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HPGL Controller for Windows

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HPGL CONTROLLER FOR WINDOWS

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Chapter 1

INTRODUCTION

What HPGL is

HPGL is the language used to control Hewlett Packard pen plotters. HPGL commands control the path of the pen across the surface of the paper and tell the plotter when the pen is to be extended down onto the paper and when it is to be retracted. HPGL also commands pen changes to accommodate varying line thicknesses or different colors.

HPGL is popular among automated engravers and routers. It is a natural choice for a low cost machine tool control language, mainly because there exists a wealth of powerful and low cost drawing and drafting programs which are capable of communicating to Hewlett Packard plotters. With minor adaptation, and the use of the **HPGL Controller**, these drawing and drafting programs can be used as powerful tool path generators.

What the HPGL Controller is

The **HPGL Controller** uses the commands contained in the HPGL plot file to control motors for milling, routing, engraving, plasma cutting, water jet cutting, laser etching, glue dispensing, flame cutting, large scale template plotting, or other operations where the motion of a tool must be directed over a specified path.

The **HPGL Controller program** also provides a convenient operator interface and includes features especially useful in managing production operations. Pop-up menus and easy-to-use manual positioning options allow the operator to conveniently position the tool for each job set-up.

Tool programming is quickly stored and retrieved for each job. Software setups for each job include tool position, plot file, tool changes, cutting speeds, etc. Setup values are entered via dialog boxes, and can also be easily duplicated, modified, and stored for later use.

What Kind of Machine is Controlled

The machine which is being controlled consists of three translation stages. Two of the stages (X and Y axes) are controlled by means of stepper motors (or step/direction controlled servos). The third stage (Z axis) can be either a step motor controlled stage (allowing it to plunge to varying depths), or it may be a simple solenoid actuated up/down control, such as is found in a plotter or an engraver. The output control signals are generated by means of the Ability Systems **Indexer LPT** device driver.

How the Machine is Controlled

The path of the tool can be defined by means of a CAD program, such as *AutoCAD*, *DesignCAD*, *RoboCAD*, *Generic CAD*, *AutoSketch*, *Designer*, *CorelDRAW*, or virtually any program which is capable of communicating to a Hewlett Packard plotter. The tool path is drawn using the CAD program. By directing the pen plot output to a file instead of the plotter, the tool path is stored on a diskette, disk, or network drive. The plot file, along with other setup information, is used by the **HPGL Controller** to control manufacturing operations. Last minute information particular to the manufacturing operation, such as tool path order and trace width (tool radius) offset compensation, is added by means of a built in **Tool Path Editor**. The job set-up information is put into action in the **HPGL Controller's Production Menu**. Using positioning options or joystick control, the operator manipulates the stages to the desired starting position and then selects automatic operation from the menu. The machine tool then traverses the defined paths in the manner determined by the set-ups.

Who Uses the HPGL Controller

The **HPGL Controller** is a design engineers tool. It provides a powerful and convenient operator interface for OEMs and machine tool retrofitters. It does not require computer programming knowledge. It does require a working knowledge of **Indexer LPT** and a knowledge of machine design. Since this product can be used on machines varying from specialized plotters to cutting tools, the depth of knowledge required will depend on the complexity of the design. Safety should be your primary concern. Due to the complex nature of software in general, safety features must be designed into machine wiring and mechanical hardware.

WARNING

ALWAYS PLAN FOR THE UNEXPECTED WHEN USING SOFTWARE! If you cannot build appropriate safety features into your hardware by virtue of cost, expertise or any other reason, you should not be using this product!

How to Use this Manual

This manual is an engineer's guide to implementing the **HPGL Controller**. Here you will find information about designing specialized machinery which requires tool path control. This text presumes that the reader has a working knowledge of the **Indexer LPT**

Chapter 2

CAD/CAM BASICS

Geometric Entities

The acronym “CAD” stands for “Computer Aided Design”. Programs such as *AutoCAD* by Auto Desk, *Design CAD* by American Small Business Computers, and *Sketchpad* by Robo Systems are considered CAD programs. CAD programs range in price from under a hundred dollars to several thousand dollars. They are usually priced according to sophistication and ease of use. Drawing programs such as *Corel Draw* and *Designer* can also be considered CAD programs. Essentially, CAD programs provide a convenient means for generating drawings using the computer, saving these drawings in electronic form, and producing paper output of the drawings using a printer or plotter. CAD programs usually contain other features helpful in manufacturing documentation, but the features which are most applicable to the **HPGL Controller** are the generation of drawings and the means of physically representing these drawings on paper.

The acronym “CAM” stands for “Computer Aided Manufacturing.” The term “CAM” is broadly applied to any process where computers interact with the manufacturing process. In our immediate application, a computer is being used to manipulate the path of a tool. The **HPGL Controller** is a CAM program in the strictest sense of the word.

When a drawing is created by means of a CAD program, the component parts of the drawing, such as lines, circles, and arcs, are stored in data objects called “entities.” Entities describe geometric properties, size, and location. When a CAD program stores the representation of a drawing in a disk file, it saves a collection of entities. When a CAD program retrieves the drawing from the file, it reads the data in the entities and visually represents on the computer screen the geometries described by the entities. CAD programs store and retrieve data in a format which is best suited for the purposes of generating and editing a screen image.

Plotting a Drawing

When a CAD program plots a drawing, it is in a sense performing a CAM operation. The CAD program assists the plotter in manufacturing a paper copy representation of the drawing. The pen plotter responds to commands which it receives from the computer. These commands describe the geometric entities of the drawing. The commands appear in a format which is best suited for plotting operations.

The most commonly used data format for plotting is Hewlett Packard Graphics Language, or HPGL. HPGL is an ASCII language designed specifically to control pen movement. It is usually transmitted from the computer to the plotter over an RS-232 serial communications line. Most CAD programs allow the user to plot directly from within the program or to store the plotting information in an ASCII disk file (“Plot File”). The **Plot File** contains the sequence of HPGL commands.

You may view the contents of the **Plot File** from a DOS prompt by TYPE'ing the file to the screen. However, since most HPGL files typically do not contain carriage return or line feed control characters, the file can only be viewed and edited by file browsers or text editors with special capabilities. In this manual we refer to the **Plot File** and **HPGL File** synonymously.

Post-Processing

The **Plot File** contains commands understood by the plotter's motion control system. Since these commands describe a geometric path, it is possible to interpret these commands in such a way

as to construct a new set of commands (describing essentially the same path) which is understood by a different motion control system. This procedure is called post-processing. A “post-processor” is a program or sub-routine which converts one set of commands to another, much the same as interpreting a spoken language. The objective in interpreting a foreign language is to express the concepts spoken in one culture in words which another culture can understand. In post-processing, geometry which is described in one language (in this case, HPGL) is converted into commands which the machine’s motion controls (in this case, **Indexer LPT**) can understand.

Beyond Post-Processing

The **HPGL Controller** software is more than a post-processor, however, since it combines features of a machine controller front panel, file manager, and post processor into a simple menu driven interface. The **HPGL Controller** can also convert features present in HPGL to purposes which are useful in specialized machine tool control. For example, HPGL uses the “SP” (Select Pen) command to change pens for purposes of color or line width. The **HPGL Controller** allows you to optionally change tools with each pen change. In addition, it allows you to re-define the tool plunge for different depths (optionally in three axis configurations). You may also specify special machine control operations, such as turning on a spindle or coolant at selected times in the manufacturing operation.

Chapter 3

IMPORTANT FILES

The HPGL Controller Program

The file name of the **HPGL Controller** program is HPIXW.EXE. It is run by snapping over its icon from the Windows **Start > Programs** menu.

The Indexer LPT Device Driver

The **HPGL Controller** communicates directly with the **Indexer LPT** motion control software and takes advantage of many of its advanced features. **Indexer LPT** is a Windows device driver which is accessed by the **HPGL Controller**. All manipulation of control signals is accomplished through the **Indexer LPT** device driver. Refer to the **Indexer LPT** manual for instructions on the proper installation of this software, and for effective use of its many unique features.

The System Configuration File

Information defining the characteristics of the machine which you are designing is kept in an ASCII file entitled HPIXW.INI. When the **HPGL Controller** (HPIXW.EXE) begins execution, it reads the HPIXW.INI file from its location in the WINDOWS

directory. The HPIXW.INI file is generated when the **HPGL Controller** is run for the first time, and is accessed for set-up and changes by means of menus and dialog boxes which are available via the **Setup** menu. Since the HPIXW.INI file contains information which is specific only to the configuration of the machine (such as the step-to-distance ratio of the motorized stages, axis designations, rapid traverse rates, etc.), it is not likely to need changing after initial configuration.

CAM Files

Information relating to the manufacturing of each part (such as **Plot File** names, cutting speeds, etc.) is kept in **CAM Files**. **CAM Files** are ASCII files with the file name extension “CAM”. The **CAM Files** are opened by means of the **File > Open** menu, and are accessible for editing by means of the **Edit** menu.

The **CAM File** can be thought of as a file that keeps all of the information relating to a particular job together. This includes not only the tool designations, cutting speeds etc., but also the names and locations of other files, described below, that relate to making a particular part.

CAM Files contain a large amount of information, but it is not necessary for you to manually enter all of this information into each field for each job. **CAM Files** are easily replicated by means of the **File > Save As** menu. One convenient approach is to save a **CAM** file for each type of job that is used often. To generate a new job, you would open the **CAM** file for that job type, then using the **Edit** menu you would only change values associated with the job at hand. Optionally, you could save each job under its own name.

On a new or upgraded installation, the **HPGL Controller**'s “Setup” program installs a file entitled “SAMPLE.CAM”. You may use this file to construct your first job. However, do not permanently save job setup information in this file, as this file is over-written each time you may run “Setup” for upgrades. Instead, after editing SAMPLE.CAM, save your work under another file name using the **File > Save As** menu.

Plot Files

The file which is produced by the CAD or drawing program (such as *AutoCAD* or *Corel Draw*) for the purpose of defining the path of the tool is called the **Plot File**, or **HPGL File**. This file contains the commands which an HPGL compatible pen plotter or engraver understands. These commands are interpreted by this program and transformed into commands which **Indexer LPT** understands.

When an **HPGL File** is converted (post-processed) by the **HPGL Controller**, **Indexer LPT** commands corresponding to the geometry represented in the **HPGL File** are placed in a file called a **Command File**.

Command Files

When a job is run, the **HPGL Controller** sends the **Indexer LPT** commands contained in the **Command File** to **Indexer LPT**.

As mentioned, the **Command File** is an ASCII file which basically contains **Indexer LPT** commands. These **Indexer LPT** commands define the centerline of the actual tool path.

In addition to **Indexer LPT** commands, the **Command File** also contains lines of information that we call **Directives**. **Directives** are special commands which are interpreted by the **HPGL Controller** at “run time” when the machine is in operation under the **Production > Run Tool Path** menu.

For example, there is a **Directive** which appears in the **Command File** as **#D**. At run time this **Directive** is expanded into **Indexer LPT** commands suitable for plunging the tool **Down** into the work. The particular **Indexer LPT** commands which are used to effect the tool plunge are determined by system and CAM set-up values. Likewise, there is a **#U** **Directive** which is expanded into a suitable retract sequence, instructing the **HPGL Controller** to retract the tool **Up**, away from the work. **Directives** are more comprehensively described in the chapter entitled **TOOL PATH EDITING**.

You may never need to work directly with **Directives**. However, it is important to understand that the **Command File**

includes both **Indexer LPT** commands and **Directives**, and that **Directives** are interpreted and expanded at run time according to system and CAM file setup values.

The name of the **Command File** can be any valid file name. However, it is recommended that you use the base name of the CAM file with “IXH” as the file name extension.

The **Command File** need not be generated from a **Plot File**. Since the **Command File** is an ASCII file, you may use third party programs or post-processors to generate this file, even a simple text editor such as **Wordpad**. (A CAM setup feature allows you to specify an independently generated **Command File**).

The **Command File** can be modified using the built in **Tool Path Editor**.

Contour Specification Files

The **Contour Specification File** has the filename extension “CTR”. It is an ASCII file originally generated from the **Command File**. When it is first generated, its contents may be identical to the **Command File**. However, the **Tool Path Editor** can add additional information into the **Contour Specification File**. Specifically, information regarding tool offsets for each shape is stored in this file. The actual amount of tool offset is determined by set-up values contained in the **Trace Width (Cutter Diameter)** field of the **Pens** menu (stored in the job in the CAM file). However, information as to whether the tool will track a contour to the left, to the right, or down the center is contained in the **Contour Specification File**.

After using the **Tool Path Editor** to specify the final path, offsets and geometry of the tool path, and saving these changes into the **Contour Specification File**, the actual path of the tool is written back into the **Command File**. The essential information regarding the geometry of the tool path is saved in the **Contour Specification File**, but the script that actually controls the tool path is contained in the **Command File**.

For example, suppose you use a CAD program like *AutoCAD* to generate a one inch square. This square shape is “plotted” to a

file named SQUARE.PLT. Using the **Edit > Translate Plot File** menu, you generate a **Command File** named SQUARE.IXH. You may use SQUARE.IXH immediately to run a job. However, if you were using a 1/4 inch diameter cutting tool to cut a square shaped hole in some material, the inside dimension of the square would be 1 1/4 inches across, since a plotter output designates the centerline of the tool path. Consequently, to cut out a one inch square you may set up the **Trace Width** field in the **Edit > Pens** menu to 1/4 inch. Then you may enter the **Tool Path Editor** to select the direction of the cut as well as an offset (left or right) that will offset the tool towards the center of the square. From the **Tool Path Editor** you select **Generate Command File** from the **File** menu. The **Command File** that was just used to generate the **Contour Specification File** will now be over-written with new information. The old information will be lost, but you will not use the old information because the most up-to-date information is now stored in the **Contour File**. The new information in the **Command File** specifies the centerline of the desired tool path, which is a square with 3/4 inch legs. When run with a 1/4 inch diameter cutting tool, this new **Command File** will cut a square hole 1 inch across the sides.

