures for the years 1980 through 1983. Your answer must be between 0 and 400,000. You must take this limitation into account when you label the Y axis. It may be necessary, for example, to use DOLLARS-THOUSANDS, DOLLARS-MILLIONS and so on.

```
10 LPRINT "RO 0;"
20 REM * DRAW X AND Y AXIS *
30 LPRINT "MA 500,500;AX 1000,250,50;"
40 LPRINT "MA 500,500;AY 1000,250,50;"
50 REM * LABEL X AXIS *
60 LPRINT "CS 1;MA 730,420;TX;80;MA 980,420;TX;81;"
70 LPRINT "MA 1230,420;TX;82;MA 1480,420;TX;83;"
80 LPRINT "MA 910,350;CS 2;TX;YEAR;"
90 REM * LABEL Y AXIS *
100 LPRINT "CS 1;MA 420,735;TX;1;MA 420,985;TX;2;"
110 LPRINT "MA 420,1235;TX;3;MA 420,1485;TX;4;"
120 LPRINT "MA 350,690;RO 90;CS 2;TX;DOLLARS (100,000);"
130 REM * STARTING POINT *
140 REM * OF GRAPH *
150 LPRINT "MA 500,500;"
160 LET YR = 1980: LET SO = 0
170 CLS: REM * CLEAR SCREEN * (This varies between computers.)
180 FOR X = 350 TO 1100 STEP 250
190 PRINT "ENTER SALES FOR"; YR; "(SUCH AS 125000)";
200 INPUT S1
210 IF S1 => 0 AND S1 =< 400000 THEN GOTO 250
220 PRINT "ANSWER MUST BE BETWEEN 0 AND 400000"
230 PRINT "FOR NEGATIVE NUMBERS INPUT 0"
240 GOTO 190
250 REM * CONVERT SALES *
260 REM * FIGURES TO *
270 REM * POINT ON GRAPH *
280 LET S1 = (S1/100000) * 250
290 REM * MAKE SURE THAT *
300 REM * PARAMETERS ARE *
310 REM * OF TYPE INTEGER *
320 LET S1 = INT(S1)
330 REM * FIND DIFFERENCE *
340 REM * IN THE Y AXIS *
350 REM * FROM LAST POINT *
360 REM * AND CURRENT POINT *
370 LET S = S1 - SO
380 LET YR = YR + 1: LET SO = S1
390 LPRINT "DR"; 250; ","; S; ";"
400 NEXT X
410 END
```

DEMONSTRATION AND PROGRAMMING DISK

NOTE: The Demonstration and Programming Disk is part of the support package.

The introductory software package demonstrates the capabilities of the Plotter. These programs are written to have you plotting graphs in minutes, even if you have never used a plotter before.

USING THE DEMONSTRATION DISK

Be sure you have your Plotter properly connected to your computer (refer to the "Installation" section of this Manual). Load the plotter with paper and pen. Turn on the computer and Plotter and insert the demonstration diskette into the computer's default drive (may be designated as SY0, Drive 1, or Drive A).

The following message will appear on the monitor:

```
PRESS ANY KEY
```

Press any key and the following message will appear:

```
WOULD YOU LIKE TO USE THE DEMO?
IF SO THEN PRESS THE RETURN KEY
IF NOT THEN PRESS ANY OTHER KEY
```

Press the RETURN key and the following message will appear:

```
PLEASE CHOOSE ONE OF THE FOLLOWING
WATCH ME DRAW A PLOT
HELP ME DRAW A PLOT
```

The Demonstration is able to draw plots with or without your help. Enter whichever you desire.

Watch Me Draw a Plot

This program offers the following demonstration Programs:

```
1) DEMO 1
2) LINE CHART
3) TITLE PAGE DESIGN
4) MATH DEMO
5) SPACE SHUTTLE
6) ROBOT
7) RETURN (Exits from this menu.)
```

All of these programs, except Return (which does not draw a plot), draw plots without your help.

Help Me Draw a Plot

This program offers the following graphic programs that require your help to draw plots:

```
1) LINE CHART
2) BAR CHART
3) PIE CHART
4) BIORHYTHM
5) PROGRAMMER'S TUTORIAL
6) RETURN (Exits from this menu.)
```

A description of the demonstration programs is provided later in this section of the Manual.

Making Your Selection

Use the SPACE bar to make your program selection. Press the RETURN key to run the desired program.

After each program completes, you are given a choice of either running the program again or selecting another program.

Once you have mastered the demonstration programs, you will understand the basic operation and capabilities of the Plotter. To expand the use of the Plotter, advanced software packages (such as LOTUS®, Graphtalk®, and Autocad®) are available from your local computer store.

DEMONSTRATION PROGRAMS

Demo I

Demo I draws the following four plots:

```
1) A logic circuit
2) A bar chart
3) A simple maze and its solution
4) Three dimensional letters that spell "Heath"
```

Each plot is drawn in a separate quadrant. The program will stop at certain intervals, which allows you to change pens. Once all of the plots are drawn, Demo I will draw a border and divide the page into four squares.

Line Chart

This program plots a line chart of an electric bill that covers three years. The program stops at certain points so you can change pens.

