ChromaCAD ™
Sculptured-Surface 3-D Modeling System

ChromaCAD ™
MODEL BUILDER 91 Program
For Atari 48K and 130XE Computers

MARVER
SEAMAN

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INTRODUCTION

The ChromaCAD MODEL BUILDER program will enable you to construct large, complex, multi-colored, sculptured-surface 3-D models that until now could only be attempted on expensive, high-memory business and engineering computer systems. ChromaCAD will introduce you to new geometric forms -- called 3-D PANELS -- for building models. 3-D PANELS are long flexible strips of triangles that can be shaped to fit the compound surface curves of any shaped 3D model that can be imagined.

Plus, each individual triangle of a 3-D PANEL can be assigned a different color and shade. Thus, ChromaCAD permits true free-form, sculptured-surface modeling. It is not a "solid-modeling" system that combines other 3-D forms (ton-olds, spheres, cubes, etc.) or use "spin" or "extrude" type construction tools to build models.

Using 3-D PANELS, you can create 3-D models of any shape that exists or can be imagined. You can build detailed human heads and replications of sculpture. This is almost impossible with most of the current microcomputer-based software now in use, including the systems presently selling for thousands of dollars on 16 and 32-bit computers. This is why you seldom see surface-shaded models of human heads in advertisements promoting 3-D solid-modeling systems.

Most 3-D modeling software is directed toward draftsman and engineers. ChromaCAD's features are directed toward designers and artists. We see 3-D computer modeling as another medium of realistic and abstract artistic expression. For the first time, the joys of true sculptured-surface modeling will be available to the owners of 8-bit computer systems.

This manual will provide you with step-by-step instruction on constructing models the ChromaCAD way. The manual first guides you through the construction of a few simple models and then discusses more complex constructions in later sections. If you follow the steps printed in bold with your own computer and construct the three block-letter demonstration models, you'll learn the drawing tools of the program in the order they are needed to draw the models. At the same time, you'll associate each tool with your own keyboard and screen.

In the near future, we plan to install this program on all of the more popular 16-bit and 32-bit computers. We intend to use virtually the same manual and the same menus and keystroke commands for all computers. In this way, the skills our users acquire in building models won't be wasted if they move on to evolving computer architectures.

There are over 60 illustrations used throughout this manual. At first glance, this may seem like the program is complicated. In fact, the illustrations were provided only to make learning the program as easy and enjoyable as learning a new game. You will be able to begin constructing models of your own after completing only the first two demonstration models.

This manual presents one way of constructing the demonstration models. There are, however, other ways of using 3-D PANELS to construct the same models. As you become more familiar with the basics of 3-D PANELS, other methods will occur to you, perhaps better suited to your own needs and style. The documentation was designed with the intention of making the basics understandable to everyone from professional engineers and designers to 1*2-year* old hobbyists.

It's important when using this manual to understand the general principles behind using 3-D PANELS for building 3-D models so that later you can apply them to your own models in your own way. The block letter demonstration models were not selected to show off the capabilities of 3-D PANELS, but only to demonstrate the basic drawing tools. In fact, constructing block letters with 3-D PANELS is a little like hauling wood with a Maserati. Once you use the tools, however, you will be able to construct more interesting models of your own.

In addition to the 9 sections listed in the TABLE OF CONTENTS, there are four appendices located at the end of the manual. These are: the HARDWARE SPECIFICS APPENDIX, the REGISTER RANGE APPENDIX, the KEYSTROKE COMMANDS APPENDIX and the ERROR NUMBER TABLE. The HARDWARE SPECIFICS APPENDIX provides specific data on a few hardware features that may be subject to change. The REGISTER RANGE APPENDIX lists the range values of the user input registers. The KEYSTROKE COMMANDS APPENDIX provides a summary of the keystroke commands available In each of the 3 modes that use keystroke

commands. The ERROR NUMBER TABLE will be explained in the course of the manual.

The first 2 sections of this manual are identical to the first 2 sections of the SURFACE SHADER XE program. Some features, such as booting up, inputting values into the registers and orientating models In space are common to both the MODEL BUILDER and SURFACE SHADER XE programs. These features are covered in the first two sections. If you have already read the SURFACE SHADER XE manual, simply skip the first two sections (SECTION 1 - A BRIEF STROLL and SECTION 2 - MODEL ORIENTATION REGISTERS).

We would like to keep in contact with all those who use our programs. Please send us your name and address (or fill out the enclosed registration card) so that we can send you news of new developments.

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SECTION 1 - A BRIEF STROLL

When most people receive a new piece of software they are curious and want to boot the program to see what the MAIN MENU selections look like. To begin, therefore, let's take a brief look at the MAIN MENU and the ten 3-D MENUS that are used for viewing models in space. Follow the directions printed in bold lettering using your own computer while reading the accompanying commentary.

Booting Up

NOTE: "Basic" must be disabled when booting the program. Either the "Basic" cartridge must be removed or the "OPTION" key must be pressed for several seconds while turning on the computer, whichever is applicable for your computer.

To boot the program, turn off the computer, turn on the disk drive and the T.V. or monitor, insert the ChromaCAD MODEL BUILDER program disk or the ChromaCAD SURFACE SHADER XE program disk into the disk drive and turn on the computer.

You will soon be presented with the ChromaCAD face screen.

Tap any key to exit the face screen.

You will then be presented with the following *information prompt:*

PRESS **SPACE BAR** TO CONTINUE
OR
TYPE **I** TO VIEW **CHROMACAD** INFORMATION

The ChromaCAD program disk contains general information on the ChromaCAD modeling system, including prices and ordering information on programs that are available as of the time of the printing of the disk. This information may change from time to time. Accessing the disk information is an option that can only be called from the above information prompt while the program disk is still in the disk drive.

Accessing The Disk Information Screens

If you want to access the disk information, type the "I" (information) key while viewing the above prompt. The information screens will prompt your return back.

Tap the SPACE BAR while viewing the *information prompt.*

You will then be presented with the ChromaCAD COPYRIGHT SCREEN. The COPYRIGHT SCREEN prompts you to insert a model disk and then to press "START".

While viewing the COPYRIGHT SCREEN, if you have the MODEL BUILDER program booted, Insert an Atari formatted blank disk. If you have the SURFACE SHADER XE program booted, insert ChromaCAD MODEL DISK #1 Included with the program.

Press "START1 to boot either disk.

If you have the MODEL BUILDER program booted and you have inserted a blank disk, the disk drive will turn on and a ChromaCAD disk index will be formatted and stored on the disk. In your case, since no ChromaCAD data has yet been stored on the disk, the program will format a new ChromaCAD index for storage on the disk. If the disk would have had information stored on it other than ChromaCAD models, the information *would have been destroyed.* ChromaCAD has a disk filing system designed for model storage. It is not compatible with any other disk filing system. ChromaCAD model disks should be used only for ChromaCAD model storage.

If you have the SURFACE SHADER XE program booted and you have inserted ChromaCAD MODEL DISK #1, the index of the model disk will be loaded into the computer. The SURFACE SHADER XE program will only accept disks with at least one ChromaCAD model stored on them. If an attempt is made to load a disk with no models, an "IMPROPER MODEL DISK" message will be displayed.

You will now be viewing the MAIN MENU of the program.

Do the following exercises but be careful not to type keys inadvertently. Many of the keys have functions that will be covered later and could produce confusing results. If this happens while following the exercises, go back to the MAIN MENU by typing " → " (Out) and start again.

Using the" ↑ " (Up)," ↓ ″(Down), the " ← " (In) and" → " (Out) Keys to Select Menu Options

Options are selected by using the" T " (Up) key or the" *i″* (Down) key to scroll the cursor up or down until it is aligned with the option that you want. The fastest way to get to the bottom from the top of the menu is to press the" T " (Up) key when the cursor is positioned at the top of the menu. The most used options are placed at the top and bottom of the menus. All of the ChromaCAD menus operate the same way. For clarity, any reference to a key in this manual will always be followed by the ChromaCAD name for that key in parenthesis.

Practice using the " T "(Up) and " A " (Down) keys a few seconds and then place the cursor opposite EDIT 3-D MENUS and select EDIT 3-D MENUS by typing the " <- " (In) key.

You will now see a menu of the input registers that are used to orientate a model in space in preparation for displaying the model. All registers contain values that can be changed by the user. The value currently stored in each register is located to the right of the register. The menu on display is 3-D MENU #1. Don't worry, you wont have to fill all of these registers to display each model. Most of the time you will only want to change a few of the registers before displaying a model.

Actually, these registers are quite simple. Only the top 11 registers (down to ANGLE OF VIEW) are accessed by both the MODEL BUILDER and the SURFACE SHADER XE. The rest are accessed only by the SURFACE SHADER XE to select colors, highlighting, number of shading tones, reverse imaging, etc. (i.e., different ways of rendering a shaded model). There are 10 of these 3-D MENUS stored on each model disk. You can use each menu to display a different model. Ail 10 of them can be used at once to display 10 different models on the screen at the same time

Type one of the number keys ("4", for example).

Notice that 3-D MENU #4 is presented as indicated by the change of value in the THIS MENU NO. register on the top row. While viewing any 3-D MENU, you can call any other 3-D MENU by typing the corresponding number key (0 to 9). You can go directly out to the MAIN MENU from any 3-D MENU by typing" -»" (Out). These ten 3-D MENUS, along with any values you may store in the

registers are stored on the disks with the models. These menus can be accessed by both the MODEL BUILDER and SURFACE SHADER XE programs.

Inputting Register Values

Return to 3-D MENU #1 by typing "1". Use the " A " (Down) key to place the cursor opposite the X OFFSET register. Select that register by typing the" <- " (In) key. The cursor will jump to the left, awaiting your Input value. Type any value within the range Of -32767 to +32767. Press RETURN.

Notice that the value to the right of the X OFFSET register has changed. This indicates that the register has accepted your input value. Input registers are selected in the same manner as MAIN MENU options - by using the" t" (Up) key and the" A " (Down) keys to select the register and the"«- " (In) key to position the cursor for input. If, after typing the' <-" (In) key to access an input register, you change your mind and decide to leave the same value in the register, type any letter key; then press "RETURN". The value in the register will be retained.

You can enter a "0" by simply pressing "RETURN*. If you type an incorrect digit while typing a value, press the "DELETE" key to back up and erase the entry. The limits for the X OFFSET, Y OFFSET and Z OFFSET registers are -32767 to +32767. If you attempt to enter any number outside of these limits (i.e., 40000) the program will ignore your attempted entry and leave the current number entered.

All input registers have a limited range of values that can be input to the registers. You will learn the ranges of the registers used in this program as you go through this tutorial. In addition, you'll find the ranges of the registers used in this program listed in the REGISTER RANGE APPENDIX at the end of the manual. Values are entered in all ChromaCAD registers the same way. The input registers were organized in the above way so that, when inputting values to any register, you can see at a glance what values are stored in other related registers.

Practice with the OFFSET registers. Try entering out-of-range values. Press the "«- " (In) key to access a register and then reenter the same value by typing any letter key and then pressing "RETURN". Access a register and enter a "0" by just

pressing "RETURN". Use the "DELETE" key to delete typed digits.

When you are finished, return to the MAIN MENU by typing " → " (Out) to go out to the MAIN MENU.

CHANGE MODEL DISK Option (MAIN MENU)

Place the cursor opposite CHANGE MODEL DISK. Select that option by typing the "«- " (In) key.

You will end up back on the COPYRIGHT SCREEN again and the prompt to insert a model disk and to press "START". This is important -- when you want to change a model disk, you must use this option!!! When the program is first booted, it prompts you to insert a model disk. The program then boots the index and 3-D MENUS of that model disk (or, in the case of a new model disk, formats and stores a new index). If you change a disk without using the CHANGE MODEL DISK option, the program will be attempting to use the index of the previous model disk. This will cause a malfunction.

Press "START" to re-boot the same disk.

Normally, you would insert a different model disk before pressing "START. Whenever you select CHANGE MODEL DISK, you can, of course, re-boot the same disk if you desire.

This ends our brief look at some of Chrcmacad's menus. The next step will be to take a look at those registers of the 3-D MENUS that are used for orientating models in space. These are quite important. Before model construction or display can proceed, it is necessary to understand the use of these registers.

Note: Both the SURFACE SHADER XE and the MODEL BUILDER programs are extremely large, among the largest programs ever installed on an 8-bit system (code size). For this reason they take a long time to boot. We have installed a special routine to make this wait time a little bit shorter. If you press the SPACE BAR as the program is loading, the boot process will not load and display the FACE SCREEN and will skip the *information prompt.* You will, instead, go directly to the COPYRIGHT SCREEN, which will prompt you to insert a model disk.

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SECTION 2 - MODEL ORIENTATION REGISTERS

Model Orientation Registers (3-D MENUS): Setting Up Models to View in Space

Select EDIT 3-D MENUS from the MAIN MENU and then make sure the values listed below are stored In the following 11 registers of 3-D MENU #1. If any value Is different, change It to that listed below. Do not change any of the other register values.

THIS MENU NO. =.....1	DISTANCE =.....400
MENU DISPLAY ORDER - 0	X OFFSET = ...0
MODEL BASE LINE - 0	Y OFFSET = ...0
PITCH ANGLE =.....0	Z OFFSET = ...0
YAW ANGLE =.....0	ANGLE OF VIEW = ...50
ROLL ANGLE =.....0	

The ten 3-D MENU registers from MENU DISPLAY ORDER to ANGLE OF VIEW are the MODEL ORIENTATION registers. They are used by the MODEL BUILDER and SURFACE SHADER XE programs to select, position and orientate models in space. ChromaCAD can also display a test pattern. The test pattern, like a model, is positioned and orientated in space by means of the orientation registers. The test pattern is a simple plot of a letter "L". The "L" is assumed to be plotted on a graph (called the BASE LINE GRAPH). The long stem of the "L" lies on the +Y axis and the short stem lies on the +X axis. The intersection of the two stems lies at the 0,0 center of the graph (see fig. 1). We will use the test pattern to demonstrate the use of the MODEL ORIENTATION registers.

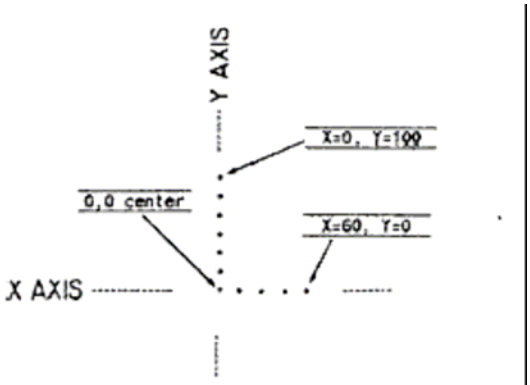


Fig. 1

"Q" (Quick) Key (3-D MENUS): Calling a 3-D MENU to Display the Test Pattern

While viewing 3-D MENU #1, type the "Q" (Quick) key.

The "L" test pattern is displayed in the SPACE SCREEN according to the values that you loaded in the orientation registers of 3-D MENU #1. These values call for an overhead view of the "L" from a distance of 400 units above the graph. You are, therefore, looking straight down on the "L" and seeing the "L" as it appears from 400 units above (see fig. 2A).

The "Q" (Quick) key provides a fast, easy way to view the effects of changed values in the orientation registers. When the "Q" (Quick) key is typed while viewing a 3-D MENU, the test pattern will always be displayed. The SPACE SCREEN appearance should be similar to that depicted in fig. 2B.

NOTE: For print clarity, the SPACE SCREEN illustrations in this manual are printed black on white, whereas the computer display is rendered white on black.

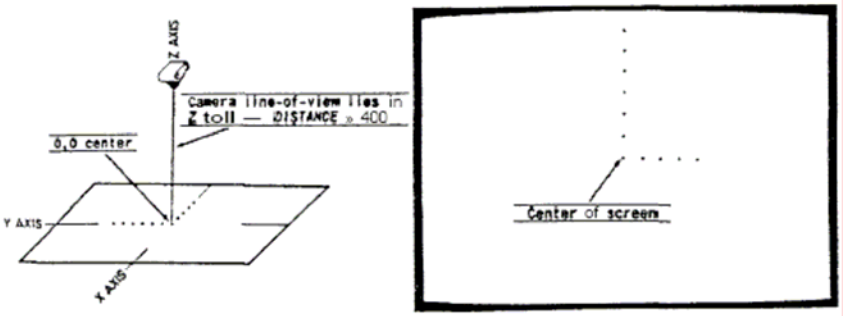


fig. 2A *fig. 2B (SPACE SCREEN)*

It helps to imagine that the SPACE SCREEN displays a picture of the "L" taken by a camera that is always aimed directly at the 0,0 point of the graph (fig. 2A). The graph is always at zero elevation. The "L" can be positioned anywhere in space by using the X OFFSET, Y OFFSET and Z OFFSET registers.

The camera can be positioned anywhere in space by using the PITCH ANGLE, YAW ANGLE, ROLL ANGLE and DISTANCE

registers. Since the camera is always aimed at the 0,0 point of the graph, the corner of the *"L"* is currently displayed at the center of the SPACE SCREEN. Let's go back to 3-D MENU #1 and move the "L" by using the X OFFSET and Y OFFSET registers.

Tap the " → " (Out) key to exit the SPACE SCREEN and return to the 3-0 MENU that was called (In this case, 3-D MENU #1). (Don't hold the " → " (Out) key down or you'll return to the MAIN MENU. If this does happen, select EDIT 3-D MENUS again.)

X OFFSET and Y OFFSET Registers (3-D MENUS): Repositioning the Model on the BASE LINE GRAPH

Store *"-100" in* the X OFFSET register of 3-D MENU #1. Leave the other registers unchanged. Type "Q" (Quick) to display the "L" again. (NOTE: For emphasis, negative input values will be printed In Italics.)

Notice that the "L" is no longer centered. By loading *"-100" In* X OFFSET, you have offset it *-100* units on the X Axis. You are now viewing the "L" as it appears from 400 units directly overhead after being moved *-100* units on the X Axis of the graph.

Return to 3-D MENU #1 again and store "-700" in Y OFFSET. Leave the other registers unchanged. Type "Q" (Quick) to display the "L" again.

Notice that the "L" has now also been offset *-100* units on the Y Axis. The X OFFSET and Y OFFSET registers can be used to offset the drawing to any location on the graph. The limits for the offset registers are -32767 to +32767, but be careful about inputting large values at this time, because the drawing may be moved off the SPACE SCREEN. You can, however, view a larger area of the graph by using the DISTANCE register to move the camera further away from the 0,0 point of the graph.

DISTANCE Register (3-D MENUS): Setting the Distance between the Camera and the 0,0 Point of the Graph

The DISTANCE register sets the distance between the camera and 0,0 point of the graph. This length is depicted by the LINE-OFVIEW line in fig. 2A. The DISTANCE range limits are also -32767 to +32767. (The X OFFSET, Y OFFSET, *Z* OFFSET and DISTANCE registers all have the same input ranges.)

Practice moving the "L" around on the graph with the X OFFSET and Y OFFSET registers of 3-D Menu #1 and viewing the result in the SPACE SCREEN. Try a few different values In DISTANCE to observe the effect of changing the DISTANCE between the camera and the 0,0 point. Try some large value in DISTANCE (like 4000) to observe the effect. Notice how you can use larger X,Y OFFSETS when you use a large DISTANCE and still keep the drawing in the SPACE SCREEN. For this exercise, be sure to change only the values In the X OFFSET, Y OFFSET and DISTANCE registers.

Z OFFSET Register (3-D MENUS): Lifting the Drawing Off the BASE LINE GRAPH

Store, where necessary (change the values In the registers where necessary), "400" in DISTANCE, "200" In Z OFFSET, "50" In ANGLE OF VIEW and "0" In all of the other orientation registers (from MENU DISPLAY ORDER to ANGLE OF VIEW) of 3-D MENU #1. view the test pattern in the SPACE SCREEN.

Notice that the "L" is now larger. In fact, the top of the "L" is now cut off in the SPACE SCREEN. A positive value in Z OFFSET has the effect of raising the model in space (i.e., offsetting it on the Z Axis). The "L" is now 200 units higher than the BASE LINE GRAPH. The camera is aimed straight down a! the 0,0 point of the graph (fig. 2A). The "L" has now been offset 200 units closer to the camera and the displayed image Is larger because the distance from the camera to the drawing is only 200 units. (The same size image can be obtained by loading "0" in Z OFFSET and "200" in DISTANCE.)

Remember, the X OFFSET, Y OFFSET and Z OFFSET registers are used to reposition the model anywhere in 3-D space. The DISTANCE register sets the distance between the camera and the 0,0 centre of the graph.

Practice inputting different values In the X OFFSET, Y OFFSET, Z OFFSET and DISTANCE registers, until you can predict the combined effect in the SPACE SCREEN.

When using the X OFFSET, Y OFFSET and Z OFFSET registers, it is possible to move a model so far out that some coordinates of points of the models may fail in a "danger* zone, if a model is moved by the offset registers so far that some points of the model fall out beyond -18918 to +18918 in any direction (X, Y or Z), It is possible that, when viewing the model from certain angles, the

points, when translated, could fall outside the dimensions of the drawing universe.

This could mean that, when viewing a 3-D model, those surfaces using the point would disappear or, worse, be weirdly distorted and possibly fill the entire screen. To be on the safe side, keep the entire model within the -18918 to +18918 range. ChromaCAD does not limit coordinates to within the above values because models can usually be moved and displayed successfully beyond these values. This is something to keep in mind, although it's not something to worry about. Such extreme offsets are rarely used. The number, "18918", is listed in the REGISTER RANGE Appendix.

PITCH ANGLE Register (3-D MENUS): Swinging the Camera Away from the Z Axis

Return to 3-D MENU #1 and store, where necessary, "60" in PITCH ANGLE, "400" in DISTANCE, "50" In ANGLE OF VIEW and "0" In all of the other orientation registers of 3-D MENU #1. View the "L" In the SPACE SCREEN.

When the PITCH, YAW and ROLL ANGLES were all "0", the camera was aimed straight down at the 0,0 center from directly overhead. The camera LINE-OF-VIEW coincided with the Z Axis. Now the PITCH ANGLE is 60 degrees. This means that the angle between the camera LINE-OF-VIEW and the Z Axis is 60 degrees. This has the effect of swinging the camera LINE-OF-VIEW 60 degrees away from the Z Axis so that the camera lens is now directly over a point on the -Y Axis (see fig. 3A).

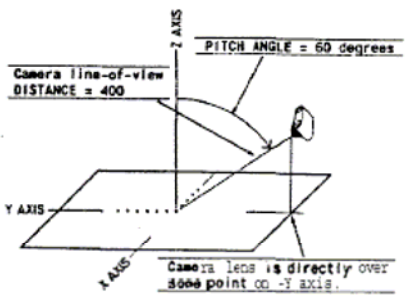


fig. 3A

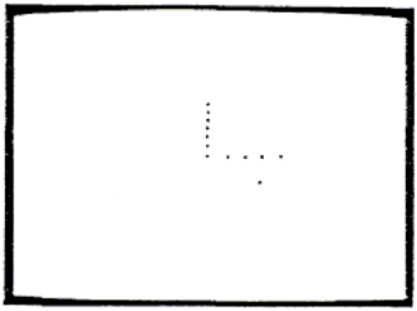


fig. 3B (SPACE SCREEN)

The camera is still aimed at the 0,0 point of the graph and the camera distance to the 0,0 point is still 400 units, but the angle the camera views the drawing has been changed. The long stem of the "L" appears shortened in the SPACE SCREEN because the letter is being viewed on a slant (fig. 36).

Return to 3-D MENU 31 and change the PITCH ANGLE to 90 degrees and view the result in the SPACE SCREEN.

The camera LINE-OF-VIEW has now swung down so far that it is in the X,Y drawing plane. The LINE-OF-VIEW now lies directly on the -Y Axis of the X,Y plane. The camera is now on the same plane the 'L" is plotted on (see fig. 4A). From this camera position, the "L" appears only as one horizontal line on the screen (fig. 4B).

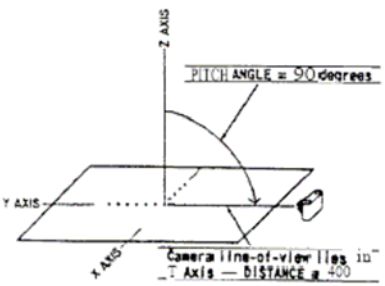


fig. 4A

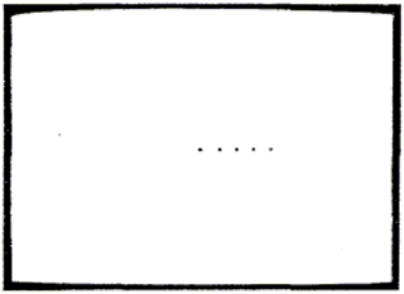


fig. 4B (SPACE SCREEN)

Practice with various PITCH ANGLE values until the effects of PITCH ANGLE become clear to you. Use PITCH ANGLE values In the range of -180 to +180 degrees.

The limits for the PITCH, YAW and ROLL ANGLE registers are –180 to +180 degrees. Notice that when you input a value in PITCH ANGLE of more than 90 degrees, the camera swings down under the X,Y plane and views the "L" from the underside. When you input negative PITCH ANGLE values, the camera swings away from the Z Axis In the opposite direction to a position directly over some point on the +Y Axis. In practice, negative PITCH ANGLE values are seldom used.

YAW ANGLE Register (3-D MENUS): Swinging the Camera around the Z Axis

Store, where necessary, "60" In PITCH ANGLE, "45" In YAW ANGLE, "400" In DISTANCE, "SO" In ANGLE OF VIEW and "0" In all of the other orientation registers of 3-D MENU #1 and then view the "L" In the SPACE SCREEN.

Previously, when YAW ANGLE contained "0" and PITCH ANGLE contained "60", the camera viewed the "L" from a point directly over the -Y Axis (fig. 3A). Storing "45" into YAW ANGLE has the effect of swinging the camera 45 degrees clockwise around the Z Axis while maintaining the same PITCH angle, so that the camera lens is directly over a point that lies midway between the -Y and the –X Axes (see fig, 5A),

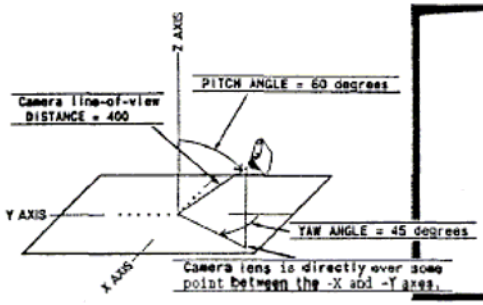


fig. 5A

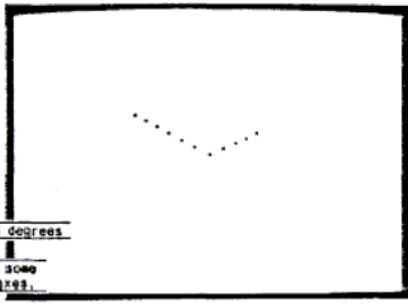


fig. **5B** (SPACE SCREEN)

Practice with the YAW ANGLE register. Leave PITCH ANGLE at 60 degrees and store various angles in YAW ANGLE while viewing the result In the SPACE SCREEN. As you do this, imagine that the "L" is plotted on an X,Y plane at zero elevation and the camera is swinging around the Z Axis, viewing it from various angles. Notice that negative YAW angles have the effect of swinging the camera around the Z Axis in a counterclockwise direction. Soon you will be using negative YAW ANGLES to view the right side of models and positive YAW ANGLES to view the left side.

NOTE: Some straight lines, when plotted on a slant, may appear slightly wobbly. This is due to the screen resolution of the computer. The coordinate points of the straight line have been calculated

properly by the computer, and, if a higher resolution graphics mode were possible, the points would be plotted in a straighter line. This is nothing to be concerned about. The effect is not noticeable when models are displayed by the SURFACE SHADER XE program.