Using the same example, suppose you wanted to cut the same 1 inch square hole, but you needed to use a smaller diameter tool (say, 1/8 inch diameter) to get a smaller corner radius. In the **Trace Width** field of the **Edit > Pens** menu you would replace “.250” with “.125”. Next, you would enter the **Tool Path Editor** and select **Generate Command File** from the **File** menu. The **Contour Specification File** will remain unchanged, but the old **Command File** will now be over-written with **Indexer LPT** commands that accommodate the new tool size.

The chapter entitled **CAM SET-UPS** describes how to call out names for the **HPGL File**, the **Command File** and the **Contour Specification File**. This section expresses the importance of these files and their use.

Single Contour Files

This manual refers to the path of a tool when the tool is engaged as a “contour”. This can be a point plunge, a simple straight line path or a complex shape. The path of the tool when

the tool is disengaged (retracted) is called a “rapid”. The **Contour Specification File** contains a succession of contours connected by rapids. The **Tool Path Editor** has the capability to conveniently save individual contours into a file, which can be later retrieved, positioned and/or rotated and added into the tool path described in the **Contour Specification File**. **Single Contour Files** are saved under a name that you provide with the filename extension “.CTS”.

Chapter 4

MOTOR CONTROL OUTPUTS

The electronic signals which are used to control the motors are generated by the **Indexer LPT** device driver. The **HPGL Controller** communicates appropriate commands to **Indexer LPT**. **Indexer LPT** performs low level control over the motors via the outputs located on the computers printer port(s). Refer to the **Indexer LPT** manual for technical information regarding the wiring and use of stepper motors, translators (amplifiers), and limit switches.

Discrete Digital Outputs

All signal output (and input) between the **HPGL Controller** and the outside world occurs through the **Indexer LPT** device driver using user-selectable **Indexer LPT** commands. Two useful commands for setting the voltage level on discrete output lines are *reduced_current* and *winding_power*. The associated output signals of these commands can be used to control external devices such as optically isolated switches and solenoid actuators.

Set-up menus allow you to specify **Indexer LPT** output commands for different purposes. When configuring your system, it is recommended that you first exercise whatever commands you intend to specify using the IXDIAG.EXE program provided with **Indexer LPT**, accessible from Windows using the **Start >**

Programs > Indexer LPT Diag menu selection. Since IXDI-AG.EXE allows you to control **Indexer LPT** directly, you can more easily troubleshoot your design.

Limit Switch Inputs

Operational limit switches define the normal operational boundaries of the motorized stages. Operational limit switches may be wired to the printer port as per the instructions found in the **Indexer LPT** manual.

In some systems, where stage over-travel is likely to present a hazard, an outer set of limit switches may be used for an emergency stop. The outer limit switches do not rely on software to arrest motion. For example, in one design an outer set of limit switches can be used to independently remove all power from the system via a “drop out” relay. In another instance, outer limit switches may be used in a circuit which interrupts the controlling step pulses. The actual implementation of your over-travel safety strategy is dependent on the machine that you are designing.

Input Query

Indexer LPT commands which are capable of determining the status of an input signal are used by the **HPGL Controller** to query the state of certain controls, such as the start switch.

Indexer LPT commands appropriate for this purpose are *-limit?*, *+limit?*, *aux?*, and *scan*. The feedback from any of these query commands is either a 1 or a 0, depending on the logic level or state of the input. The **HPGL Controller** setup menus allow you to assign query commands to different control functions. The **Indexer LPT** manual explains the usage and syntax of these input query commands.

All inputs to this program can be verified by means of the **Diagnostic** menu. The dialog boxes contained in this portion of the program continuously exercise the queries which you have specified in associated set-ups, and displays a live view of the results of these queries. You should verify all of your input query commands using the diagnostics before using them in production operations.

Feed-Hold Input

In all but the smallest and simplest machines the **Indexer LPT** *feed hold* feature must be installed.

When the motors are in motion, **Indexer LPT** occupies the computers' processor as a necessary requirement for fast and accurate timing. Consequently, keyboard input is suspended temporarily when the motors are being controlled. However, the *feed hold* feature provides for immediate and controlled interruption of tool motion. With the introduction of extensive look-ahead contouring, where **Indexer LPT** has continuous control over the tool path for longer times without interruption, incorporation of the *feed hold* feature into the machine design has become more important - and in most cases absolutely necessary.

The *feed hold* feature is conceptually simple and easy to install as per the documentation provided in the **Indexer LPT** users guide and the chapter in this manual entitled SYSTEM SET-UPS.

The X-Y Stages

Similar to a pen plotter, the tool path follows a pattern along a plane which is defined by two translation stages situated on perpendicular axes. Movement along these axes is controlled by means of pulse(step)/direction signals generated by **Indexer LPT**.

Each pulse results in an incremental movement of the associated stage. For example, assume the motor operates at a resolution of 200 steps (pulses) per revolution, and assume the stage is directly driven by a .200 pitch lead screw. In this case, the step resolution is .001 inch per step.

The **HPGL Controller** requires the step resolution of the X and Y axes to be the same.

The Z Stage

The Z stage is situated along an axis which is perpendicular to the plane which is defined by the X and Y axes. Movement along the Z axis causes the tool to plunge into or retract from the work.

The Z stage can be controlled by pulse/direction signals, similar to the X and Y stage. The **HPGL Controller** does not require the step resolution of the Z stage to be equal to the step resolution of the X and Y stages (although making the step resolution of all stages equal may ease hardware compatibility with three dimensional modeling software).

When the Z stage is motor controlled, the **HPGL Controller** can adjust the plunge depth of the tool to user-selectable levels for each HPGL pen number.

Optionally, the Z stage can be configured to be bi-positional: extended or retracted by means of a solenoid or air cylinder. For simple plunge operations, which only require a single depth tool plunge, this option saves the cost of a third motorized stage. Plunge timing can be implemented by using **Indexer LPT dwell** commands, or by optional plunge and retract input switches. Using *dwell* commands, the system provides a time delay to allow the Z axis sufficient time to plunge or retract. Using plunge and retract switches, the system uses the switch inputs to determine if the plunge or retract operation is complete.

Chapter 5

MENU USAGE

General

The **HPGL Controller** is set up and controlled by means of menus and dialog boxes. Options are selected similarly to many Windows programs using the mouse or keyboard.

If a mouse is not available, press and release the **Alt** shift to move the highlight to the **Main Menu** bar. Use the cursor keys to navigate the menu or press the character key corresponding to the underlined letter of the menu item to select. Use the cursor keys or character keys in a similar manner to select the menu item from the drop down list. Drop down menu selections which contain an elipsis (three dots ...) invoke another menu or a dialog box. You may navigate the dialog boxes using the **Tab** key to change the highlight, and the **Space** key to select an item, change a check box, or press a button. Use the cursor keys to change Radio Button selections (these buttons look like little radio dials), or to scroll through selections of a list box. Press the **Enter** key to accept changes, or **Escape** to abandon changes.

Making selections using a mouse is much easier. Simply locate the cursor over the desired item and snap the left button on the mouse. (The mechanisms in a conventional mouse may not be suitable for a shop environment. You may consider using a Touch-

Pad as an alternative). When making changes in a Dialog Box, select **Ok** to accept changes, or **Cancel** to abandon changes.

Two Types of Setups

From the **Main Menu** you may obtain access to the **Setup**, **Production** and **Diagnostic** menus. Set-up features are broken down into two categories: system **Setup**, and **CAM Edit**.

The first category of set-ups involves parameters relating to the design of the machine ,and are not likely to be changed in normal production operations. These set-up values are stored in a file named HPIXW.INI (located in the WINDOWS directory) and are accessed by means of the **Setup** menu. This menu can be password protected. The initial password to access this menu is “abc”. Once you have access to this menu, you may change the password. The password helps prevent inadvertent access to system setups and is NOT an iron-clad access lock. If you forget your password, you can find it by printing the HPIXW.INI file. The password will appear to the right of the keywords:

```
system password=
```

The other category of set-ups involves parameters relating to a particular machine operation, such as the name and location of the tool path files (**Plot Files**), cutting speeds, scaling etc. These set-ups are stored in files with “CAM” as the filename extension. We refer to them as **CAM Files**.

CAM Files are loaded using the **File > Open CAM File** menu. **CAM Files** are changed using the **Edit** menu. You may use the changes you have made to the CAM set-up without saving the changes to disk. Alternatively, you may save the changes using the **File > Save** menu, or save changes to a **CAM File** of another filename using **File > Save As**.

You may optionally restrict access to the CAM set-up by means of a password. Similar to the system password, the password protection for the CAM set-up is only meant to prevent inadvertant changes, and not as an iron clad access lock. The initial password to access CAM set-up is “def”. If you forget your password, you can find it by printing the HPIXW.INI file. The password will appear to the right of the keywords :

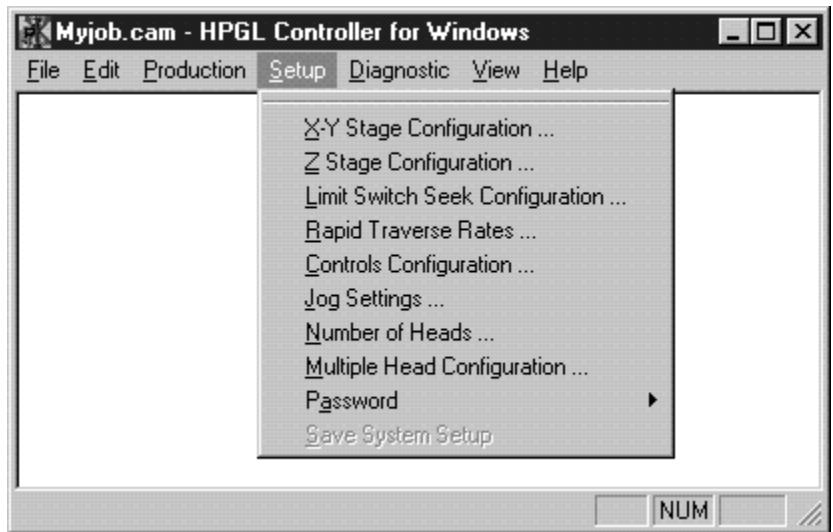
camedit password=

Tool Motion

All tool motion is controlled from within the **Production** menu. All selections under this menu bring up a dialog box presenting to the user the opportunity to proceed or cancel the operation. If the user selects **Ok** to proceed, a prompt appears requiring the user to press **Start** (or **Ctl-F2** if the software is set up for **Keyboard Start**). At this point the user can still abort the operation by selecting **Cancel**. Once the **Start** signal is received, motion commences. The software can be set up to accommodate three different **Start** options: **Keyboard Start**, **Start Switch**, or **Dual Start Switch**.

Chapter 6

SYSTEM SET-UPS



System set-up values may be accessed by means of the **Setup** selection of the **Main Menu**. Values are stored in the HPIXW.INI file, which is located in the WINDOWS directory.

X-Y Stage Configuration

Feed Motor X Axis

Feed Motor Y Axis

These fields contain the **Indexer LPT** axis designation for the X and Y stages. Acceptable values are “a” through “f”.

XY Units Name

Select the name of the dimensional units for X and Y motion from the list e.g. **in** for inches, **cm** for centimeters etc. This selection **ONLY** affects the units annotations, which appear in various places in this program, and **DOES NOT** automatically set up the appropriate ratio of step motor steps to units which is explained below.

Ratiometric Steps per Unit(s)

Ratiometric Units

The ratio of the **Ratiometric Steps per Unit(s)** to **Ratiometric Units** defines the motion of the stages in proportion to the step pulses generated by **Indexer LPT**. Use a convenient number for **Ratiometric Steps per Units(s)** and a corresponding number for **Ratiometric Units**.

Your machine must be constructed to use the same steps to

distance ratio for both the X and the Y axes.

For instance, assume you are directly driving a .200 inch lead screw with a step motor configured for 400 steps per revolution. In this case, 400 steps would move the stage by .200 inches. You may enter a value of 400 in the **Ratiometric Steps per Unit(s)** field and a value of .200 in the **Ratiometric Units** field. Select “in” from the **XY Units Name** list box to make the other menus and dialogs read correctly.

Assume this same machine is to be used in CAD/CAM operations where centimeters is the standard of measure. In this case, since $.200\text{in} = .508\text{cm}$, enter a value of .508 in the **Ratiometric Units** field. In this case “cm” is the most appropriate selection for **XY Units Name**.

In another example, assume that you are driving the X and Y stage by means of a cable system. You have determined experimentally, using the **Indexer LPT** Diagnostic Program and an appropriate measuring device, that commanding the motor to move 3000 steps results in a movement of 3.103 inches. In this case, enter a value of 3000 in the **Ratiometric Steps per Unit(s)** field, enter a value of 3.103 in the **Ratiometric Units** field, and select “in” for **XY Units Name**.

Total Distance Along X Axis **Total Distance Along Y Axis**

These fields represent the distance of travel along the associated axis. Typically this is the distance between the high and low operational limit switches. In a **Limit Switch Seek** operation (available from the **Production** menu), if the stage does not contact the limit switch after traveling the distance specified here, motion will cease and a warning message will appear.

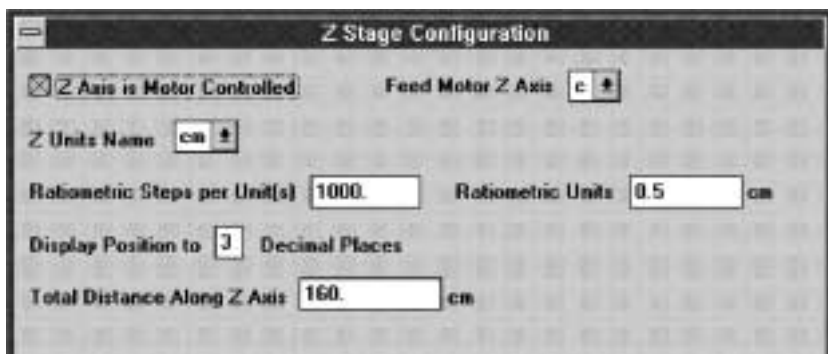
Z Stage Configuration

Z Axis is Motor Controlled?