Line Chart begins by plotting the X and Y axes. The X axis is labeled "Months" and the Y axis is labeled "Kilowatt Hours." The plots are then drawn one year at a time. After all three years have been plotted, the chart is labeled.

Title Page Design

Title Page Design draws a fancy border on an 8-1/2" × 11" sheet of paper.

Math Demo

Math Demo graphs twelve different mathematical equations on an 8-1/2" × 11" sheet of paper.

The paper is first partitioned into 12 squares. The program will pause at various points to allow you to change pens. The following equations are graphed:

1) $y = (x^2 - 16)/8$
2) $y = a \sin(2\theta)$
3) $y = 2 \sin(x)$
4) $y = x^{-1}$
5) $y = \text{ABS}(x^2 - 25)/8$
6) $y = 2 \sin(x) - \cos(2x)$
7) $y = x^3/10$
8) $y = 2 \cos(x) + \sin(2x)$
9) $y = \text{ABS}(x/1.15)$
10) $y = x^{-2}$
11) $y = \cos(x)$
12) $4y^2 + x^2 = 100$

Space Shuttle and Robot

Both Space Shuttle and Robot were stored in a digitizing program. Pictures of the Space Shuttle and Robot may appear on your monitor screen before the plots are drawn (depending upon your brand of computer).

GRAPHIC PROGRAMS

Line Chart II

This program graphs a line chart with data that you enter. You will first enter the number of data points that you desire, up to a maximum of 18 per line. You can then label the X axis. You have the following options:

```
1) NUMBERS
2) MONTHS
3) OTHER LABELS OF YOUR CHOICE
```

If you choose the Numbers option, you will enter the range (highest and lowest values) for the X and Y axes. The program will then draw and label the axes.

The Line Chart II program will show an X axis point on your monitor. You will then be asked for a corresponding Y-axis point.
For example, the screen might show:

```
Y AXIS                          RANGE       POINTS TO PLOT
100,5000                                          8
(Point #1) X = 300, Y =
```

In this example, the X-axis point is 300 and the program asks you for the Y-axis point. You can choose any number between 100 and 5000. This point will be the first of eight points.

You must press the RETURN key to enter each value. The program will continue to ask for Y-axis points until all of the points have been plotted, or you press the RETURN key without entering any data.

Line Chart II will then ask you to label the line that results from the plotted points. You now have the option of plotting another set of points on the same piece of paper. If you do not desire any other plots, you will then label both axes and title the chart. You are then given the following options:

```
1) RUN THIS PROGRAM AGAIN
2) RUN A DIFFERENT PROGRAM
3) QUIT
```

Bar Chart

This program graphs a bar chart with data that you enter. You will first enter the range for the Y axis. The program will then draw both axes. You have the following options for labeling the X axis:

```
1) NUMBERS
2) MONTHS
3) YEARS
4) OTHER LABELS OF YOUR CHOICE
```

Option 1 requires you to enter the X-axis range. Option 2 requires you to enter a starting month, and option 3 requires you to enter a starting year. Option 4 allows you to enter your own labels.

You will then enter the number of bars you desire on the chart, and whether the bars are to be drawn lined or filled solid. Values are then assigned to each bar. For example:

```
Y-axis range:        50.3250
X axis:              10 years
Point #5 on the X axis is 1985

Enter your Y axis value.
```

In this example, there are 10 bars to graph. The program asks you for the Y-axis value of the fifth bar. You can choose any value between 50 and 3250.

After the Plotter draws all of the bars, you are given the opportunity to change pens so you can label the graph in a different color. You can then choose one of the following options:

```
1) RUN THIS PROGRAM AGAIN
2) RUN A DIFFERENT PROGRAM
3) QUIT
```

Pie Chart

Pie Chart draws a circle and separates the whole into percentage parts. This program also has the capability to isolate (cut-out) one section of the pie.

You will first choose between drawing a whole pie or a pie with an isolated section. If you decide to isolate a section, you will then enter the percentage of that section.

After the isolated section is labeled and drawn, the program will enable you to section off the remainder of the pie. For example:

```
YOUR TOTAL PERCENTAGE IS 20
ENTER THE PERCENTAGE OF YOUR NEXT SECTION? 25
WHAT DO YOU WANT TO LABEL THIS SECTION? PAYROLL
```

In this example, 20% of the pie has been sectioned, which means that 80% remains to be sectioned. The next section will be 25% of the pie and it will be labeled PAYROLL.

When the pie is completely sectioned off, you can then title the chart. You have the following options:

```
1) RUN THIS PROGRAM AGAIN
2) RUN A DIFFERENT PROGRAM
3) QUIT
```

Biorhythm

This program plots a person's biorhythm. The following cycles are graphed:

```
1) PHYSICAL
2) EMOTIONAL
3) INTELLECTUAL
```

You will enter personal information and the date of birth. You are then asked for the month of the biorhythm that you desire. The program will draw the axes and plot each of the three cycles. Biorhythm will stop at certain break points to allow you to change the pens. The program completes the chart by labeling it and printing a legend that explains the cycles.

Finally, you have the option of running another biorhythm or selecing a different program.

Programmer's Tutorial

This program follows the examples under "Programming Examples" in this Manual.