ROLL ANGLE Register (3-D MENUS): Spinning the Scene around the Center of the Screen

The ROLL ANGLE register is the easiest of all. After all of the other orientation registers are set, ROLL ANGLE simply spins the scene around the center point of the SPACE SCREEN. A positive ROLL ANGLE will spin the scene counterclockwise, and a negative ROLL ANGLE will spin the scene clockwise.

Display the "L" in the SPACE SCREEN by using any desired values In the orientation registers. Then change the value In ROLL ANGLE to see this spin effect.

ROLL is not used as often as PITCH and YAW in displaying models. It is sometimes used for models such as airplanes or missiles that have been constructed in an upright attitude to display them in a flying attitude. Sometimes, it's useful to display a tall model by using a 90 degree ROLL. This ensures that the longest dimension of the model (height) corresponds to the longest dimension of the monitor or T.V. (width). This technique often makes it possible to bring more pixels to bear in displaying the model.

ANGLE OF VIEW Register (3-D MENUS): Producing a Wide-angle or Telephoto View

The final orientation register is the ANGLE OF VIEW register. The default value for this register is 50. The ANGLE OF VIEW limits are 10 to 90 (degrees). Using "90" in ANGLE OF VIEW produces the effect of a wide-angle lens. Using "10" in ANGLE OF VIEW produces the effect of a telephoto lens. DISTANCE must be changed when ANGLE OF VIEW is changed in order to maintain the same image size. (As ANGLE OF VIEW increases, DISTANCE must be decreased to maintain similar image size.)

It might be assumed that a large ANGLE OF VIEW combined with a short DISTANCE would produce the same image as a small ANGLE OF VIEW combined with a long DISTANCE. This is not the case. A large ANGLE OF VIEW combined with a short DISTANCE will produce images which seem to relatively enlarge that portion of the model nearest the point of view (the camera). This can often be

used to produce dramatic model perspectives. The default value for ANGLE OF VIEW is 50. This is the angle of view of the "normal" camera lens.

A full discussion of the effect of ANGLE OF VIEW is beyond the scope of this manual. It should be noted, however, that ChromaCAD does reproduce this effect and can be used to study it in detail.

Try inputting a few different values In ANGLE OF VIEW and observing the changes in the SPACE SCREEN.

Notice how changing4ne value in ANGLE OF VIEW changes the size of the "L". It's not possible to study the artistic effects that ANGLE OF VIEW can produce by displaying a plot of the test pattern. These effects can be observed more clearly later when complete models are displayed.

OFFSET Registers (3-D MENUS): Placing the Test Pattern at a Desired Location in Space

You can easily orientate and place the test pattern at any desired location in the space of the SPACE SCREEN. Knowing this technique will be especially important when you want to place a number of models in the same 3-D space in various orientations and view them all together.

Store, where necessary, "60" In PITCH ANGLE, "45" In YAW ANGLE, "400" In DISTANCE, "50" In ANGLE OF VIEW and "0" in all of the other orientation registers of 3-D MENU #1. Read the following material while viewing the "L" In the SPACE SCREEN.

The long stem of the "L" always points in the direction of the +Y axis of the BASE LINE GRAPH and always has a length of 100 units. (Remember, you are now taking a slant view of the BASE LINE GRAPH.). If you were now to go back to 3-D MENU #1 and add "100" to the value presently in the Y OFFSET register and then view the "L" again, the "L" would be moved 100 units in •the direction the long stem is now pointing. Since the long stem is 100 units long, the "L" would move a distance, on the screen, approximately equal to the displayed length of the long stem. Similarly, the short stem of the "L" always points in the direction of the +X axis and has a length of 60 units. Adding "60" to the X OFFSET register will move the "L" the length of the short stem in

the direction the short stem is now pointing.

To see this graphically, make a mental note of the screen location of the tip of the short stem. Return to 3-D MENU #1 and add "60" to the value currently In the X OFFSET register (0 + SO = 60). View the test pattern again.

Notice that the entire figure has now been moved the length of the short stem (60 units in perspective) in the direction of the short stem.

Think of the "L" as if it's inside a 3-D graph space with the long stem always pointed in the -s-Y direction and the short stem always pointing in the +X direction of the graph axis. This is always true regardless of from what PITCH, YAW or ROLL angles are used to view the 0,0,0 center of the graph or what X, Y or Z offsets are used to move the "L" within the graph space.

Changing X, Y or 2 offsets serves to move the model (in this case, the test figure) around in the 3-D space and changing PITCH, YAW or ROLL angles serves to view the center of the graph from different angles, but no change of any value can ever change the axis orientation of the model within the 3-D graph. The long stem of the "L" will always point in the +Y direction and the short stem will always point in the +X direction of the 3-D graph space. (This is, of course, not a limitation because the model can always be placed anywhere in 3-D space with the offset registers and viewed from any angle with the PITCH, YAW or ROLL registers.)

Use the following procedure when you want to reposition the "L" to a new location in the 3-D graph space.

1. Calculate the approximate amounts of X, Y or Z offsets needed to reposition the "L to the new location. (Remember, adding 100 units to Y OFFSET will send the "L" the length of the long stem in the direction of the long stem and adding 60 units to X OFFSET will send the "L" the length of the short stem in the direction of the short stem. Adding or subtracting values to Z OFFSET raises or lowers the "L" on the *7.* axis of the 3-D graph.)

2.. Return to the 3-D MENU being used and add (or subtract) the calculated amounts to the current values in the registers. View the "L" again.

3. Repeat steps 1 and 2 until the "L" is properly positioned.

Practice moving the "L" around In 3-D space by first displaying the "L" using any desired PITCH, YAW and ROLL ANGLE values and then moving the "L" to other locations in space. Practice this until you understand the use of all of the orientation registers when moving the "L" around in 3-D space.

OFFSET and DISTANCE Registers (3-D MENUS): Changing the Displayed Size of Models

Sometimes you'll want to keep the model at the same screen location but change the size of the model. This can be accomplished by changing all the values in DISTANCE, X OFFSET, Y OFFSET and Z OFFSET inversely proportionally. For example, if DISTANCE were set at "200', X OFFSET at "100", Y OFFSET at "60" and Z OFFSET at "20", the model would be rendered in a size close to half its original size while remaining at the same screen location by setting DISTANCE to "400", X OFFSET to "200", Y OFFSET to "120 and Z OFFSET to "40" (i.e., double their original values).

Practice the procedure described above by first placing the "L" at some desired off-center location and then changing the size of the "L" without changing Its screen location. Repeat the above procedures until you can accurately place the "L" anywhere in any orientation in the space of the SPACE SCREEN in any size desired.

Later, when you want to orientate, then place and size an actual model in space for the purpose of fitting it into a scene with other models, you can first place the "L" test pattern in the approximate orientation, location and size desired. Later, when the same register values are used to display a model, the model will be displayed in the same orientation, location and relative size as the "L" This is much faster than placing the model directly.

Whenever the test pattern is not displayed, check the X, Y and Z offset registers to make sure that the "L" isn't positioned outside the viewing range. If you have any doubts about this, load "0" into all of the offset registers, load a large value like "2000" into the DISTANCE register and a large number like "80" in ANGLE OF VIEW and try again. The model will be small when displayed but should fall within viewing range.

Eventually, you'll want to create multi-model scenes of different views of the same model or of different models in different orientations. ChromaCAD permits up to 10 model views to be displayed at once.

"CONTROL Q" Key-combination (3-D MENUS) and the MENU DISPLAY ORDER Registers (3-D MENUS): Displaying Multiple Views of the Test Pattern on One Screen

Load, as necessary, the following values into the first 11 input registers of 3-D MENU #1:

THIS MENU NO. =.....1	DISTANCE =.....600
MENU DISPLAY ORDER - 2	X OFFSET = ...50
MODEL BASE LINE - 0	Y OFFSET = ...100
PITCH ANGLE =.....50	Z OFFSET = ...0
YAW ANGLE =.....70	ANGLE OF VIEW = ...50
ROLL ANGLE = ...0	

Load, as necessary, the following values Into the first 11 input registers of 3-D MENU #2: (Type "2" to access 3-D MENU # 2.)

THIS MENU NO. =.....2	DISTANCE =.....400
MENU DISPLAY ORDER = ...1	X OFFSET = ...10
MODEL BASE LINE = ...0	Y OFFSET = ...10
PITCH ANGLE =.....40	Z OFFSET = ...0
YAW ANGLE 45	ANGLE OF VIEW = ...50
ROLL ANGLE =.....0	

Hold the "CONTROL" key down and type the "Q" (Quick) key.

The program displays both views of the "L" on the same screen. First, you will see the "L' displayed using 3-D MENU #2, and then the "L" displayed using 3-D MENU #1. The 'CONTROL Q" key combination can call up to 10 different views of the test pattern (or of models) on one screen at a time - one for each 3-D MENU. Later, when models are used, the views can all be of the same model or of any combination of up to 10 different models.

The 3-D MENUS will be called for display in the order of the numbers you enter into the MENU DISPLAY ORDER register of the 3-D MENUS. Not all menus need be called for display. If you load '0" into the MENU DISPLAY ORDER register of a 3-D MENU, that menu will not be called.

The MENU DISPLAY ORDER register will only accept numbers in the range from 0 to 10. If a number in the series is skipped, the display of the 3-0 MENUS will stop at that number.

For example, if you load the MENU DISPLAY ORDER register of MENU #7 with '1", the MENU DISPLAY ORDER register of MENU #3 with "2", the MENU DISPLAY ORDER register of MENU #5 with "3" and no menu has a '4' loaded in MENU DISPLAY ORDER, the #CONTROL Q- key-combination will first call MENU #7, then MENU #3 and finally MENU #5. No more menus will be called regardless of what the other menus have in MENU DISPLAY ORDER.

If two menus have the same number loaded in MENU DISPLAY ORDER, only the lower menu will be called. In the example above, if both MENU #3 and MENU #5 had *"2'* loaded in MENU DISPLAY ORDER, only MENU #3 would be called. MENU #5 would be skipped.

NOTE: When using the 'Control Q" key-combination, all 3-D MENUS called for display use the same ANGLE OF VIEW value loaded in the ANGLE OF VIEW register of 3-D MENU #0. ANGLE OF VIEW values loaded in 3-D MENUS other than 3-D MENU #0 are ignored. One advantage of this feature is that once the group of models is 'fitted* together in space, the image size of the entire group can be changed by changing the one value in the ANGLE OF VIEW register of 3-D MENU #0.

Practice with the "CONTROL Q" key-combination. See If you can display three "L"s in a row (LLL). (HINT: Ail of the positioning registers, except the X OFFSET register, should be loaded the same way in the three menus used.)

Now change the image size of the entire group by changing the value in the ANGLE OF VIEW register (range of 10 to 90) of 3-0 MENU #0. (Remember, the image size changes inversely.)

Now that you have three "L"s displayed In a row, change the values in the PITCH, YAW, ROLL and DISTANCE registers of the menus used, but make sure the PITCH, YAW, ROLL and DISTANCE registers are loaded the same way in ail three menus. View the results.

Notice that although you changed your point of view, the spatial

relationship between the three letters was maintained. Once you place a set of models together in the same space, the spatial relationships will be maintained when the group is viewed with different PITCH, YAW, ROLL and DISTANCE values.

SECTION 3 - 3-D DRAWING TOOLS

LOAD DEFAULT VALUES Option (MAIN MENU): Loading the Default Values Back into the Registers of the 3-D MENUS

Before proceeding with this section, you should load the program's default values back into the registers of the 3-D MENUS.

Go to the MAIN MENU and select LOAD DEFAULT VALUES. At the "LOAD DEFAULT VALUES?" prompt, type "Y" (Yes).

The MAIN MENU win be redrawn and the menu cursor wil! return to the top of the menu. You have just loaded the program's default values back into the 3-D MENU registers. The default values are the values that are loaded in the 3-D MENU registers when a new model disk is first booted. (If you left any of your own values in any of the 3-D MENU registers they will have now been replaced with the default values.)

The LOAD DEFAULT VALUES option was designed to fill the registers of the 3-D MENUS with values that provide useful, frequently used viewing angles. You can, of course, change the register values again to obtain other views whenever you wish.

To familiarize yourself with the default views, return to the 3-D MENUS and view the "L" In the SPACE SCREEN using the 3-D MENU default values now loaded In the 3-D MENU registers (type "1" to access 3-D MENU #1, "2" to access 3-D MENU #2, etc. and view the test pattern from each menu).

PLOT BASE LINE Option (MAIN MENU): Accessing the BASE LINE GRAPH

Select the PLOT BASE LINE option of the MAIN MENU.

You will see the BASE LINE GRAPH. This is the graph that the "L" test pattern was plotted on. Just below the center of the screen is a small"+". To the left of the "+" is the plotting cursdr. It helps to think of the monitor screen as a piece of graph paper that you're looking down on -- as if you're sitting at a desk with a piece of graph paper lying on the surface of the desk.

The"+" is the 0,0 point of the graph. To the right of the V are the positive X coordinates and to the left of the"+" are the negative X coordinates. Similarly, the positive Y coordinates are above the"+",

ranging toward the top of the screen and the negative Y coordinates are below the V, ranging downward.

The PLOT BASE LINE option calls the BASE LINE GRAPH. The BASE LINE GRAPH is used to plot the BASE LINE of the model. This is always the first contour line of the model - the contour line at the lowest elevation. This is often only one point.

The CONSTRUCT 3-D PANEL option calls the HIGH LINE GRAPH and Is used to construct all of the remaining contour lines of the model.

"." (Plot) Key (BASE LINE GRAPH Mode): Plotting a Point

To plot a point on the graph, use the joystick to move the cursor to any desired graph location and then type the period "." (Plot) key to plot the point. Use the joystick to plot a line of 3 or 4 points In any direction. Do not touch the red button. Try to plot two successive points at the same graph location without moving the cursor between points.

Notice that every plotted point leaves a dot that marks the point. Notice also that the computer "beeps" when you try to plot two successive points at the same location. Whenever you hear a "beep* the program is telling you of a possible problem, in this case, the "beep" Is telling you to move the cursor between successive points. The program will not plot two successive points on top of one another.

Now type " -»" (Out) to exit to the MAIN MENU.

LAST ERROR Register (MAIN MENU): Using the ERROR NUMBER TABLE to Diagnose a Mistake

Notice the number "2" displayed after the LAST ERROR register on the MAIN MENU. This is the error number that was generated when you tried to plot two successive points at the same location. Whenever the computer beeps, a new error number is generated.

When the computer beeps and you are not sure what you did wrong, you can always go out to the MAIN MENU and read the number in the LAST ERROR register. You can then look up the error number in the ERROR NUMBER TABLE located at the end of the manual. The table contains explanations of each error and, in

many cases, suggests corrected procedures.

In this case, if you look up the error number "2" in the ERROR NUMBER TABLE, it will tell you that you cant plot two consecutive points on top of one another. You must always move the cursor between points.

RETURN TO CURRENT LINE Option (MAIN MENU): Returning without Destroying

Drop the cursor down to the RETURN TO CURRENT LINE option of the MAIN MENU. Select that option by typing " «- " (In).

You will go back to the BASE LINE GRAPH and the BASE LINE points will be visible again. !f you go out to the MAIN MENU after plotting points, you cannot return by way of the PLOT BASE LINE option without destroying the points. If you go out to the MAIN MENU to read an error number, return immediately via RETURN TO CURRENT LINE.

ChromaCAD doubles up on the use of computer space and many of the MAIN MENU options will destroy plotted points. You can go out and select any of the last three options on the MAIN MENU without destroying your plotted points. These options are: STORE 3-D MENUS TO DISK, LOAD DEFAULT VALUES and LIST MODEL BASE LINES. These are the only MAIN MENU options that you can select and still return to the graph via RETURN TO CURRENT LINE without destroying plotted points.

"X' (X OF CURSOR) Key (BASE LINE GRAPH and HIGH LINE GRAPH Modes): Accessing the GRAPH MENU - the Read-only Registers

Using the joystick is one way to position the cursor in preparation for plotting a point. You may, however, want to position the cursor directly to some specific X,Y location on the graph before plotting a point.

Type the "X" (X OF CURSOR) key.

You will see a menu of input registers. This menu is called the GRAPH MENU. Notice the last three registers displayed with inverse letters at the bottom of the menu. Registers displayed with inverse letters are read-only registers. You cannot change their

values directly from the menu. The NO. OF PTS. PLOTTED register simply displays the number of points plotted so far.

The SECTORS REQ. register first displays the maximum number of disk sectors that are permitted for the storage of one line of plotted points (this is a constant) and then displays the number of sectors that would be required to store the currently plotted line (the line of points you just plotted). You cannot plot lines that would require more sectors to store than the maximum permitted - you will get a "beep" if you try. The Z OF LAST LINE register will be covered in a later section.

The cursor should now be positioned for you to enter a value into the X OF CURSOR register.

Store "10" into the X OF CURSOR register and "15" into the Y OF CURSOR register. Return to the graph by typing " -»" (Out).

On return to the graph, the graph cursor will be at the new X = 10, Y = 15 location that you just input into the X OF CURSOR and Y OF CURSOR registers. Whenever you want to know the exact X,Y location of the graph cursor, you can always type the "X" (X OF CURSOR) key to go to the GRAPH MENU. You then have the option of either changing the cursor location by inputting new values or simply reading the X,Y values and then returning to the graph.

Familiarize yourself with the coordinate system and the scale of the graph by using the "X" (X OF CURSOR) key to Input a few different X,Y values and then observing the location of the plotting cursor when you return to the graph. Keep the values within the -60 to +60 range so you do not |ump the cursor off the graph screen.

The plotting range of the monitor screen is less than 150 in any direction. This is quite small considering that the X,Y cursor input registers have an input range from -32767 to +32767.

Red Button (BASE LINE GRAPH and HIGH LINE GRAPH Modes): Scrolling the Screen.

Uss the "X" (X OF CURSOR) key to input X = 150 and Y = 10. Return to the graph. 24

This time the cursor will not be visible. You have positioned the

cursor far enough to the right so that it fell off the screen.

To find the cursor, hold the joystick so that the red button on the joystick is in the upper left corner. Press the red button with your left thumb and move the stick to the right. The screen will jump to the right. As soon as the screen jumps once, center the stick and release the red button.

The cursor should now be in view and can, as before, be moved with the joystick. The scrolling screen exposes a large graph on which to plot large, complex models, if you were limited to a graph that would fit on one screen, models would, of necessity, be quite simple.

The graph possible with a scrolling screen is extremely large, from -32767 to +32767 in any direction. A popular graph paper commonly used in schools is ruled 5 squares to the inch. By comparison, for example, if such a piece of graph paper ranged from -32767 to +32767 squares, it would be more than one-fifth of a mile wide. This is large enough for the most demanding detail. As mentioned before, in practice, there are possible problems in using coordinates beyond -18918 to +18918 near the edge of the drawing universe. This is not much of a limitation. In practice, you will seldom ever need values beyond -10000 to +10000.

It helps to imagine the screen as a window that is scrolled around the surface of the graph. You can scroll the screen by holding the red button down and using the stick to scroll the screen across the graph in the desired direction. If you move the joystick to the right while pressing the red button, the screen will scroll to the right toward the higher X values. If you move the stick to the left, the screen will scroll to the left. Pushing the stick forward scrolls the screen toward the higher Y values and pulling the stick back scrolls the screen toward the lower Y values.

Use the joystick and the "." (Plot) key to plot a line of points to the edge of the screen. Scroll the screen and continue plotting the line. Now scroll the screen away so the line Is off the screen. Scroll the screen back to view the line again. Notice that once a point is plotted It will always be visible when the screen Is scrolled to the point's location.

Practice until you understand how to plot a line of points spanning several screens by using the scrolling screen. Don't

scroll too far, however, or you may not be able to find the cursor or the points you plotted.

"H" (Hop Screen) Key (BASE LINE GRAPH and HIGH LINE GRAPH Modes): Finding the Cursor

Sometimes, if you scroll too far or if you use the "X" (X OF CURSOR) key 5o send the cursor to a remote graph location, you may have difficulty finding the cursor again. It is sometimes difficult to locate the cursor by scrolling the screen around, especially if the cursor is very far from center (0,Q). To send the screen directly to the cursor, type the "H" (Hop Screen) key. The screen will hop directly to a location where the cursor will be visible.

Use the "X" (X OF CURSOR) key to send the cursor to a remote location (for example, X = 1000, Y = 1000). Return to the graph. The cursor will not be visible because it will be at X = 1000, Y a 1000. Type the "H" {Hop Screen) key.

The screen will hop to a location where the cursor is visible. If you wished, you could now scroll the screen back to 0,0 but it would Sake a long time. A better way is to use the "X" (X OF CURSOR) key to send the cursor back to a location near the 0,0 center. Then use the "H" (Hop Screen) key to reposition the screen.

Use the "X" (X OF CURSOR) key to return the cursor to some location near 0,0. Return to the graph. The cursor will be gone because it will now be at the location near 0,0. Use the "H" (Hop Screen) key to reposition the screen to a location where the cursor is visible.

The "H" (Hop Screen) key can also *ba* used to renew the screen display.

Erase the screen Image of the' V (at 0,0 center) and some of the points that you just plotted toy running over the points with the cursor {sometimes this requires a few passes). Notice that you cannot erase the last point plotted.

Many times, when a complex fine is being plotted some of this screen display may inadvertently be erased by the cursor. The points, however, have not been erased in memory - only the screen images have been erased. To get the screen images back, simply type the "H" {Hop Screen) key. The display will be renewed.

Scrolling the screen will also automatically renew the display. (The last point is automatically renewed every time the cursor is moved.)

Practice with the "X" (X OF CURSOR) key and the "H" (Hop Screen) key until you are confident you can send the cursor and screen anywhere on the graph and be able to return both to the 0,0 area without difficulty. When you are finished, return the cursor and screen to some location near 0,0 where both the cursor and the 0,0 point are visible.

Of course, there will be times when you want to erase points, both on the screen and in computer memory.

"E" (Erase) Key (BASE LINE GRAPH Mode): Erasing Points

The "E" (Erase) key is used to erase points both on the screen and in memory. When you type the •£" (Erase) key, the most recently plotted point will be completely erased as if it had never been plotted.

Type the "E" (Erase) key successively until the last point is erased. Type the "E" (Erase) key once more until you hear a "beep".

The "beep" reminds you that you have already erased the last point. To erase all of the points, you can either hold the "E" (Erase) key down until you hear a "beep", as you just did, or go out to the MAIN MENU and then return to the graph by selecting PLOT BASE LINE again. Both accomplish the same thing.

It's often difficult to plot curves or straight lines by using the joystick. Therefore, ChromaCAD has a tool to simplify this task.

"D" (Draw) Key (BASE LINE GRAPH and HIGH LINE GRAPH Modes): Accessing the DRAW MENU and Using the Straight Line Function

Go to the MAIN MENU, select PLOT BASE LINE and then type the "X" (X OF CURSOR) key. Input X = 10, Y = 10. Return to the graph and plot a point at that location by typing "." (Plot). Use the Joystick to move the cursor to any location on the upper half of the screen. Then type the "D" (Draw) key.

You will see a seven-register menu displayed. This is the DRAW MENU. It is used to draw both straight and curved lines. The

values displayed in X DRAW and Y DRAW of the DRAW MENU are the present X,Y coordinates of the cursor. The input registers necessary for using this menu to draw straight lines are the NO. OF POINTS register, the X DRAW register, the Y DRAW register and the L!NE(1)CURVE{0) register.

The RADIUS, AXIS RATIO and ROTATE ANGLE registers are only used for drawing curves and can be ignored when drawing straight lines. The use of the DRAW MENU to draw curves will be covered later. A "1" stored in the L!NE{1 }CURVE(0) register calls for a straight line and a '0" calls for a circle or curve to be generated. The LINE(1)CURVE(0) register will accept no value other than "1" or "0".

Store a "8" In NO. OF POINTS and make sure a "1" Is stored in LINE(1)CURVE(0). Do not change the values In the other registers. Return to the graph by typing " -> " (Out).

You will notice a line of 6 more points displayed from the last point plotted (pt. 1) to the current cursor location. (The 6th point is under the cursor.) These points have not been plotted. They are only displayed to suggest to you possible plot points. Whenever you are not satisfied with the displayed direction of the line or the number of points, you can move the cursor to a more desired location and repeat the process until! you get the line you want.

If you use the "D" (Draw) key to access the DRAW MENU and want to display a line to some location other than the current cursor location, change the values in X DRAW and Y DRAW while in the DRAW MENU to the desired location. When you return to the graph, the line of suggested points will then be displayed to the desired location.

If you try to use the DRAW MENU to draw a straight line, but do not have at least one point already plotted on the graph, you will get a "beep" reminding you to plot at least one point first. Remember, the suggested line of points always begins at the last point plotted on the graph. The actual number of points in the straight line will, therefore, always be one more than the number loaded in the NO. OF POINTS register.

The next step is to plot the points of the line.

"A" (Advance/Draw) and "B" (Back/Draw) Keys (BASE LINE GRAPH and HIGH
LINE GRAPH Modes): Jumping the Cursor to Successive Suggested Line Points

Once you have set up a desired line of points, you can type the "A" (Advance/Draw) key to jump the cursor to the first point location. You can then plot the point by typing "." (Plot) as usual. Whenever you want the cursor to jump to the next point in the line, type "A" (Advance/Draw) and then plot the point by typing".' (Plot). To jump the cursor back to a previous point, type "B" (Back/Draw).

If you scroll the screen or type the "H* (Hop Screen) key, the screen display of the suggested plot points will be destroyed. Typing the "A" (Advance/Draw) or "B" (Back/Draw) key, however, even after the screen display of the points are destroyed will continue to send the cursor to the screen location of one of the suggested points.

When in the graph mode, be careful not to inadvertently type the "A" (Advance/Draw) or "B" (Back/Draw) keys. Typing either key, when in the graph mode, will always send the cursor to one of the suggested points on the last line that was set up by the DRAW MENU (or to 0,0 if the DRAW MENU hasn't been accessed yet).

Type the "H" (Hop Screen) key once to erase the screen display of the suggested plot points and then plot all of the points of the line by using the "A" (Advance/Draw) and "." (Plot) keys. Check to make sure you have plotted ail of the points by typing the "A" (Advance/Draw) key one extra time after the last point of the line is plotted - notice that the cursor jumps back to the first point.

NOTE If you return to the graph from the DRAW MENU and a circle of suggested points is displayed (rather than a straight line), it simply means that a "0" is loaded in the LINE(1) CURVE(O) register (rather than a "1").

Plot a few straight lines until you are familiar with the line plotting tool. Load a "0"in the L!HE(1) CURVE{0) and observe the display of suggested points.