This box is checked if you are using a step motor controlled stage for tool plunge. If it is not checked, the tool plunge may be controlled by a discrete digital output command. The status of this check box changes the dialog box to present an appropriate set of

set-up options.

Note: A step motor controlled Z stage will allow you to specify the plunge depth for each pen number (**Edit -> Pen Definitions Plunge Depth**). It will also allow you to plunge incrementally deeper with each tool path pass (**Edit -> Tool Path Plunge Offset**) for special operations such as pocket milling.



Feed Motor Z Axis

This field contains the **Indexer LPT** axis designation for the Z axis. Acceptable values are “a” through “f”. This field may not specify an axis which is being used for the X or Y stages.

Z Units Name

Ratiometric Steps per Unit(s)

Ratiometric Units

Total Distance Along Z Axis

Display Position to Total Distance Along Z Axis

These categories are similar in function to their counterparts in the **XY Stage Configuration**.

Z Stage Solenoid Configuration

These fields in the **Z Stage Configuration** dialog box appear only if the check box **Z Axis is Motor Controlled** is not checked.

Indexer LPT Command to Plunge

This field contains an **Indexer LPT** command which will be

executed upon each tool plunge (pen down). This command typically controls a discrete digital output used to control a solenoid actuator.

Indexer LPT Command to Plunge

Indexer LPT Command to Retract

Wait for Input Events on Plunge and Retract

Indexer LPT Command to Query Plunge Switch

Plunge Query Result

Indexer LPT Command to Query Retract Switch

Retract Query Result

Indexer LPT Command to Retract

This field contains an **Indexer LPT** command which will be executed upon each tool retract (pen up). This command typically controls a discrete digital output and reverses the operation of the command to plunge.

Wait for Input Events on Plunge and Retract

It is usually necessary to make provision for the time it takes for the tool to plunge (and retract) before proceeding with the following X-Y motion command. One method which can be used is to introduce a time delay using the CAM set-up menu. Another method is to wait for an event, such as a switch closure, before proceeding. A check in this check box chooses the latter method. The following **Plunge Query** fields only appear in this dialog box if this check box is checked.

Indexer LPT Command to Query Plunge Switch Plunge Query Result Indexer LPT Command to Query Retract Switch Retract Query Result

Indexer LPT commands are used to determine the status of

the plunge and retract switch signals. **Indexer LPT** commands which are appropriate for this purpose are *-limit?*, *+limit?*, *aux?*, and *scan*. The value of the **Query Result** field should be the **Indexer LPT** response, “1” or “0”, when the switch is actuated at the completion of the cycle. These fields are only visible when the the **Z Axis is Motor Controlled** check box is not checked and the **Wait for Input Events on Plunge and Retract** check box is checked.

Limit Switch Seek Configuration

	Seek Low Switch	Set Home After Retract	Retract Distance	Seek Rate	
X Axis	<input checked="" type="checkbox"/>	<input checked="" type="checkbox"/>	3. in	100. in/min	1548. max
Y Axis	<input checked="" type="checkbox"/>	<input checked="" type="checkbox"/>	2.5 in		
Z Axis	<input type="checkbox"/>	<input checked="" type="checkbox"/>	5.5 cm	150. cm/min	1966. max

Options for the Z axis will only appear if **Z Axis is Motor Controlled** option is checked in the **Setup > Z Stage Configuration** dialog. (Maximum value numbers and dimensional annotations (in, cm) that appear in the sample dialog in this manual do not pertain to your system).

Seek Low Limit Switch

This dialog box allows you to choose whether the **Production > Limit Switch Seek** operation will seek the high or low limit switch of the associated axis.

(If the **Z Axis** options are visible) note that since the direction of travel to retract the tool is positive (plunge is negative), it is usually convenient to configure the Z axis to seek the high limit switch, as this cycles the stage towards the most retracted location.

Set Home After Retract

A check in this check box causes the program to automatically set the position counter of the associated axis to zero (home position) after the **Production > Limit Switch Seek** sequence.

Retract Distance

These fields specify the distance the stage will retract from its associated limit switch when using the **Production > Limit Switch Seek** operation.

Rapid Traverse Rates

Rapid Traverse Rates			
X-Y Axes			
Starting Speed	50.	in/min	
Running Speed	1540.	in/min	1548. max
Acceleration	600.	in/min per sec	774. max

Starting Speed Running Speed Acceleration

Options for the Z axis will only appear if **Z Axis is Motor Controlled** option is checked in the **Setup > Z Stage Configuration** dialog. (Maximum value numbers and dimensional annotations (in, cm) that appear in the sample dialog in this manual do not pertain to your system).

Generally speaking “rapid traverse” relates to stage motion when the tool is not in contact with the material. For the X-Y axes, rapid traverse rates apply when the tool is retracted. For the Z axis, the rapid traverse rates apply to the rates used in plunging to the offset position and in retracting the tool.

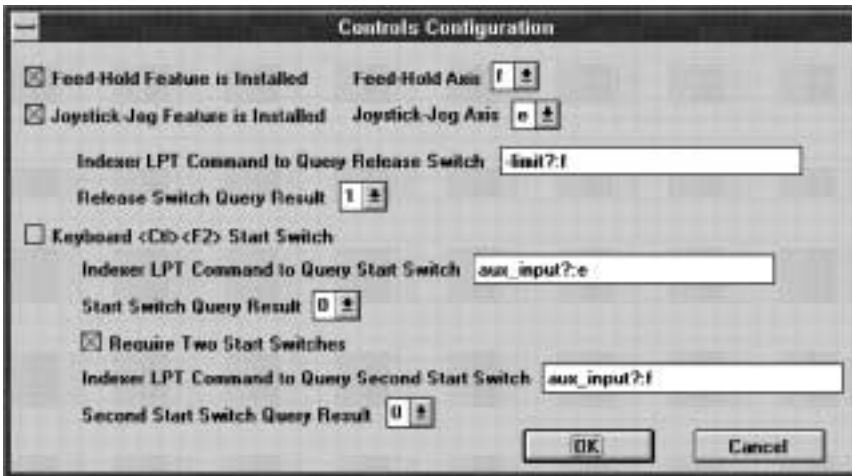
Speeds are represented in units per minute. The names of the units which are represented (in, cm etc.) are the names which were set up in the **Setup > Stage Configuration > Units Name** fields. Acceleration is represented in units per minute per second.

The **Starting Speed** field represents the instantaneous rate at which the stepper motor will begin motion. The motors then accelerate to the plateau velocity defined by contents of the **Running Speed** field. The **Starting Speed** must never be set to exceed the **Running Speed**. The values which you set up in this dialog box will largely depend on the limitations of your system.

One limitation is the maximum step rate of which your computer is capable. The dialog box displays maximum values of speed and acceleration which can be attained by your computer. (Note that these values are calculated on the basis of computer speed in combination with other setups).

Another limitation depends on the power of your step motor drive system. You should not set the starting speed faster than your motors can instantaneously start. Neither should you set the acceleration faster than the capabilities of the motor drive system. Safety and the physical strength of your system components are also considerations.

Controls Configuration



Feed-Hold Feature is Installed

This feature must be installed in all but the smallest and simplest applications.

This check box should be checked if the system is designed to utilize the **Indexer LPT *feed hold*** feature. Refer to the **Indexer LPT** documentation for a detailed explanation of the *feed hold* feature.

Feed-Hold Axis

This item only appears if the **Feedhold Axis is Installed?** check box is checked. This field contains the axis designator for the *feed hold* feature. Allowable values are “a” through “f”. You cannot designate the same axis for both *joystick* and *feed hold*. You cannot specify here any axis which is being used for motion control on the X, Y or Z stages.

Joystick-Jog Feature is Installed

This check box should be checked if the system is designed to utilize the **Indexer LPT *joystick*** feature. When this box is checked, fields which relate to setting up the *joystick* controls appear in the dialog box.

Joystick-Jog Axis

This field contains the axis designator for the *joystick jog* feature. Allowable values are “a” through “f”. You cannot designate the same axis for both *joystick* and *feedhold*. You cannot specify here any axis which is being used for motion control on the X, Y or Z stages.

For a more thorough explanation on the implementation and wiring of the *joystick* and *feedhold* features, consult the **Indexer LPT** documentation.

Indexer LPT Command to Query Release Switch Release Switch Query Result

The release switch input is used by the **HPGL Controller** to determine when the operator wishes to exit the joystick jog mode. The release switch input can be set up for any **Indexer LPT** query which responds with “1” and “0”.

The machine designer may consider using the *feedhold abort* input for this purpose. Since *feedhold abort* releases the machine from a suspended motion state, and since the *feedhold* feature is never active in joystick jog mode, a single input entitled “release”

may be used to accomplish a dual purpose.

Keyboard <Ctl><F2> Start Switch

When this check box is checked motion sequences requiring a **Start** sequence are initiated by simultaneously pressing the keyboard **Ctrl** and function key **F2** . If this box is not checked, external signals are used for **Start**, and appropriate set-up fields appear in the dialog box.

Indexer LPT Command to Query Start Switch Start Switch Query Result

The **Start** input is used by the **HPGL Controller** to determine when the operator wishes to initiate motor movement. The **Query Start Switch** field can be set up for any **Indexer LPT** query which responds with “1” and “0”. **Start Switch Query Result** represents the query result necessary for motion to commence.

CAUTION

Using the *Auxiliary Input* signal for the start switch may present a safety hazard. Unless terminated to either ground or logic 1 (5 Volts), the *Auxiliary Input* signal may randomly fluctuate and could possibly cause a spurious Start, a dangerous condition. Even if properly terminated, note that an accidentally unplugged cable could break external termination and present this hazard. If you use the *Auxiliary Input* for a Start signal, you must design appropriate safeguards into your wiring. Otherwise, avoid using the *Auxiliary Input* for this purpose.

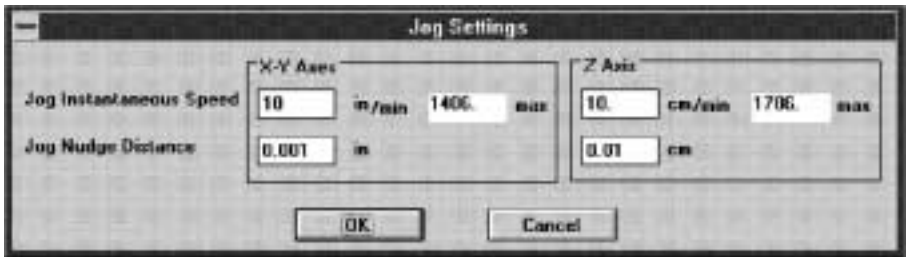
Require Two Start Switches Indexer LPT Command to Query Second Start Switch Second Start Switch Query Result

In some applications it is prudent for safety to require the operator to occupy both of his hands before motion is allowed to commence. This option provides for a second switch input for **Start**.

Jog Settings

This dialog is available only if the **Setup > > Controls >**

Joystick-Jog Feature is Installed check box is checked.



Joystick Instantaneous Speed

This field sets up the speed for *joystick* control when the instantaneous rate switch de-selects accelerated motion. (“Instantaneous” rate means constant speed). Refer to the **Indexer LPT** documentation relating to *joystick* hard-wired options.

Joystick Nudge Distance

One of the *joystick* hard-wired options allows the operator to switch select a “nudge” mode, which sends a pre-selected burst of steps every half second whenever the operator activates a *joystick* switch. The resulting motion appears to “nudge” the stage in small increments, allowing for very fine positioning. This field sets up the distance corresponding to the burst of steps.

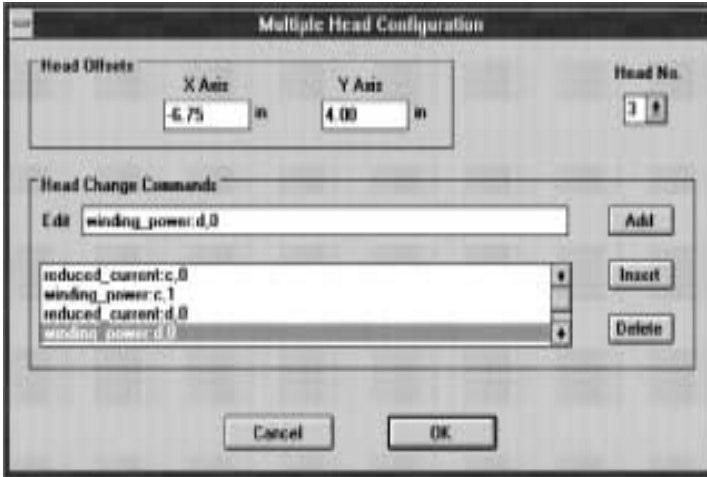
The after pressing **OK**, the value is rounded off to the resolution of the nearest step increment. To view the actual value being used simply bring in the dialog again. Very small values will be presented in scientific notation. The decimal precision of the displayed values will correspond to the set-up entry in the **Setup > Stage Configuration > Display Position to Decimal Places** field.

Multiple Head Configuration

Head No.

When the **Setup Number of Heads** setup-up calls for more than one head, this dialog box is available from the **Setup** menu. **Heads** are associated with HPGL pen numbers in the **Edit Pen Definitions** dialog. This feature may accommodate a variety of

physical configurations depending on the design of the machine. The **Head No** list box allows you to select a set-up menu pertaining to each **Head**.