GEOMETRIC PATTERN PROGRAM

The following program causes the Plotter to draw geometric patterns. By changing four variables (A1, B1, C1, and D1), you can obtain many different patterns. NOTE: This program draws many lines and uses up a pen fairly fast. You can only expect to make five or six patterns per pen, depending upon the size of each drawing and how long you let the Plotter run.

To try the program, perform the following steps:

1. Enter the program into your computer's memory exactly as it is shown below.

2. After you have the program entered, type RUN and press the RETURN key.

3. The program will now ask you where you want the center of the pattern. As written, the program defaults to location (1250,937), which is the center of an 8-1/2″ × 11″ sheet of paper. You could enter different values if you desire, but if this is the first time you have tried the program, we recommend you press the RETURN key in response to X? and Y?. This causes the program to use the default values.

4. The program will now ask you how large you want the pattern. Since there is no default value for this question, you must enter a value. We recommend you use 900 if this is the first time you have tried the program. After you enter the value, press the RETURN key.

5. The program will now ask you for four pattern factors. These values determine the shape of the pattern, and you must enter four values. Try entering 4, 8, 4, 8 (be sure to include the commas between each number). Then press the RETURN key.

6. The Plotter will now begin to draw the pattern. After about five minutes, it will ask you if you wish to continue. Enter Y if you wish to continue and N if you wish to terminate the pattern. Then press the RETURN key.

```
10 REM    THIS PROGRAM DRAWS PATTERNS
20 REM    THE PATTERN IS AFFECTED BY THE INPUTS A1, B, C1, AND D1
30 REM    THE SIZE OF THE PATTERN IS DETERMINED BY SIZE
40 REM    THE POSITION OF THE PATTERN IS DETERMINED BY X,Y
50 FOR I = 1 TO 15:PRINT:NEXT I
60 PRINT:PRINT
70 DEFINT X,Y
80 LPRINT "RE;
90 PRINT "THIS PROGRAM DRAWS GEOMETRIC PATTERNS"
100 PRINT "IT TAKES A WHILE FOR THE PATTERNS TO DEVELOP, SO BE PATIENT"
110 PRINT:PRINT
120 PRINT "WHERE DO YOU WANT TO CENTER THE PATTERN"
130 PRINT "       THE CENTER IS AT: 1250,937
140 INPUT "  X=   <CENTERED>";X
150 IF X=0 THEN X=1250
160 INPUT "  Y=   <CENTERED>";Y
170 IF Y=0 THEN Y=937
180 REM   NOW DETERMINE THE MAXIMUM SIZE POSSIBLE AT THIS POSITION
190 SMAX=2500-X
200 IF X<SMAX THEN SMAX=X
210 IF 1875-Y <SMAX THEN SMAX=1875-Y
220 IF Y <SMAX THEN SMAX=Y
230 PRINT:PRINT
240 PRINT "HOW LARGE DO YOU WANT IT (MAXIMUM SIZE IS";SMAX;")";
250 INPUT SIZE
260 IF SIZE>SMAX THEN GOTO 240
270 PRINT:PRINT
280 INPUT "INPUT THE FOUR PATTERN FACTORS";A1,B1, C1,D1
290 PRINT:PRINT"   TYPE ANY CHARACTER TO STOP DRAWING"
300 LPRINT"MA"; X;",";Y;";"
310 A=0:B=0:C=0:D=0
320 FOR I=0 TO 1000
330 XP=X+SIZE*SIN(A)*SIN(B)
340 YP=Y+SIZE*SIN(C)*COS(D)
350 Y$=INKEY$
360 IF Y$<>"" THEN GOTO 430
370 LPRINT"DA"; XP;",";YP;";"
380 A=A+A1:B=B+B1:C=C+C1:D=D+D1
390 NEXT I
400 PRINT:PRINT"I'VE DRAWN QUITE A FEW LINES. ARE YOU SURE YOU WANT TO CONTINUE?"
410 INPUT"< Y OR N>";Z$
420 IF Z$="Y" THEN GOTO 320
430 LPRINT"MA 2500,1875;"
440 PRINT:PRINT:PRINT:PRINT
450 GOTO 80
460 END
```

IN CASE OF DIFFICULTY

Begin your search for any trouble that occurs after assembly by carefully following the steps listed below under "Visual Checks." After you complete the "Visual Checks," perform the steps under "Locating the Problem". Then refer to the "Trouble-shooting Charts" that follow. Start with the chart labeled "General Problems" and locate your particular problem in the left column of this chart. The right column of the chart shows you what items to check. Refer to the "Circuit Board X-Ray View" for the physical locations of parts on the circuit board.

VISUAL CHECKS

1. Recheck the wiring. Trace each lead with a colored pencil on the Pictorial as you check it. It is frequently helpful to have a friend check your work. Someone who is not familiar with the unit may notice something that you have consistently overlooked.

2. About 90% of the kits that are returned to the Heath Company for repair do not function properly due to poor connections and soldering. Therefore, you can eliminate many troubles by reheating all of your connections to make sure they are soldered as described on Page 16 of this Manual. Be sure there are no solder "bridges" between circuit board foils.

3. Check to be sure all diodes are in their proper locations. Make sure each lead is connected to the proper point. Make sure that each diode band is positioned above the band printed on the circuit board or as directed in its step.