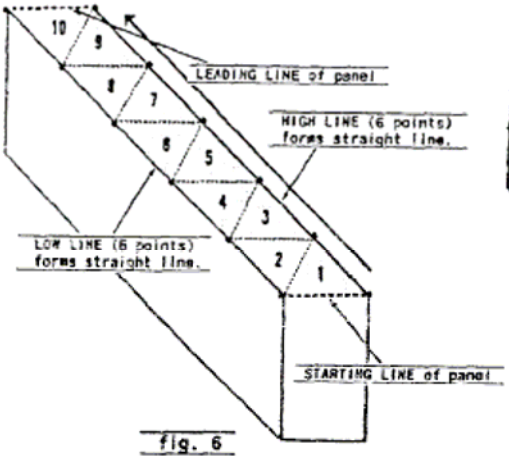


fig. 6

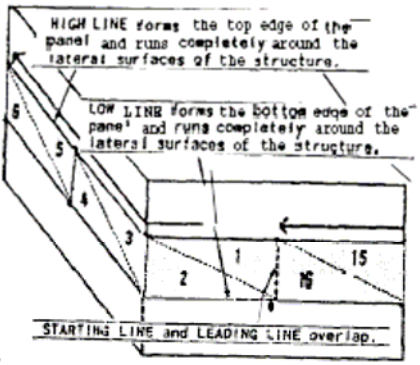


fig. 7

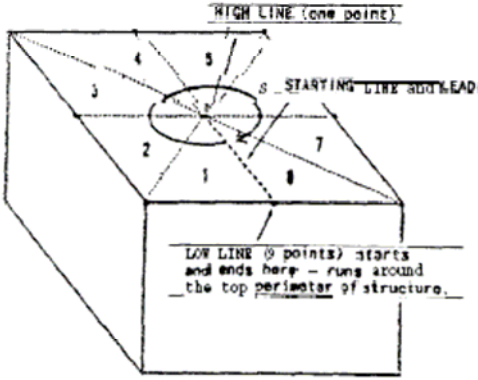


fig. 8

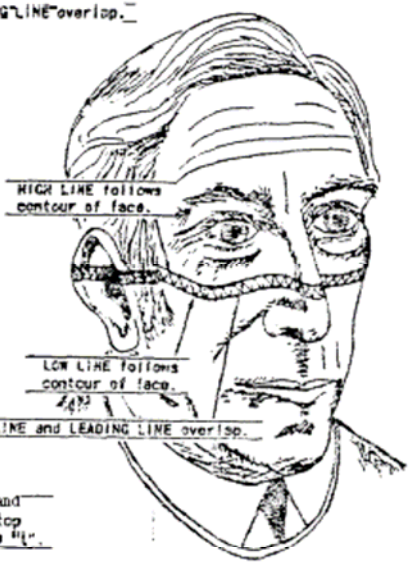


fig. 9

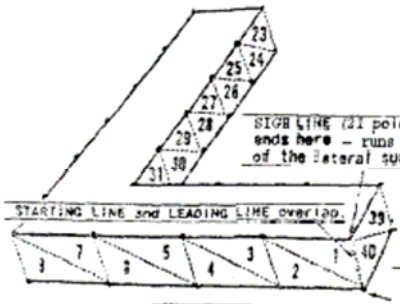


fig. 10

SECTION 4-aL" MODEL

At this point we still haven't covered ail of the graph tools. We will cover the rest of the graph tools by using them to construct 3-D PANELS. The 3-D PANEL is the basic building material of ChromaCAD 3-D models.

A Closer Look at 3-D PANELS

Look at figures 6, *7, 8,* 9 and 10. The numbered strips of triangles in the illustrations are 3-D PANELS. Notice that, in all cases, 3-D PANELS are strips of connected triangles that are used to describe a portion of the surface of a model. in the illustrations, She triangles are numbered to indicate the order in which they were constructed.

Notice also that, in all cases, the boundaries of the 3-D PANELS are described by 4 lines -- the STARTING LINE, the LEADING LINE, the HIGH LINE and the LOW LINE. The STARTING LINE is always the first side constructed of the first triangle of the panel. The LEADING LINE is always the last side constructed of the last triangle constructed (the leading edge of the panel in the direction of construction).

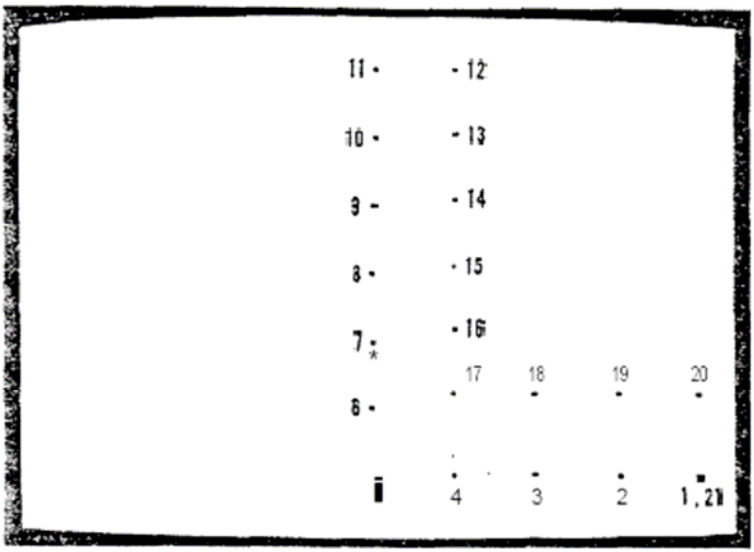
In fig. 6, the 3-D PANEL describes the top surface of a wall and the LEADING LINE ends at a different location than the STARTING LINE. In the other cases, the panels wrap completely around the model and the STARTING LINES and LEADING LINES overlap.

The LOW LINES and HIGH LINES can have any shape or number of points. Notice that in one instance (fig. 8), the HIGH LSNE has only one point. In another case (fig. 9), both the HIGH LINE and LOW LINE follow She contours of a human face.

In these examples, individual 3-D PANELS are shown isolated. Normally, however, the entire outer surface area of the model would be covered with multi-colored 3-D PANELS. There would be no openings between the panels to see into the interior of the model.

The easiest way to (earn 3-D PANEL construction is to work on constructing a model. For this first model we'll use our old friend, the "L" (see fig. 10). First, the BASE LINE of the model must be constructed. The BASE LINE will start the model and also serve as the LOW LINE of the first 3-D PANEL of the model (fig. 10).

Drawing the BASE LINE ("L" Model)



tig. 11 (BASE LINE GRAPH)

Follow the 8 steps below to plot the BASE UNE (see fig. 11)

1. Select the PLOT BASE L!NE option from the MAIN MENU.

2. Use the "X" (X OF CURSOR) key to send the cursor to X s 120, Y s *-40* and then return to the graph and plot a point at that location.

3. Use the DRAW MENU (accessed by the "D" (Draw) key) to help plot a 5-point line to X = 0, Y = *-40* (add the 4 pts. 2 to 5, fig. 11). (To accomplish this, go to the DRAW MENU and load "4" into NO. OF POINTS, "3" *Into* X DRAW, *"-40"* into ¥ DRAW and "1" Into UNE{1) CUFIVE(O). Return to the graph and then use the A {Advance/Draw} key to jump the cursor to each point and the "." (Plot) key !o plot the points.)

4. Use the DRAW MENU to set up a 7-point line to X = 0, Y = 110 (add 8 pts. 6 to 11). Return to the graph and use the "A" (Advance/Draw) and "." (Plot) keys to plot the points.

5. Use the "X" (X OF CURSOR) key to send the cursor to X = 30, Y = 110 (pt. 12). Use the "." (Plot) key to plot a point at that location.

6. Use the DRAW MENU to set up a 6-poini line to X = 30, Y = *-10.* Return to the graph and plot the points (add 5 pts. 13 to 17).

7. Use the CRAW .MENU to set up a 4-point line to X = 120, Y = *•10* and then plot the points (add 3 pts. 18 to 20).

One more point must be plotted and the BASE LINE will be finished. When you plot contour lines you will, in meet cases, be joining the ends of the line or "closing" the line to make a completed loop. This means that the last point of a contour line will usually fall directly on the first point.

"J" (Join) Key (BASE LINE GRAPH and HIGH LINE GRAPH Modes): Sending the Cursor to the Location of the First Point Plotted

The "J" (Join) key positions the cursor directly over the first point plotted in preparation for plotting the last point.

8. Type the "J" (Join) key to position the cursor directly over the first point and then plot the last point (pt. 21) of the BASE LINE by typing "," (Plot). Move the cursor off the last point so that the last point is visible.

The BASE LINE is now finished. It should took like fig. 11. It helps to make a final check before saving the BASE LINE to disk. The following check is recommended:

Make sure the cursor is moved away from the last point plotted and then scroll the screen once back and forth to make sure all points are displayed properly after the screen scrolling.

Often, when plotting BASE LINES, the line will be so large that it won't fit, In entirety, on the monitor screen. When this happens, you should scroll the screen around the path of the BASE LSNE in order to check all of She points.

Type "X" (X OF CURSOR) to make sure 21 points have been recorded.

Notice that this BASE LINE will require only 1 disk sector of storage

space. (With 28 sectors available per contour line, BASE LINES of more than 800 points are possible.)

Number Keys (BASE LINE GRAPH and HIGH LINE GRAPH Modes): Calling the SPACE SCREEN for a 3-D View

You can view the BASE LINE in perspective in the SPACE SCREEN. This permits any size BASE LINE to ba viewed in entirety on one screen.

Return to the graph and type the number "0" key.

You will notice that the BASE LINE is plotted in perspective. You are now in the SPACE SCREEN. The BASE LINE is plotted according to the values loaded in the orientation registers of 3-D MENU#0.

Return to the graph by typing " → " (Out); then type the number "3" key.

The BASE LINE is now displayed according to the values in the orientation registers of 3-D MENU #3. When in the BASE LINE GRAPH mode, if you type any number key (0 to 9) the BASE LINE will be displayed in perspective in the SPACE SCREEN using the values currently in the orientation registers of the corresponding 3-D MENU.

This feature permits you to load up the 3-D MENUS with up to 10 desired points of view and then display the drawing at any time from any of the points of view by simply typing the corresponding number key. This is a powerful tool for doing 3-D drawings. This tool can also be used to view 3-D PANELS as they are being constructed on the HIGH LINE GRAPH.

You can change the values in the orientation registers of the 3-D MENUS at any time white you are plotting the line. To change the values, It is not necessary to exit the graph and access the 3-D MENUS from the MAIN MENU. In fact, you cannot do this because you will not be able to return to your plotted line. A direct route to the 3-D MENUS from the graph has been provided.

“M” (Menus) key (BASE LINE GRAPH and H!GH LINE GRAPH Modes): Going Directly to the 3-D MENUS from the Graphs

Return to the graph and type the "M" (Menus) key.

You will go directly to the 3-D MENUS. You can now change any of the orientation register values of any of the 3-D MENUS. When you return to the graph, typing any number key will display the BASE LINE in perspective in the SPACE SCREEN according to the corresponding 3-D MENU. Later, when you construct 3-D PANELS, the power of being able to call any of ten user-selected points of view at a keystroke will be more clearly appreciated.

STORE LINE TO DISK Option (MAIN MENU): The LINES USED and DISK SECTORS USED Read-only Registers

Type " → " (Out) to return to the graph. Type " → " (Out) again to return to the MAIN MENU.

Before storing a line to disk, always check the last two read-only registers at the bottom of the MAIN MENU. The LINES USED register first displays the maximum number of lines that can be stored to a disk (a constant) and then displays the number of lines already stored on the disk so far (in our case, "0").

Never attempt to store another line to disk if the maximum number has already been attained. The DISK SECTORS USED register displays the number of disk sectors that have already been used. (Even if no lines have yet been stored, some sectors have been used in setting up ChromaCAD's disk filing system.)

The number appearing after "STORE LINE TO DISK" displays the total number of disk sectors that would be required to store what is already on the disk plus the current line in memory. If this number exceeds the number of sectors permitted by your disk format (See HARDWARE SPECIFICS Appendix), do not attempt to store the line. If an attempt would be made, line storage would be attempted and then rejected.

Store the BASE LINE to disk by selecting the STORE LINE TO DISK option.

The disk drive will activate and the line will be stored on the disk. The program will then return to the MAIN MENU. Notice that the numbers in the LINES USED and DISK SECTORS USED registers at the bottom of the MA!N MENU have been updated.

NOTE: As you proceed through this manual you will notice that at various points in the manual two "CHECKPOINT" numbers are printed. These numbers represent the correct values that should be displayed in the LINES USED and DISK SECTORS USED registers at that point in the manual. If the numbers in the manual do not correspond to the numbers displayed in the registers a mistake has been made and the last line constructed should be erased with the ERASE LAST LINE FROM DISK option of the MAIN MENU and constructed again. (The reverse is not always true – correct CHECKPOINT numbers do not always mean that line construction was correct.)

CHECKPOINT: LINES USED = 1, DISK SECTORS USED = 14

Now try returning to the line of plotted points by selecting the RETURN TO CURRENT LINE option.

The program will "beep* and return you to the MAIN MENU. Once a line has been saved to disk, it is no longer on the graph and cannot be returned to. Notice the new error number "9" appearing after the read-only LAST ERROR register. If you looked up this error number in the ERROR NUMBER TABLE in the back of the manual, you would be informed that there is no longer a line of plotted points to return to.

Select the PLOT BASE LINE option.

Again, the program will "beep" and return you to the MAIN MENU. You cannot plot and store one BASE LINE on top of another. Every BASE LINE must be used to construct a model before another BASE LINE can be drawn. Each BASE LINE starts a new modal, but at least one or more 3-D PANELS must ba constructed on the BASE LINE before a modal is completed. Onca you plot a BASE LINE you must either construct a model that uses that BASE LINE or erase the BASE LINE !rom the disk and start another model with a new BASE LINE.

The next step is to construct the the lateral sides of the "L". In fig. 10, one 3-D PANEL is used to form the lateral sides of the "L" model. Notice that this panel runs completely around the perimeter of the "L* and is a erased panel (the STARTING LINE and LEADING LiNE overlap).

CONSTRUCT 3-D PANEL Option (MAIN MENU) and Z OF THIS LINE Register:

Preparing For Constructing a 3-D PANEL Sometimes, it's a good idea to load the program default values into the 3-D MENU registers before selecting the CONSTRUCT 3-D PANEL option. This ensures that unsuitable angles and offsets in the 3-D MENU registers that were left from the previous contour line aren't carried over when construction of the next line begins.

Select the LOAD DEFAULT VALUES option on the MAIN MENU. Type "Y" (Yes) at the "<Y/N>" prompt. On return to the MAIN MENU, select the CONSTRUCT 3-D PANEL option.

You'll be greeted with the GRAPH MENU again. This time, the cursor will be opposite the Z OF THIS LINE register. The program is now waiting for you to input the elevation desired of the plane that you will now plot another contour line on - i.e., the elevation desired of the HIGH LINE of the 3-D PANEL (fig. 10).

The lower limit of this register is always the elevation of the last line stored to disk (indicated by the Z OF LAST LINE register located at the bottom of the menu) and the upper limit is always +32767. In the case of the letter "L", the last line stored was the BASE LINE (always at "0" elevation). Therefore, the limits, in this case, are 0 to -t-32767.

Input the value "18" In Z OF THIS LINE. Do not change the values In the other registers. Type " → " (Out) to go to the HIGH LINE GRAPH.

You will now see that the line you stored previously (in this case the BASE LINE) is already plotted on the graph. In addition, the cursor is displayed slightly to the left of the first point of the BASE LINE. The HIGH LINE GRAPH is always initiated with a display of the previous line stored. This previous line is referred as the LOW LINE of the 3-D PANEL because it has a lower line number than the new contour line you will now be plotting.

The new contour line is referred to as the HIGH LINE of the 3-D PANEL. .Most of the time, as it is in this case, the HIGH LINE will be higher in elevation but not always. Sometimes, the HIGH LINE and the LOW LINE will have the same elevation. The HIGH LINE will never, however, have a lower elevation than the LOW LINE.

The plotting cursor is now on the HIGH LINE GRAPH, 18 units above the BASE LINE plane. (The elevation of the BASE LINE plane is always 0 and the elevation of the HIGH LINE GRAPH is, in this case, 18.) You can't see that the cursor is higher than the BASE LINE, because you're looking straight down on the graph. The cursor is, however, on the HIGH LINE GRAPH, positioned to draw the HIGH LINE of the 3-D PANEL

The next step is to position the cursor to the desired location to initiate the STARTING LINE of the 3-D PANEL.

Use the "X" (X OF CURSOR) key to send the cursor to X = 120, Y = -*46.*

This is a location that appears, on the graph, to be quite close to the first point of the LOW LINE, because the X,Y coordinates of this location are close to the X,Y coordinates of the first point of the LOW LINE. The Z coordinate of the cursor is, of course, 18 units above the LOW LINE points. This location will be the location of the first point of the HIGH LINE. The next step will be to plot the first point of the HIGH LINE and form the STARTING LINE of the panel. (The STARTING LINE of a panel always connects the first point of the LOW LINE with the first point of the HIGH LINE.)

"." (Plot) Key (HIGH LINE GRAPH Mods): Plotting the First Point of the HIGH LINE and Forming the STARTING LINE of a 3-D PANEL

Type the "." (Plot) key; then use the Joystick to move the cursor a few spaces away from the lower mark.

Notice the first point of the LOW LINE is marked by a "+" shaped marker. Notice, also, that the first point of the HIGH LINE is marked by a *"<-"* shaped marker. You have just plotted the first point of the HIGH LINE and, at the same time, initiated the STARTING LINE of the 3-D PANEL. This line extends from the first point of the BASE LINE up to the first point of the HIGH LINE. The two markers mark both ends of the STARTING LINE.

To see this line in perspective type "M" (Menus) to access 3-D MENU # 1. Make sum the following values are loaded Into the model orientation registers of 3-D MENU #t.

PITCH ANGLE 75	X OFFSET =.....-60
YAW ANGLE 0	Y OFFSET =.....0
ROLL ANGLE = ...0	Z OFFSET = ...0
DISTANCE ».....200	ANGLE OF VIEW = ...50

Return to the graph; then type "1" to view the STARTING LINE in the SPACE SCREEN.

Notice that the LOW LINE is plotted in perspective in the SPACE SCREEN. Notice, also, the two"+" marks. The lower mark is centered on pt. 1 of the LOW LINE and the higher mark is above it (In perspective, at aligner elevation) on the HIGH LINE where the first point of the HIGH LINE was just plotted. These !wo marks mark the end points of the STARTING LINE of the 3-D PANEL now under construction. The construction viewed in the SPACE SCREEN should correspond with the construction depicted by fig. 12.

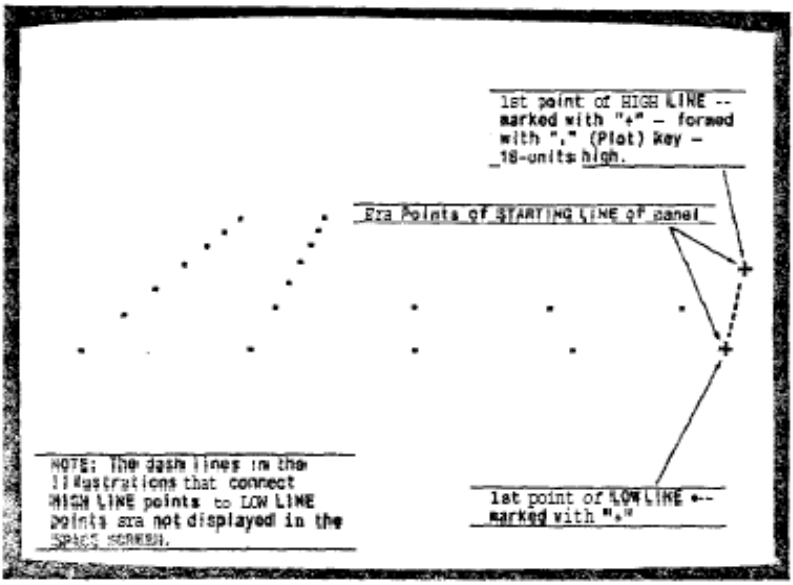


fig. **12** *(SPACE SCREEN)*

The values you stored in the registers of 3-D MENU #1 will be used to view the "L" model for the remainder of this section. These values were used to make illustrations 12 through 17 and are convenient values for perspective viewing of the "L" model. These values should be temporarily saved to disk until the "L" model is

completed so that they will automatically be loaded in 3-D MENU #1 whenever the model disk is booted.

STORE 3-D MENUS TO DISK Option (MAIN MENU): Saving Currently loaded 3-D MENU Register values to Disk

Return to the graph; then go out to the MAIN MENU. Select STORE 3-D MENUS TO DISK (Not STORE LINE TO DISK!). Type "Y" at the "<Y/N>" prompt.

All of the values that are currently loaded into all of the 3-D MENU registers will be saved to disk and you will be returned to the MAIN MENU. These saved values will be loaded into the 3-D MENU registers (rather than the default values) whenever this model disk is booted again by any ChromaCAD program.

Return to the graph by selecting RETURN TO CURRENT LINE.

(Remember, you can go out to the MAIN MENU and select only STORE 3-D MENUS TO DISK, LOAD DEFAULT VALUES and LIST MODEL BASE LINES and still return to your line of plotted points. If you select any of the other MAIN MENU options, the points will be destroyed and you won't be able to return to your line by way of RETURN TO CURRENT LINE.)

The next step is to construct the first triangle of the 3-D PANEL. First, however, it is necessary to decide the surface paint number of the triangle and the shade of the paint.

"P" (PAINT NUMBER) and "S" (SHADING TINT) Keys *(HIGH LINE* GRAPH Mode): Setting the PAINT NUMBER and SHADING TINT of Triangles

While viewing the graph, type the "P" (PAINT NUMBER) key.

You will be presented with the GRAPH MENU again. This time, the menu cursor is opposite the PAINT NUMBER register. (Typing "S" (SHADING TINT) would have placed the cursor opposite the SHADING TINT register.) The PAINT NUMBER register will accept values from 1 to 127. The default value is 1.

Input the number "2" In PAINT NUMBER. Do not change SHADING TINT.

When a triangle of a 3-D PANEL is constructed, the triangle is

“imprinted" with the numbers that are in the PAINT NUMBER and SHADING TINT registers at the time of the triangle's construction. These numbers are always displayed in the upper left comer of the HIGH LINE GRAPH. Once values are loaded into the registers, they will remain in the registers until changed. You can, however, change the values whenever you desire.

This is a major advantage of the ChromaCAD algorithms. Every surface triangle of a model can be individually imprinted with any PAINT NUMBER and SHADING TINT combination. This feature provides great power for constructing 3-D and 2-D models according to exact color-scheme specifications - making it possible for highly detailed multi-colored lettering and designs to be placed on the surfaces of 3-D models.

The MODEL BUILDER program cannot display colors or shading tints directly. Later, however, when you display the model using the SURFACE SHADER XE, you will be able to assign your choice of actual colors to the paint numbers. If, for example, you later assign "blue" to paint number 2, all of the triangles formed when the PAINT NUMBER register contained "2" will be displayed in blue. (For a full understanding of the meaning of the PAINT NUMBER and SHADING TINT registers, see the HARDWARE SPECIFICS APPENDIX at the end of the manual.)

Notice that the default value of SHADING TINT is 0. The SHADING TINT register will accept even numbers only in the range from 0 to 100. The SHADING TINT register is used to "tint" the paint that is currently loaded in the PAINT NUMBER register with black. The higher the value, the more black is mixed with the paint.

Most of the time, when constructing 3-D models, you will want no black in the color. Therefore, you will leave the SHADING TINT register at "0", the default value. If you store "100" in SHADING TINT the triangle will be completely black regardless of what color is eventually assigned to the corresponding PAINT NUMBER.

The SHADING TINT register is used more frequently in constructing shaded color 2-D models than 3-D models. 2-D models are similar to "paintings* that can be moved around in 3-D space. They often serve as backdrops for 3-D models. 2-D models can also be positioned on 3-D models to provide the effect of lettering, logos, color scenes, etc. "painted" on the surface of 3-D models. 2-D models will be covered in a later section. Shading of 3-D models is

done automatically by the SURFACE SHADER XE program. Sometimes, however, you may want to selectively shade the surface triangles ol 3-D models to produce a surface pattern.

Now that the PAINT NUMBER and SHADING TINT registers are loaded with desired values, the next step is to construct the first triangle of the 3-D PANEL.

"L" (LOW LINE) Key (HIGH LINE GRAPH Mode): Using the Next Point on the LOW LINE to Construct a Triangle

Return to the graph. Then type the "L" (LOW LINE) key once.

You have now constructed the first triangle of the 3-D PANEL. Notice, also, that the LOW LINE "+" marker has jumped to the second point of the LOW LINE.

Type "1" to view the triangle in perspective In the SPACE SCREEN.

The construction viewed in the SPACE SCREEN should correspond to that of fig. 13. (NOTE: The dotted lines and lettering in the illustrations do not appear in the SPACE SCREEN display.) Notice that each of the three points of the triangle is marked with a *"+* and that the triangle was formed using the STARTING LINE (the line connecting the first point of the HIGH LINE with the first point of the LOW LINE) and the next point of the LOW LINE.

Notice that the PAINT NUMBER and SHADING TINT values of the triangle are displayed in the upper left hand comer of the SPACE SCREEN. The triangle is labeled "1L" in fig. 13 because it is the first triangle of the panel and because it was constructed with the "L" (LOW LINE) key.

The "L" (LOW LINE) key constructed a new triangle by using the next unused point on the LOW LINE (in this *case,* the second point of the LOW LINE because the STARTING LINE used the first point). The LEADING LINE of the 3-D PANEL is now the line connecting the second point of the LOW LINE with the first point of the HIGH LINE. As more triangles are added, the LEADING LINE will move further and further away from the STARTING LINE. The LEADING LINE is always the last side constructed of the last triangle constructed and represents the leading edge of the panel in this direction of construction.

"." (Plot) Key (HIGH LINE GRAPH Mode): Plotting Another HIGH LINE Point and Constructing Another Triangle

Return to the graph and then use the "X" (X OF CURSOR) key to send the Cursor to X s 90, Y s -46. Return to the graph and type the "." (Plot) key.

This plotted a new HIGH LINE point and, at the same time, used the new point to construct another triangle of the panel. In the BASE LINE GRAPH mode, the V (Plot) key only plots a point. In the HIGH LINE GRAPH mode, the"." (Plot) key has two functions: if no HSGH LINE point has yet been plotted, the V (Plot) key plots the first point of the HIGH LINE and then uses the point to form the STARTING LINE of the panel (as was previously demonstrated), or, if the first HIGH LINE point has been plotted, the"." (Plot) key plots another HIGH LINE point and then uses the point to construct a new
triangle.

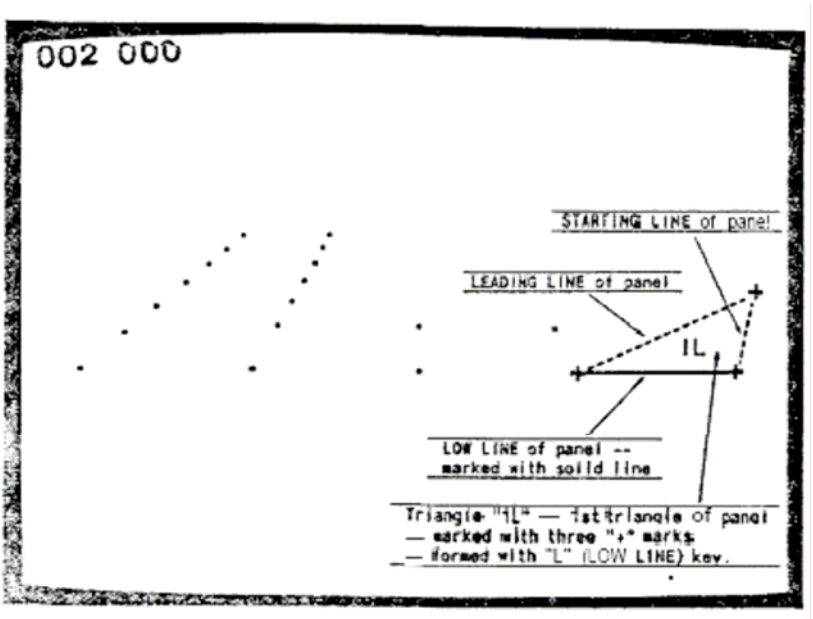


fig. 13 (SPACE SCREEN)

Notice, also, that the previously plotted HIGH LINE point is now marked with a ">" shaped marker. Ail plotted HIGH LINE points are always marked in this way. This makes it easy to distinguish HIGH LINE points from LOW LINE points on the HIGH LINE GRAPH.