Head Offsets

These values designate a distance from an arbitrary location on an X-Y gantry. For simplicity, this position is often selected as the position of **Head No 1** (offsets for Head No 1 would be zero). In this case, the **Head Offsets** of subsequent heads comprise the distances that the particular head resides from **Head 1** in the X and Y directions. In actual operation, when the **Head** is changed by means of a menu selection, or as a result of a pen change, the **X-Y Stages** automatically adjust in position according to the set-up values in these fields.

Head Change Commands

This section contains an arbitrarily long list of **Indexer LPT** commands which are performed during a **Head** change operation. When a different **Head** is selected, first the X-Y carriage is adjusted according to the **Head Offsets**, then this list of commands is sent to **Indexer LPT**.

The list editor allows you to easily add, insert, and delete commands to the list. To add a command to the end of the list, simply type the command into the **Edit** field and snap on the **Add**

button. To insert the command into the list, snap on the location in the list where you want the command to be inserted, then snap on the **Insert** button. Likewise, to delete any item from the list, highlight the list item with the cursor, and snap on the **Delete** button.

Password

System Setup

CAM Edit

Change Passwords

Password access is provided to protect System and CAM set-ups from accidental modification. **These passwords should be used only to avoid accidental modification of setup values and not as an iron-clad protection against access to certain features.** The initial password which comes with the product is “abc” for the **System Setup** and “def” for **CAM Edit**. You may choose not to use this feature, or temporarily restrict access without changing the set-up.

If you forget your password, you can find it by printing the HPIXW.INI file. The password will appear on the line under the section:

[Password]

Save Setup File

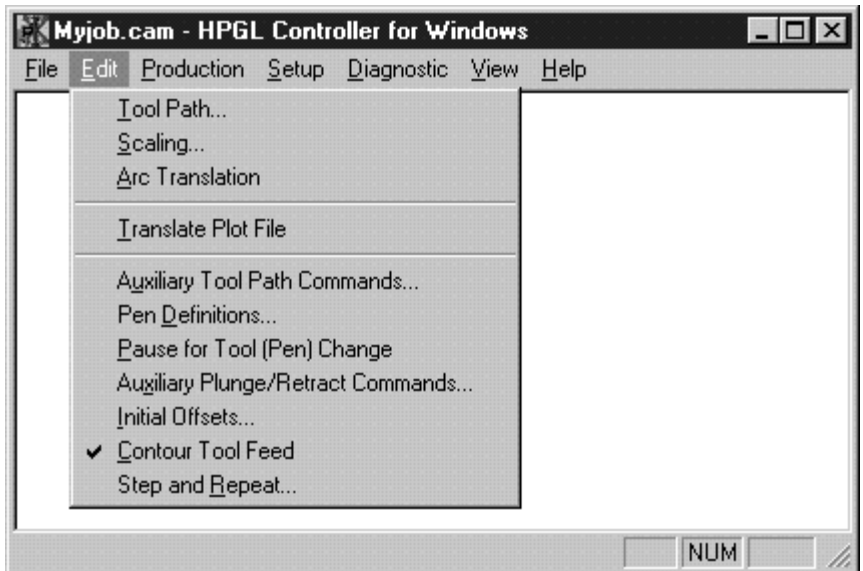
This selection will save the current system configuration to the HPIXW.INI file, located in the WINDOWS directory.

Chapter 7

CAM SET-UPS

CAM set-ups can be modified by means of the **Edit** menu. These set-ups are stored in ASCII files with “CAM” as the file-name extension. We refer to them as **CAM Files** (Chapter 3).

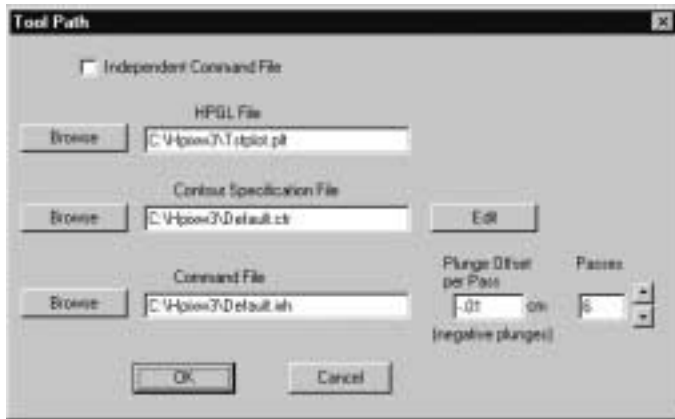
A **CAM File** is selected by means of the **File > Open** menu selection. Note that the initial directory which the file browser displays is the “Start in:” field which is set up under the



Windows Shortcut. (To change the working directory, right snap over the **HPGL Controller's** icon and snap over the **Properties** selection of the pop-up menu that appears. Snap over the **Shortcut** tab, then enter the complete path to the location of your **CAM File's** in the field entitled "Start in:").

The **CAM Files** contain information which pertains to the individual part which is being manufactured. **CAM Files** contain a substantial amount of information, some of which will change from job to job and some of which will not. To save you the trouble of having to enter information that will not change, the **HPGL Controller** makes it easy to duplicate **CAM Files**, so that you may edit only the items that need to be changed. It may be convenient, therefore, to have a number of template, or "default" **CAM files** that contain information pertinent to different types of jobs that you may run. Refer to the section of this manual entitled **Making "default" CAM Files**, located in the chapter entitled **CAM FILE SET-UPS**.

Tool Path



Independent Command File

Check this box if you wish to decouple the **Command File** from the **HPGL File**. This feature can also be used when you are generating the **Command File** by means of another program, making the **HPGL File Specification** irrelevant.

HPGL File

This field contains the file specification (drive:path\filename) of the **HPGL File** which is being used to generate the tool path. The **Edit > Convert CAM File** menu selection converts the HPGL instructions into **Indexer LPT** commands, and places them in a **Command File**.

Contour Specification File

This file is originally generated from information in the **Command File**. The purpose of the **Contour Specification File** is to store additional information regarding the tool path, such as the tool path offset, contour order and direction.

The **Tool Path Editor** can be used to order the tool path and specify the offsets. The **Tool Path Editor** is entered by snapping over the **Edit** button located to the right of the **Contour Specification File** field in this dialog.

If the **Contour Specification File** field contains no entry, or if it contains the entry “none”, when the **Edit** button is snapped a file name will be created using the name of the **CAM** file as the base, and “.ctr” as the file name extension.

Command File

This field contains the file specification of the **Command File**. The **Command File** controls the actual path of the tool when a job is run. Any valid file name can be used. It is recommended, however, that you use the same file name root as the **CAM** file with “.ixh” as the extension. For example MYJOB.CAM would have a **Command File Specification** of MYJOB.IXH.

Use Caution when Naming Command Files

It is possible to specify the same **Command File** in more than one **CAM File**. This can be very useful. Suppose you are manufacturing a particular part from different materials. The **Command File** will be the same, but the tool speeds may vary according to the material being used. In this case you simply set up the different pen speeds under different **CAM Files**, but keep the **Command File Specification** the same in each **CAM File**. You are at liberty to change other **CAM** set-ups as well: plunge

depth, tool passes, offsets, etc. without needing a separate **Command File** for each CAM file.

This flexibility introduces a possibility for error, since changes which affect the generation of the **Command File**, such as changes to the **HPGL File**, changes to Scaling, or other changes introduced under the **Tool Path Editor** will affect all CAM files which specify the same **Command File** name. Consequently, in most applications it is desirable to give the **Command File** a unique name. It is recommended that the name of the **Command File** reflect the base name of the **CAM File**, only with "IXH" as the extension. You are given an option to have this done for you automatically when you save a **CAM File** using **File > Save As**.

Plunge Offset per Pass

This field only appears when the Z axis is stepper motor controlled. In some applications it is desirable to repeat a tool path, while incrementally lowering the Z stage to increase the depth of cut. This field represents the distance the plunge depth will be offset after each pass. If incremental increase in plunge depth is not desired, zero depth should be specified. Plunge depth is always a negative value.

Passes

The value in this field determines the number of times the **Command File** will be traversed.

Scaling

Scale Factor

This field governs the proportional size of the tool path when converting the **HPGL File** to the **Indexer LPT** commands in the **Command File**. For example, if you desire the tool path to be equivalent to the size specified in the **HPGL File** (1:1 scale), make the value of this field 1. If you wish the tool path to be three-quarter size, make the value .75, double-size 2, etc. This field **ONLY** affects the **Edit > Convert HPGL File** process and has no effect on independent or pre-existing **Command Files**. (When you change the Scale Factor you must execute **Edit >**

Convert **HPGL File** for the change to take effect.)

Ratiometric Plotting Units Ratiometric Motion Units

The ratio of these fields determines the proportional size of the tool path. Unlike the “Scale Factor” field, however, once you determine the values for these fields, you will have little need to change them.

The values that you enter into these fields are determined by the plotter characteristics with which your CAD program is set to work. For example, if your CAD program plotter driver is configured for use with the HP 7475 plotter, the numerical values which define motion in inches will reflect a ratio of 1020.9:1. The number “1020.9” is in dimensions of “plotting units.” In this case the number “1” is in units of inches. Your CAD program, therefore, designates a distance of 1/1020.9 or (.0009795) inches per plotting unit. Be careful to use the same dimensional motion units in this field (e.g., inches, millimeters, etc.) as you use for the X-Y stage in system set-up: **Setup > XY Stage Configuration**.

Plotting units are generally integer values. Consequently, the plot unit resolution of a 1:1 plot for an HP 7475 plotter is .0009795 inches. One way to increase the plot resolution with the **HPGL Controller** is to increase the scale factor in your CAD program when generating the plot file. You may then compensate for the increased size by decreasing the scale factor in the **Scale Factor** field of this dialog box. Plot unit resolution will vary in proportion to scale factor. In the previous example a double-size plot and an accompanying .5 scale factor will result in a plot unit resolution of $(.5) \times (.000975) = .0004897$ inches.

As with the **Scale Factor** field, if you make changes to these fields you must execute **Edit > Convert HPGL File** for the changes to have effect.

Arc Translation

In order to more completely control the tool path look-ahead, feed hold, and re-trace, the **HPGL Controller** breaks up circular motion into individual straight line segments. The manner in which these segments are generated is controlled by this menu.

Ultimately, the **Command File** that is used to control tool path motion must only contain **Indexer LPT feed** commands for contouring and *move* commands for rapid traverse. The **HPGL Controller** converts circular motion commands to *feed* commands in two different manners.

HPGL Conversion

Most CAD programs convert circles and arcs to HPGL line segments before generating the **Plot File**. In these cases, the CAD program itself may have a similar menu to this, giving the user control over the resolution and accuracy of the approximation process. When circles and arcs are broken up into line segments within the CAD program before generating the HPGL **Plot File**, set-ups in this menu have no effect.

However, if the CAD program generates HPGL circular interpolation commands, this menu governs how they are to be interpreted. The specific HPGL commands are **AA** (Arc Absolute), **AR** (Arc Relative) and **CI** (Circle). (If you have a text editor that enables you to view the data in your **Plot File**, you may be able to determine if your CAD program is generating these commands by looking for them. You can also **TYPE** a **Plot File** to the screen from a DOS prompt using the /p option to avoid rapid scrolling, and try to visually detect the presence of these commands).

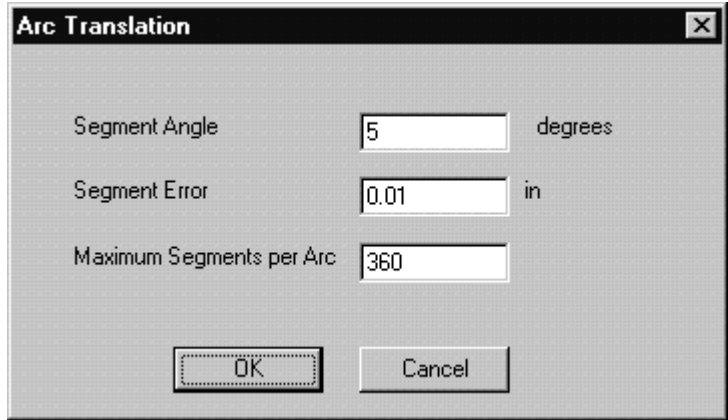
Independent Command File

If **Indexer LPT arc_to** and *circle* commands occur in a **Command File** (that, for example may have been generated outside of the **HPGL Controller**, or generated by earlier versions of the **HPGL Controller**) then that **Command File** is not suitable for production operations. However, you can use this file to generate a suitable **Command File** by bringing it into the **Tool Path Editor** using the **Tool Path > Edit** button. From the **Tool Path Editor** you must over-write the old **Command File** with a newer, segmented type using the **Tool Path Editor's File > Generate Command File** menu.

Guidelines

Do NOT enter tolerance requirements that greatly exceed your manufacturing requirement. A greater number of segments will result in larger file sizes and longer pre-calculation dwell at

run time. Excessive values may even compromise the quality of the machine motion.



Segment Angle

This is the maximum angle that the arc will be approximated across. In other words, as long as the geometry does not violate the **Segment Error**, or the **Maximum Segments per Arc**, the arc will be constructed in segments subtending **Segment Angle** or less.

It is important to note that **Segment Angle** is a maximum angle, and that the total included angle of the arc is not limited to resolve to this angle. In other words, if the **Segment Angle** was specified as 5 degrees, an 8 degree arc will be drawn using two segments subtended by 4 degrees. A ten degree arc will be drawn using two segments subtended by five degrees.

This setup is useful in optimizing jobs where tolerances of smaller radii arcs are held tighter than the **Segment Error** allowed in larger radii arcs.

Segment Error

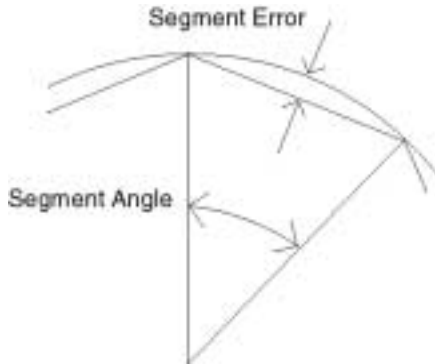
This value is the maximum dimensional error due to linear approximation. In other words, it is the farthest distance that the segment deviates from the true theoretical arc.