4. Check electrolytic capacitors to make sure their positive (+) or negative (−) mark is at the correct location.

5. Check to be sure that each IC is properly installed, and that the pins are not bent out or under the IC. Also, be sure the ICs are installed in their correct locations.

6. Check the values of the parts. Be sure in each step that you wired the correct part into the circuit, as shown in the Pictorial. It would be easy, for example, to install a 22 kΩ red-red-org) resistor where a 2200 Ω (red-red-red) resistor should have been installed.

7. Check for bits of solder, wire ends, or other foreign matter which may be lodged in the wiring.

8. Be sure all of the component leads are cut close to the foil on the circuit board so the

leads do not short to the chassis when the circuit board is installed.

9. A review of the "Circuit Description" may also help you determine where the trouble is.

If you still have not located the trouble after you complete the "Visual Checks," and a voltmeter is available, check the voltage readings against those shown on the Schematic. Read "Precautions for Troubleshooting" before you make any measurements. NOTE: All voltage readings were taken with a high-input impedance voltmeter. DC voltages and resistances may vary as much as ± 20%.

PRECAUTIONS FOR TROUBLESHOOTING

Be sure you do not short any terminals to ground when you make voltage measurements. If the probe should slip, for example, and short across components or voltage sources, it is very likely to cause damage to one or more components.

NOTE: In the unusual event that you are unable to resolve a difficulty, refer to the "Customer Service" information inside the rear cover of this Manual. Your Warranty is located inside the front cover.

LOCATING THE PROBLEM

A self-test program is built into your Plotter to help you locate a particular problem. Use the following steps to run the self-test program:

1. Turn the Plotter off, if this has not already been done.

2. Disconnect the Plotter from your computer.

3. Load paper and pen.

4. Turn the Plotter on and press the SELF TEST key.

The Plotter should draw a test plot. If the Plotter runs the test plot correctly, the problem is probably not in the Plotter. Check the connections to your computer. If the Plotter still does not operate properly, proceed to the "Troubleshooting Charts" which follow.

TROUBLESHOOTING CHARTS

The following charts list the condition and the possible causes of several malfunctions. If a particular part is mentioned as a possible cause, check that part to see if it was correctly installed. Also check the parts connected to it for poor connections. It is also possible, on rare occasions, for a part to be faulty and require replacement.

GENERAL PROBLEMS

CONDITION	POSSIBLE CAUSE
Plotter hangs up (interrupts).	1. You pressed the RESET button while the Plotter was communicating with your computer. To correct, turn the power off and then back on (this resets the Plotter).
Plotter plots incorrectly.	1. You pressed a keyboard button while the Plotter was plotting. The Pause key is the only key you may press during plotting operations. To correct, turn the power off, reload paper or Mylar, turn the power on, and start again.
Inconsistent drawing.	1. Worn pen or the pen is out of ink. Install a new pen.
Pen lifts and stops drawing at the edge of the plotting surface.	1. The program extends beyond the physical plotting area of the Plotter. The Plotter will continue to run the program until it returns within boundaries. The pen will then lower and continue plotting.
Incomplete plot.	1. Programming statement is too long. Break long statements into two or more lines.

MECHANICAL/ELECTRICAL PROBLEMS

CONDITION	POSSIBLE CAUSE
Plotter is completely inoperative.	1. Line cord not plugged in. 2. Power switch S2. 3. Fuse F1. 4. Power transformer T1 is not plugged into the circuit board. 5. Integrated circuit U19. 6. Capacitors C9, C10, C11, or C13. 7. Diodes CR11 or CR12.
The pen moves, but the paper does not.	1. Loose drive coupling. 2. Paper motor M2 is not plugged into the circuit board. 3. Paper drive motor M2. 4. ICs U12, U13, U17, or U18.
The paper moves but the pen does not.	1. Loose pulley. 2. Loose drive pulley. 3. Belt is off the pulleys. 4. Pen motor M1 is not plugged into the circuit board. 5. Pen drive motor M1. 6. ICs U5, U6, U9, or U10.
Pen overdrives (does not stop at the edge and lift, belt jumps on the drive pulley.	1. Limit switch S1 is misadjusted. 2. Limit switch S1 is not plugged into the circuit board. 3. Limit switch S1. 4. IC U14.
The pen hits the right pinch wheel.	1. The pen holder support is not installed properly. 2. The pen carriage is misadjusted.
The pen does not go down.	1. The solenoid is not plugged into the circuit board. 2. Broken or missing pen down spring. 3. Wires interfering with the left pen-down arm. 4. Solenoid. 5. IC U16. 6. Diode CR10. 7. Penlift arms not installed correctly on lift shaft.
The pen does not go up.	1. Broken or missing solenoid spring. 2. Solenoid. 3. IC U16. 4. Diode CR10. 5. Penlift arms not installed correctly on lift shaft.

Mechanical/Electrical Problems (Cont'd.)