To see this new triangle in perspective, type "1" to view the SPACE SCREEN

The construction viewed in the SPACE SCREEN should correspond to that of fig. 14.

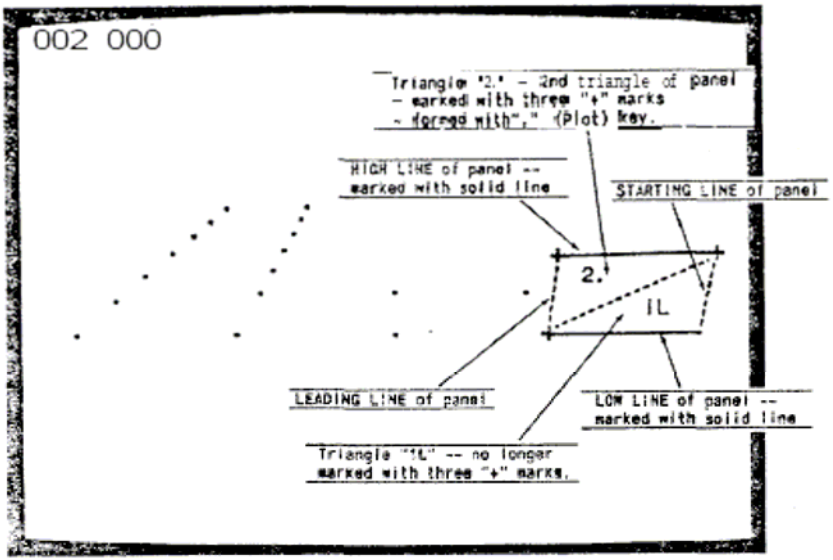


fig. 14 (SPACE SCREEN)

Notice that the new triangle was formed using the two points of the LEADING LINE and the new HIGH LINE point just plotted. This moved the LEADING LINE of the panel ahead so that it now connects the second point of the HIGH LINE with the second point of the LOW LINE.

Notice also that the new triangle is the only triangle marked (with 3 "+" marks) in the SPACE SCREEN. The previous triangle is no longer marked. Whenever you view a panel in the SPACE SCREEN, only She last triangle constructed is marked with three "+" marks. The triangle is labeled "2." in fig. 14 because it is the 2nd triangle of the panel and it was formed with the"." (Plot) key.

NOTE: The two triangles so far constructed form part of the bottom "side-wail" of the short stem of the "L" model. As you may have noticed, the wall, as constructed so far Is not perfectly vertical. It

has a slight "lean" to it in the direction of the -X Axis. For a perfectly vertical wall, the first point of the HIGH LINE should have been plotted at X = 120, Y = *-40* directly above the first point of the LOW LINE and the second point of the HIGH LINE should have been plotted at X = 90, Y = *-40* directly above the second point of the LOW LINE.

The present construction was chosen merely for demonstration purposes so that LOW LINE points and HIGH LINE points would not overlap on the HIGH LINE GRAPH. Normally, of course, to form sides that are perfectly vertical, you would plot HIGH LINE points directly above LOW LINE points.

You have two ways of forming the triangles of 3-D PANELS:

1.) You can use the "L" (LOW LINE) key to form a new triangle with the two points of the LEADING LINE and the next unused point in succession on the LOW LINE, or
2.) 2.) You can move the cursor and then use the"." (Plot) key to plot a new HIGH LINE point and form a new triangle with the two points of the LEADING LINE and the newly plotted HIGH LINE point.

To better visualize this, return to the graph and type "P" (PAINT NUMBER). Change the number In the PAINT NUMBER register from "2" to "3" and then return to the graph. Use the "X" (X OF CURSOR) key to send the cursor to X = 50, Y = -45. Return to the graph and type "." (Plot) once and then "L" (LOW UNE) once to construct two more triangles of the panel. View the construction in the SPACE SCREEN.

Notice that the last triangle marked has two points on the LOW LINE, because it was constructed with the "L (LOW LINE) key. Notice, also, that the entire lengths of both the HIGH LINE and LOW LINE of the 3-D PANEL so far constructed are displayed with solid lines. In addition, the SPACE SCREEN marks the vertices and displays the PAINT NUMBER and SHADING TINT values of the last triangle constructed. The SPACE SCREEN can also mark the vertices and display the PAINT NUMBER and SHADING TINT values of all the triangles of the panel so far constructed.

"T" (Trace) Key (SPACE SCREEN Mode): Checking the Construction of Each Triangle

While remaining in the SPACE SCREEN mode, typa 'T' (Trace) once.

Notice that the 3 markers are now marking the previous triangle constructed (the second to last triangle constructed).

Continue typing the "T" (Trace) key (or holding it down) while noticing which triangle the markers are marking and the PAINT NUMBER and SHADING TINT values displayed for each triangle In the upper left corner of the screen. Stop when you hear a "beep".

All triangles constructed were marked, in turn, back to the first triangle of the panel. The PAINT NUMBER and SHADING TINT register values of each triangle, in turn, were displayed in the upper left corner when the triangle was marked on the screen, the T" (Trace) key was used to trace each triangle of the 3-D PANEL back in the SPACE SCREEN to the first triangle.

This feature makes it easy to double check the PAINT NUMBER and SHADING TINT numbers of each triangle prior to saving the panel to disk. The "T" (Trace) key does not erase triangles. Its only function is to display each triangle, in turn, in perspective in the SPACE SCREEN.

Return to the graph and try typing the "." (Plot) key several times without moving the cursor.

You will hear a "beep" each time. The cursor must be moved to *a* new location each time prior to using the"." (Plot) key. The"." (Plot) key first plots a new point on the HIGH LINE before constructing a triangle. It will not plot two successive HIGH LINE points at the same location.

"E" (Erase) Key (HIGH LINE GRAPH Mode): Erasing the Last Triangle Constructed

Type the "E" (Erase) key once; then type "1" to view the SPACE SCREEN again.

The second-to-last triangle constructed is now displayed. In the BASE LINE GRAPH mode, the "E" (Erase) key erased the last point plotted. In the HIGH LINE GRAPH mode, the '£" (Erase) key erases the last triangle constructed. Whenever the you want to erase the most recently constructed triangle, type the "E" (Erase)

The "X" (X OF CURSOR) key is not, of course, the only way to move the cursor prior to constructing a triangle with the"." (Plot) key. You can also use the joystick. Each new point on the HIGH LINE can be plotted at any location on the graph and the HIGH LINE can have any number of points.

If some HIGH LINE points must be plotted in a straight line, you can set up the straight line with the DRAW MENU and then use the "A" (Advance/Draw) and "B" (Back/Draw) keys to advance the cursor along the points of the line while constructing the panel. This is similar to the procedure that was used to plot a straight line on the BASE LINE GRAPH.

Study figs. 15,16 and 17 for a minute. These figures illustrate different ways of constructing the bottom side-wall (I.e., the labeled triangles In the illustrations) of the lateral panel of the "L" model.

There are, in fact, many ways of constructing any 3-D PANEL. It's not necessary to alternate "L" (LOW LINE) and"." (Plot) triangles. Some panels may have more "L" (LOW LINE) triangles than V (Plot) triangles (fig. 15) and other panels will have more"." (Plot) triangles than "L" (LOW LINE) triangles (figs. 16 and 17).

You're free to construct the HIGH LINE of any panel in any shape with any number of points you wish. Of course, the LOW LINE could have been drawn with any shape or number of points too. This feature provides great flexibility in following surface contours of models and gives ChromaCAD its free-form sculptured-surface capability.

Practice constructing panel triangles. Do the three exercises below. Be sure to observe your panels in the SPACE SCREEN as you construct them. Use 3-D MENU #1 to view your work in the SPACE SCREEN when referring to Illustrations 15 through 17. Use any of the other 3-D MENUS, as desired, to view your work from different angles, distances, etc.. *

As you are constructing the triangles, view the construction in the SPACE SCREEN whenever desired. Change the PAINT NUMBER and SHADING TINT values for any triangle if you wish. When you view the panel In the SPACE SCREEN, trace the triangles back with the 'T' (Trace) key to confirm your construction and to confirm that your PAINT NUMBER and SHADING TINT numbers were registered as you intended.

Learning how to construct 3-D PANELS Is probably the most Important skill covered In this manual. Refer to the Illustrations but try to do the three exercises without reading the solutions. If you have problems, consult the solutions (Immediately following). When you are finished, be sure to read the solutions and commentary.

NOTE: When constructing 3-D PANELS, a good habit to develop is to always construct a"." (Plot) triangle immediately after moving the cursor to the next HIGH LINE location. In other words, wait until you're ready to make a new"." (Plot) triangle before moving the cursor to the next location and then construct the triangle immediately after the move.

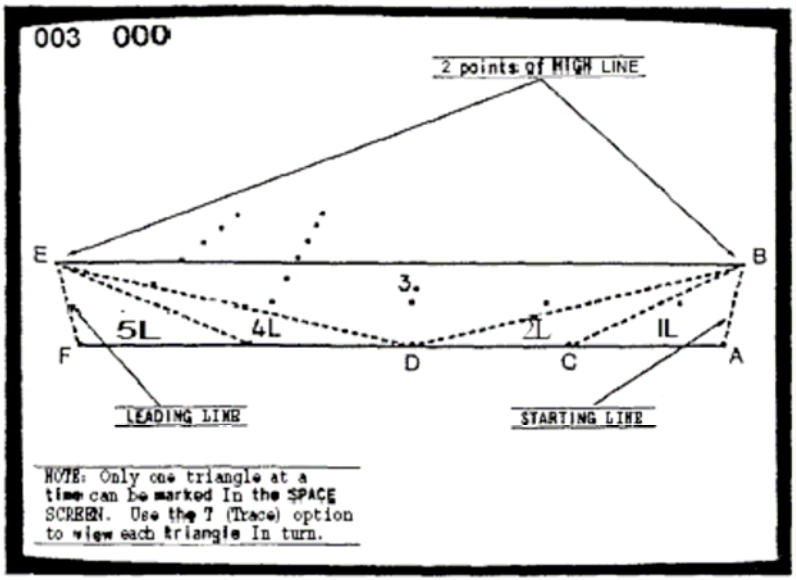


fig. 15 (SPACE SCREEN)

Exercise #1

Go to the MAIN MENU and select CONSTRUCT 3-D PANEL. Load "18" in Z OF THIS LINE; then go to the graph. Construct the bottom wall (only the labeled triangles In fig. 15) of the lateral panel by plotting only two points on the HIGH LINE (see fig. 15). (NOTE: Pt. A of fig. 15 Is located at X = 120, Y = *-40* and pt. F is located at X = 0, Y = *-40.)* Construct the wall so that It's vertical.

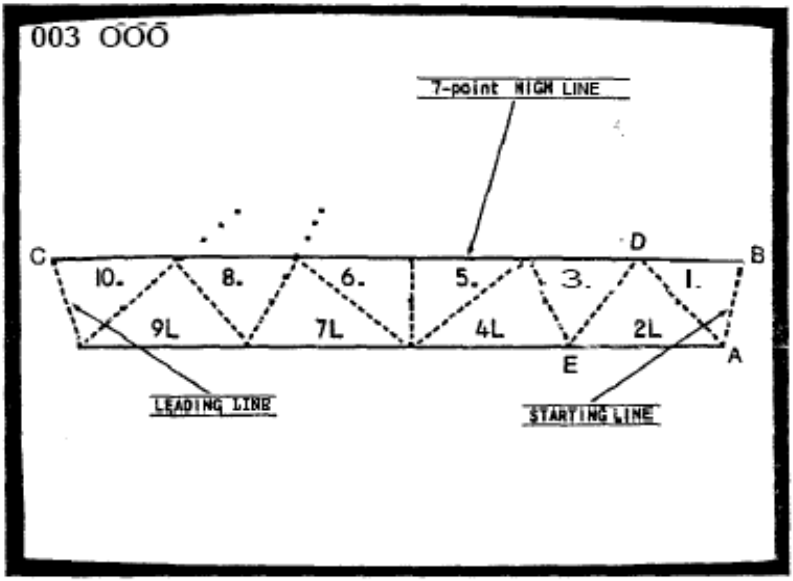


fig. 16 (SPACE SCREEN)

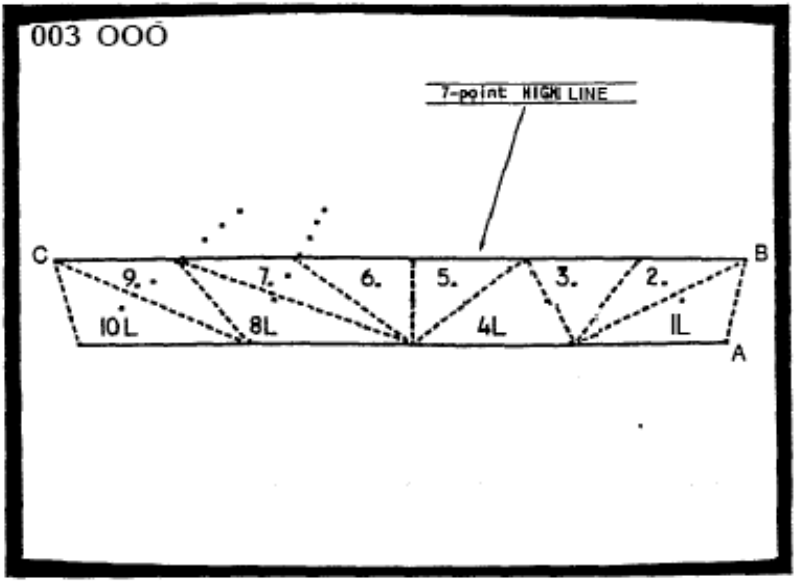


fig. 17 (SPACE SCREEN)

Exercise #2

Go to the MAIN MENU and select CONSTRUCT 3-D PANEL. Load "18" In Z OF THIS LINE; then go to the graph. Construct a vertical bottom wall of the "L" by plotting 7 points on the HIGH LINE (see figs. 16 and 17). (HINT: Place the cursor over the first point of the LOW LINE (X = 120, Y = -40) and form a panel STARTING LINE. Use the DRAW MENU to set up a 7- point line (add 6 points) to pt. C (X = 0, Y = -40) of fig. 16. Return to the graph and use the "A" (Advance) key to advance the cursor while constructing the wall.)

Exercise #3

Go to the MAIN MENU and select CONSTRUCT 3-D PANEL. Load "18" in Z OF THIS LINE; then go to the graph. Use the joystick to construct the bottom wall of the "L" In such a way that the HIGH LINE Is "S" shaped (see fig. 18).

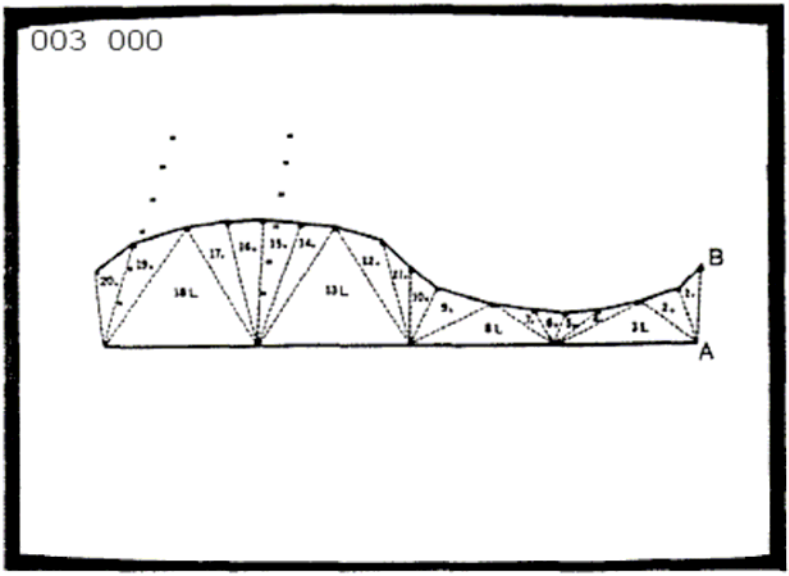


fig.18 (SPACE SCREEN) I

Solution, exercise #1

Refer to fig. 15 while observing the following steps:

1. Select CONSTRUCT 3-D PANEL from the MAIN MENU. Load "18" In Z OF THIS LINE. Go to the graph. Use the "X" (X OF CURSOR) key to send the cursor to X = 120, Y r *-40* (pt. B) and then form a panel STARTING LINE by typing the "." (Plot; key.

The"." Plot key plotted a point and formed a STARTING LINE by connecting the first point of the LOW LINE (pt. A) with the first point of the HIGH LINE (pt. B).

2. Type the "L" (LOW LINE) key once to construct the first triangle of the panel (triangle 1L of fig. 15).

The "L" (LOW LINE) key constructed a new triangle by using the LEADING LINE - (in this case, the LEADING LINE of the pane! Was also the STARTING LINE because no panel triangles have been constructed yet) - and the next unused LOW LINE point (pt. C). After this step, the LEADING LINE of the panel is the line that connects pt. C with pt. B.

3. Type the "L" (LOW LINE) key once again to construct the second triangle of the panel (triangle 2L of fig. 15).

After this step, the LEADING LINE is the line that connects pt. D with pt. B.

4. Use the "X" (X OF CURSOR) key to send the cursor to X = 0, Y = *-40* (pt. E). Type the "." (Plot) key once to plot the second HIGH LINE point (pt. E) and construct triangle 3..

The"." (Plot) key plotted a new HIGH LINE point (pt. E) and then constructed a triangle (triangle 3.) by using the current LEADING LINE (line DB) and the new HIGH LINE point (pt. E). After this step, the LEADING LINE is the line that connects pt. D with pt. E.

5. Type the "L" (LOW LINE) key twice to construct triangles 4L and 5L thereby completing the bottom wall portion of the lateral panel. Trace the triangles back in the SPACE SCREEN to confirm proper construction.

After this step, the LEADING LINE of the panel is the line that connects pt. F with pt. E.

Solution, Exercise #2

Refer to fig. 16 while observing the following steps:

1. Select CONSTRUCT 3-D PANEL from the MAIN MENU. Load "18" In Z OF THIS LINE. Go to the graph. Use the "X" (X OF CURSOR) key to send the cursor to X = 120, Y = *-40* (pt. B) and then form a panel STARTING LINE by typing the "." (Plot) key.

2. Type the "D" (Draw) key. Load "6" In NO. OF POINTS, "0" in X DRAW, *"-40"* In Y DRAW and "1" In LINE(1)CURVE{0). Do not change the other registers. Return to the graph.

3. Use the "A" (Advance/Draw) key to Jump the cursor to the first point of the straight line (pt. D); then type the "." (Plot) key to plot pt. D and construct triangle 1..

After this step, the LEADING LINE is the line that connects pt. A with pt. D.

4. Type the "L" (LOW LINE) key to construct triangle 2L.

After this step, the LEADING LINE is the line that connects pt. E with pt. D.

5. Construct the remainder of the bottom wall by using the "." (Plot) and "L" (LOW LINE) keys. Use the "A" (Advance/Draw) key to Jump the cursor to each new HIGH LINE point on the straight line prior to each use of the "." (Plot) key. Follow fig. 16 closely as you are constructing the wall. Notice that, In this case, the illustration calls for two "." (Plot) triangles to be constructed In succession near the center of the wall. When finished, trace the triangles back In the SPACE SCREEN.

The exact shape of triangles used to fill the wall isn't important. Fig. 17, for example, suggests another, equally valid combination.

One exception to the above statement would occur it you wanted to place a design on the wall. In fig. 15, for example, if triangles 1L, 2L, 4L and 5L were all assigned the same PAINT NUMBER value and triangle 3. was assigned a different PAINT NUMBER value, the bottom wall of the 'L', when displayed by the SURFACE SHADER XE, would be displayed with a V-shaped pattern on it. When putting designs on a surface, it's necessary to carefully select the location

of LOW LINE and HIGH LINE points to produce the desired pattern.

You can place complicated patterns, such as letters and numbers, on model surfaces by continuing the pattern across numerous panels. For example, in fig. 22, the bottom wall of the "L" is formed using 3 panels, each 6 units high, rather than using one 18-unit high panel. Since each triangle of each panel can be painted with any paint number, a desired pattern could be placed on the bottom wall by selectively assigning different paint numbers and/or shading tints to the triangles *as* they are being constructed and by purposely choosing HIGH LINE and LOW LINE point locations that produce the desired pattern.

Unless you are placing a special pattern on a 3-D PANEL, you should try to keep the LEADING LINE as reasonably short as practical. In other words, as the panel is being constructed, don't let HIGH LINE points run way out ahead of LOW LINE points or LOW LINE points run way out ahead of HIGH LINE points. Keep the end points of the LEADING LINE up with each other as much as possible as the LEADING LINE moves around the model.

Solution, Exercise #3

Refer to fig. 18 and follow the steps below:

1. Select CONSTRUCT 3-D PANEL from the MAIN MENU. Load "18" In Z OF THIS LINE. Go to the graph. Use the Joystick to position the cursor to a desired HIGH LINE location to start the "S"-shaped HIGH LINE (e.g., pt. B) and then Initiate a STARTING LINE with the "." (Plot) key.

2. Use the "." (Plot) or "L" (LOW LINE) key to construct each triangle of the panel. Use the Joystick to position the cursor each time prior to constructing a triangle with the "." (Plot) key. Fig. 18 shows a SPACE SCREEN display of one possible construction.

The above three exercises all used a LOW LINE composed of points plotted in a straight line. It would be possible, of course, to have a curved LOW LINE. Fig. 19 shows one possible construction, where a curved LOW LINE is connected to a straight HIGH LINE. It's also possible to connect a curved LOW LINE of any shape to a curved HIGH LINE of any shape. In fact, using V (Plot) triangles and "L- (LOW LINE) triangles, any shaped HIGH LINE of any

number of points can be connected to any shaped LOW LINE of any number of points.

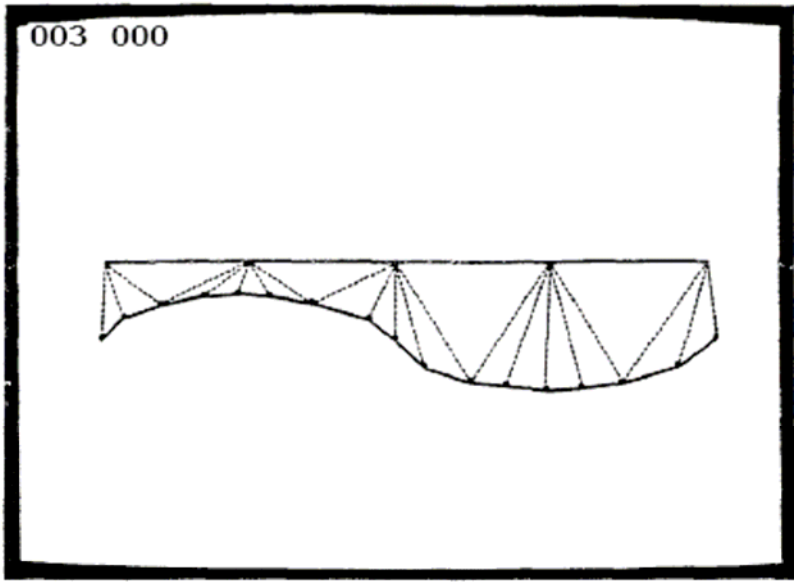


fig. 19 (SPACE SCREEN)

Often when constructing 3-D PANELS a"." (Plot) triangle is immediately followed by an "L" (LOW LINE) triangle. This happens quite often. A tool, Therefore, was designed to combine the two functions.

"R" (Rectangle) Key (HIGH LINE GRAPH Mode): Combining the"." (Plot) and "L" (LOW LINE) Keys

By now, you know how the"." (Plot) and "L" (LOW LINE) keys work to construct panel triangles. Typing the "R" (Rectangle) key is exactly like typing the"." (Plot) key and then immediately typing the "L" (LOW LINE) key.

In other words, if you know you want to form a Wangle with "." (Plot) key and then immediately form another triangle of the same PAINT NUMBER and SHADING TINT with the "L" (LOW LINE) key, you can simply type the "R" (Rectangle) key instead. (The two triangles constructed do not actually produce a rectangle. The word "rectangle" was chosen merely as an easy way to remember the "R" key).

Erase any HIGH LINE points or triangles you have constructed and then, after moving the cursor to X = 120, Y = *-40* and forming a STARTING LINE with the "." (Plot) key, use the Joystick to move the cursor directly above each successive LOW LINE point location and construct a vertical bottom wall of the "L" by using the "R" (Rectangle) key after each cursor move. Trace back the triangles In the SPACE SCREEN to confirm their construction as predicted.

As you may have experienced in the above exercise, using the joystick to place the cursor directly above a line of LOW LINE points in order to construct a vertical panel is not always easy.

Many times, when constructing 3-D models, you will want truly vertical panels. The easiest way to achieve this is to plot the points of the HIGH LINE directly above the points of the LOW LINE. This means that the HIGH LINE paints will have the same X,Y coordinates as the LOW LINE points but not the same Z coordinates. A tool has been provided to make positioning the cursor directly above LOW LINE points an easy task.

The" >" (Advance/LOW LINE) and the" <" (Back/LOW LINE) Keys (HIGH LINE GRAPH Mode): Positioning the Cursor Directly over LOW LINE Points

Go to the MAIN MENU. Select CONSTRUCT 3-D PANEL. Load "18" In Z OF THIS LINE and then go to the graph. Type the " > " (Advance/LOW LINE) key on the top row of the keyboard.

You will see the cursor jump to a point directly above the first point of the LOW LINE. The X, Y coordinates of the cursor are now the same as the X,Y coordinates of the first point of the LOW LINE. The Z coordinate of the cursor is, of course, 18 units higher than the Z coordinate of the first point of the LOW LINE.

Continue typing the " > " (Advance/LOW LINE) key until the cursor can go no further and you hear a "beep".

You will notice that the cursor has jumped successively to each point directly above each point on the LOW LINE and is now directly above the last point of the LOW LINE.

Now bring the cursor back above the first point of the LOW LINE by typing the " < " (Back/LOW LINE) key (on the top row) until you hear a "beep".

The cursor will now be positioned directly above the first point of the LOW LINE again. The " > " (Advance/LOW LINE) key repositions the cursor to a location directly over the next point on the LOW LINE and the" <" (Back/LOW LINE) key repositions the cursor to a location directly over the previous point of the LOW LINE. The direction the arrow is printed on the keys has nothing to do with the direction the cursor will jump on the screen.

The' >' (Advance/LOW LINE) and the" <" (Back/LOW LINE) keys are used on the HIGH LINE GRAPH to position the cursor directly above points on the LOW LINE. These keys do not plot points. They're only used to move the cursor prior to plotting. Often, during the construction of 3-D models, HIGH LINE points will be plotted directly above LOW LINE points. The" >" (Advance/LOW LINE) and the" <" (Back/LOW LINE) keys make this an easy maneuver.

Follow the steps below to construct a vertical bottom wall of the "L".

1. With the cursor positioned over the first point of the LOW LINE, form a STARTING LINE by typing the "." (Plot) key.

2. Type the " > " (Advance/LOW LINE) key to Jump the cursor over the second point of the LOW LINE and then type the "R" (Rectangle) key to construct the first two triangles of the panel.

3. Continue typing the " *>* " (Advance/LOW LINE) key followed by the "R" (Rectangle) key until the bottom wall of the "L" is finished.

4. Trace back the triangles In the SPACE SCREEN to confirm correct construction.

As you can see from the above exercise, it's much easier to use the " >" (Advance/LOW LINE) and" <" (Back/LOW LINE) keys to place the cursor over LOW LINE points than to try to use the joystick for that purpose. Nevertheless, the job of constructing truly vertical panels can still be automated even further.