This set-up over-rides **Segment Angle**. Smaller arcs subtended at **Segment Angle** may generate errors which are less than this

set-up value. Larger arcs are broken down into more segments so that **Segment Error** is not violated.

Maximum Segments per Arc

This value over-rides both **Segment Error** and **Segment Angle**. The number of segments used to approximate an arc is limited by this value.



Translate Plot File

Select this menu item when you wish to generate a **Command File** from the **Plot File** specified in the **Tool Path** dialog.

If the **Plot File > Independent Command File** check box is checked, then this menu item has no meaning and is therefore disabled. The **Command File** in this case is not associated with a **Plot File**.

If you are not set up to use an independent **Command File**, then you may use this menu function to generate one, since it is the **Command File** which is actually used to direct the tool path.

If you have already generated a **Command File**, and you make changes to the **Plot File**, or if any change are made in the **Scaling** dialog, then you must repeat this menu function to incorporate the changes. You do not have to repeat this menu function if changes are made to the **Plot File > Plunge Offset per Pass**, or the **Plot File > Passes** set-ups.

You do not have to repeat this function if CAM set-up

changes are made to dialogs accessed from below the separator bar in the Edit menu: **Auxiliary Tool Path Commands**, **Pen Definitions**, **Pause for Tool Change**, **Auxiliary Plunge/Retract Commands**, **Initial Offsets**, **Contour Tool Feed**, and **Step and Repeat**.

Auxiliary Tool Path Commands

Indexer LPT Commands Before Tool Path Indexer LPT Commands After Tool Path

These list editors specify **Indexer LPT** commands which will be executed before and after each tool path traversal.

Pen Definitions

When this selection is made, a menu appears which allows you to edit parameters which are associated with each HPGL pen. In an ordinary plotter, the pen number usually designates a color or line width. The **HPGL Controller** uses the pen number to designate additional machine control features.

Pen Number

This list box selects the HPGL pen number. When the menu is first invoked, Pen 1 is selected, along with set-up parameters which are associated with Pen 1. When Pen 1 is selected the **Copy** button is active, which allows you to automatically copy the values of Pen 1 to all the other pens. If any of the values have been changed, the program allows you to cancel the change. Once the pen change is accomplished, the values for the previous pen are saved into the program as if you snapped the **Ok** button during the editing session.

Head

If **Setup > Number of Heads** specifies more than one **Head**, then a unique **Head** number may be associated with each pen number. During the **Production > Run** operation the program will execute a **Head** change operation when the pens are changed if the the head number of the new pen changes from the previous pen. A head change operation consists of moving the X-Y carriage to the relative offset specified in the **Setup > Multiple Head**

Configuration dialog, and executing the command list specified in the **Setup > Multiple Head Configuration** dialog.

Pen Definitions

Pen Number

Head

Feed Starting Speed in/min

Feed Cutting Speed in/min 2176 max

Feed Acceleration in/min per sec 7740 max

Max Contouring Feed Shift in/min

Plunge Depth (negative plunges) cm

Plunge Starting Speed cm/min

Plunge Cutting Speed cm/min 2764 max

Plunge Acceleration cm/min per sec 9830 max

Trace Width (Cutter Diameter) in

Copy values from Pen 1 to all pens

Feed Starting Speed Feed Cutting Speed Feed Acceleration

These fields determine the motion dynamics of the X-Y axes during the pen down phase of the tool path traversal. The **Feed Cutting Speed** is the vector rate, or the speed of the tool along its path. The dominant axis (“dominant” refers to the axis which is being moved the greatest extent) starts motion instantaneously at the **Feed Starting Speed**, then accelerates at the **Feed Acceleration** rate until it reaches the speed required to maintain the **Feed Cutting Speed**.

Max Contouring Feed Shift

The value in this field only has significance if the **Contour Tool Feed** feature is enabled. Contouring **Feed Shift** is a value which represents the maximum instantaneous shift in velocity which is allowed when passing from *feed* command to *feed* command in contouring operations. (For a more thorough explanation of the implications of **Feed Shift**, refer to the **Indexer LPT** manual.) Generally speaking, increasing the value of **Feed Shift** will cause a more uniform cutting velocity across complex tool paths. Increasing **Feed Shift** will also increase the stress on the X-Y motor drive system.

The value of **Feed Shift** cannot exceed the value of **Feed Starting Speed**.

Plunge Depth

This field only appears when the Z axis is configured for step motor control. The value in this field determines the distance the Z axis will plunge during a pen down operation. It should be noted that the total distance which the Z axis will plunge is the sum of the accumulated plunge offset per pass (if any) in addition to this value. **Plunge Depth** is always a negative value.

Plunge Starting Speed

Plunge Cutting Speed

Plunge Acceleration

These fields only appear when the Z axis is configured for step motor control. These fields determine the motion dynamics of the Z axis during lower portion of the plunge cycle. (The motion dynamics of the Z axis during the upper plunge offset portion of the plunge cycle, and the retract cycle, are set up in the **Setup > Rapid Traverse Rates** dialog.)

Trace Width (Cutter Diameter)

This field determines the offset distance from the contour path that the **Tool Path Editor** will use when it over-writes the **Command File**.

The **Contour File** specifies whether there is no offset, or whether there is left offset, or whether there is right offset for each contour. The **Contour File** also specifies which pen number

is used for each contour. This field determines the amount of offset to be used.

For example, consider a contour using Pen 1 and having the offset properties of “Right Offset”. If this field contains the value of 0.250 inches, then the amount of offset would be one half of this amount, or 0.125 inches.

It is important to note that this field is **ONLY** used by the **Tool Path Editor** when the **Command File** is being over-written by means of the **Tool Path Editor**'s **File > Generate Command File** menu selection. Changes to this field do **NOT** take effect apart from this action within the **Tool Path Editor**.

For example, suppose you wish to cut out one inch square shapes using a .250 diameter cutter. You may draw a one inch square shape using your CAD program, generate an **HPGL File**, then generate an initial **Command File** using the **Edit > Translate Plot File** selection from the **Main Menu**. Now, select the **Pen Definitions** menu for Pen 1, and enter 0.250 into the **Trace Width (Cutter Diameter) field**. Next enter the **Tool Path Editor** by snapping over the **Edit** button in the **Edit > Tool Path** dialog. Select (highlight) the contour using the mouse or the **Tab** key on the keyboard. Using the dialog that appears when you snap over the **Edit > Offset Properties** menu selection of the **Tool Path Editor**, make sure that Pen 1 is assigned to the contour, and select an appropriate offset. The offset path associated with Pen 1, which is a distance of 0.125 inches from the contour, will appear on the screen when you select the offset. To make the offset take effect, from the **Tool Path Editor** select **File > Generate Command File**. The original **Command File**, which was generated by means of the **Edit > Translate Plot File** action, will be over-written with new geometry that accounts for the offset tool path.

In this example, suppose that you wish to run the job at a later time, but you wish to use a .375 diameter tool instead of a the .250 diameter. Enter the **Pen Definition** dialog for Pen 1 and change the value of the **Trace Width (Cutter Diameter) field** from 0.250 to 0.375. Please note that changes will **NOT** be immediately effected. You must then enter the **Tool Path Editor**. (At this time, you can visually inspect the change in offset value). To make the change take effect, from the **Tool Path Editor** select

Generate Command File from the **File** menu to over-write the old **Command File**. Once the **Command File** is over-written, the changes in **Trace Width (Cutter Diameter)** will become effective.

Pause for Tool (Pen) Change

If the entry in the dialog box field is “Yes,” the system will pause the **Production > Run** operation when the HPGL pen number is changed. This option is useful when a tool or set-up must be manually changed for each pen number.

Auxiliary Plunge/Retract Commands

Indexer LPT Commands Before Plunge

Indexer LPT Command After Plunge

Indexer LPT Command Before Retract

Indexer LPT Commands After Retract

These fields designate **Indexer LPT** commands which are executed in conjunction with each plunge and retract process. The sequencing of the commands occurs as the respective field names imply.

Initial Offsets

X Axis

Y Axis

Z Axis

At the start of the **Production > Run Tool Path** operation the stages will be positioned to an initial offset specified by these fields. Note that the Z axis field will only appear in this dialog box if the Z axis is set up for stepper motor control.

Contour Tool Feed

If “Yes” is selected, the **HPGL Controller** will take advantage of the **Indexer LPT** contouring feature. The contouring feature queues the *feed* commands, then executes the queue as a sin-

gle command, smoothly controlling the velocity from *feed* command to *feed* command. If “No” is selected each *feed* command is sent to **Indexer LPT** individually.

Step and Repeat

This feature uses the **Command File** to manufacture a matrix of parts arranged along rows and columns. The tool path is completed on each part before progressing to the next. Row and column positions are incrementally indexed starting with the part in the first row in the first column.. This part is located in the corner of the matrix which faces the negative direction of the X and Y axes. Consequently, the row and column positions increase as the row and index increases.

Part to part progression occurs up and down along the rows. Row to row transition occurs up the end most columns. This “zig-zag progression from part to part is repeated until the upper-most row is complete.



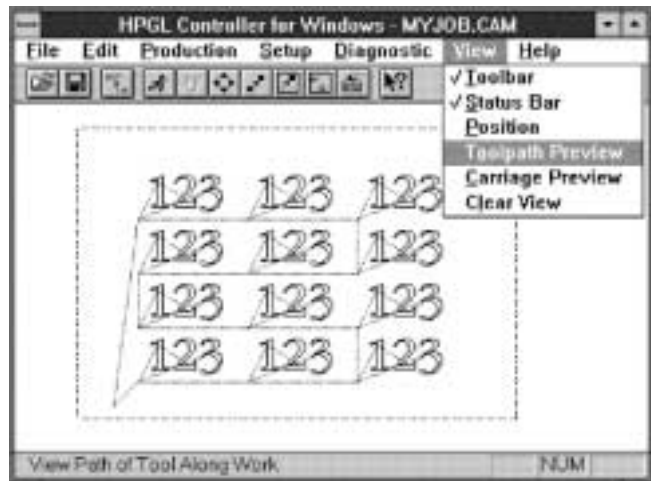
Number of Parts in Row Number of Parts in Column

The names of these fields denote their purpose. Note that **Number of Parts in Row** designates the number of columns, and **Number of Parts in Column** designates the number of rows in the matrix. The number of parts in the matrix is the product of these two fields. If both of these fields designate “1”, then only one part is being made (a 1x1 matrix), and the **Step and Repeat**

feature is essentially disabled.

Index Distance Along X Axis Index Distance Along Y Axis

These fields designate the distance between the parts in the matrix. The **Index Distance Along X Axis** designates the part to part distance along the X Axis, or the distance between columns. The **Index Distance Along Y Axis** designates the part to part distance along the Y axis, or the distance between rows. Note that the specified distance is between corresponding points on each part and NOT the separation distance between the closest adjacent points on each part.



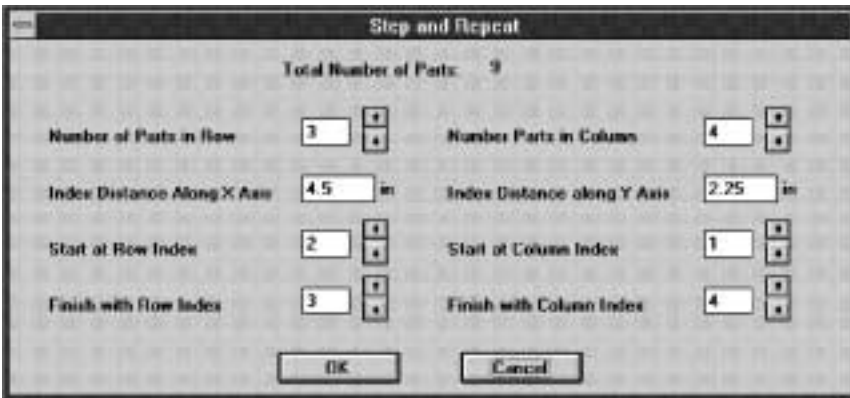
Start Row Index Start Column Index Finish Row Index Finish Column Index

Parts in the matrix can be located by their **Row** and **Column Index**. The **Row Index** value designates the part position along the row. **Row Index** can be thought of as “Column Number”. Likewise, **Column Index** value designates the part position along the column. **Column Index** can be thought of as “Row Number”.

In production operations it may be necessary to start and stop

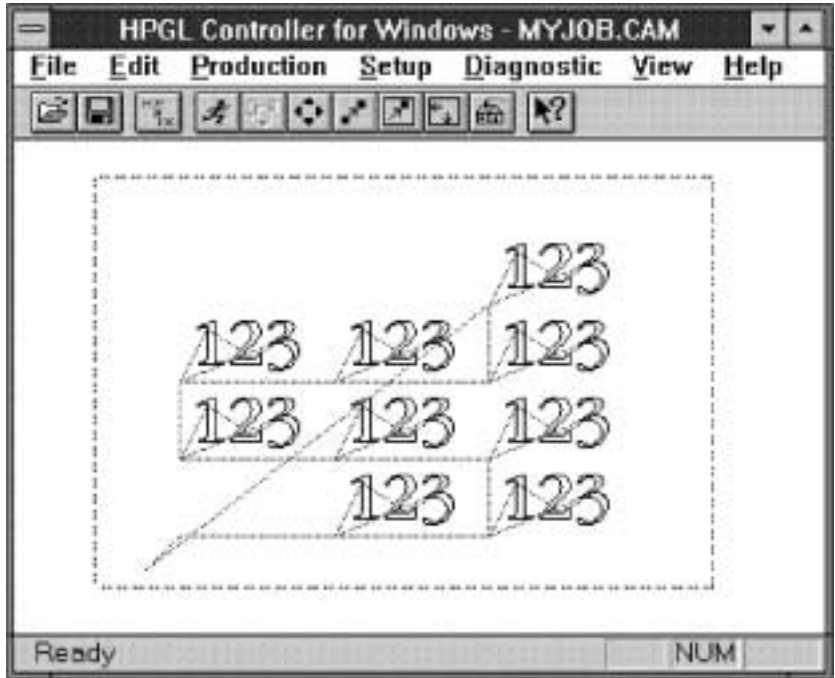
at intermediate positions in the matrix. Use these fields to designate which part position to start and which to stop. As you change these fields the dialog will display the number of repeat patterns adjacent to **Total Number of Parts**.