CONDITION	POSSIBLE CAUSE
Erratic or skewed paper movement.	1. Broken or missing extension springs. 2. Worn grit wheels. 3. Worn or binding pinch wheels. 4. Paper catches on the case. 5. Loose paper drive coupling. 6. Paper drive motor M2. 7. Power transformer T1 or its circuit board connector.
The quality of the test plot is poor in the direction of the pen movement.	1. Loose timing belt. 2. Loose drive pulley. 3. The pen holder support is binding. 4. Broken or missing pen-down spring. 5. Solenoid. 6. Pen drive motor M1.
The quality of the test plot is poor in the direction of the paper movement.	1. Worn grit wheels. 2. Broken or missing extension springs. 3. Dirty platen. 4. Broken or missing pen-down spring. 5. Solenoid. 6. Loose paper drive coupling. 7. Paper drive motor M2.
One or more of the keyboard buttons are inoperative.	1. The keyboard is not plugged into the circuit board. 2. ICs U4, U8, or U14.
Poor retrace.	1. Misadjusted timing belt. 2. Timing belt. 3. Grit pads incorrectly installed.
The pen drags.	1. Weak solenoid spring.
No Y axis movement.	1. Loose drive pulley. 2. Pen drive motor M1.
The Plotter draws the test plot but does not operate with a computer.	1. Connections between the Plotter and the computer. 2. Solder bridge on the circuit board between foils going to connector H1.

SPECIFICATIONS

Plotting Area	Y-axis 7.4″. X-axis variable from 1″ to 120″. 2500 × 1838 plotter units.
Resolution	Smallest addressable step size = 0.004″.
Maximum Pen Velocity	6 inches per second.
Interface Options	8-bit parallel-I/O port (Centronics compatible).
Media	Paper sheets or transparencies; width 8.5″, length variable to 120″.
Repetition Accuracy	0.004″.
Distance Accuracy	0.004″.
Power Requirements	115 VAC ± 5%, 55 – 65 Hz, 30 watts.
Operating Tenperature Range	32° F to 130° F (0° C to 55° C).
Operating Relative Humidity	10% to 95% RH.
External Dimensions	14″ W × 8-1/2″ D × 3″ H (10.2 × 21.6 × 7.6 cm).
Weight	7.2 lbs. (3.3 kg).

CIRCUIT DESCRIPTION

Refer to the Schematic Diagram as you read the following description. Each major section of the Plotter is described below separately.

CONTROLLER

The heart of the Model IR-5208 Plotter is formed by U3, a custom 6802 single-chip microprocessor. This circuit scans and debounces the keyboard, determines the timing for the other circuits, retrieves data from ROM (read-only memory) U2, and supplies information to the motor-driver circuits.

The 4 MHz crystal (X1) determines the frequency of the internal clock circuitry. This frequency is divided inside the microprocessor to provide the basic timing signal for many of the remaining circuits.

Capacitor C2 and resistor R1 provide a power-on reset to the microprocessor. Diode CR1 allows capacitor C2 to discharge quickly when you turn the Plotter off and insures that a reset occurs if the power is only briefly interrupted.

Lines A0 through A12 coming from the microprocessor form an address bus for the external ROM, and lines A13 through A15 form the address bus for 3-to-8 line decoder U7 in the motor-drive circuit.

Lines D0 through D7 allow data to pass between the microprocessor and the ROM, motor-drive circuit, keyboard scanning circuit, and I/O (input/output) port for connection to a computer.

Integrated circuit U7 properly divides the timing signal coming from the microprocessor into six separate clock signals that are used by the ROM, keyboard scanning, motor drive, and I/O circuits.

The ROM integrated circuit contains a permanent self-test program that allows you to check the operation of the Plotter. Whenever you press the Self Test button on the keyboard, the program begins to execute and performs several plotting functions that check the motor-drive circuit, pen up/down circuit, and microprocessor.

KEYBOARD SCANNING

Integrated circuit U8, which contains eight D-type flip-flops and buffers U4A, U4B, and U4E, sequentially scans the three horizontal lines of the keyboard, which is made up of a 3 × 4 matrix.

Resistor network RN1, which contains six pull-up resistors, holds the four vertical keyboard lines normally high. As soon as you press one of the keyboard keys, the corresponding line is pulled low and is detected by integrated circuit U14. Line driver U14 places the key closure information onto the data bus, which informs the microprocessor and motor drive circuits.

Limit switch S1 is also connected to one of the inputs of line driver U14 to inform the microprocessor when the pen has reached the maximum end of travel.

A separate line coming from the I/O circuit prevents the keyboard from being read while data from the computer is being placed onto the data bus.

Other lines coming from U8 apply drive signals to the pen up/down circuit formed by U16 and its associated circuitry and the motor-drive circuit described later.

Dual-peripheral driver IC U16 applies drive to the pen up/down solenoid so it will raise and lower the pen upon command. Diode CR10 protects U16 from the back EMF produced by the solenoid as the magnetic field collapses.

MOTOR-DRIVE CIRCUIT

Ten integrated circuits form this circuit, which controls the pen and paper motor circuits.

Data lines D0 through D7 are applied to D-type flip-flop integrated circuit U11 along with one of the clock signals coming from U7. This circuit provides the controlling signal for the eight dual-peripheral drivers (U5, U6, U9, U10, U12, U13, U17, and U18).

Four driver circuits are connected to each stepping motor. This increases the resolution of each motor for more precise tracking. The actual drive signal for the motors comes from integrated circuit U8.

Diodes CR2 through CR9 protect each driver from the back EMF produced by the motors as the magnetic fields collapse.