"F" (Follow) Key (HIGH LINE GRAPH Mode): Jumping the Cursor over the Next Unused LOW LINE Point and Forming Two Triangles

If you want to first jump the cursor directly over the next LOW LINE point that has not yet been used to construct a triangle and then to

type the "R" (Rectangle) key, you can combine both functions in one operation by simply typing the "F" (Follow) key. The "F" (Follow) key is used if you want truly vertical panels that follow the LOW LINE exactly. If no point has yet been plotted, the "F" (Follow) key will jump the cursor to a point directly over the first point of the LOW LINE and then plot a point and form a STARTING LINE.

Follow the instructions below to construct the bottom wall of the "L" using only the "F" (Follow) key:

Go to the MAIN MENU and select CONSTRUCT 3-0 PANEL. Load "18" In Z OF THIS LINE and then go to the graph. Construct the bottom wall of the "L" by simply typing the "F" (Follow) key (or holding It down) until the wall Is complete. View the wall In the SPACE SCREEN to confirm the construction.

By now you know enough about the theory of 3-D PANEL construction to complete the block letter "L" model.

Constructing the First Lateral Panel of the'L" Model

The block letter "L" is a simple model. There are only two panels required - the panel making up the lateral sides of the letter and the panel making up the top surface. The lateral sides of the "L" are no more than extensions upward of the BASE LINE. Any number of panels could be used to construct the lateral sides of the letter (see figs. 20,21 and 22).

For simple upward extended sides like the "L", only one panel is necessary (fig. 20). In fig. 20, one panel with a height of 18 units was used for the lateral sides. In fig. 21, two panels, each with a height of 9 units were used. In fig. 22, three panels, each with a height of 6 units were used. Each of these constructions will produce the same shape model.

The advantages in using fewer panels and fewer triangles per panel are that less memory is required to store the model and less time is required for the computer to plot and display the model. On the other hand, there are also several advantages in using many panels and many triangles per panel: (1) Since each triangle of a panel can be "painted" individually (using the PAINT NUMBER and SHADING TINT registers), designs, patterns, letters, etc. can be applied to the surface of models by painting and shading the triangles selectively.

The more panels and triangles, the better the quality of the design. And, (2) the shapes of true 3-D sculptured surfaces are better described with many panels and many triangles.

A sophisticated model, such as a human face, for example, would require at least 50 panels with hundreds of triangles per panel to adequately reproduce all the complex surface contours that make up a human face.

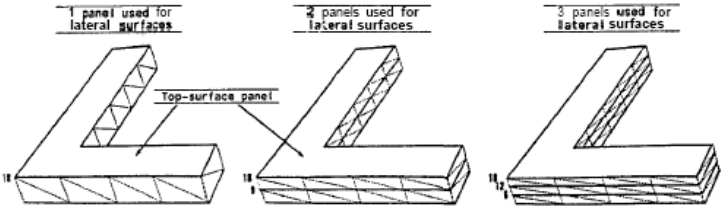


fig. 20 *fig. 21* *fig. 22*

All ChromaCAD models are constructed the same way. The model is constructed from the bottom up using 3-D PANELS in a layered fashion until the model is closed at the top.

We will construct our "L" using 3 lateral panels and one top-surface panel - 4 panels total (as in fig. 22). We'll assign all of the triangles of a panel the same PAINT NUMBER but change the PAINT NUMBER for each panel. The result will be a three-layered "L" model that will display 4 of the colors that can be displayed by the SURFACE SHADER XE. Each lateral panel will be 6 units high, making the overall height of the letter 18 units.

1. Go to the MAIN MENU. Select CONSTRUCT 3-D PANEL. Load "6" Into Z OF THIS LINE. Store "4" In PAINT NUMBER. Leave "0" In SHADING TINT. Go to the graph. Construct the panel by simply holding down the "F" (Follow) key until a you hear a "beep". /

This constructs a 6-unit high lateral panel, with all triangles assigned a PAINT NUMBER of "4" and a SHADING TINT of "0" around the perimeter of the L". Now you should understand the reason for plotting the last point of the BASE LINE directly on the

first point of the BASE LINE. This ensures that the final position of the LEADING LINE of the finished panel can align with the STARTING LINE of the panel. In other words, the panel can describe a closed band around the model.

2. To confirm the construction and to ensure that all triangles were formed with "4" In PAINT NUMBER and "0" In SHADING TINT, type "1" to view the panel In the SPACE SCREEN and then use the "T" (Trace) key to trace the triangles back In the SPACE SCREEN.

This should always be the last check before saving a panel to disk, All panels should be traced back in the SPACE SCREEN to confirm that PAINT NUMBER and SHADING TINT assignments are correct and to confirm closure of the panel if closure is called for.

3. Go to the MAIN MENU and save the panel to disk with the STORE LINE TO DISK option.

The screen will go blank and you will hear a slight ticking sound as the program formats the panel for saving to disk. After a few seconds (this varies with the number of triangles in the panel), the disk drive will activate and the panel will be stored to the disk.

Notice that the panel required only 2 sectors of disk storage. With 28 sectors available per HIGH LINE, 3-D PANELS of more than 600 triangles are possible. The sample models constructed here are quite modest compared to the capabilities of the program. (Theoretically, if one large 150-panel model were constructed and each panel contained 600 triangles, the model would have approximately 90,000 individually colored and orientated faces and require a disk drive with almost 540K bytes of disk storage.)

CHECKPOINT: LINES USED = 2, DISK SECTORS USED = 16

Constructing the 2nd and 3rd Lateral Panels of the "L" Model

1. Select the CONSTRUCT 3-D PANEL option to construct the second lateral panel.

Notice that both 2 OF THIS LINE and Z OF LAST LINE now read "6". This, of course, refers to the elevation of the HIGH LINE of the panel that was just stored.

2. Store "12" In the Z OF THIS LINE register.

This panel will be constructed on top of the previous panel – the HIGH LINE of the previous panel will be the LOW LINE of this panel. The previous panel was 6 units high. This panel will also be 6 units high. Therefore the height ("Z") of the HIGH LINE of this panel will be 12.

3. Store "3" In PAINT NUMBER. Leave "0" In SHADING TINT. Go to the graph and construct the panel by holding down the "F" (Follow) key until the panel Is closed. View the panel In the SPACE SCREEN.

Notice that even though the LOW LINE of this panel is 6 units higher than the LOW LINE of the previous panel, it is displayed at the same elevation in the SPACE SCREEN.

NOTE: When individual panels are displayed in the SPACE SCREEN they are always displayed at 0 elevation. For example, if the LOW LINE of a panel has an actual elevation of 100 and the HIGH LINE has an actual elevation of 130, the panel will be displayed as if the LOW LINE was set at "0' and the HIGH LINE at "30". This keeps the 3-D PANEL centered in the SPACE SCREEN. (Without this feature, in the example above, it would be necessary to load *"-W0"In* the Z OFFSET register of the corresponding 3-D MENU to drop the panel down for convenient viewing in the SPACE SCREEN.) Of course, when the entire model is viewed (all the lines at once), this feature is excluded.

4. Go to the MAIN MENU and store the panel to disk using the STORE LINE TO DISK option.

CHECKPOINT: LINES USED = 3, DISK SECTORS USED = 18

The next step is to construct the third and last lateral panel.

5. Select CONSTRUCT 3-D PANEL. Load "18" In Z OF THIS LINE and "2" In PAINT NUMBER. Leave "0" In SHADING TINT. Construct the panel with the "F" (Follow) key In the same manner as the previous two panels and save It to disk.

CHECKPOINT: LINES USED = 4, DISK SECTORS USED = 20

You have now constructed the 3 lateral panels of the block letter "L",

using different PAINT NUMBERS for each panel. The next step is to construct the top-surface panel (see figs. 20 and 21).

Constructing the Top-Surface Panel of the "L" Model

1. Choose the CONSTRUCT 3-D PANEL option. Leave "18" In Z OF THIS LINE. Store "1" In PAINT NUMBER. Leave "0" In SHADING TINT.

Notice that Z OF LAST LINE now reads "18". This refers to the elevation of the HIGH LINE of the last lateral panel stored to disk and the LOW LiNE-of the panel under construction. Both the HIGH LINE and the LOW LINE of the top-surface panel will have the same elevation of 18.

2. Go to the Graph. Type the " > " (Advance/LOW LINE) key until the cursor lies over the second-to-last point of the LOW LINE (see pt. ©, fig. 23). (In the illustration, numbers marking LOW LINE points are circled. Numbers marking HIGH LINE points are not circled.) Type the "." (Plot) key to plot the first point (pt. 1, fig. 23) and to form the STARTING LINE of the panel

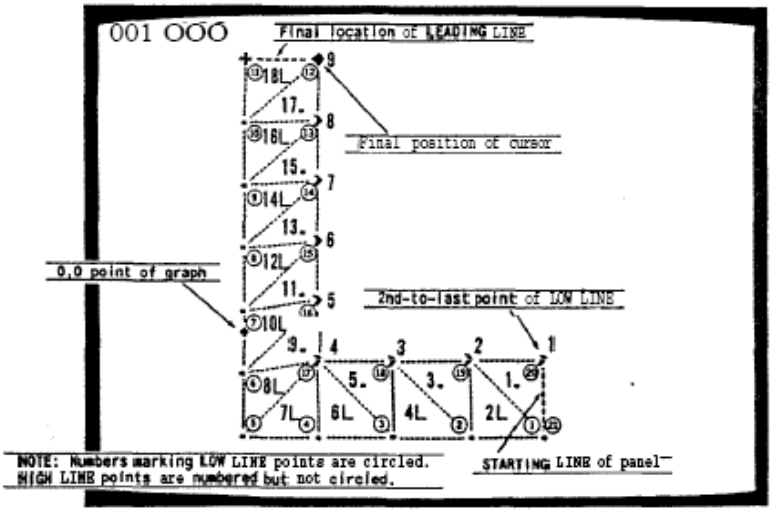


fig. 23 (HIGH LINE GRAPH)

Notice that pt. 1 of the HIGH LINE falls directly on pt. (20) of the LOW LINE and that, this time, the entire STARTING LINE lies on a plane that is 18 units high and parallel to the X,Y plane of the BASE LINE GRAPH.

3. Type "1" to view the STARTING LINE in the SPACE SCREEN.

4. Return to the graph and type the " < " (Back/LOW LINE) key once to jump the cursor back one point so It Is over the previous point of the LOW LINE (pt. (19), fig. 23). Type the "R" (Rectangle) key to form the first two triangles of the panel (triangles 1. and 2L of fig. 23). View the construction in the SPACE SCREEN.

5. Return to the graph and continue using the " < " (Back/LOW LINE) key to jump the cursor back while constructing the triangles of the top-surface panel. Use fig. 23 as a guide. Use the "R" (Rectangle) key to construct triangles 3. to 6L. Use the "L" (LOW LINE) key to construct triangles 7L and 8L. Use the " < " (Back/LOW LINE) and "R" (Rectangle) keys for triangles 9. to 18L. Stop when the top surface of the letter Is completely covered with triangles. (See "final location of LEADING LINE" and "final position of cursor" captions, fig. 23.)

As you see, in this case, when the panel is finished, the LEADING LINE does not coincide with the STARTING LINE. This panel is not closed.

6. Trace the panel back In the SPACE SCREEN to confirm proper construction

7. Store the panel to disk.

CHECKPOINT: LINES USED = 5, DISK SECTORS USED = 21

The block letter "L" is now finished. The "L" model was constructed using 5 lines -- the BASE LINE and the HIGH LINES of the four 3-D PANELS. For simplicity, we used the *"F"* (Follow) key to construct the 3 lateral panels. All the lateral contour lines, therefore, have the same shape as the BASE LINE. This produces a simple "extruded"-type block letter. This type of construction does not take full advantage of ChromaCAD's sculptured-surface capability. Most of the time, you'll want to construct models with more personality

than simple extruded shapes.

For example, we could have constructed the "L" using the same BASE LINE but using the joystick to construct the HIGH LINE of the first lateral panel so that it "bulged out" by a small amount (see fig. 24). The shape of the HIGH LINE of the second lateral panel could have continued this "bulging" effect and the shape of the HIGH LINE of the third lateral panel could have changed back to the shape of the BASE LINE so that the model, when completed, would have a bulged-out, inflated appearance.

Of course, thousands of such variations are possible. The model could have been constructed with concave sides for the opposite effect, or one side concave and the other convex for a "wind-blown" effect. The more panels you use, the more accurately you can describe contoured surfaces. Most ChromaCAD models are constructed with a great many lateral panels, each plotted with the unique shape that conforms to the contours of the model at that particular elevation.

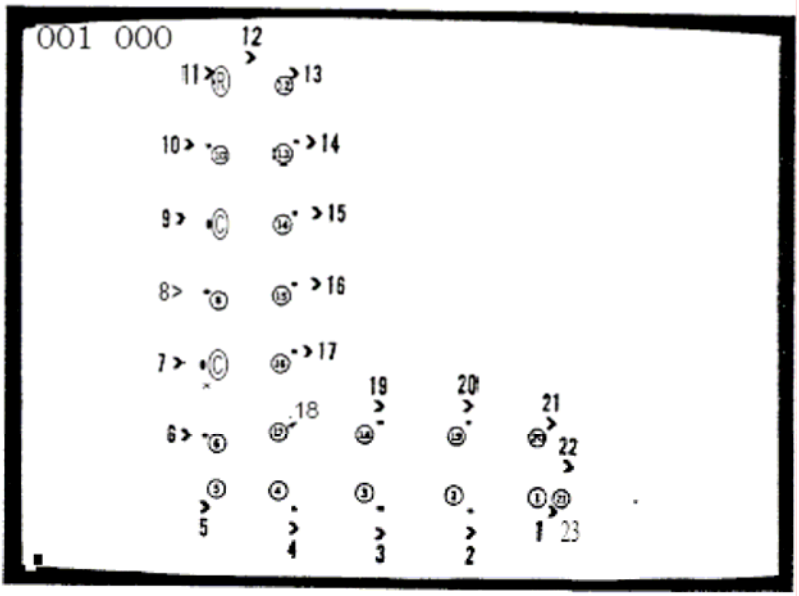


fig. 24 (HIGH LINE GRAPH)

"V" (View) Key (EDIT 3-D MENUS Mode): Orientating, Positioning and Sizing Models Quickly in the SPACE SCREEN

You have already used the Q (Quick) key to display the "L" test pattern. You can also use the contour-line display mode of the MODEL BUILDER program to display entire models in the SPACE SCREEN. This method of display is much faster than the 3-D fill routines of the SURFACE SHADER XE.

The orientation registers are used the same way in both the MODEL BUILDER and SURFACE SHADER XE programs. You can, therefore, use the MODEL BUILDER program to place and orientate models in the SPACE SCREEN and then save the 3-D MENU values to the model disk with the STORE 3-D MENUS TO DISK option of the MODEL BUILDER program. Later, when the model disk is booted by the SURFACE SHADER XE program, these registers will already be filled with the values desired to place and orientate the model on the screen. First, it's necessary to know how to display an entire model in the SPACE SCREEN.

LIST MODEL BASE LINES Option (MAIN MENU): Listing BASE LINE Numbers

Select LIST MODEL BASE LINES from the MAIN MENU.

You will see two numbers printed in the upper left-hand corner. The first number is the line number of the BASE LINE of the first model stored on the disk. This model is, of course, the letter "L" and the line number of the BASE LINE of the "L" is "1". The second number lists the number of disk sectors used by that model. Later, when other models are stored on the same disk and this option is selected, the BASE LINE number and the number of sectors used will be displayed for each model stored.

The LIST MODEL BASE LINES option lists the BASE LINE number of every BASE LINE that is stored on the disk. No two models stored on the same disk can ever have the same BASE LINE number. Therefore, the BASE LINE number of a model is used to reference the model.

MODEL BASE LINE Register (3-D MENUS): Listing a Model for Display

Return to the MAIN MENU and choose the EDIT 3-D MENUS option. Drop the cursor down two spaces to the MODEL BASE LINE register on 3-D MENU #1.

Only one model has been saved to disk ~ the model of the letter "L". The BASE LINE number of this model is "1". The MODEL BASE LINE register will, therefore, at this point only accept two values -- "1" and "0" "1" is the only line number of a BASE LINE of a model so far stored on disk and "0" will always be accepted.

Later, when other models are saved on the same disk, this register will accept the BASE LINE number of any model that is stored on the disk. A model is composed of a BASE LINE and at least one 3- D PANEL. The MODEL BASE LINE register, therefore, will not accept a BASE LINE number unless at least one 3-D PANEL has been constructed on the BASE LINE.

Try to input a few different values in MODEL BASE LINE. Notice that only "0" or "1" are accepted. Store "1" In the MODEL BASE LINE register of 3-D MENU #1.

While viewing 3-D MENU #1, type "V" (View) to display the model.

The disk drive will activate and the model will be loaded and drawn in contour-line form according to the values currently loaded into the orientation registers of 3-D MENU #1.

"DELETE" Key (SPACE SCREEN Mode): Stopping the Display

Return to 3-D MENU #1. Type "V" (View) again. This time, however, hold down the "DELETE" key as the model Is being drawn.

The program will finish the contour line that is being drawn and then stop. The purpose of the "DELETE" key is to save time. It's usually not necessary to draw an entire model for the purpose of orientating, positioning, or sizing it on the screen. Usually, only the first few lines of the model are needed.

NOTE: The MODEL BUILDER will not draw a line if, from the current point-of-view, one of the end points of the line falls outside of a 90-degree angle-of-view. If a portion of a model contour line near the outside edge of the SPACE SCREEN is not drawn, move the current point-of-view back by using a larger value in DISTANCE. (If you want to maintain the same image size, decrease the value in ANGLE OF VIEW at the same time.)

Orientation Registers (3-D MENUS): Orientating, Positioning and Sizing a Model in the SPACE SCREEN

The following 3 steps can be used to orientate, position and size a model in the SPACE SCREEN.

1. Load the PITCH, YAW and ROLL angle registers of a 3-D MENU with estimated values to obtain the desired viewing angle.

2. Use the OFFSET registers and the "Q" (Quick) key to position the corner of the "L" test pattern to a desired screen location. (This procedure was covered in Section 2.)

3. Load the MODEL BASE LINE register of the 3-D MENU with the model's BASE LINE number and use the OFFSET registers, together with the DISTANCE register to size the model. (This procedure was covered in Section 2 to size the test pattern. The same procedure is used to size a model.)

Place the "L" model at some desired screen location and then re-size the model while keeping it at the same location. Use the "DELETE" key for speed whenever possible. Practice until you can quickly move and size the model In the SPACE SCREEN.

"CONTROL V Key-combination (3-D MENUS) and the MENU DISPLAY ORDER Registers (3-D MENUS): Displaying Multiple Views of Models on One Screen

The "CONTROL V" key-combination functions to display multiple views of models on one screen in a similar manner as the "Control Q* key-combination displayed multiple views of the test pattern. If you hold down the "DELETE" key as the models are being drawn, only the first line of each drawing will be displayed. This saves time when setting up multiple-model displays.

Always make sure a model base line number is loaded in any 3-D MENU called for display by the "CONTROL V" key-combination. It's a good idea to always make this a two-step process: first, check to make sure the desired model base line number is loaded in the MODEL BASE LINE register and only then load the menu display order number in the MENU DISPLAY ORDER register.

NOTE: The ANGLE OF VIEW value loaded in 3-D MENU #0 is

used for all 3-D MENUS called by the "CONTROL V" key combination. ANGLE OF VIEW values loaded in 3-D MENUS other than 3-D MENU #0 are ignored.

Set up an "LLL" multiple-model display using the "L" model as you did previously with the test pattern. Use the "DELETE" key to speed the positioning process. Change the size of the model group by changing the value In the ANGLE OF VIEW register of 3-D MENU #0.

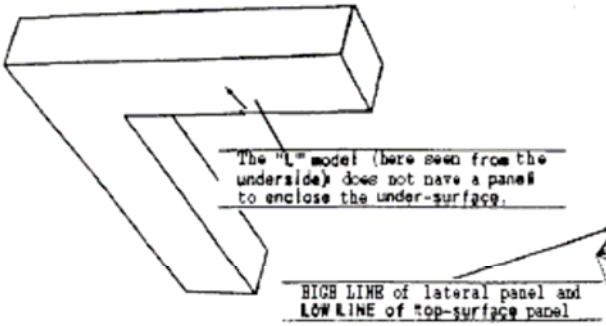

The "L" model (here seen from the underside) does not have a panel to enclose the under-surface.
HIGH LINE of lateral panel and LOW LINE of top-surface panel

fig. 25

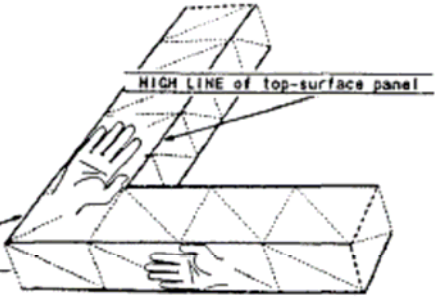

HIGH LINE of top-surface panel

fig. 26

SECTION 5 - UNDER-SURFACE PANEL, "L" MODEL

The 3 lateral 3-D PANELS and the top-surface 3-D PANEL of the "L" model were constructed so that the outside-facing sides of the triangles of the panels are visible to the SURFACE SHADER XE program. If, for some reason, you tried to use the SURFACE SHADER XE program to display any of the inside-facing surfaces of the panels, these surfaces would not be displayed because the sides of the triangles facing toward the inside of the model are normally invisible to the SURFACE SHADER XE.

The model of the letter "L" has no underside surface (see fig. *25).* If, for example, you tried to view the "L" from the underside (PITCH ANGLE of more than 90 degrees) with the SURFACE SHADER XE, you would be attempting to view the inside-facing surfaces of the panels and they would not be displayed. (When you want to display a model from the inside, the SURFACE SHADER XE program has a "switch" which makes the inside-facing surfaces visible and the outside-facing surfaces invisible.)

RIGHT HAND RULE: Determining Which Side of a 3-D PANEL is the Visible Side

It's important, when constructing 3-D PANELS, to be able to test the panels as they are being constructed to make sure that the desired side is the visible side. For this purpose, the RIGHT HAND RULE has been devised:

Imagine that the little finger of your right hand is placed on the LOW LINE of the 3-D PANEL and that your fingers are aimed in the direction of construction of the panel. Imagine, also, that your thumb is placed on the HIGH LINE of the panel (see fig. 26). The palm of your hand will face the same direction as the visible side of the panel.

Look at fig. 26. This is the same as fig. 20, but a "right hand" has been drawn on both the lateral and top-surface panels of the model in accordance with the above rule. Notice that the palms face outward, thereby confirming that the visible sides of the panel are the sides that face out.

This rule is easy to remember if you just remember that the little finger is placed on the LOW LINE. The RIGHT HAND RULE should be mentally applied each time you start construction of a panel or draw a BASE LINE. Remember, the direction of the BASE LINE will determine the direction of construction of the first panel.

When you constructed a model of the letter "L", you did not construct the underside surface. All surfaces of models should be completely covered before the model can be considered complete. This ensures that the model can be viewed from any location in space. Of course, there would seldom ever be a need to view a block letter from the underside. Constructing an under-surface panel will, however, introduce an important new technique and should be accomplished.

It's not possible to go back and insert another 3-D PANEL within a completed model without erasing and reconstructing higher panels. In the case of the "L" model, all of the panels (the three lateral panels and the top-surface panel) are higher than the under-surface panel. In this case, if s easier, therefore, simply to begin another "L* model with an under-surface panel. This will demonstrate how the previous model could have been constructed with an under-surface panel.

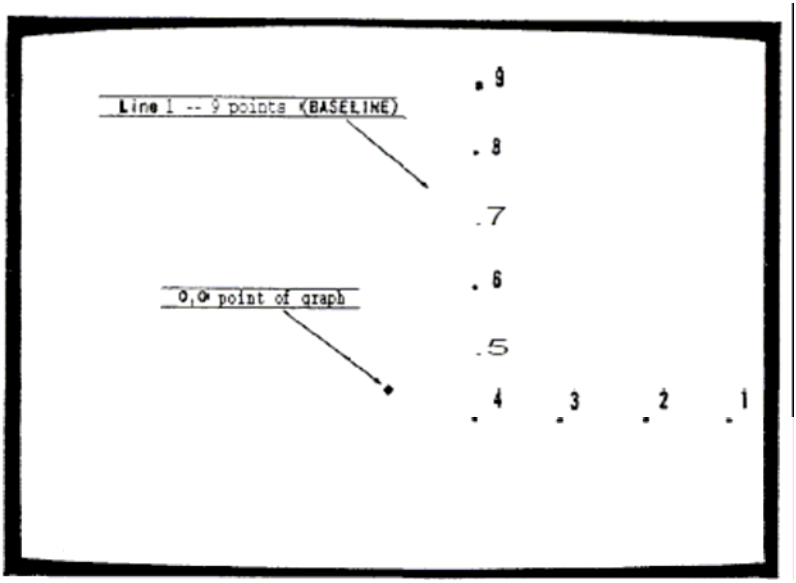


fig. 27 (BASE LINE GRAPH)

Drawing the BASE LINE ("L" Model with Under-surface Panel)

Make sure the model disk with the "L" model Is Inserted In the disk drive. Select PLOT BASE LINE from the MAIN MENU.

Follow the procedure below to plot the BASE LINE. Refer to fig. 27.
1. Plot one point at X = 120, Y = -H?(pt. 1).
2. Use the "D" (Draw) key to help plot a 4-point (add 3 points) straight line to X = 30, Y = *-10* (pt. 4).
3. Use the "D" (Draw) key to help plot a 6-point straight line to X = 30, Y = 110 (pt 9). (Point 4 Is shared by both lines.)
You should now have an "L"-shaped BASE LINE consisting of 4 points on the horizontal stem and 6 points on the vertical stem (fig. 27).
4. Save this BASE LINE to disk.
CHECKPOINT: LINES USED = 6, DISK SECTORS USED = 22

Constructing the Under-surface Panel ("L" Model with Under-surface Panel)

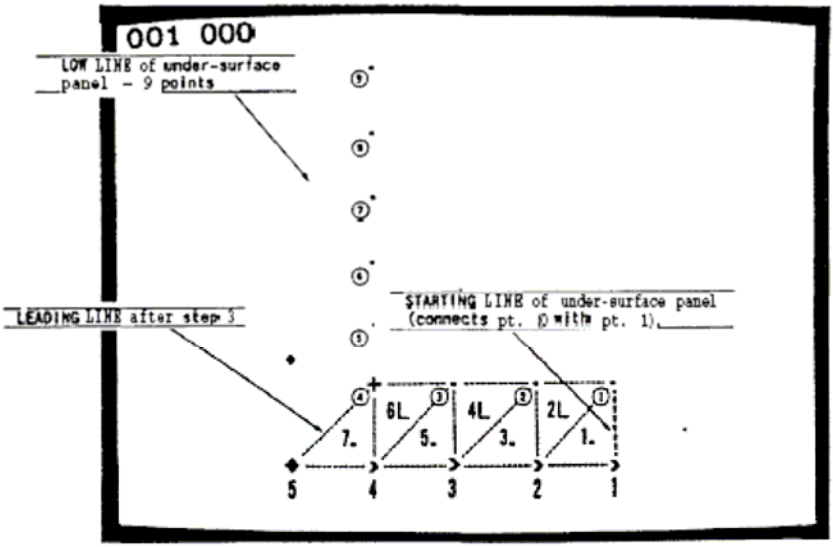


fig. 28 (HIGH LINE GRAPH)

Refer to figs. 28 through 32. while constructing the undersurface panel (Remember, numbers marking LOW LINE points are circled. Numbers marking HIGH LINE points are not circled.)