In the example below, a **Step and Repeat** pattern is set-up with three parts to each row (three columns), and four parts to each column (four rows). Production will begin with the part designated by **Row Index 2 (Column 2)**, and **Column Index 1 (Row 1)**. Parts will be completed along **Row 1** from left to right until the end of the row is reached, at which time the part in the next row immediately above (**Row 2**) will be started. From there, parts will be completed from right to left until the beginning of the row is reached. **Row 3** will then be completed from left to right. **Row 4** will be completed from right to left until the part designated by the **Finish Row Index** and **Finish Column Index** is reached. In the example, this part is in **Column Index 4 (Row 4)**, and **Row Index 3 (Column 3)**.



The easiest way to visualize the **Step and Repeat** process is by means of the **View > Toolpath Preview** menu function. Using this function the part paths are drawn on the screen in the order in which they would occur in production operations, making it easy to experiment with different set-up values and to observe the order of operations. (Note that in the illustration the limit switch boundaries are shown with a dashed line. You must first execute **Production > Set Home** on the X and Y axes in order to see the

limit boundaries using **View > Toolpath**).



Chapter 8

TOOL PATH EDITING

Generating Command Files

As mentioned in the chapter entitled IMPORTANT FILES, the **Command File** contains the information that the **HPGL Controller** uses when the job is run. This information includes **Indexer LPT** commands that are sent to **Indexer LPT** without modification, such as *move* and *feed* commands, as well as **Directives**, which are expanded at run time into appropriate **Indexer LPT** commands or sequences of commands. The specific commands that the **Directives** may be expanded into is determined by job and system setups at run time. **Indexer LPT move** commands are used for rapid traversal when the tool is retracted. **Indexer LPT feed** commands are used to traverse a contour when the tool is engaged after a plunge cycle.

(It may be helpful to review the chapter entitled IMPORTANT FILES at this time).

One way to generate a **Command File** is to use the built in HPGL conversion utility, which is accessible from the **Main Menu's Edit > Translate Plot File** menu.

Another way to generate a **Command File** is with an ordinary text editor, such as *Notepad* or *Wordpad*. You must be careful

always to save the **Command File** as ASCII text. (You can use an ordinary text editor to view the text of a **Command File** that was generated by another method).

Still another way to generate a **Command File** is by means of the built in **Tool Path Editor**. The **Tool Path Editor** initially reads the information contained in a **Command File**, then it allows you to graphically add certain information and make modifications. The modified and new information is stored in another file, called the **Contour Specification File**. Finally, using the additional information contained in the **Contour Specification File**, the **Tool Path Editor** lets you generate a new **Command File**, over-writing the old.

Command File Directives

These directives are ASCII characters that appear in the **Command File** as lines of text.

#D

Pen Down - This directive causes a tool plunge sequence.

#P

Pen Park - This directive causes the carriage to return to zero position. Note that this directive DOES NOT include a number following the “P”, as in the **Select Pen** directive “P1”, “P2” etc.

#Pn

Select Pen - The “n” in this directive designates a pen number, such as “#P1”, #P2 etc. This directive causes the pen to change from its present pen assignment to the assignment specified by “n”.

#U

Pen Up - This directive causes a tool retract sequence.

Command File Rules

Command Files contain a sequence of commands in the order that they shall be executed at run time. **Indexer LPT** *move*

commands are used for rapid traversal when the pen is retracted at the beginning of the job or after the **#U** directive. **Indexer LPT feed** commands are used when the pen is plunged (engaged) after the **#D** directive. The default pen number when a job is started is Pen 1. Pen numbers remain in effect until changed by the **#Pn** directive. Each directive and **Indexer LPT** command is delimited by a carriage return and line feed, making each directive and each **Indexer LPT** command appear on separate lines when viewed with an ASCII text editor. No additional white spaces (such as space and tab), or control characters are permissible.

Always be mindful of your **HPGL Controller** set-ups, both system set-ups and CAM set-ups. Develop a consistent strategy of operation based on shared control between **Indexer LPT** commands generated by the **HPGL Controller** on the basis of your set-ups, and the **Indexer LPT** commands embedded in the **Command File**.

Please also be mindful that while the structure and use of the **Command File** introduces a measure of flexibility in the design of your automated system, it can also be used to inappropriately bypass some safety features built into the **HPGL Controller**. If you do modify or generate a **Command File** outside of the **HPGL Controller**, you must do so only with the proper understanding and the utmost care.

Working With Contour Specification Files

The **Contour Specification File** exists for the purpose of storing changes that you make to the shape and order of the tool path contours, as well as additional information relating to offset compensation. The **Contour Specification File** is an ASCII file, very similar to the **Command File**. However, the **Contour Specification File** can contain additional directives relating to tool path offset. These directives are **#DR** and **#DL**.

#DR is similar in meaning to the **Command File** directive **#D**. It indicates a pen down action. However, the **#DR** directive also indicates that an offset path to the **Right** of the contour shall be traversed. The distance to the right, which is to say, the amount of right offset compensation, is determined by the value of the **Trace Width (Cutter Diameter)** for the current pen.

#DL functions similarly to **#DR**, except **#DL** indicates that the offset shall be to the **Left** of the contour.

In the **Contour Specification File**, **#D** simply means no offset. In this case the path of the tool shall track to the centerline of the contour.

The actual amount of offset compensation is not stored within the **Contour Specification File**. Instead, when the **Command File** is over-written from within the **Tool Path Editor** by means of the **Tool Path Editor's File > Generate Command File** menu, the actual centerline that the tool path will follow at run time is calculated from the values set up under the current Pen's the **Trace Width (Cutter Diameter)** setting.

It is important to note that if you change the **Trace Width (Cutter Diameter)** field of any of the Pens, you must enter the **Tool Path Editor** and over-write the **Command File** using the **Tool Path Editor's File > Generate Command File** menu before the **Trace Width** changes will take effect.

Except for a short header identifying itself, when the **Contour Specification File** is first created it is identical to the **Command File**. Once the **Contour Specification File** is created, the old **Command File** is obsolete, and must be over-written before you actually run the job.

Generating a Contour Specification File

If the **Contour Specification File** does not exist, it will be generated automatically when you snap over the **Edit** button from the **Edit > Tool Path** dialog. The file name that is in the **Contour Specification File** field will be used. If this field is blank, however, a file name will be constructed using the base name of the **CAM File** as a base and ".ctr" as the extension.

When the **Contour Specification File** is first created the contents of the **Command File** are copied into it. If the **Command File** does not exist, then an empty **Contour Specification File** is created. You may graphically add contours using the **Tool Path Editor**.

If the **Command File** field in the **Tool Path** dialog is empty, a file name for the **Command File** will be assigned using the

base name of the **CAM File** as a base and “.ixh” as the extension.

Once the **Contour Specification File** has been created, each time you enter the **Tool Path Editor**, the **Contour Specification File** will be used and the **Command File** will be ignored. If you have made changes from within the **Tool Path Editor** you must over-write the **Command File** using the **Tool Path Editor’s File > Generate Command File** menu for these changes to take effect at run time. If you wish to save changes that you have made to the **Contour Specification File**, you may use the **Tool Path Editor’s File > Save** menu.

The Tool Path Editor

The **Tool Path Editor** is entered by snapping over the **Edit** button which appears next to the **Contour File Specification File** field in the **Edit > Tool Path** dialog. Information stored in the **Contour Specification File** is graphically displayed in the **Tool Path Editor’s** window.

Display

We call the succession of commands that describes the tool path when the tool is engaged (pen down) a “contour”. If the tool path is not offset, then the actual tool path coincides with the contour. If the tool path is offset, then the contour represents the desired path of the edge of the tool. Contours are displayed as solid dark grey lines. Offset paths are displayed as solid red lines. When there is no offset, the coincident paths of the contour and the actual tool path appear as solid red lines. Offsets can be optionally hidden from view for clarity using the **View > Hide Offsets** menu.

Optionally, the entire width of the trace of the offset tool path can be displayed by selecting **View > Show Trace Width**. The trace width, which is governed by the current value set up in the **Trace Width (Cutter Diameter)** field of the associated **Pen Definitions** menu, will appear in light grey.

Over the start point of each contour the **Tool Path Editor** displays a small square. A small diamond appears over the end point. If the contour is closed, which is to say, if the contour ends over the start point, then that point appears as a diamond drawn

within a square.

A point plunge (plunge and retract sequence over a single point) is also considered a contour. This contour appears as a small diamond drawn within a square.

We call the path that the tool takes when the tool is retracted (pen up) a “rapid”. This is because once the tool is retracted it rapid traverses to the position of the tool plunge associated with the next contour. Rapids appear on the screen as dark grey dotted lines. Rapids can be optionally hidden from view for clarity using the **View > Hide Rapids** menu.

The **Tool Path Editor** initially provides for enough room to display the contours that were saved when the job was loaded. You may increase the amount of room available using the **View > More Room** menu. After this selection you may need to use the scroll bars to position the area that you are editing within view on the screen.

Selection

Some editing operations are specific to one contour. Other operations, such as order arranging and combining, require selecting two contours. Two selection types are defined: **Select First** and **Select Next**. You may choose which selection type is active by snapping over its name in the **Edit** menu.

You may select a contour by snapping over its start point with the cursor. When the contour is selected it changes color. **Select First** types appear blue. **Select Next** types appear green. You may deselect a contour by snapping over its start point a second time. You may also deselect a contour by selecting another contour.

Alternately, you may use the **Tab** key on the keyboard to select and deselect contours. If no contour is selected, then pressing the **Tab** key once will select the first contour in the order of operation. Pressing the **Tab** key a second time will deselect the first contour and select the next in the order of operation. Successive depression of the **Tab** key will progress through the contours in a like manner until the last contour is selected. Once the last contour is selected, further depression of the **Tab** key will have no effect. However, you may select successively backwards through the order of operation by depressing the **Shift** key and

pressing **Tab**.

Pressing **Tab** sequentially selects in the order of operation. Pressing **Shift-Tab** sequentially selects in the reverse order of operation.

A contour cannot be deselected unless the selection type is set to the selected contour type. For example, using the **Select First** default setting you may select a contour, which indicates to you that its selection type is “First” by turning blue. Now you change the default selection type by snapping **Edit > Select Next**. A check appears next to that menu, indicating that **Select Next** is the new default selection type. Snapping over the start point of an unselected contour would highlight that contour in green. However, snapping over the blue (**Select First** type) contour will have no effect.

In the same example, if you were using the **Tab** key to successively progress the **Select Next** contour selection through the order of contours, it would skip over the contour selected under the **Select First** type (it would skip over the blue contour).

Selection of contours using these features is particularly suitable for rapid ordering and combining of contours.

Swap Order

The **Edit > Swap Order** menu selection reverses the operational order of two contours.

Move to Combine

The **Edit > Move to Combine** menu selection moves the contour which was selected under the **Select Next** type so that its start point is coincident with the end point of the contour which was selected under the **Select First** type. In other words, the contour highlighted in green is always the one that moves. Also remember that when combining two contours, the **Select First** type is always the first in the new order of operation. The retract cycle of the **Select First** contour and the plunge cycle of the **Select Next** contour is removed, combining the two into a single contour.

Connect to Combine

The **Edit > Connect to Combine** menu causes a straight line segment to connect the end point of the contour that was selected under **Select First** with the start point of the contour that was selected under **Select Next**. The retract cycle of the **Select First** contour and the plunge cycle of the **Select Next** contour is removed, combining the two into a single contour.

Delete First Rapid Delete Final Rapid

It is sometimes difficult to control the starting position of pen plotter commands from within a CAD program. Some CAD programs automatically position the plot to the center of an imaginary page. In a translated plot file this shows up as an undesired rapid traversal to the starting position at the beginning of the operation, and also as an undesired rapid at the end. The **Edit > Delete First Rapid** and the **Edit > Delete Final Rapid** menu selections allow you to conveniently remove these undesired rapids.

Insert First Rapid Append Final Rapid

These commands allow you to insert a rapid from the zero position to the first contour and append a rapid from the last contour back to the zero position. This is particularly useful in jobs where control of the tool position at the start and finish of a tool path is essential, such as in **Step and Repeat** operations.

Delete Selection

The **Edit > Delete Selection** menu deletes the selected contour. The rapid into the selected contour is automatically connected to the following contour.

Reverse Direction

The **Edit > Reverse Direction** menu reverses the direction in which the selected contour will be traversed. This is particularly useful in tool offset operations, where you must control which side of the cutting tool is in contact with the work.

Move

When you snap over the **Edit > Move** menu the menu disappears and the cursor appears as a crosshair over the start point of the selected contour. The X and Y coordinates of the contour will appear in the lower border of the window. As you move the mouse, the shape of the contour will follow and the displayed coordinates will track. If you snap the right mouse button the operation will be cancelled. If you snap the left mouse button the contour will be placed at the new position. Don't worry if you cannot rapidly place the contour at the exact location that you desire. After you place the contour in the approximate position using a left snap, you can bring in a **Contour Position** control box using a right snap to more easily locate the contour over the exact position you desire.