I/O (Input/Output)

Data passes from the computer to the data bus through integrated circuit U1, which contains eight edge-triggered flip-flops. Integrated circuits U15, U20A, U20B, and U20D control the operation of IC U1.

When the strobe signal coming from the computer goes high, a pulse is applied to the clock input of IC U1. Some delay is built into this clock signal by resistor R12 and capacitor C8 to stretch the length of this pulse. When data is being received, the busy line to the computer (which is normally pulled high by a resistor in resistor network RN1) is pulled low to signal the computer that the data is being received.

POWER SUPPLY

Diodes CR11 and CR12, integrated circuit U19, and the associated circuitry form the power supply circuit.

Power transformer T1 steps the 115-volt AC line voltage down to approximately 26-volts. Diodes CR11 and CR12 form a full-wave rectifier that changes this AC voltage to approximately 12-volts DC. Capacitor C13 provides filtering for this DC voltage before it is applied to integrated circuit U19.

Integrated circuit U19 is a 3-terminal regulator that reduces the 12-volts DC to a constant 5-volts DC for use by the digital circuits. Capacitors C15 and C10 provide further filtering for this 5-volts DC source.

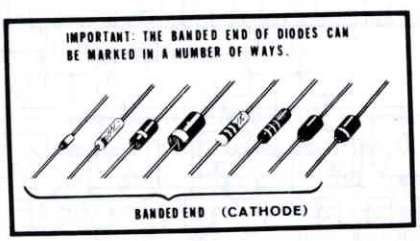
Resistor R15 and LED CR13 are connected to the 5-volt DC source to provide a visual power-on indication.

SEMICONDUCTOR IDENTIFICATION CHARTS

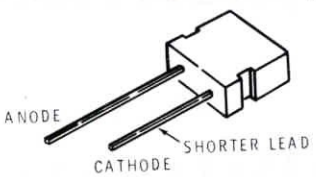
DIODES

COMPONENT NUMBER	HEATH PART NUMBER	MAY BE REPLACED WITH	KEY NUMBER
CR1	230-5288	1N4001	A1
CR2	230-5288	1N4001	A1
CR3	230-5288	1N4001	A1
CR4	230-5288	1N4001	A1
CR5	230-5288	1N4001	A1
CR6	230-5288	1N4001	A1
CR7	230-5288	1N4001	A1
CR8	230-5288	1N4001	A1
CR9	230-5288	1N4001	A1
CR10	230-5288	1N4001	A1
CR11	230-5287	1N5401	A1
CR12	230-5287	1N5401	A1
CR13	230-5257	LED	A2

A1



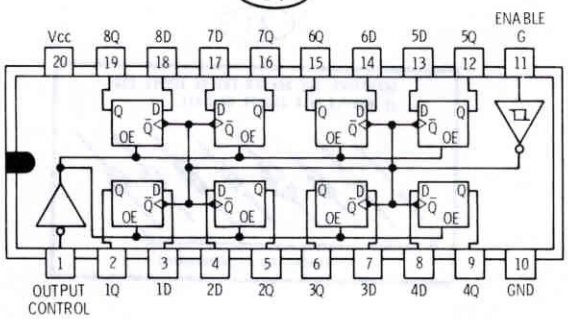
A2



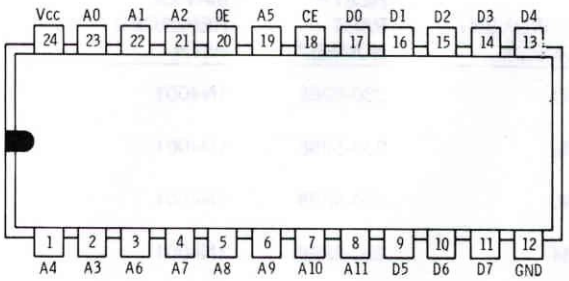
INTEGRATED CIRCUITS

COMPONENT NUMBER	HEATH PART NUMBER	MAY BE REPLACED WITH	KEY NUMBER
U1	230-5293	74LS374	B1
U2	230-5297	150008-1	B2
U3	230-5296	6802	B3
U4	230-5267	74LS05	B4
U5	230-5268	75452	B5
U6	230-5268	75452	B5
U7	230-5264	74LS138	B6

B1



B2



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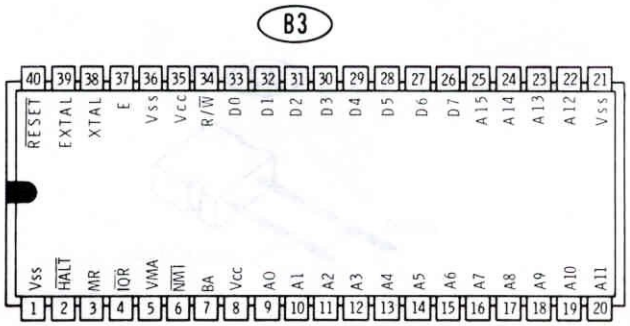

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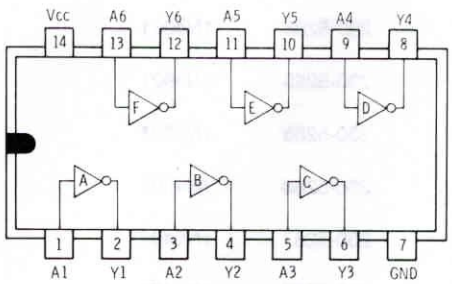