Follow the procedure below:

1. Select the CONSTRUCT 3-D PANEL option. Leave "0" In Z OF THIS LINE. Do not change the values In the PAINT NUMBER and SHADING TINT registers. Go to the graph.

The under-surface panel will lie entirely on the BASE LINE GRAPH (always at 0 elevation). Therefore, the HIGH LINE elevation of this panel (the value stored in Z OF THIS LINE) must be "0".

2. Use the "X" (X OF CURSOR) key to place the cursor at X = 120, Y = *-40* (pt. 1, fig. 28). Form the panel STARTING LINE by typing the "." (Plot) key.

3. Use the "D" (Draw) key to set up a 5-polnt line to X = 0, Y = *-40* (pt. *5,* fig. 28). Use the "A" (Advance/Draw) key followed with either the "R" (Rectangle) or"." (Plot) key, as necessary, to construct the lower stem of the undersurface panel (to triangle 7. - see "LEADING LINE after Step 3" caption, fig. 28).

4. Use the RIGHT HAND RULE to confirm that the visible side of the panel faces downward. (With little finger on LOW LINE, thumb on HIGH LINE, fingers pointing in direction of construction, the palm of hand faces In the same direction as the visible side of the panel. Notice that in fig. 29, the palm faces downward thereby confirming that the downward facing side of the panel Is the visible side.)

5. Use the "D" (Draw) key to set up a 7-point straight line to X = 0, Y = 110 (pt. 11, fig. 30). Use the "A" (Advance/Draw) key followed with either the "." (Plot) or "R" (Rectangle) key, as necessary, to construct the upper stem of the under panel using fig. 30 as a guide.

The visible portion of the under-surface panel is now finished. One problem remains. The next panel of the model will be a lateral panel -- the first lateral panel that runs around the perimeter of the letter. The HIGH LINE of the under panel that was just constructed will become the LOW LINE of the next panel and, if the under panel is saved in its current form, there won't be enough points to construct the first lateral panel all the way around. Fig. 31 shows the HIGH LINE points so far plotted (pts. 1 to 11). Fig. 32 shows the extra HIGH LINE points that are needed (pts. 12 to 21) to set up for the next panel (the first lateral panel).

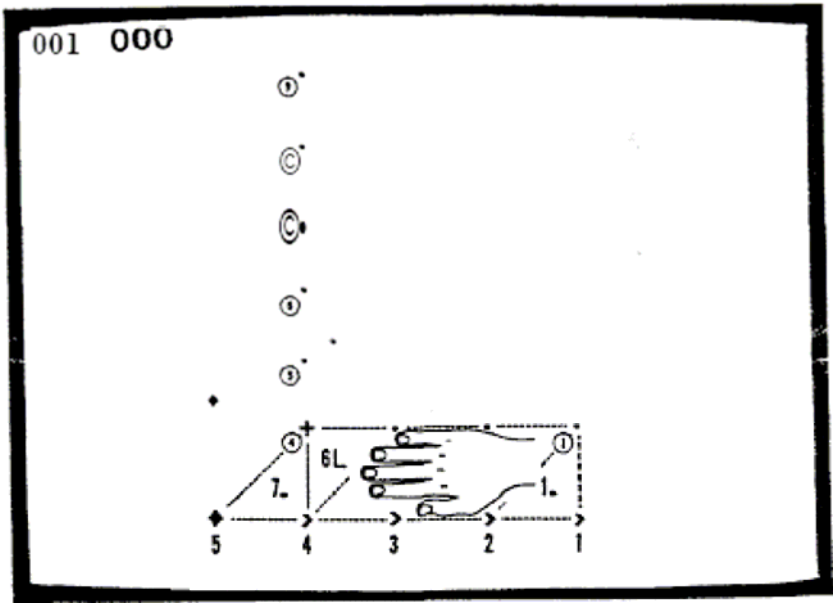


fig. 29 (HIGH LINE GRAPH)

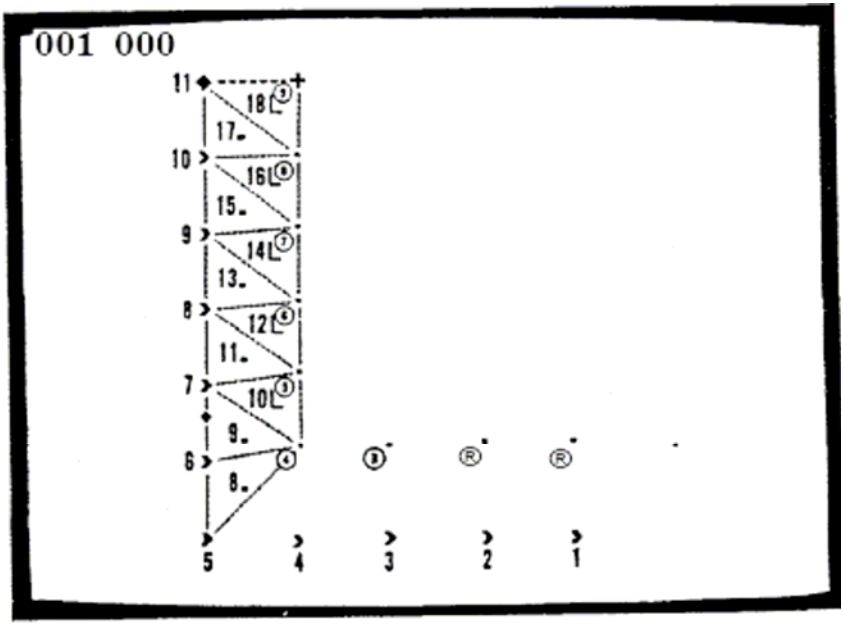


fig 30 (HIGH LINE GRAPH)

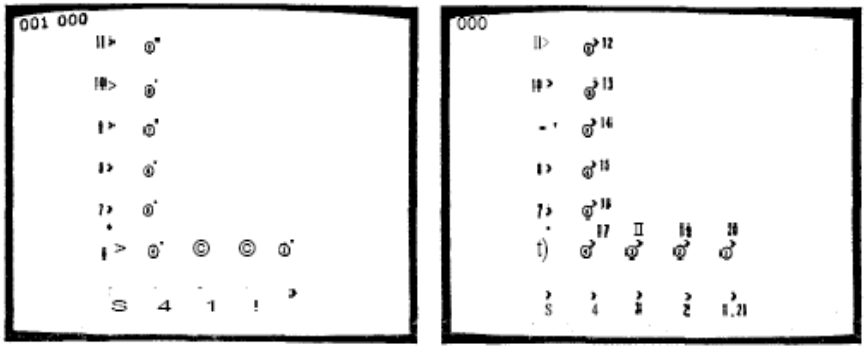


fig. 31 (HIGH LINE GRAPH fig 32 (HIGH LINE GRAPH)

What is needed is a way of adding extra points to the HIGH LINE without constructing more visible panel triangles.

"Z" (Zero) Key (HIGH LINE GRAPH Mode): Recording EXTRA POINTS by Constructing Invisible JUMP TRIANGLES

Type the "Z" (Zero) key.

Notice, in the upper left corner of the graph screen, that the value in the PAINT NUMBER register changed to "0" and no value is displayed for the SHADING TINT register. When the "Z" (Zero) key is typed, the value that is currently in the PAINT NUMBER register is saved in an internal register and a "0" is stored in the PAINT NUMBER register.

The next time the "Z" (Zero) key is typed, the value that was saved in the internal register will be stored back into the PAINT NUMBER register. In other words, whenever a paint number is in the PAINT NUMBER register, the "Z" (Zero) key saves the paint number and stores a "0" in the register. Whenever *a* "0" is in the PAINT NUMBER register, the "Z" (Zero) key restores the saved paint number back into the PAINT NUMBER register. In our case, since a "1" was stored in the PAINT NUMBER register, the "Z" (Zero) key saved the "1" in the internal register and stored a "0" in the PAINT NUMBER register.

While remaining in the graph mode, type the *"Z"* (Zero) key several times In succession to observe this effect.

Any triangle constructed when a "0" is stored in the PAINT NUMBER register will be completely invisible to both the MODEL BUILDER and SURFACE SHADER XE display routines. Both sides of such a triangle are invisible. These are called JUMP TRIANGLES. The display routines waste very little time with "0"- painted (i.e., invisible) JUMP TRIANGLES. They simply skip over such triangles as if they didn't exist.

The HIGH LINE points of such triangles are, however, recorded. Since these triangles are invisible, it makes little difference what their shape is or what 3 points they connect. When you need EXTRA POINTS for the purpose of preparing for the next panel, use the *7* (Zero) key to store "0" into the PAINT NUMBER register and then plot the EXTRA POINTS with the "." (Plot) key.

Adding EXTRA POINTS to the HIGH LINE ("L" Model with Under-surface Panel)

1. Use the *"Z"* (Zero) key to load "0" Into the PAINT NUMBER register. Use the " > " (Advance/LOW LINE) key to move the cursor up to pt. (9) of the LOW LINE (or pt. 12 of HIGH LINE, fig. 32). Use the "." (Plot) key to plot an EXTRA POINT at that location (HIGH LINE pt. 12).

2. Use the " < " (Back/LOW LINE) and "." (Plot) keys to plot EXTRA POINTS 13 to 20 directly on top of LOW LINE pts. (8) to (1) (fig. 32).

3. Type the "J" (Join) key to position the cursor directly over the first point of the HIGH LINE; then use the "." (Plot) key to plot the last EXTRA POINT of the HIGH LINE (pt. 21, fig. 32).

4. Before saving the panel to disk, scroll the screen once to make sure all of the HIGH LINE points are plotted correctly. Trace the triangles back In the SPACE SCREEN to make sure all visible (non "0"-palnted) triangles are constructed properly.

Notice that all 3 points of each "0"-painted JUMP TRIANGLE are marked when traced back in the SPACE SCREEN. The shapes of these triangles, however, are of no importance because the triangles are invisible. (Two of the JUMP TRIANGLES display only two markers because two points of those triangles were plotted at the same location.)

5. Return to the MAIN MENU and save the panel to disk.

CHECKPOINT: LINES USED = 7, DISK SECTORS USED = 24

Adding EXTRA POINTS (HIGH LINE GRAPH Mode)

There will be times when you'll want to add EXTRA POINTS to the HIGH LINE of the current panel to set up a more appropriate LOW LINE for the next panel. When this happens, you can always use the following procedure to add the EXTRA POINTS: **(Read the following three steps only.)**

1. Type the "Z" (Zero) key to store a "0" in the PAINT NUMBER register.

2. Plot the EXTRA POINTS as needed with the"." (Plot) key.

3. Type the "Z" (Zero) key to reload the original value back into the PAINT NUMBER register.

No visible panel triangles will be formed. The EXTRA POINTS will, however, be recorded and called up as part of the LOW LINE when the next panel is constructed.

Go to the MAIN MENU and select CONSTRUCT 3-D PANEL. Load "6" in Z OF THIS LINE and then go to the graph.

Notice that the LOW LINE has the same shape and number of points as the BASE LINE of Model #1.

You could, at this point, use the "F" (Follow) key to construct the lateral panels of the model. Since this has already been accomplished, however, there's very little reason to continue with this model. Instead, we will use the 2 lines so far constructed – the BASE LINE and the under-surface panel -- to demonstrate the use of the ERASE LAST LINE FROM DISK option of the MAIN MENU.

ERASE LAST LINE FROM DISK Option (MAIN MENU): Erasing the Last Line Stored

When you use the ERASE LAST LINE FROM DISK option, the last line recorded on the disk will be erased. This is true whether the line is a HIGH LINE of a 3-D PANEL or a BASE LINE. The quantity after the LINES USED register of the MAIN MENU will be reduced by "1" and the quantity after DISK SECTORS USED will be reduced by the number of disk sectors that the erased line had used. These sectors will be available again for storage of succeeding lines.

Go to the MAIN MENU and select LIST MODEL BASE LINES.

Notice that the BASE LINES of both Model #1 and Model #2 are listed, along with the number of sectors used by both models.

Go back to the MAIN MENU. Note the values In LINES USED and DISK SECTORS USED; then select ERASE LAST LINE FROM DISK. At the <Y/N> prompt, type "Y".

CHECKPOINT: LINES USED = 6, DISK SECTORS USED = 22

Notice that the values in LINES USED and DISK SECTORS USED changed accordingly.

Select CONSTRUCT 3-D PANEL. Leave all values in the GRAPH MENU registers unchanged and go to the graph.

As you see, only the BASE LINE of Model #2 is now displayed. The under-surface panel has been erased. You could now use the displayed BASE LINE to construct a different under-surface panel.

Go to the MAIN MENU and select ERASE LAST LINE FROM DISK again. At the <Y/N> prompt, type "Y".

CHECKPOINT: LINES USED - 5, DISK SECTORS USED = 21

Select CONSTRUCT 3-D PANEL from the MAIN MENU again.

Notice that Z OF LAST LINE now reads "18". This refers to the elevation of the HIGH LINE of the last unerased panel that was saved to disk. This is, of course, the HIGH LINE of the top-surface panel of Model #1.

Leave all values In the GRAPH MENU registers unchanged again and go to the graph.

You are now viewing the HIGH LINE of the top-surface panel of Model #1. By coincidence, this line has the same appearance as the BASE LINE of Model #2 that was just erased. It is, however, a completely different line.

Return to the MAIN MENU and select LIST MODEL BASE LINES.

Notice that only Model #1 is now listed. The BASE LINE of Model *#2* has now been erased.

There may be times when you forget to add the EXTRA POINTS necessary for the next higher panel - when you store a panel to disk and then realize too late that the HIGH LINE of the panel you just saved will not satisfactorily serve as the LOW LINE of the next higher panel.

When this happens, you have two options. The first option is to use the ERASE LAST LINE FROM DISK option of the MAIN MENU to erase the 3-D PANEL or BASE LINE you just saved and then construct the line over again. The second option is to draw an INSERT LINE. An INSERT LINE is a 3-D PANEL composed of nothing but EXTRA POINTS.

Drawing an INSERT LINE

The only purpose of an INSERT LINE is to establish a new, more desirable, LOW LINE for the next higher panel. Normally, the HIGH LINE of the last panel saved will become the LOW LINE of the next higher panel. If you draw and save an INSERT LINE before going on to the next panel, however, the INSERT LINE will become the LOW LINE of the next panel.

For example, let's suppose you saved the under-surface panel of the "L" model without having added the extra points. If, for some reason, you preferred not to erase the under-surface panel and construct it over again, you could construct an INSERT LINE to set up a good LOW LINE for the next panel by following the steps below: (Read the following three steps only.)

1. Select the "CONSTRUCT 3-D PANEL option. Don't change the values in the Z OF THIS LINE, PAINT NUMBER or SHADING TINT registers. Go directly to the graph.

An INSERT LINE has no height, no color or shade. It's no more than a line of points plotted at the same elevation as the HIGH LINE of the previous panel. The same value must be stored in Z OF THIS LINE as in Z OF LAST LINE. |

2. Type the "Z" (Zero) key immediately to load "0" into the PAINT NUMBER register and then use the"." (Plot) key to plot all of the points of the "L" that are to be used for the LOW LINE of the next

higher panel.

3. Save the INSERT LINE to disk.

When you construct the next higher panel the plotted points will appear as the LOW LINE on the HIGH LINE GRAPH.

The HIGH LINES of INSERT LINES can be drawn in any shape with any number of points you wish. In most cases, however, it's important to maintain the exact shape and size of the HIGH LINE of the previous panel. This ensures that when the next panel is constructed, there will be a precise alignment of panels (i.e., there will be no "cracks" between panels to see into the interior of the model).

It's always better, when possible, to use the HIGH LINE of the previous panel for the LOW LINE of the next higher panel. This way, each line of plotted points is utilized by both panels. There's a small price to pay in speed and memory efficiency by inserting INSERT LINES between visible panels. This price, however, is quite small.

If you would forget to add necessary EXTRA POINTS prior to saving a panel of a simple model like the "L", it would be easier to do the panel over again. ChromaCAD 3-D PANELS, however, can contain hundreds of triangles, each triangle individually assigned its own PAINT NUMBER and SHADING TINT value. Sometimes, it's easier, if a mistake is made, to simply use the" >" (Advance/LOW LINE) key and"." (Plot) keys to construct an INSERT LINE directly on the previous line and then add the points to the INSERT LINE rather than doing the entire panel over. Another use for INSERT LINES will be discussed later in the "ADVANCED TECHNIQUES" section.

NOTE: Sometimes, when constructing large models with many panels, if you have the SURFACE SHADER XE program, you may want to view the partially constructed model in surface-shaded format. The best time to do this is immediately after storing a panel. To do this, simply boot the SURFACE SHADER XE program, set up the lights and desired viewing angles and display the model normally. When doing this, remember that views of inside-facing surfaces of the model will not normally be displayed.

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SECTION 6 - "i" MODEL

The next model to be constructed will be a model of the block letter "i". An "i" has two separate structures - the stem and the dot. This exercise will demonstrate how models made of separate parts are constructed.

Load the following values into the following orientation registers of 3-D MENU #1:

PITCH ANGLE-=.....60	X OFFSET = ...*-60*
YAW ANGLE =.....*-30*	Y OFFSET =.....15
ROLL ANGLE = ...0	*2* OFFSET = ...0
DISTANCE =.....150	ANGLE OF VIEW = ..50

Go to the MAIN MENU and save the 3-D MENUS to disk with the STORE 3-D MENUS TO DISK option.

CHECKPOINT: LINES USED = 5, DISK SECTORS USED = 21

These values provide a convenient perspective for viewing the "i" model and were used to help make fig. 36.

Plotting the BASE LINE ("i" Model)

1. Choose the PLOT BASE LINE option. Use the "X" (X OF CURSOR) key to send the cursor to X = 60, Y = 15 and then plot a point at that location.

2. Use the "X" (X OF CURSOR) key to send the cursor to X = 60, Y = 100 and then plot a 2nd point at that location.

The "i" model will be constructed using a different technique for the under-surface panel than was used with the "L" model. These two points will be the entire BASE LINE of the model.

3. Return to the MAIN MENU and save this 2-polnt BASE LINE to disk.

CHECKPOINT: LINES USED = 6, DISK SECTORS USED = 22

Constructing the Under-surface Panel of the Stem ("i" Model) 1.
Choose the CONSTRUCT 3-D PANEL option. Leave "0" In the Z OF THIS LINE, register. Store "3" In PAINT NUMBER.

Leave "0" In SHADING TINT. Go to the graph.

2. Send the cursor to X = 75, Y = *-40* (pt. 1, fig. 33). Plot a point to form a STARTING LINE by typing the "." (Plot) key.

The STARTING LINE connects LOW LINE pt. (1) with HIGH LINE pt. 1 (see "STARTING LINE of under-surface panel" caption, fig. 33).

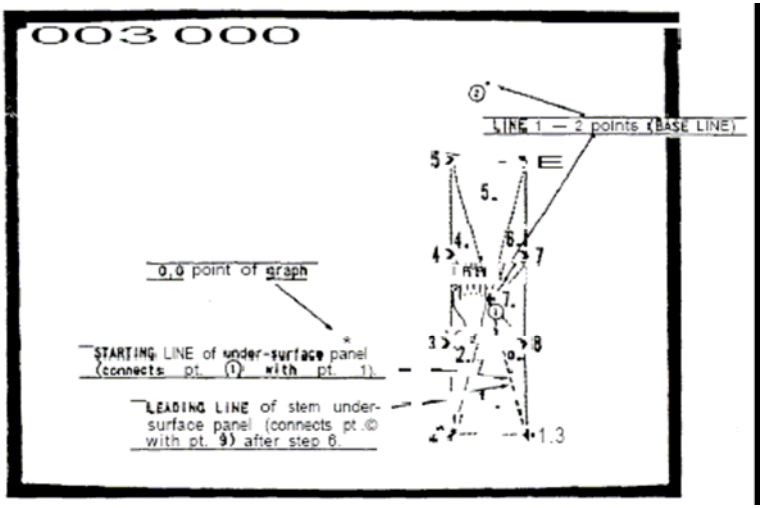


fig. 33 (HIGH LINE GRAPH)

3. Send the cursor to X = 45, Y = -40 and construct a triangle with the "." (Plot) key (Triangle 1. of fig. 33).

4. Use the "D" (Draw) key to form a 4-point line to X = 45, Y = 70 {pt. 5, fig. 33). Use the "A" (Advance/Draw) and "." (Plot) keys to construct 3 more triangles (triangles 2., 3. and 4. of fig. 33).

5. Send the cursor to X = 75, Y = 70 (pt. 6) and use the "." (Plot) key to construct the fifth triangle (triangle 5.).

6. Type the "J" (Join) key to send the cursor to X = 75, Y = -40 (pt. 9); then use the "D" (Draw) key to form a 4-poInt line to X = 75, Y = -40. Use the "A" (Advance/Draw) and "." (Plot) keys

to construct triangles 6., 7., and 8. of fig. 33.

7. Apply the RIGHT HAND RULE to make sure the panel is visible from the underside (fig. 33).

Notice that the little finger is on the LOW LINE and the fingers are pointing in the direction of construction. In this example, the LOW LINE has only one point. The palm side of the hand faces in the same direction as the visible side of the panel. Here the palm is facing down. Therefore, the underside surface of the panel will be the visible side.

The under surface of the stem is finished. Next, it's necessary to construct the under surface of the dot. To do this, the LEADING LINE of the panel must be advanced to a position to construct the under-surface of the dot without constructing visible triangles.

Advancing the LEADING LINE of the Under-surface Panel to the Dot ("i" Model)

At this point, the LEADING LINE of the panel connects LOW LINE pt. (1) with HIGH LINE pt. 9 in figs. 33 and 34. The task is to move the LEADING LINE up so that it connects LOW LINE pt. (2) with HIGH LINE pt. 10 (fig. 34) without constructing visible triangles. Once the LEADING LINE is advanced, the visible triangles of the under-surface of the dot can be constructed. The answer is to use invisible, "0"-painted JUMP TRIANGLES again.

1. Use the "X" (X OF CURSOR) key to send the cursor to location X = 75, Y = 90 (pt. 10, fig. 34 - the lower right corner of the dot).

2. Type the "Z" (Zero) key to load "0" Into the PAINT NUMBER register. Type the "." (Plot) key once to construct invisible triangle "9." and the "L" (LOW LINE) key once to construct invisible triangle "10L" (or, If you prefer, type "R" (Rectangle) to do both operations In one step).

The JUMP TRIANGLES are shown by dotted lines (fig. 34). The LEADING LINE of the panel now connects LOW LINE pt. (2) with HIGH LINE pt. 10. (See "LEADING LINE advanced to start the dot under-surface" caption, fig. 34.)

3. Type "Z" again to reload the saved PAINT NUMBER value (in this case "3") back into the PAINT NUMBER register.

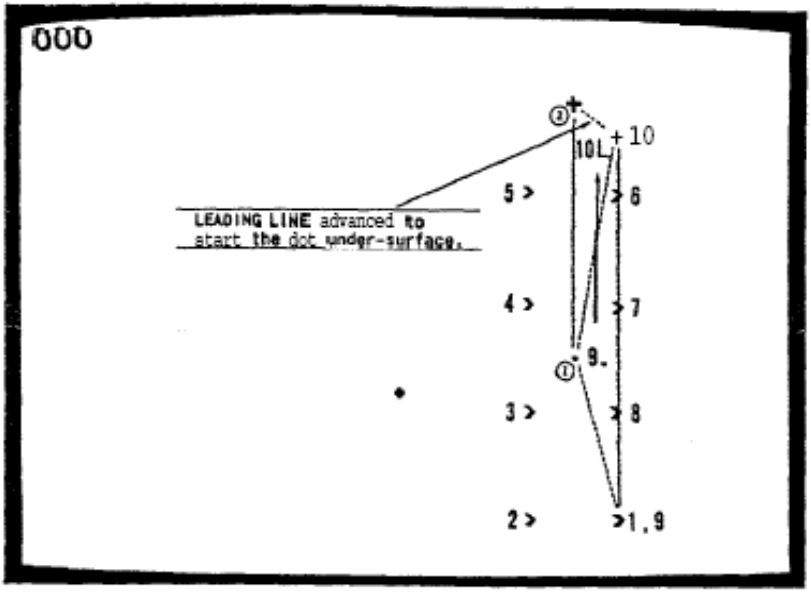


fig 34 (HIGH LINE GRAPH)

The LEADING LINE is now in position to construct the undersurface of the dot.

Constructing the Under-surface of the Dot ("i" Model)

1. Use the "X" (X OF CURSOR) key to move the cursor successively to the four points listed below. Type the "." (Plot) key after each move to construct the four triangles of the dot under-surface (see fig. 35):

1) X = 45, Y = 90(pt. 11)
2) X = 45, Y = 110(pt. 12)
3) X = 75, Y = 110(pt. 13)
4) X = 75, Y = 90(pt. 14)

2. Type "1" to view the BASE LINE in the SPACE SCREEN. Use the "T" (Trace) key to trace the triangles back while making sure that the PAINT NUMBER register contains "0" when the JUMP TRIANGLES are marked In the SPACE SCREEN.

3. Save the under-surface panel to disk.

CHECKPOINT: LINES USED = 7, DISK SECTORS USED = 23

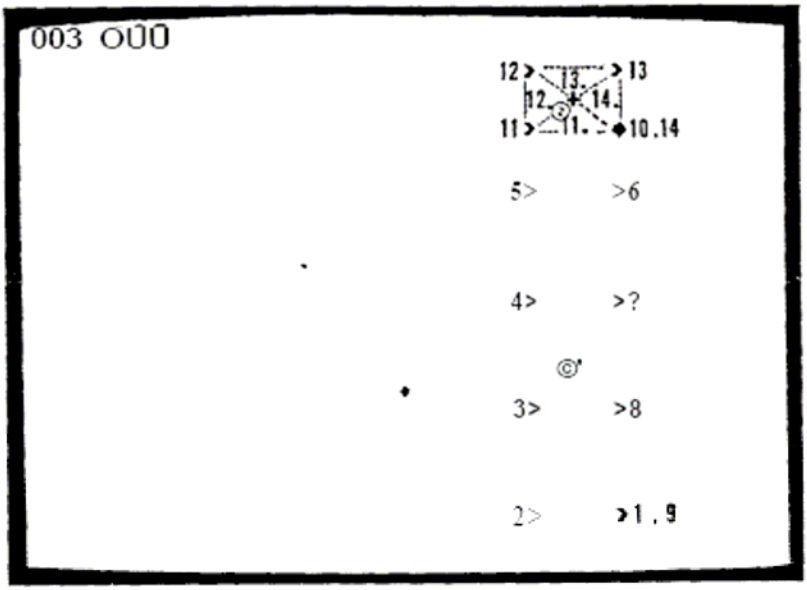


fig. 35 (HIGH LINE GRAPH)

Portions of panels separated by one or more JUMP TRIANGLES are called sub panels of the 3-D PANEL. For example, the STARTING LINE of the stem sub panel in fig. 34 connects pts. (1) and 1. The LEADING LINE of the stem sub panel connects pts. (1) and 9. (Since pts. 1 and 9 overlap, the stem sub panel is a closed sub panel.) Similarly, the STARTING LINE of the dot sub panel connects pts. (2) and 10 and the LEADING LINE of the dot sub panel connects pts. (2) and 14. (Since pts. 10 and 14 overlap, the dot sub panel is also closed.) The STARTING LINE of the 3-D PANEL, however, connects pts. (1) and 1 and the LEADING LINE of the 3-D PANEL connects pts. (2) and 14. The 3-D PANEL is composed of the entire panel including the JUMP TRIANGLES.