Position

The **Contour Position** control box can be invoked for a selected contour by snapping the right button on the mouse or by selecting **Edit > Position**. The arrow buttons allow you to move the contour a step at a time. If you snap over one of the arrows the contour will move in the associated direction by a distance corresponding to one step. Holding the mouse button down automatically repeats the operation. As the position of the contour is moved with the arrow buttons, an outline of the contour at its new position is shown.

The resolution of the position display is determined by the system set-up entered in the **Setup > X-Y Configuration > Display Position to __ Decimal Places** field. If the display resolution is lower than the step resolution, position changes effected by the arrow buttons may not be immediately seen.

Alternately, you may type in the new position of the contour in the **X** and **Y** position fields. To view the contour at this revised position, snap over the **Apply** button.

To accept the new position snap the **Ok** button. To abandon this operation snap **Cancel**.

Rotate

The **Rotate Contour** control box can be invoked for a selected contour by means of the **Edit > Rotate** menu. Buttons on this

dialog allow you to rapidly rotate the contour around its start point by incremental amounts. A rotated image of the contour will appear on the screen.

Alternately, you may type in rotational values into the display field. Fractional (decimal) amounts of rotation are acceptable. To view the rotated contour snap over the **Apply** button.

To accept the rotated contour snap the **Ok** button. To abandon this operation snap **Cancel**.

Offset Properties

The **Offset Properties** control box can be invoked for a selected contour by means of the **Edit > Offset Properties** menu. This dialog allows you to designate the type of tool offset as well as the pen number associated with the contour.

When a **Tool Offset** type of **Left** or **Right** is selected, the tool offset path associated with the **Pen Number** immediately appears on the screen. As mentioned, the amount of offset is determined by the value of the **Trace Width (Cutter Diameter)** field of the **Main Menu's Edit > Pen** dialog. If different values of **Trace Width** are set up under different pen numbers, you can view the effect that these different values have on the offset path by changing pen numbers.

The tool offset path is automatically generated and displayed. The offset tool path is optimized to avoid undercutting on inside angles and to avoid excessive tool overshoot on outside angles. The software does not account for every geometry, such as some types of cusps, and the software does not automatically flag conditions where the tool is too large. However, by visually inspecting the offset tool path, and by using the **View > View Trace Width** option, problems can be identified and corrected. The **Contour Editor**, described in the next chapter, will assist you in interacting with the automatic offset path generator to correct offset irregularities should they occur.

Joystick Teach

This this feature allows you use the **Joystick Jog** feature to record contours using the carriage of your machine as a guide. The **Joystick Jog** feature must be installed for **Joystick Teach** to be accessible.

Segments can be added to any selected contour using the joystick. First select the segment that you wish to modify. If you want to construct a new contour, first create the contour using the **New Contour** selection. Then select **Joystick Teach** and enter the teaching mode by simultaneously pressing **Mark** and **Release**.

Once in **Joystick Teach** mode, you can move the carriage around using the joystick. When you press the **Mark** button, a tail segment will be added to connect the previous end of the contour to the position of the carriage. You may move the carriage over a contour shape using the joystick, pressing **Mark** over each point that you wish to record. When you press **Mark**, the additional segment will appear on the screen.

When entering the **Joystick Teach** mode, the software assumes that the carriage is located at the end of the selected contour. The next recorded point will be relative to that point.

You may not be overly concerned about the exact position of each point. You can always add, remove or adjust the position of each point later using the **Contour Editor**. (Enter the **Contour Editor** using **Edit > Edit Contour Shape**). You can even alternate between the **Joystick Teach** feature and the **Contour Editor**. To exit the **Joystick Teach** mode, simultaneously press **Mark** and **Release**.

New Contour

When you snap over the **Edit > New Contour** menu a new contour appears under the cursor. This new contour is a point plunge, designated by a small diamond surrounded by a square. You may place this contour in the work area by snapping the left mouse button, or you may cancel the operation by snapping the right mouse button. Once placed, the new contour is placed at the end of the contour list.

Put to File

The **Edit > Put to File** menu allows you to save the selected contour to disk as a **Single Contour File**. Please refer to the description of the **Single Contour File** in the chapter entitled **IMPORTANT FILES**. You can optionally name this file with any valid file name that has “.cts” as the extension. However, the name “instant.cts” is given by default to eliminate typing time for

contours you may want to temporarily store.

Get from File

The **Edit > Get from File** menu retrieves individual contours from **Single Contour Files** saved on disk. You may select the contour from the list of files, or accept “instant.cts”, which appears as the default name to save time when working with contours that are temporarily stored. The head of the retrieved contour appears under the cursor when it is retrieved, and an outline of the contour appears as you move the cursor for placement. Snapping the left mouse button places the contour. Snapping the right mouse button cancels the operation. Once placed, the retrieved contour is ordered at the end of the contour list.

Edit Contour Shape

Snapping over the **Edit > Edit Contour Shape** launches the **Contour Editor**, which can be used to modify the selected contour. The **Contour Editor** is described in detail in the following chapter, entitled **CONTOUR EDITING**.

Chapter 9

CONTOUR EDITING

General Description

The **Contour Editor** is entered from the **Tool Path Editor** by selecting the contour that you wish to modify and snapping over the **Edit > Edit Contour Shape** menu. The selected contour is displayed in the **Contour Editor**'s window.

Similar to the **Tool Path Editor**, the **Contour Editor** displays the contour's start point as a small square and its end point as a small diamond. A point plunge, which we have also considered a type of contour, is displayed as a start point and a superimposed end point. Otherwise, the start point and the end point are connected by one or more line segments. In the **Contour Editor** the transition point between segments, which we call a "node", is indicated by a smaller square.

We call the last segment in the contour the "tail". If the end point of the tail coincides with the start point of the contour we call the contour "closed".

You may select a node by positioning the cursor over it and snapping the left mouse button. You can deselect the node by either snapping over it once again, or by selecting another node. When a node is selected, the node and the following segment

changes color from black to magenta.

Alternately, you may select a node by means of the **Tab** key on the keyboard. If no node is selected, pressing **Tab** once selects the node associated with the start point. Pressing **Tab** again selects the next node in the series of segments. Pressing **Shift-Tab** selects the previous node in the series of segments.

Selection by means of the **Tab** key is useful to speed editing operations, especially when nodes are in very close proximity. Successive selection by means of the **Tab** key is also useful in quickly determining the direction of tool motion in a closed contour.

Viewing options in the **Contour Editor** function similarly to the viewing options of the **Tool Path Editor**.

Operations

Add Tail

When you snap over the **Edit > Add Tail** menu, the cursor automatically positions itself over the end point of the contour. As you move the mouse you will see a highlighted segment connect the end of the previous tail to the end point that you are creating. The coordinates of the end point of the new tail is tracked in the lower border of the window. Left snap the mouse to place the end of the new tail. Right snap to cancel the operation.

Delete Tail

When you snap over the **Edit > Delete Tail** menu, the tail of the contour will be removed.

Stretch to Close

When you snap over the **Edit > Stretch to Close** menu, the end point of the tail of the contour will be moved to the start point of the contour.

Add to Close

When you snap over the **Edit > Add to Close** menu, a tail will be added connecting the end point of the contour to the start point of the contour.

Insert Node

When you snap over the **Edit > Insert Node** menu, a new node will be added in the midpoint of the highlighted segment. The segment associated with the new node will be automatically selected.

Delete Node

When you snap over **Edit > Delete Node** the selected node will be removed, and the previous segment will be stretched to connect to the subsequent node.

Move Node

When you snap over **Edit > Move Node**, the cursor will automatically position itself over the selected node. As you move the mouse the node and the segments attached to it will follow. The coordinates of the node are tracked in the lower border of the window. Left snap the mouse to place the node. Right snap to cancel the operation.

Position Node

When you snap over **Edit > Position Node**, or when you right snap the mouse button, a **Position Control** dialog appears on the screen. The **Position Control** box in the **Contour Editor** functions similarly to the one in the **Tool Path Editor**.

Accept

When you snap over **Exit > Accept**, the changes that you have made to the contour are accepted into the **Tool Path Editor**.

Cancel

When you snap over **Exit > Cancel**, the changes that you may have made to the contour are abandoned.

Chapter 10

PRODUCTION OPERATIONS

This menu provides manual control for tool and workpiece set-up as well as automatic control for production operations. In a typical manufacturing cycle, the operator would select a **CAM File** using **File > Open**. Then using selections from the **Production** menu, the operator sets up the tool home position appropriate to the job. Once the proper position of the tool is set up with regard to the workpiece, automatic operations may be started.



Run Tool Path

Danger of Pre-Calculation Dwell

Prior to **Indexer LPT** version 4, where look-ahead contouring capability was limited to about 125 interpolations, the time to pre-calculate the largest contour was relatively short. However, with the introduction of the massive look-ahead capability, the time to precalculate a large contour can be long enough to deceive an operator or bystander into thinking that the machine is either not in operation or malfunctioning. This may be dangerous if unexpected motion occurs at an inopportune time. Consequently, in control settings where pre-calculation dwell times may constitute a safety hazard, it is recommended that appropriate measures be designed into the machine, such as annunciator lights and/or lock-out mechanisms.

Start

The **Run CAM Operation** menu selection initiates automatic tool control. After making this selection, the operator is prompted for **Start** (external start switch or **Ctrl-F2** depending on **Setup Controls**). Once the **Start** input is received, automatic tool path operation commences.

Keyboard Stop

The Keyboard Stop is NOT a reliable method to interrupt a job. In all but the simplest applications the **Indexer LPT feedhold** feature must be installed.

Once automatic tool path operation commences, the **HPGL Controller** coordinates control over hardware external to the computer by means of sequential interaction with **Indexer LPT**. During the time periods that **Indexer LPT** has control over the computer (such as when motors are in motion), the computer's mouse and keyboard have no effect. However, during brief periods of time when control passes from **Indexer LPT**, such as the time immediately following the execution of a tool motion and immediately preceding the next motion, the keyboard can be used to stop the job. To stop the job from the keyboard, press and hold the **Space** key until the machine pauses. When the **HPGL Controller** recognizes this input, the job will pause with the tool retracted. A **Pause** dialog will pop up, displaying options to con-

tinue, suspend, or cancel the job.

Feed-hold Stop

Installation of the *feed hold* feature, as explained in the **Indexer LPT** users guide, comprises two external switches: the *feed hold* switch, which is typically a normally closed contact to ground, and the *abort* switch, which is typically a normally open pushbutton. During a **Production Run** operation, when *feed hold* is activated by opening the contacts of the *feed hold* switch, motion immediately decelerates to a controlled stop. All control activity is suspended as long as *feed hold* is activated. If *feed hold* is deactivated by releasing the *feed hold* switch, then the job will resume. However, if contact closure of the *abort* input is made to ground via the *abort* switch, then the tool will be immediately retracted, and a **Pause** dialog will be displayed giving the operator options to continue, to suspend, or to cancel the job.

Back Along Tool Path

This feature is effective when the **Contouring** feature is selected and *feed hold stop* is being utilized. To use this feature, the operator would have aborted from a *feed hold stop* by means of the *abort* input, and the operator would have selected **Suspend** from the **Pause** dialog that followed. The tool would be in a retracted position. Two options are available under this menu:

Back to Transition Point

This option allows the operator to retrace the tool path backwards (with the tool retracted) one linear segment at a time. Each time **Start** is pressed the tool backs up to the start of the preceding segment, thereby allowing for rapid positioning. You may cancel out of this control at any time, and select **Production > Resume Job** to continue the job.

Back to Last Plunge

This option allows the operator to position the tool at the point of the previous tool plunge, and to resume the job from there.

Head Change

In multiple head machines it is necessary for the software to initialize to a “current” **Head** before automatic operations can proceed. In the **Setup > Multiple Head Configuration** dialog, **Head** offsets (if any) are specified, as well as lists of **Indexer LPT** commands which are used to switch from **Head** to **Head**.

If a current **Head** has not been selected yet, the **Head Change** dialog will inform the user that the current **Head** is not initialized. In order to initialize to a **Head**, the user selects the desired **Head** by snapping on the appropriate Radio button, and then snapping on the **Ok** button. The dialog will respond by asking for **Start** to “Move”. (“Move” means move from **Head** to **Head**, which may or may not entail some form of physical motion).

To remove this dialog after **Head** selection, snap on the **Cancel** button.

When first initializing the **Heads**, **Start** causes the command list for the selected **Head** to be sent to **Indexer LPT**. The present location of the carriage becomes the relative offset of the selected **Head**. Subsequent selection of **Heads** will first move the carriage to the relative offset position, then send the list of commands associated with the selected **Head** to **Indexer LPT**.

Once a **Head** is selected, the current **Head** number is displayed across the bottom of the dialog. Selecting a **Head** number equivalent to the current **Head** will send the command list associated with the **Head** to **Indexer LPT**, but will not cause offset movement of the carriage, since the carriage is already situated at the relative offset of the selected **Head**. This feature is useful in troubleshooting machine set-ups since it allows the technician to execute the command list with each **Ok - Start** sequence.

Jog

This option uses the **Indexer LPT joystick** control for manually controlled positioning. The *joystick* options that are available to the operator will depend on the options that you include in the system wiring. Refer to the **Indexer LPT** documentation to determine the options which are available.

Since **Indexer LPT** assumes complete control over the sys-

tem when in *joystick* mode, a continuously updated report on stage position is not possible. To report position, the **HPGL Controller** must drop from **Indexer LPT joystick** mode, read the positions from **Indexer LPT**, place position information on the screen (if the **Position** box has been activated), then re-enter *joystick* mode. The switch input entitled **Mark** is actually the **Indexer LPT joystick “exit”** input. The **HPGL Controller** checks the input entitled **Release** whenever **Indexer LPT** drops from *joystick* mode. If **Release** is active the dialog is removed.

Should the **Mark** and **Release** input fail to function, the program would not be able to exit from the **Jog** menu. Consequently, the **HPGL Controller** checks for proper operation of these inputs by requiring the user to activate them to gain entry into the **Jog** mode. This is a simple safeguard against a hardware-induced program hang.