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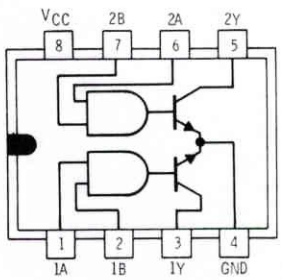

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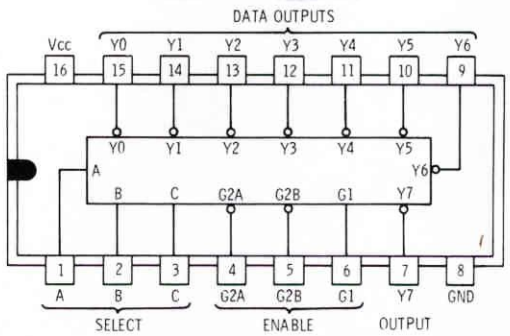
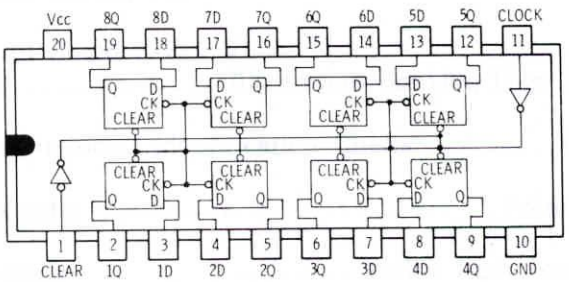


Heathkit®

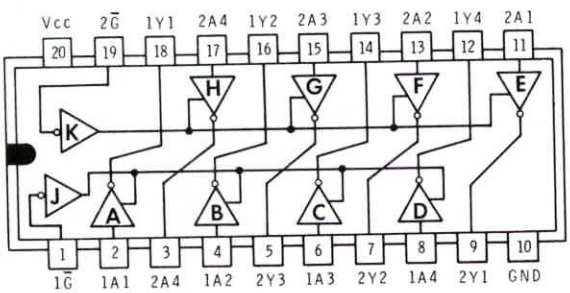
Integrated Circuits (Cont'd.)

COMPONENT NUMBER	HEATH PART NUMBER	MAY BE REPLACED WITH	KEY NUMBER
U8	230-5269	74LS273	B7
U9	230-5268	75452	B5
U10	230-5268	75452	B5
U11	230-5269	74LS273	B7
U12	230-5268	75452	B5
U13	230-5268	75452	B5
U14	230-5265	74LS240	B8
U15	230-5266	74LS74	B9
U16	230-5268	75452	B5
U17	230-5268	75452	B5
U18	230-5268	75452	B5
U19	230-5262	7805	B10
U20	230-5292	74LS00	B11

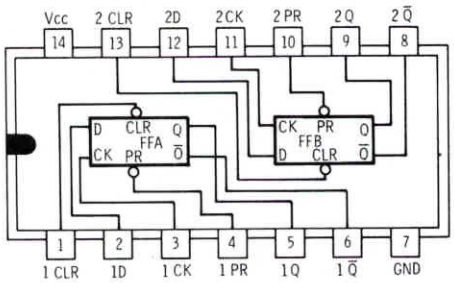
B7



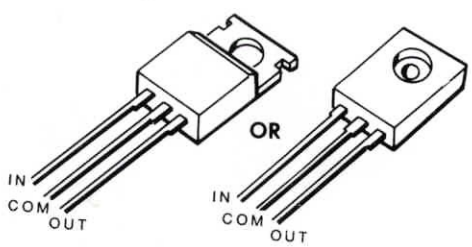
B8



B9



B10



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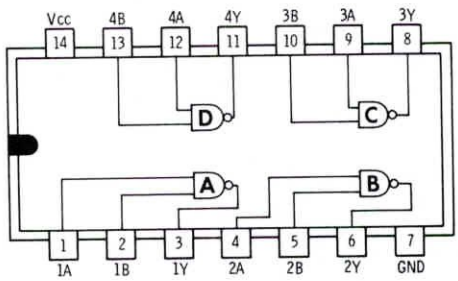

FOR PARTS REQUESTS ONLY

- Be sure to follow instructions carefully.
- Use a separate letter for all correspondence.
- Please allow 10 - 14 days for mail delivery time.

DO NOT WRITE IN THIS SPACE

INSTRUCTIONS

- Please print all information requested.
- Be sure you list the correct **HEATH** part number exactly as it appears in the parts list.
- If you wish to prepay your order, mail this card and your payment in an envelope. Be sure to include 10% ($1.00 minimum, $5.00 maximum) for insurance, shipping and handling. Michigan residents add 4% tax.

  Total enclosed $ _____
- If you prefer COD shipment, check the COD box and mail this card. COD ☐

NAME _____

ADDRESS _____

CITY _____

STATE _____ ZIP _____

The information requested in the next two lines is not required when purchasing nonwarranty replacement parts, but it can help us provide you with better products in the future.