The next step is to construct the lateral panel. This panel, like the under-surface panel, will also have two sub panels -- the "stem" sub panel and the "dot" sub panel.

Constructing the Stem Lateral Sub panel ("i" Model)

1. Select CONSTRUCT 3-D PANEL. Load "18" into Z OF THIS LINE and "2" Into PAINT NUMBER. Leave "0" In SHADING TINT. Go to the graph.

This time, for simplicity, only one lateral panel will be used to construct the lateral sides of the model. Therefore, "18" was loaded into Z OF THIS LINE to provide the same overall height model that was obtained with the 3 lateral panels (each panel 6-units high) of the "L" model. Of course, if a special sculptured-shaped "i" model were desired, more panels would be necessary to describe the contour lines of the model.

2. Type the "F" (Follow) key once to jump the cursor to a point (pt. 1, fig. 36) directly over the first point of the LOW LINE (pt. (1), fig. 36) and to form the panel STARTING LINE. (Remember, if no points have yet been plotted, the "F" (Follow) key jumps the cursor directly over the first point of the LOW LINE and then plots a point and initiates the STARTING LINE of the panel.) Fig. 36 Is a perspective SPACE SCREEN view using the viewing angles currently loaded in 3-D MENU #1.

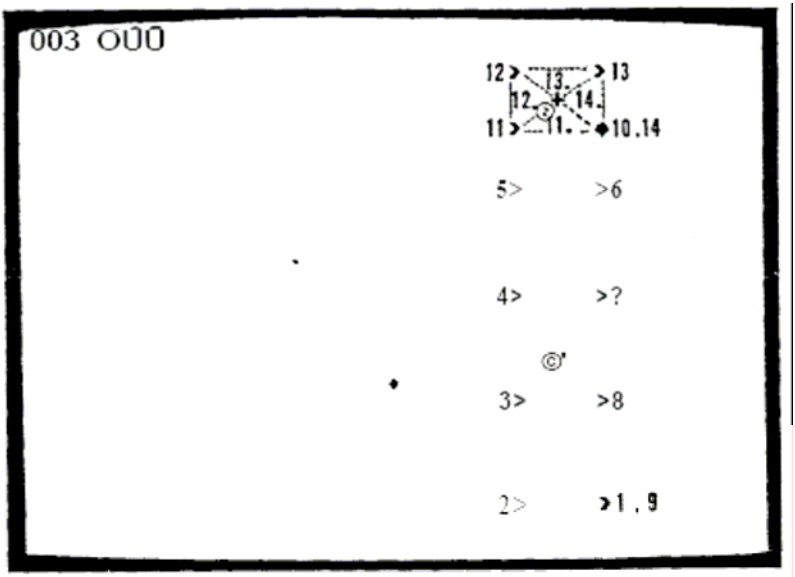


fig. 36 (SPACE SCREEN)

3. Hold down the "F" (Follow) key to construct the lateral sub panel around the stem. Stop when the LEADING LINE connects LOW LINE pt. (9) with HIGH LINE pt. 9 (fig. 36). Do not let the LEADING LINE advance to the dot. Use the RIGHT HAND RULE to make sure the outside surface of the panel Is the visible side. Check the construction by tracing the triangles back In the SPACE SCREEN.

The next step is to advance the LEADING LINE up to the dot without constructing visible triangles. This will place the LEADING LINE in position to construct the lateral sub panel of the dot (fig. 36).

Advancing the LEADING LINE of the Lateral Panel to the Dot ("i" Model)

1. Type the "Z" (Zero) key to load "0" Into the PAINT NUMBER register.

2. Type the "F" (Follow) key once.

When you type the "F" (Follow) key, the cursor first hops directly over the next unused LOW LINE point and then forms a"." (Plot) triangle followed by an "L" (LOW LINE) triangle. In this case, the cursor hopped toot. 10 (fig. 36), directly over the next point on the LOW LINE (pt. (10)) and then two JUMP TRIANGLES were constructed (triangles 17. and 18L, drawn with dotted lines). This advanced the LEADING LINE to a position to begin construction of the lateral sub panel of the dot.

3. Type the "Z" (Zero) key again to load the saved value (In this case "2") back Into the PAINT NUMBER register.

The LEADING LINE is now positioned to construct the dot lateral sub panel.

Constructing the Dot Lateral Sub panel ("i* Model)

1. Hold the "F" (Follow) key down until the dot lateral sub panel is completed.

2 Trace back the entire 3-D PANEL In the SPACE SCREEN to make sure both sub panels were constructed properly and to ensure that the PAINT NUMBER register reads "0" when the JUMP TRIANGLES are marked In the SPACE SCREEN.

3. Save the panel to disk.

CHECKPOINT: LINES USED = 8, DISK SECTORS USED = 25

The lateral panel is now finished. The next step is to construct the top-surface panel. This panel will also consist of two sub panels.

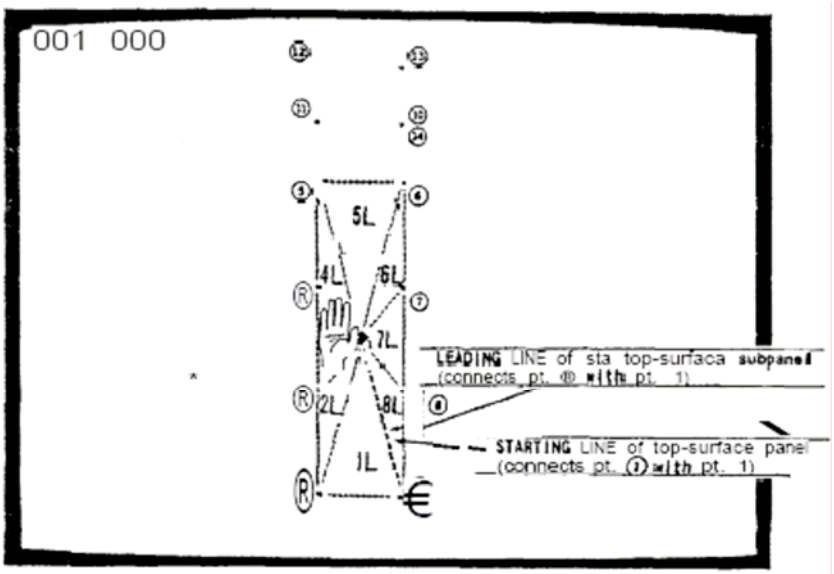


fig. 37 (HIGH LINE GRAPH)

Constructing the Stem Top-surface Sub panel "i" Model

1. Choose the CONSTRUCT 3-D PANEL option. Leave "18" in Z OF THIS LINE. Store "1" in PAINT NUMBER. Leave "0" In SHADING TINT. Go to the graph.

2. Use the X (X OF CURSOR) key to send the cursor to X = 60, Y = 15 (pt. 1, fig. 37). This Is a point at the center of the stem.

3. Form a STARTING LINE (fig. 37) by typing "." (Plot).

4. Construct the top-surface stem sub panel by holding down the "L" (LOW LINE).key until the surface sub panel of the stem is closed. (Stop when the LEADING LINE connects LOW LINE pt. (9) with HIGH LINE pt. 1, fig. 37.)

Notice that, this time, the RIGHT HAND RULE (little finger on LOW LINE, thumb on HIGH LINE, fingers pointing in the direction of construction) indicates that the visible side of the panel faces up (fig. 37).

The next step is to advance the LEADING LINE up to the dot without constructing visible triangles so that it will be in position to construct the top-surface sub panel of the dot.

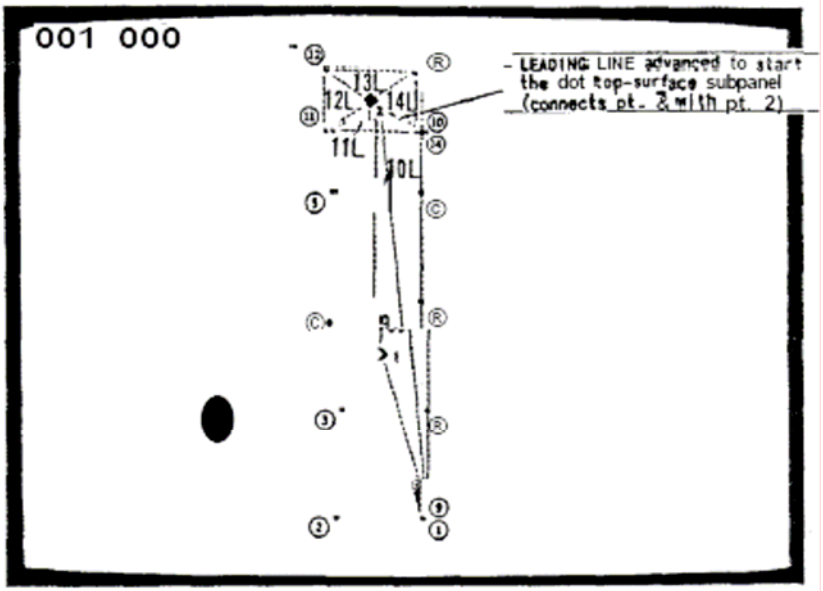


fig. 38 (HIGH LINE GRAPH)

Advancing the LEADING LINE of the Top-surface Panel to the Dot ("i" Model)

1. Send the cursor to X = 60, Y = 100 (pt. 2, fig. 38), the center of the dot.

2. Type the "Z" (Zero) key to load "0" into the PAINT NUMBER register. Construct two JUMP TRIANGLES (triangles 9. and 10L of fig. 38) by typing "." (Plot) and "L" (LOW LINE) (or combine the last two operations by simply typing "R" (Rectangle)).

3. Type the "Z" (Zero) key to restore the value (in this case "1") back into the PAINT NUMBER register.

The LEADING LINE of the panel is now in position to construct the top-surface sub panel of the dot.

Constructing the Dot Top-surface Sub panel ("i" Model)

1. Type the "L" (LOW LINE) key four times until the top-surface sub panel of the dot Is closed. This constructs triangles 11 L, 12L, 13Land14L(fig.38).

2. Trace the panel back In the SPACE SCREEN. Make sure the PAINT NUMBER register reads "0" when triangles 9. and 10L are marked in the SPACE SCREEN.

3. Save the pane! to disk.

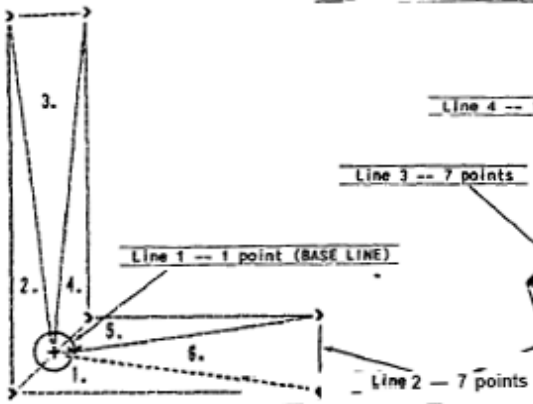
CHECKPOINT: LINES USED = 9, DISK SECTORS USED = 26

The "i" model was started with a 2-point BASE LINE -- one point for each separate structure of the model. Most ChromaCAD models are constructed this way. One point starts a structure; then the structure is built from the bottom up with successive 3-D PANELS - each panel describing the model's contoured surface area between the panel's low (LOW LINE) and high (HIGH LINE) elevation range.

In the case of the "i" model, as was the case with the "L" model, you could build a more elaborate model by using more panels to describe more interesting contour shapes. As many panels could be used as desired. Each panel would be composed of two sub panels - the first sub panel would describe the contoured surface area of the stem within the panel's elevation range; then two JUMP TRIANGLES would jump to the dot and the second sub panel would describe the contoured surface area of the dot within the panel's elevation range. JUMP TRIANGLES may jump through empty space or through previously constructed visible triangles of the model without harm.

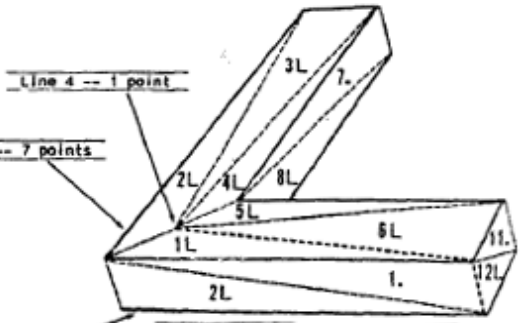
The block letter "i" is now complete. This model has only two parts - the stem and the dot. Many models will have 3-D PANELS composed of numerous sub panels (e.g., the legs of a chair). The same technique can always be applied — jump from sub panel to sub panel with "0"-painted JUMP TRIANGLES.

"L" model: 1-point BASE LINE



STEP 1: Plot BASE LINE (1 pt.) and construct under-surface panel of lower stem.

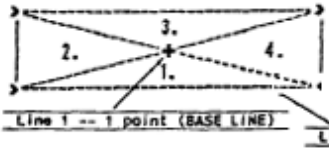
fig. 39



STEP 2: Construct lateral panel and top-surface panel of "L".

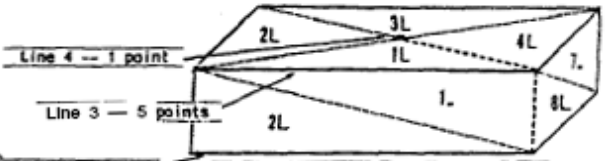
fig. 40

"L" model: standing



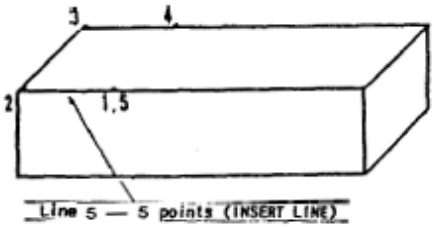
STEP 1: Plot BASE LIKE (1 pt.) and construct under-surface panel of "L".

fig. 41



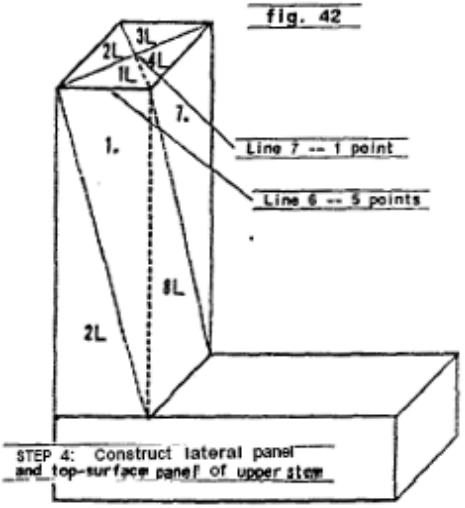
STEP 2: Construct lateral panel and top-surface panel of lower stem.

fig. 42



STEP 3: Use an INSERT LINE to plot points 1, 2, 3, 4 and 5 on top-surface panel of lower stem (or add the 5 points as EXTRA POINTS to line 4).

fig. 43



STEP 4: Construct lateral panel and top-surface panel of upper stem

fig. 44

Alternate Ways of Constructing the “L" and "i" Models

Read the steps below to understand alternate ways of constructing the "L" and "I" models. It's not necessary to actually construct the models. Understanding the basic principles, however, Is important. If you do decide to construct the models, use a different model disk. Otherwise, your checkpoints won't agree with the manual when you construct the "O" model in the next section.

The techniques used to construct the "L" and "i" models were chosen to teach the use of 3-D PANELS. There were not necessarily the most efficient methods of construction. A more efficient way of constructing the "L" model would have been to use a 1-point BASE LINE, similar to the method used to construct the "i" model. Study figs. 39 and 40 to see the steps used to construct the "L" model when using a 1-point BASE LINE.

Notice that one advantage of using a 1-point BASE LINE is that it isn't necessary to add extra points to the under-surface panel to set up for the lateral panel. There are many different ways of constructing any one model.

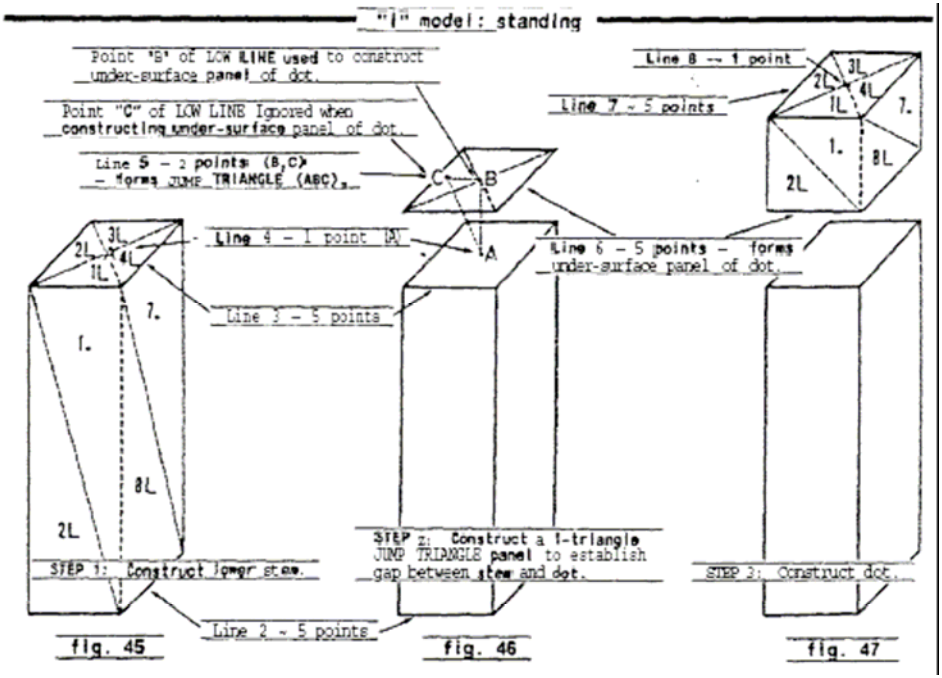
The "L" could have been constructed standing up rather than lying down (figs. 41 to 44). Similarly, the "i" could also have been constructed standing up (figs. 45 to 47).

The steps below explain how the "i" model could have been constructed standing up.

1. (fig. 45) Construct the lower stem using a 1-point BASE LINE and ending with a 1 -point HIGH LINE (pt. A, line 4, fig. 45)

2. Establish a gap between the lower stem and the dot by constructing and saving to disk a 1-triangle 3-D PANEL composed of one JUMP TRIANGLE (triangle ABC, fig. 46). (ChromaCAD will not save a 1-point 3-D PANEL. At least one triangle must be formed. To establish a gap between separate structures in a construction like the one above, use one JUMP TRIANGLE.)

3. Construct the under-surface panel of the dot by using pt. B as the LOW LINE (line 6, fig. 46) and then construct the lateral panel and the top-surface panel of the dot to complete the model (lines 7 and 8, fig. 47).



You can construct models in any orientation desired (standing up, lying down, upside down, etc.) because they can always be displayed in any other orientation with the orientation registers. Before starting a model, you should try to select an orientation that makes drawing the model easy.

ChromaCAD can construct any model in any orientation. Every model, however, has an orientation that makes construction easier. As you gain experience with the drawing tools, you'll be able to better choose model construction orientations. '

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SECTION 7 --"O" MODEL

The next model to be constructed will be a model of the block letter "O". This exercise will introduce you to another drawing tool – the curve-forming tool of the DRAW MENU. First, let's take a look at how this tool works.

"D" (Draw) Key (BASE LINE GRAPH and HIGH LINE GRAPH Modes): Accessing the DRAW MENU and Using the Curve Forming Tool

Select PLOT BASE LINE. Use the "X" (X OF CURSOR) key to send the cursor to X = 20, Y = 20. Type the "D" (Draw) key. oad the following values Into the registers of the DRAW MENU; then go to the graph:

NO. OF POINTS = ...24
RADIUS = ...60
AXIS RATIO =.....10000
X DRAW = ...20
Y DRAW = ...20
ROTATE ANGLE - 0
L!NE(1)CURVE(0)= ...0

The "0" loaded into LINE(1)CURVE(0) calls for a curved line to be displayed. The program displays a 24-point circle with center point at X = 20, Y = 20 and RADIUS of 60. The X DRAW and Y DRAW registers establish the center of the circle.

Notice that X DRAW and Y DRAW were already filled with center point values when the DRAW MENU was accessed. This is because the current X,Y coordinates of the drawing cursor are automatically loaded into the X DRAW and Y DRAW registers when the DRAW MENU is called. This way, the circle can be placed at any desired screen location by first using the "X" (X OF CURSOR) key or the joystick to place the cursor at the location desired for the center of the circle prior to calling the DRAW MENU.

If, after accessing the DRAW MENU, you decide to establish the center of the circle at a location other than the current cursor location, simply change the values in X DRAW and Y DRAW to the desired location.

When a "1" is stored in LINE(1)CURVE(0), a straight line is called for and the X DRAW and Y DRAW registers establish the end point

of the line. When a "0" is stored in LINE(1)CURVE(0), a circle is called for and X DRAW and Y DRAW establish the center.

The points of the circle are displayed only to suggest a path for successive cursor jumps. Whenever a suggested path is not suitable, you can either move the cursor to another center and then type the "D" (Draw) key or, if you prefer, you can first type the "D" (Draw) key and then directly change the X DRAW and Y DRAW values in the DRAW MENU. When you return to the graph, a new circle using the new values will be displayed. You can continue this process until you place and size the circle (or portion of the circle) exactly where you want it on the graph.

Change the values in the X DRAW, Y DRAW and RADIUS registers of the DRAW MENU a few times and view the results. When you are finished, reload the registers with the values listed above and return to the graph.

Once the circle is placed and sized on the graph, you must place the cursor on the circle to plot the points of the curve.

"A" (Advance/Draw) and "B" (Back/Draw) Keys (BASE LINE GRAPH and HIGH LINE GRAPH Modes): Jumping the Cursor to Successive Points of the Curve

Type "A" (Advance/Draw) to place the cursor on the circle. The cursor will jump to the furthest point to the right of the circle. Type the "A" (Advance/Draw) key to advance the cursor clockwise around the points and the "B" (Back/Draw) key to back the cursor counterclockwise. Try this a few times. This is similar to the use of the "A" (Advance/Draw) and "B" (Back/Draw) keys when plotting a straight line.

Scrolling the screen or typing "H" (Hop Screen) will destroy the screen image of the points. The "A" (Advance/Draw) key will, however, continue to send the cursor to the next point of the circle even though the screen image of the point is not present.

Circles are not the only curves that the drawing tool can provide.

AXIS RATIO Register (DRAW MENU): Flattening the Circle

Use the "X" (X OF CURSOR) key to move the cursor to X = 20, Y = 20. Type the "D" (Draw) key again. This time load "5000" (instead of "10000") into AXIS RATIO. Do not change the

values in the other registers. Return to the graph.

Notice that the width of the figure is still 60 but the height has now changed to 30. The circle is now flattened by one half (or 5000/10000). The number (here called "N") loaded in AXIS RATIO serves to shorten the height of the figure by "N/10000". The upper limit of "N" is 10000. When N = 10000, there's no shortening (10000/10000) and the resultant figure will be a circle.

Practice changing AXIS RATIO a few times and viewing the effect In the graph. When you are finished, load "5000" back into AXIS RATIO and return to the graph.

Notice that the points are closer together where the curve is sharpest. This is necessary because more points are needed to display sharply curving portions of curves. When using this tool, examine the sharpest curved portion and decide if you have assigned enough points to display that part of the curve adequately.

There's no formula for this. If you are working on a model with many curved surfaces, it's better to scale the drawing large enough so an adequate number of points can be used at the most sharply curving portions without plotting points too tightly together.

ROTATE ANGLE Register (DRAW MENU): Spinning the Flattened Circle Around the Center Point

Type "D" (Draw) again. Leave "5000" In AXIS RATIO and load "45" Into ROTATE ANGLE, leave "20" In X DRAW and "20" In Y DRAW. Do not change the other registers. Return to the graph.

Notice that the figure is now tilted at a 45-degree angle. The range limits of the ROTATE ANGLE register are -180 to +180 degrees.

Input a few different angles In ROTATE ANGLE and view the effect on the graph.

Sometimes it is difficult to place the curved figure exactly on the line of points that are being plotted. A tool has been provided to make this easier.

"G" (Graft) Key (BASE LINE GRAPH and HIGH LINE GRAPH Modes): Grafting the Curved Figure to the Current Line of Plotted Points

Once you are satisfied with the desired size and shape of the curved figure and you want to move the figure to the line of plotted points in preparation for plotting points along the curve, follow the two steps below:

1. Use the "A" (Advance/Draw) and/or "B" (Back/Draw) keys to jump the cursor to a desired point on the curved figure.

2. Type the "G" (Graft) key.

The curved figure, with the cursor remaining at the same location on the figure, will move to a location where the cursor will be centered exactly on the last point plotted. To plot the next point on the curve, simply type the "A" (Advance/Draw) or "B" (Back/Draw) to jump the cursor to the next point on the curve and continue constructing the panel (or plotting the BASE LINE) as usual. This tool makes it easy to smoothly change among various curves and straight lines while plotting a continuous line of points.

Plot a straight line of points on the graph and then use the curve-forming tool of the DRAW MENU to construct any curved figure. Follow the two steps above to graft the curve onto the plotted line so that the curve smoothly blends into the straight line; then continue plotting the line along the curve. Try this a few times until you can blend straight lines and curves together at will.

The curve-forming tool of the DRAW MENU allows you to place and plot just about any shaped curve (or portion of a curve) in any orientation anywhere on the graph, using any number of desired points.

We will now use the curve-forming function to help construct a model of the block letter "O".

Load the following values Into the following orientation registers of 3-D MENU #1:

PITCH ANGLE = ...50	X OFFSET = ...-60
YAW ANGLE = *.....-90*	Y OFFSET = ...-35
ROLL ANGLE = ...0	Z OFFSET = ...0
DISTANCE = ...220	ANGLE OF VIEW = .50

Go to the MAIN MENU and save the 3-D MENUS to disk with the STORE 3-D MENUS TO DISK option.

These values provide a convenient perspective (a slant view from the side) for viewing the "O" model and were used to help make fig. 50.

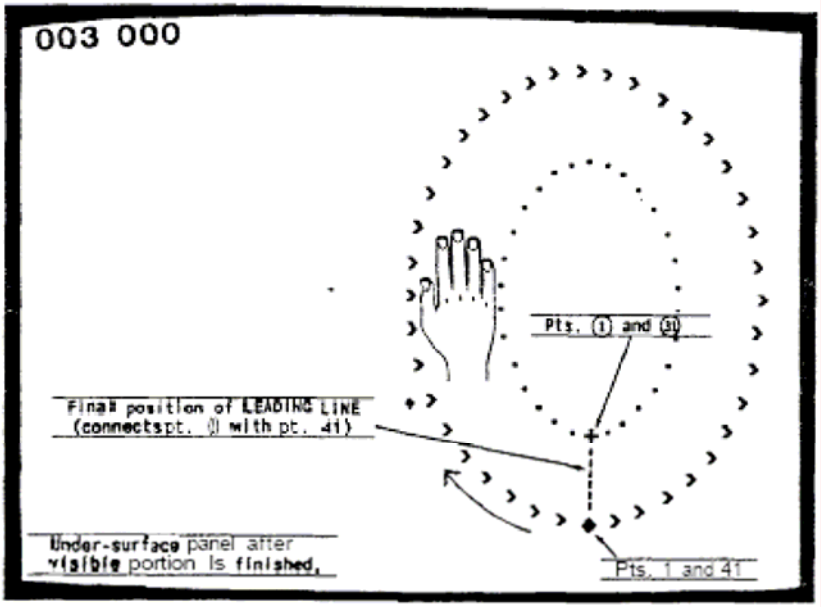

fig 48 (BASE LINE GRAPH)

Plotting the BASE LINE ('O" Model)

1. Select PLOT BASE LINE from the MAIN MENU. Type the "D" (Draw) key. Load the following values Into the registers of the DRAW MENU and then return to the graph.