Move by

This option allows the operator to move the stages by incremental amounts relative to the present position. The contents of the fields in the dialog box represent the desired motion, and the check boxes are used to select which axes are to be moved. When the **Ok** button is snapped, the distances displayed are rounded off to the step resolution of the system (The step resolution is the minimum distance which can be moved, or the distance which is moved as a result of a single control pulse.) and the user is prompted for **Start**. **Start** will initiate motion. Holding **Start** will automatically repeat the motion.

This option does not require position tracking to be initialized (via the **Set Home** menu). The field entries are persistent and remain effective until over-typed by another value.

This dialog is removed by snapping the **Cancel** button.

Position to

This selection allows the operator to move the stages to a designated position relative to the home position. Similar to the **Move by** selection, this selection also prompts for **Start** and displays the selected values rounded off to the step resolution of the

system.

Unlike the **Move by** dialog, **Position to** requires position tracking to have been initialized via the **Set Home** dialog. The default values in the fields of the **Position to** menu represent the current position, making it easier for the operator to move each axis individually. To send an axis to its “home” position, simply enter zero into its associated field by snapping over the **Home** button.

This dialog is removed by snapping the **Cancel** button.

Limit Switch Seek

This menu provides a means for the system to automatically seek the operational limit switches on each or every axis. The set-up values in **Setup > Limit Switch Seek Configuration** governs the motion during a limit switch seek cycle.

Check boxes select which axes you wish to limit seek. If more than one axis is chosen, the limit seek sequence will occur first on the Z axis, followed by the X axis, and finally on the Y axis.

Snapping on **Ok** prompts the user for **Start**. Once the operator activates **Start**, the stage will seek its associated limit switch until contact with the switch is made, or until it has moved the distance specified in **Setup > Stage Configuration > Total Distance**. If a limit switch closure is not encountered within the specified distance, the stage will stop and a message will appear. If the limit switch is contacted, the stage will immediately retract by the distance specified in **Setup > Limit Switch Seek Configuration > Retract Distance**. **Setup > Rapid Traverse Rates** governs the speed of retraction. “Home”, or “zero” position is automatically set at the final position after retraction. If the **Limit Switch Seek** operation fails to find the limit switch, “Home” position is not automatically set.

This dialog is removed by snapping the **Cancel** button.

Set Home

Position tracking for any or all axes is initiated by means of

this menu. The “home” or zero position is set at the present position of the selected axis. Position tracking is required for automatic operations.

Chapter 11

GETTING STARTED

Before Starting

Before starting read and understand the terms and conditions of the Program License Agreement. If you do not agree with the terms and conditions do not use the software, and return it to the place of purchase for full credit allowance.

Make an archival copy of the distribution diskette. Keep the distribution copy in a safe place.

Be sure to read the notes in the README file for important information regarding the latest software release.

System Set-up

CAUTION

There is no short-cut to getting started. You are the machine designer. The HPGL Controller can help you automate tool path control, but you must think through every implication of your design, especially safety factors. ALWAYS PLAN FOR THE UNEXPECTED WHEN USING SOFTWARE! Build adequate electrical and mechanical safeguards into your system. If you think that adequate safeguards are impractical, then do not use this product!

You do not need knowledge of computer programming to use or install the **HPGL Controller**. You must have a working knowledge of Windows and its file directory structure. You must be able to copy files, make directories, and specify paths. If you are new to file this type of information, one of the best introductory textbooks is *Running MSDOS* by Van Wolverton (Microsoft Press).

In order to get the **HPGL Controller** to run, you must have **Indexer LPT** installed correctly. Refer to the **Indexer LPT** manual for installation instructions. You must have a good working knowledge of **Indexer LPT** before setting up your machine with the **HPGL Controller**. Use the diagnostic program, IXDIAG.EXE (supplied with **Indexer LPT**) to exercise and become familiar with its features.

To copy the **HPGL Controller** files on to your system, place the **HPGL Controller** diskette in drive A, Snap **Start > Run** then type

```
A:\SETUP
```

Follow the menus in the **SETUP** program to install the appropriate files on to your hard disk. After running the **SETUP** program, installation of the **HPGL Controller** is still **NOT COMPLETE**. You must first review every set-up field in every dialog of the **HPGL Controller's Setup** menu, then make an appropriate **CAM File** template by reviewing every field in every dialog in the **Edit** menu. To make the **Setup** menu available, run the **HPGL Controller** program by double snapping on its icon. To make the **Edit** menu available, use **File > Open** and load the **SAMPLE.CAM** file provided.

The best way to get started with this software is to become familiar with the menu structure and the meanings of all of the set-ups. Since many of the set-ups are dependent on other set-ups, there is no quick way to configure a system without learning the implications of each set-up field. Fortunately, the menus are logically arranged and easily accessible. This manual is organized according to the appearance of the menus. A good method of completing the installation is to systematically review each **Setup** dialog, changing parametric set-up values as per the instructions in this manual.

The initial values which appear in the Setup dialogs are arbitrary.

trary. Since each machine design can vary in substantial ways, and each set-up field can potentially affect others, there are **NO** default set-up values. Each and every field must be reviewed by the designer and replaced by a meaningful value.

After the first change is made, the **Setup > Save System Setup** menu becomes available. The first time this selection is chosen, the **HPGL Controller** constructs the system setup file entitled HPIXW.INI, and deposits this file in the WINDOWS directory.

When changing **Setup** values you may find the **Diagnostic** menu to be very helpful. This menu makes screens available which give a live display of the state of configured limit and control switches. Also, it is useful to periodically check the **Diagnostic > Error List** dialog, which is included to help you troubleshoot different kinds of set-up and run-time problems.

If you are unable to get satisfactory results using the built in diagnostics, run the **Indexer LPT** diagnostic program, IXDIAG.EXE, to troubleshoot your system using individual **Indexer LPT** commands. (All physical input and output performed by the **HPGL Controller** goes through the **Indexer LPT** device driver).

CAM File Set-up

Making “default” CAM Files

The **CAM Files** contain information which pertains to the individual part which is being manufactured. The **CAM File** not only contains the file specification of the **HPGL File**, but also other vital information necessary in controlling your machine. Some of this information will change from one job to the next. Other information will remain the same. For this reason, the **HPGL Controller** makes **CAM Files** easy to change and replicate.

One **CAM File** is provided on the distribution diskette entitled SAMPLE.CAM. This file must be modified to accommodate the design of your machine and the type of manufacturing operations which you are anticipating. After the SAMPLE.CAM file has been read by means of the **File > Open** menu, you can modify it by means of the **Edit** menus. You can save your modified file

using **File > Save**, or save it under another name (leaving the original intact) using **File > Save As**.

Using the **Edit** menu, you may change set-up values by means of dialog boxes which are available from each menu selection. Make sure each set-up is appropriate. When you are finished editing SAMPLE.CAM, it can be easily saved and/or duplicated under a different name, such as DEFAULT.CAM. You may wish to have several “default” **CAM Files**, one for each general type of operation which you anticipate. For example, you may have one **CAM File** set up with cutting speeds for plastics, another for aluminum, steel, etc. Save your files under descriptive names.

As you carefully edit your first “default” **CAM File**, make sure that each dialog box has reasonable entries, even if you do not immediately foresee a use for the particular function. You may only anticipate using Pen 1. Nonetheless, entries for all pens should reflect reasonable values, just in case a different pen is inadvertently called from within a plot file. One strategy is to assign setup values for unused pens sufficiently slow, so that machine or tool damage will be avoided. Another strategy is to make the values of all of the unused pens the same as **Pen 1**. The strategy that you adopt will depend on the design of your machine and the types of operations that you anticipate.

Once you have generated a working set of “default” **CAM Files**, setting up a job may be as simple as specifying the **Plot File** and, if necessary, adjusting a few other parameters. Then, if you expect to be manufacturing the same part again at a later time, you may save the revised **CAM** set-up under a different file name, and/or in a different directory.

DO NOT USE SAMPLE.CAM TO SAVE YOUR DEFAULT SETUPS. SAMPLE.CAM may be overwritten by the installation SETUP program, should you need to re-install the software, or when you perform subsequent upgrades. **CAM Files** that you create, as well as other files that are not part of the initial installation, will not be automatically removed by the installation SETUP program during the de-installation procedure, nor overwritten during upgrades.

Making Working CAM Files from “defaults”

Assuming you have created a **CAM File** with the most com-

mon settings, you may follow these simple steps to generate working **CAM Files**. Let us assume that you have named this **CAM File** DEFAULT.CAM Also, for the sake of an example, let us assume that you will be using the plot file included on the distribution diskette entitled **123 sample.plt**

1) First load DEFAULT.CAM using File > Open.

2) Using **File > Save as**, generate a CAM File entitled MYJOB.CAM by typing MYJOB in the dialog field when prompted.

3) Follow the recommendations from the dialog prompts that pop up until you are no longer prompted. Notice that “MYJOB.CAM” now appears in the title bar at the top of the window frame.

4) Use **Edit > Tool Path** to bring in the **Tool Path** dialog. Use the **Browse** control associated with the **HPGL File** field to enter the plot file name. Locate the desired plot file (**123 sample.plt**) and double snap over it to transfer its name into the **HPGL File** field. Snap **Ok** to accept the settings and to leave the **Tool Path** dialog

5) From the **Main Menu**, use **Edit > Translate Plot File** to generate an initial **Command File**.

6) Select Yes from the dialog prompt that follows to view an image of the tool path from within the **Tool Path Editor**. If you edit the **Tool Path**, you can overwrite the **Command File** from within the **Tool Path Editor**.

7) You may wish to make changes appropriate to the job using the **Edit Menu** - changes such as cutting speeds, tool off-sets etc.

8) Your job is now ready to run.

Use Caution when Naming Command Files

If you follow the method of generating working **CAM Files** that was outlined in the previous section, the **Command File** associated with each job will be automatically named according to the root name of the **CAM File**. However, it is possible to specify the same **Command File** name in different **CAM Files**. This can

be very useful. Suppose you are manufacturing a particular part from different materials. The **Command File** will be the same, but the tool speeds may vary according to the material being used. In this case you simply set up the different pen speeds different under **CAM Files** , but keep the **Command File** specification the same. You are at liberty to change other **CAM** set-ups as well: plunge depth, tool passes, offsets, etc. without needing a separate identical **Command File** for each **CAM** file.

This flexibility introduces a possibility for error, since changes which affect the generation of the **Command File**, such as changes to the **HPGL File**, or changes to **Scaling**, will affect all **CAM** files which specify the same **Command** file name. Consequently, in most applications it is desirable to give the **Command File** a unique name. It is recommended that the name of the **Command File** reflect the base name of the **CAM File**, only with “IXH” as the extension. As mentioned, are given an option to have this done for you automatically when you replicate a **CAM File** using **File > Save As**.

Working with Plot Files

The **HPGL Controller** is written to accept a subset of the HPGL command set for the HP 7475 plotter. Since most CAD programs utilize only a subset of the HPGL command syntax, you may find that a variety of HP plotter drivers will generate files which can be used successfully. Since there are many different types of HP plotters and numerous CAD programs, it is impractical to deal with each in detail here. Here are some simple guidelines to help you develop a procedure to accommodate your operations.

At first some amount of experimentation is necessary to learn the peculiarities of the **Plot Files** that your CAD program generates. For example, some CAD programs limit the size of the plot when specifying the HP7475. In this case you must experiment with other plotter setups until a suitable one is found.

Some CAD programs begin the plot in the center of the page. Others begin at a “home” reference point. Others allow you to choose. Beginning with a “home” reference point is easiest. Start out with simple experimental tool paths to determine how your CAD program begins the plot, then use the **HPGL Controller**

set-ups and features to develop a job setup procedure.

View Your Work

View > Distance can be helpful in estimating the time that it will take to run the job. The **Distance** dialog shows the accumulated traversal distances for each pen, as well as the accumulated rapid traversal distance.

Use **View > Toolpath Preview** to view the tool path defined by the **Command File**. The tool path is shown in a solid line in places where the pen is extended (down or “plunged”), and in a dotted line where the pen is retracted (up). If a **Production > Limit Switch Seek** operation has been performed on the X and Y axes, then a box representing the area surrounded by the limit switch positions is shown in dashed lines. The limit switch delimited area will only be shown if a **Production > Limit Switch Seek** sequence has been performed.

View > Carriage Preview is similar to **View > Toolpath Preview**, except that it shows motion of the tool carriage considering **Head Offsets**. If your set-up only uses one **Head**, or if the values of the **Head Offsets** are all zero, then both **Toolpath** and **Carriage Preview** operations will display the same graphic.

Note that the **Preview** selections operate only on the **Command File** and NOT on the any of the other files associated with the job..

Also note that you may overlay the **Preview** of one **Command File** over another. This is useful in manufacturing operations where two or more CAM operations are performed on the same part piece. Be careful, however, because this feature also makes it possible to view one **Command File** while another is loaded. It is always wise to clear the screen using **View > Clear View**, and view the current CAM set-up using **View > Toolpath Preview** before running a job.

The **Toolpath Preview** feature is especially convenient when setting up for **Step and Repeat**. Graphics are drawn in designated positions relative to each step and repeat operation, and in the order in which the tool will follow. The time which is required for the **Preview** operation depends on the complexity of the graphic.

If you wish to abort the operation, press the **Space** key at any time.

The job cannot be run unless the home positions are set. The **Production > Limit Switch Seek** operation automatically sets the home positions after it completes its task. You can re-position the home position by first moving the carriage via the **Production > Jog**, **Production > Move by** or **Production Position to** menus, and then setting the new home reference using the **Production > Set Home** menu. After you have relocated the home positions, you may once again preview the tool path in relation to the limit boundaries.

Having conveniently placed tool in the starting position use **Production > Run** to run the job!