Model # _____ Invoice # _____

Date Purchased _____ Location Purchased _____

LIST **HEATH** PART NUMBER	QTY	PRICE EACH	TOTAL PRICE
TOTAL FOR PARTS			
HANDLING AND SHIPPING			
MICHIGAN RESIDENTS ADD 4% TAX			
TOTAL AMOUNT OF ORDER			

SEND TO: **HEATH COMPANY**
BENTON HARBOR
MICHIGAN 49022
ATTN: PARTS REPLACEMENT

Phone (Replacement parts only): 616 982-3571

THIS FORM IS FOR U.S. CUSTOMERS ONLY
OVERSEAS CUSTOMERS SEE YOUR DISTRIBUTOR

CUT ALONG DOTTED LINE

FOR PARTS REQUESTS ONLY

- Be sure to follow instructions carefully.
- Use a separate letter for all correspondence.
- Please allow 10 - 14 days for mail delivery time.

DO NOT WRITE IN THIS SPACE

INSTRUCTIONS

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- Be sure you list the correct **HEATH** part number exactly as it appears in the parts list.
- If you wish to prepay your order, mail this card and your payment in an envelope. Be sure to include 10% ($1.00 minimum, $5.00 maximum) for insurance, shipping and handling. Michigan residents add 4% tax.

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- If you prefer COD shipment, check the COD box and mail this card. COD ☐

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CITY _____

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TOTAL AMOUNT OF ORDER			

SEND TO: **HEATH COMPANY**
BENTON HARBOR
MICHIGAN 49022
ATTN: PARTS REPLACEMENT

Phone (Replacement parts only): 616 982-3571

THIS FORM IS FOR U.S. CUSTOMERS ONLY
OVERSEAS CUSTOMERS SEE YOUR DISTRIBUTOR

CUSTOMER SERVICE

REPLACEMENT PARTS

Please provide complete information when you request replacements from either the factory or Heath Electronic Centers. Be certain to include the **HEATH** part number exactly as it appears in the parts list.

ORDERING FROM THE FACTORY

Print all of the information requested on the parts order form furnished with this product and mail it to Heath. For telephone orders (parts only) dial 616 982-3571. If you are unable to locate an order form, write us a letter or card including:

- Heath part number.
- Model number.
- Date of purchase.
- Location purchased or invoice number.
- Nature of the defect.
- Your payment or authorization for COD shipment of parts not covered by warranty.

Mail letters to: Heath Company
Benton Harbor
MI 49022
Attn: Parts Replacement

Retain original parts until you receive replacements. Parts that should be returned to the factory will be listed on your packing slip.

OBTAINING REPLACEMENTS FROM HEATH ELECTRONIC CENTERS

For your convenience, "over the counter" replacement parts are available from the Heath Electronic Centers listed in your catalog. Be sure to bring in the original part and purchase invoice when you request a warranty replacement from a Heath Electronic Center.

TECHNICAL CONSULTATION

Need help with your kit? — Self-Service? — Construction? — Operation? — Call or write for assistance. you'll find our Technical Consultants eager to help with just about any technical problem except "customizing" for unique applications.

The effectiveness of our consultation service depends on the information you furnish. Be sure to tell us:

- The Model number and Series number from the blue and white label.
- The date of purchase.
- An exact description of the difficulty.
- Everything you have done in attempting to correct the problem.

Also include switch positions, connections to other units, operating procedures, voltage readings, and any other information you think might be helpful.

Please do not send parts for testing, unless this is specifically requested by our Consultants.

Hints: Telephone traffic is lightest at midweek — please be sure your Manual and notes are on hand when you call.

Heathkit Electronic Center facilities are also available for telephone or "walk-in" personal assistance.

REPAIR SERVICE

Service facilities are available, if they are needed, to repair your completed kit. (Kits that have been modified, soldered with paste flux or acid core solder, cannot be accepted for repair.)

If it is convenient, personally deliver your kit to a Heathkit Electronic Center. For warranty parts replacement, supply a copy of the invoice or sales slip.

If you prefer to ship your kit to the factory, attach a letter containing the following information directly to the unit:

- Your name and address.
- Date of purchase and invoice number.
- Copies of all correspondence relevant to the service of the kit.
- A brief description of the difficulty.
- Authorization to return your kit COD for the service and shipping charges. (This will reduce the possibility of delay.)

Check the equipment to see that all screws and parts are secured. (Do not include any wooden cabinets or color television picture tubes, as these are easily damaged in shipment. Do not include the kit Manual.) Place the equipment in a strong carton with at least THREE INCHES of *resilient* packing material (shredded paper, excelsior, etc.) on all sides. Use additional packing material where there are protrusions (control sticks, large knobs, etc.). If the unit weighs over 15 lbs., place this carton in another one with 3/4" of packing material between the two.

Seal the carton with reinforced gummed tape, tie it with a strong cord, and mark it "Fragile" on at least two sides. Remember, the carrier will not accept liability for shipping damage if the unit is insufficiently packed. Ship by prepaid express, United Parcel Service, or insured Parcel Post to:

Heath Company
Service Department
Benton Harbor, Michigan 49022

HEATH

ZENITH

HEATH COMPANY • BENTON HARBOR, MICHIGAN

THE WORLD'S FINEST ELECTRONIC EQUIPMENT IN KIT FORM

LITHO IN U.S.A.