NO. OF POINTS = ...30
RADIUS = ...45
AXIS RATIO = ...6800
X DRAW - 60
Y DRAW - 35
ROTATE ANGLE - .....-90
LINE(1)CURVE(0) = ...0

You will see a 30-point oval of suggested points. This oval will establish the perimeter of the Inside 'hole" of the letter.

2. Use the "A" (Advance/Draw) key to send the cursor to the bottom-most point of the oval. Use the "." (Plot) key to plot a point at that location. (Observe the location of the first point carefully, because you must plot the last point of the BASE LINE directly on the first point.)

3. Use the "A" (Advance/Draw) key, with the "." (Plot) key to plot all points of the oval (see fig. 48). Plot the last point directly on the first point. (Note: You may find It easier to type "H" (Hop Screen) and destroy the screen display of the suggested points before doing this step.)

4. Check the BASE LINE by scrolling the screen (or by typing "H" (Hop Screen)). Type the "X" (X OF CURSOR) key; then check the NO. OF PTS. PLOTTED register to make sure 31 points have been plotted.

5. Return to the MAIN MENU and save the BASE LINE to disk.

CHECKPOINT: LINES USED = 10, DISK SECTORS USED = 27

Constructing the Under-surface Panel ("O" Model)

1. Select CONSTRUCT 3-D PANEL option. Leave "0" In 2 OF THIS LINE. Load "3" into the PAINT NUMBER register and go to the graph.

2. Type the "D" (Draw) key and load the following values into the registers of the DRAW MENU. Return to the graph.

NO. OF POINTS = ...40
RADIUS = ...75
AXIS RATIO = ...8000
X DRAW = ...60
Y DRAW = ...35
ROTATE ANGLE = ...-90
LINE(1)CURVE(0)= ...0

You will see a 40-point oval of suggested points. These points will establish the outside perimeter of the model.

3. Type the "A" (Advance/Draw) key to send the cursor to pt. 1 of fig. 49A (the bottom-most point of the outside perimeter); then type the "." (Plot) key to form a STARTING LINE between pt. (1) of the LOW LINE and pt. 1 of the HIGH LINE (fig. 49A).

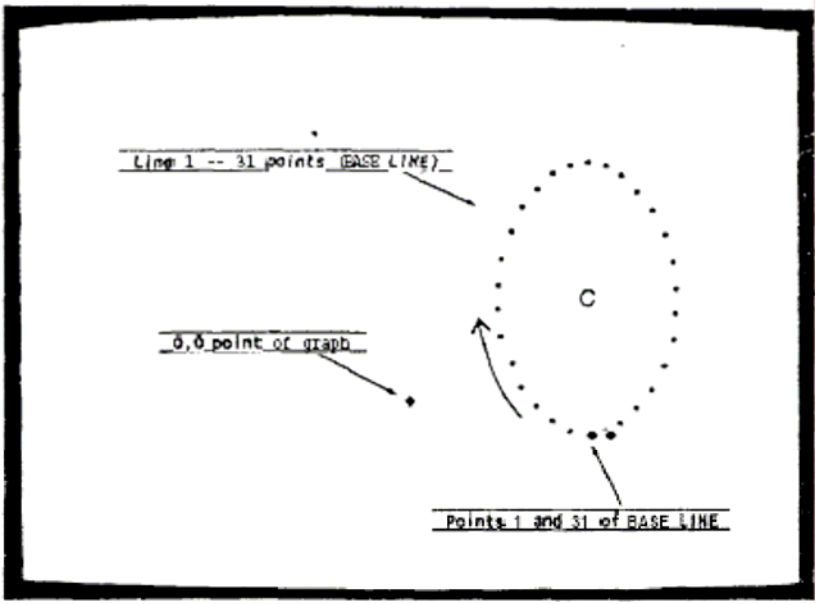

fig. 49A (HIGH LINE GRAPH)

4. Construct all of the triangles of the under-surface panel by first moving the cursor with the "A" (Advance/Draw) key; then constructing either two triangles with the "R" (Rectangle) key or one triangle with the "." (Plot) key as needed. (NOTE: Since there are more points on the outer perimeter than there are on the Inner perimeter, It Is necessary to use the "." (Plot) key occasionally to keep both points of the LEADING LINE as close together as possible as the LEADING LINE moves around the oval. Try not to let the outer point of the LEADING LINE lag behind as the LEADING UNE moves around the oval.) Stop when the LEADING LINE coincides with the STARTING LINE (fig. 49A). Use the RIGHT HAND RULE to confirm that the under-surface surface Is the visible surface of the triangle. (Remember, little finger on LOW LINE.)

The visible portion of the under-surface panel is now finished. A problem remains similar to the problem with the under-surface panel of the "L" model. The next panel will be a lateral panel and the HIGH LINE of the under-surface panel just constructed will become the LOW LINE of the next panel. If the under-surface panel is saved in its current form, there will not be points to construct a

lateral panel around the inner perimeter because no HIGH LINE points have been plotted yet around the inner perimeter.

Notice that, this time, we want the inside surface of the sub panel that runs around the inner perimeter (sub panel B, fig. 50) to be the visible surface. Applying the RIGHT HAND RULE, notice that the LOW LINE of sub panel B must move counter-clockwise for the inside surface to be visible.

Usually, the LOW LINE of a panel must move clockwise because the outside-facing surface of the panel must be the visible surface, as is the case with sub panel A. This is an exception. Sub panel s that lie entirely within other sub panel s (sub panel s that form "holes") move in the opposite direction. When in doubt, always apply the RIGHT HAND RULE when setting up points for the next higher panel. It's necessary, therefore, to add extra points that move counter-clockwise to set up for the inside-facing lateral sub panel B.

5. Use the "2" (Zero) key to load "0" Into the PAINT NUMBER register. Use the " > " (Advance/LOW LINE) key to jump the cursor to the first point of the LOW LINE (Pt. Q), fig. 49A). Do not plot a point at that location yet. First, use the " > " (Advance/LOW LINE) key to advance the cursor all the way around the loop, In a clockwise direction, until you hear a "beep". This positions the cursor over the last point of the LOW LINE (Pt. (31), which is at the same screen location as the first point of the LOW LINE). Plot the first EXTRA POINT of the inner loop at that location.

6. Use the " < " (Back/LOW LINE) key to move the cursor each time, while plotting all extra points of the loop, In a counterclockwise direction, completely around the Inner perimeter. Plot the last point directly on the first point at the bottom of the inner loop (see fig. 49B).

7. Type "Z" (Zero) to restore the value in the PAINT NUMBER register. Trace the triangles back In the SPACE SCREEN; then save the panel to disk. (When tracing the triangles back, don't forget that "Q"-painted JUMP TRIANGLES are invisible; therefore, no visible triangles were constructed In the "hole" of the letter.)

CHECKPOINT: LINES USED = 11, DISK SECTORS USED = 33

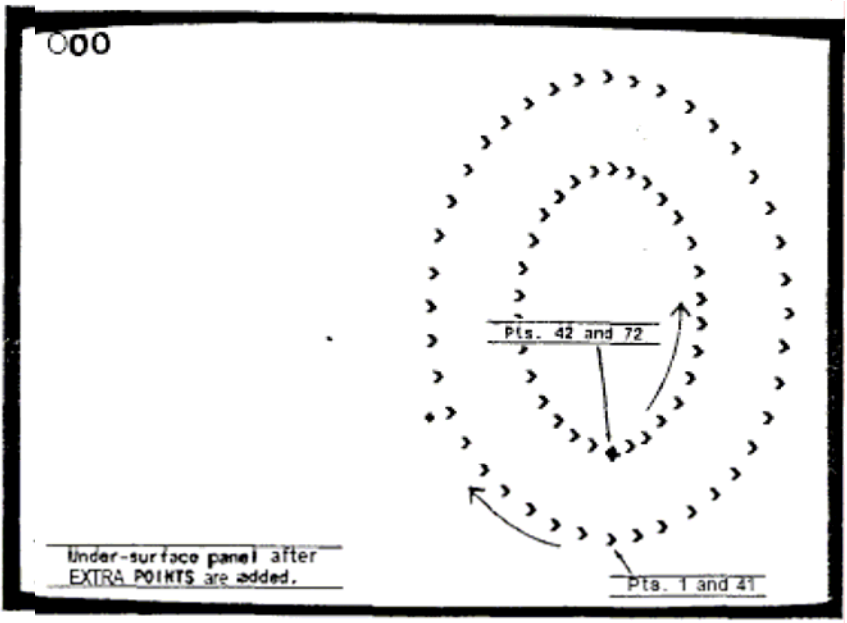

fig. 49B (HIGH LINE GRAPH)

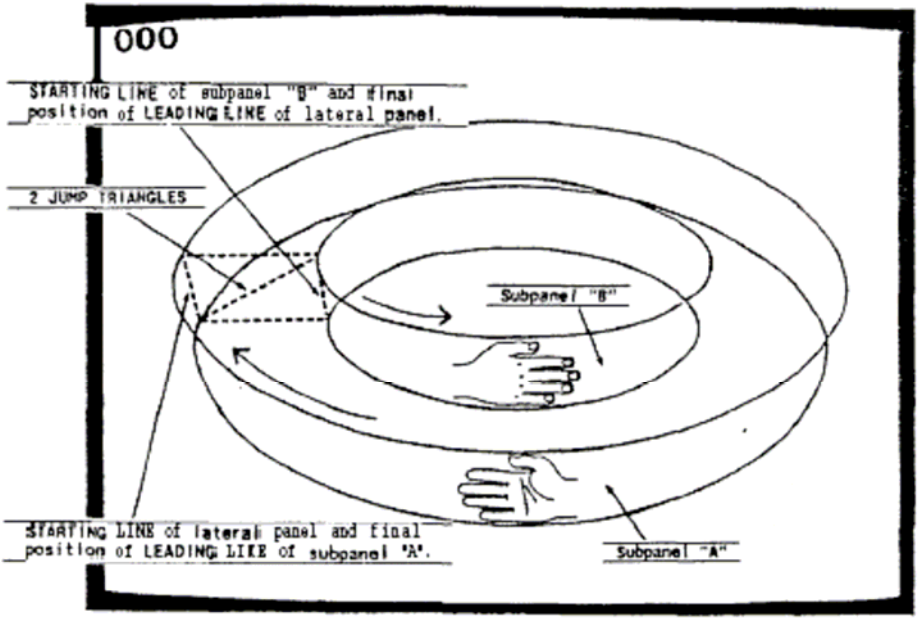

fig. 50 (SPACE SCREEN)

Constructing the Lateral Panel ("O" Model)

1. Select the CONSTRUCT 3-D PANEL option. Load "18" In 2 OF THIS LINE and "2" Into PAINT NUMBER. Go to the graph. Hold the "F" (Follow) key down until the outside-facing sub panel (sub panel A, fig. 50) is closed. (Stop before jumping up to the inner loop - see "STARTING LINE of lateral panel and final position of LEADING LINE of sub panel A" caption, fig. 50.)

2. Type the "Z" (Zero) key to load "0" into PAINT NUMBER. Type the "F" (Follow) key once to construct the two JUMP TRIANGLES (shown in dotted lines, fig. 50) that serve to advance the LEADING LINE to the starting position to construct the Inside-facing sub panel (sub panel B, fig. 50).

3. Type the "Z" (Zero) key to reload the saved value back (in this case, "2") into the PAINT NUMBER register. Hold down the "F" (Follow) key until the inside-facing sub panel Is closed.

All of the visible triangles of both sub panel A and sub panel B of the lateral panel are now constructed.

4. Trace the panel back in the SPACE SCREEN to ensure that the Jump from the outside sub panel to the inside sub panel was made correctly ("0"-painted triangles).

5. Save the panel to disk.

CHECKPOINT: LINES USED = 12, DISK SECTORS USED = 40

The next step is to construct the top-surface panel.

Constructing the Top-surface Panel ("O" Model)

1. Select the CONSTRUCT 3-D PANEL option. Leave "18" in Z OF THIS LINE. Store "1" In PAINT NUMBER. Go to the graph.

2. Hold down the " > " (Advance/LOW LINE) key until you hear a "beep". This advances the cursor to the last point of the LOW LINE (the bottom-most point of the inner loop). This provides a convenient location for the 1st point of the HIGH LINE. (Notice that the cursor destroyed the screen display of one of the points near the bottom of the outer loop. Type "H" (Hop Screen) If you wish to restore the display of this point.)

3. Type the "." (Plot) key to form a STARTING LINE between pt. (1) of the LOW LINE and pt. 1 of the HIGH LINE (see fig. 51).

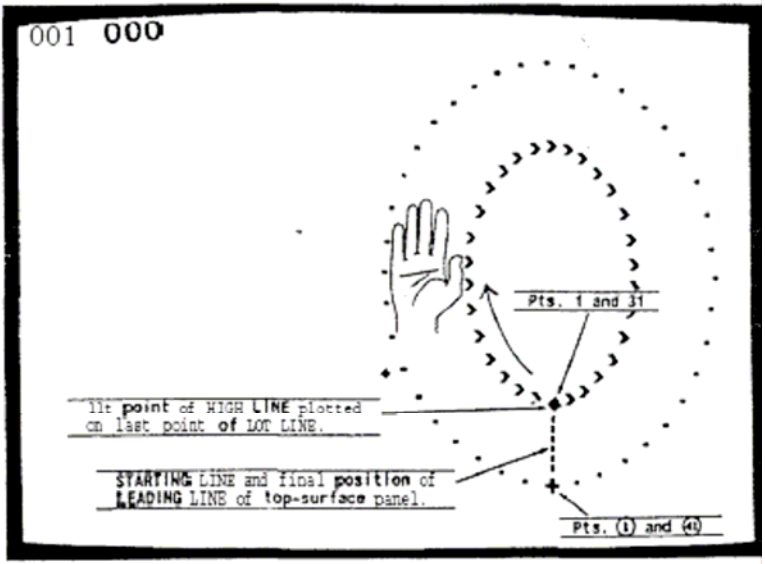

fig. 51 (HIGH LINE GRAPH)

3. Construct all of the triangles of the top-surface panel by first moving the cursor with the " < " (Back/LOW LINE) key; then constructing either two triangles with the "R" (Rectangle) key or one triangle with the "L" (LOW LINE) key as needed, (NOTE: this time It is necessary to occasionally use the "L" (LOW LINE) key to keep both points of the LEADING LINE as close together as possible as the LEADING LINE moves around the oval.) Stop when the LEADING LINE coincides with the STARTING LINE. Use the RIGHT HAND RULE to confirm that the top surface side of the panel Is the visible side (fig. 51).

4. The model Is now complete. Trace the panel back In the SPACE SCREEN; then save the panel to disk.

CHECKPOINT: LINES USED = 13, DISK SECTORS USED = 44

When you constructed the lateral and top-surface panels of the "O" model, the plotting cursor was positioned over existing LOW LINE points with the" >" (Advance/LOW LINE) and" <" (Back/LOW

LINE) keys. The "D" (Draw) tool could also have been used instead to plot new HIGH LINE point locations along the path of LOW LINE points. The joystick could have been used for the same purpose.

Usually, however, if LOW LINE points already fall along the desired path, it's better and easier to position the cursor directly over the existing LOW LINE points with the" <" (Back/LOW LINE) and" >" (Advance/LOW LINE) keys rather than attempt to use the "D" (Draw) tool or joystick. This ensures that the higher panel will fit exactly on the lower panel with no accidental misalignment along the edge where the two panels meet. (Accidental misalignments between panels can cause "cracks" between the panels to appear on close-ups when displayed with the SURFACE SHADER XE.)

Don't be afraid to make a mistake when using a cursor moving key such as" >" (Advance/LOW LINE)," <" (Back/LOW LINE), "A" (Advance/Draw), "B" (Back/Draw) or "J" (Join). These are only cursor moving tools. If you make a mistake, the cursor can easily be moved again.

Inside-facing and Outside-facing Sub panel s

The "O" model is an example of a type of model that is quite common in 3-D modeling - the 3-D form with an internal space (or spaces) in the model. Fig. 52 is a drawing of a lateral panel of a cinder-block type structure with two such internal spaces. In this panel there are three sub panel s: the outside-facing perimeter sub panel and the two inside-facing sub panel s. Notice that the outside-facing sub panel runs in a clockwise direction while the inside-facing sub panel s run counterclockwise. Models can have as many internal spaces as desired. Each one is bounded by a different sub panel .

In fact, internal spaces can have structures inside the spaces and those structures can have internal spaces in them (see fig. 53). Also, combinations of outside structures and internal spaces are possible, as in the case of the three cylinders where one cylinder has a square-shaped internal space (see fig. 54).

Whether structures are constructed inside other structures (fig. 53) or outside (external cylinders, fig. 54), when you construct sub panel s, it's important to apply the RIGHT HAND RULE separately for each sub panel and also to make sure to use JUMP

TRIANGLES to jump between sub panel s regardless of whether they face inside or outside.

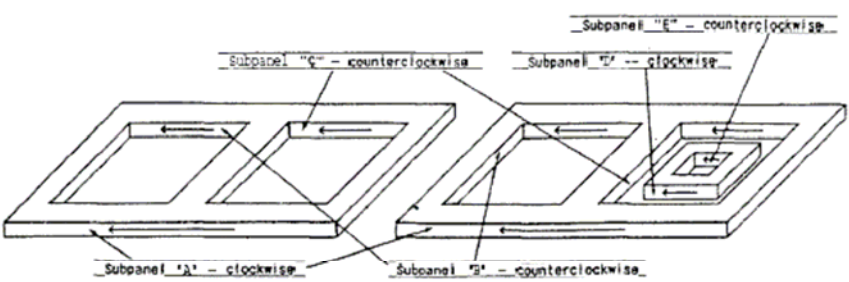

fig. 52 *fig.* 53

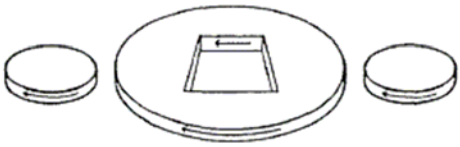

fig. 54

Most models are composed of a great number of 3-D PANELS. Forty or fifty are not uncommon. In most cases, 3-D PANELS, such as those In figs. 52,53 and 54, with numerous inside-facing and outside-facing sub panel s, would be only one lateral panel of a large sculptured-surface model (see fig. 61 for an example of this).

By now, if you have constructed the 3 demonstration models, you should have a good understanding of the basics of the use of 3-D PANELS for model construction.

Remember these three procedural rules:

1. Always apply the RIGHT HAND RULE when you begin a panel or sub panel to ensure the desired side will be the visible side.

2. Before saving a panel to disk, think ahead to the next panel. Add EXTRA POINTS, if necessary, to set up for the next panel. Remember, the HIGH LINE of the current panel will be the LOW LINE of the next panel. Of course, if you forget, you can always

construct a points-only INSERT LINE for the purpose of establishing new LOW LINE points. This technique, however, does cost a little in extra computer imaging time and disk space.

3. Always trace back the triangles of a 3-D PANEL in the SPACE SCREEN before saving it to disk. This ensures that your PAINT NUMBER and SHADING TINT assignments were correct and that your JUMP TRIANGLES were not accidentally assigned a paint number value that will cause them to be displayed by the SURFACE SHADER XE.

In addition, two construction rules should be observed:

1. Never allow a BASE LINE or HIGH LINE to loop back and cross its own path. (A BASE LINE or HIGH LINE may, however, loop back and touch its own path. This is what happens when a closed panel or sub panel is constructed.)

2. Make sure that the area enclosed by the HIGH LINE of closed panels or sub panel s overlap (at least slightly) the area enclosed by the LOW LINE. In other words, if the area enclosed by the HIGH LINE is projected straight down so that it is superimposed on the area enclosed by the LOW LINE, the two areas should have some common overlapping zone The amount of overlap isn't important. Merely touching is good enough.

You will rarely need to construct closed panels or sub panel s that are so slanted that you need to worry about the above 2nd rule. Once in a while, however, you may need to construct long slender constructions that project upward at a slant (like the leg of a tripod). When this happens, use enough 3-D PANELS to make sure the above condition is met for each closed panel or sub panel .

SECTION B - CONVERGING AND DIVERGING STRUCTURES

It's not necessary to construct the models presented In this or the following sections unless you wish to do so. It's Important, however, to read and understand the construction steps for each model so that you can apply them to the construction of your own models.

This section covers the construction of complicated models made up of separate or connected model parts that start or end at different elevations in space-. Sometimes models have two or more structures that protrude out and up from the main body of the model. Assume, for example, that you want to construct a model of a block letter "Y" in a standing orientation. If you start construction of the letter from the bottom, at some point near the center of the "Y", two structures will diverge out to form the top part of the "Y". At that center point, you will have to create two structures from the main body and then end both structures separately at the top.

The opposite case is also common. Some models have downward protruding or overhanging structures that converge into the main body at a higher elevation. A tripod, for example, has three legs which merge into a common structure at the top. Each leg must be initiated separately at the bottom and then merged into one structure at the top.

Cane Model (Standing)

Consider a model of a standing cane (see fig. 55). The long cane shaft is constructed of 4 panels (not shown in the illustration). Line 5 is the HIGH LINE of the fourth panel. At line 5, an EXTRA POINT is added (Pt. P) that will be used by the next panel to initiate construction upward of a new structure, the overhanging handle. Line 6 constructs both the cone-shaped under-surface sub panel of the overhanging handle-end (sub panel B) and sub panel A of the shaft.

As higher panels are added (Lines 7,8,9 and 10), the HIGH LINES of the two sub panel s come closer together until, at Line 10, they touch at the top. Line 11 is an INSERT LINE that serves to rearrange the order of the points of Line 10 so that the succeeding higher panels can be constructed of single panels with no sub panels.

Standing Cane Model: Construction Steps

Read the steps below while referring to fig. 55.

1. Plot a 1 -point BASE LINE and then construct a circular undersurface panel in a clockwise direction at zero elevation to establish the underside of the shaft (Line 2 - not shown in fig. 55).

2. Construct a series of cylindrical panels to form the long cane shaft. After constructing the last panel of the series (here, Line 5, fig, 55) around the cane shaft, type *"2"* (Zero) to load "0" into the PAINT NUMBER register and add an EXTRA POINT (pt. P) to line 5 at the location where the center of the overhanging handle will begin.

The overhanging handle is a new structure that will be initiated in space at pt. P . The EXTRA POINT (pt. P) will be used by the next higher panel to start the upward construction of the overhanging handle. Pt. P will be used to initiate a new sub panel . (Generally, any number of separate new structures can be initiated after constructing any HIGH LINE. To start new structures, load "0" into the PAINT NUMBER register; then add an EXTRA POINT at the X,Y location where you want the bottom-most point of each structure to begin. The next higher panel will use these extra points to begin upward construction of the new structures.)

The next panel (Line 6, fig. 55) will start construction of the overhanging handle. Only a small value should be added to Z OF THIS LINE for this panel. The height of the panel should be quite small, because this panel will be used to construct the cone-shaped sub panel that describes the bottom-most end of the handle.

In this example, only one panel is used to construct the cone-shaped end of the handle. A rounded handle end could also be constructed by using more panels to "round out" the cone.

3. Follow the steps below to construct the panel (Line 6):

A. Select DRAW 3-D PANEL. Construct and close cylindrical sub panel A around the shaft of the model.

B. Use the 'D" (Draw) option to form a circle around the EXTRA POINT (Pt. P); then use the "A" (Advance/Draw) key to jump the cursor to the first point of the circle.

C. Type the "Z" (Zero) key to load "0" into the PAINT NUMBER register. Type the "R" (Rectangle) key once to advance the LEADING LINE to a position to start the cone. Type the "Z" (Zero) key once again to reload the PAINT NUMBER register.

D. Use the "A" (Advance/Draw) and"." (Plot) keys to construct and close the cone sub panel .

E. Trace the 3-D PANEL back in the SPACE SCREEN; then save the panel to disk.

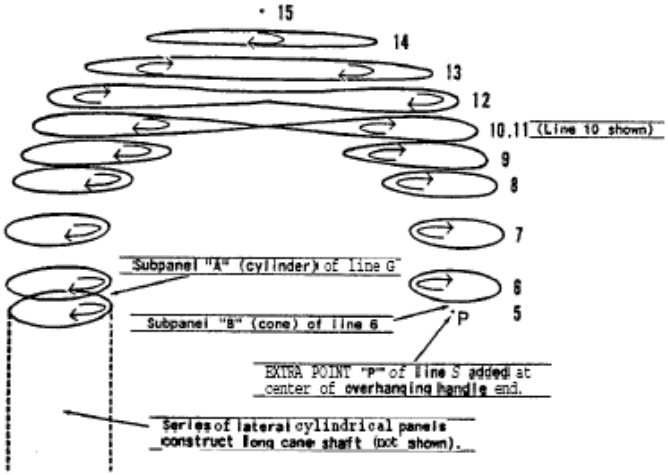

fig. 55

Line 11 is an INSERT LINE used to rearrange the plot order of Line 10 so that the next higher panel can be constructed in one continuous loop (no subpanels - see Line 12, fig. 55).

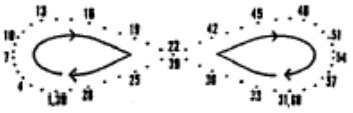

fig. 56 - line 10

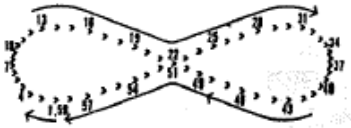

fig. 57 -- line 11

The next step is to continue the construction of both the cane shaft and the overhanging handle upward until they meet at Line 10.

4. Construct a series of two-sub panel panels upward to describe the curve of the handle (here, 4 panels -- Lines 7,8, 9 and 10) until the HIGH LINES of the sub panel s of the highest panel touch (here, Line 10). (The more panels used, of course, the better the curve of the handle can be described.)

At this point, it would be awkward to continue constructing the remainder of the cane using panels consisting of two sub panels. It's easier to merge the two sub panel s so that the rest of the cane (the topmost portion) can be constructed of single panels.

To merge the two sub panel s, use an INSERT LINE to rearrange the order in which the points of Line 10 are plotted (see figs. 56 and 57).

5. Follow the steps below to draw the INSERT LINE.

A. Select DRAW 3-D PANEL. Use the same value in Z OF THIS LINE for Line 11 as was used for Line 10 (the default value). Go to the graph.

B. Use the "Z" (Zero) key to immediately load "0" in PAINT NUMBER. Use the " <" (Back/LOW LINE) and " > " (Advance/LOW LINE) keys, along with the"." (Plot) key, to re-plot the points of Line 10 so that the order in which the points are plotted are rearranged from the double loop of Line 10 (figs. 55 and 56) to the single loop of Line 11 (fig. 57). Save this INSERT LINE to disk.

6. All the remaining panels of the model (here, lines 12 through 15) can now be constructed of single panels with no sub panels. As mentioned before, the more panels used, the better the description. (NOTE: the topmost panel should have only one point for the HIGH LINE -- all triangles of the topmost panel will be constructed with the "L" (LOW LINE) key.)

The cane model demonstrates an important point: all surfaces of a model that fall within a panel's HIGH LINE and LOW LINE elevation range must be constructed by that panel. If a model has an overhanging structure, such as the cane handle, the lower portion of that structure must be constructed by the same panel that constructs the main body of the model within that elevation range.

The standing cane model above used an extra point (pt. P, fig. 55) to initiate a new sub panel at Line 5 and an INSERT LINE to merge

two sub panel s at Lines 10 and 11. It's also possible to use an INSERT LINE to start a sub panel and a single point to end it, as the next example of a cane model constructed upside-down with the handle down will illustrate.

Cane Model (Handle Down)

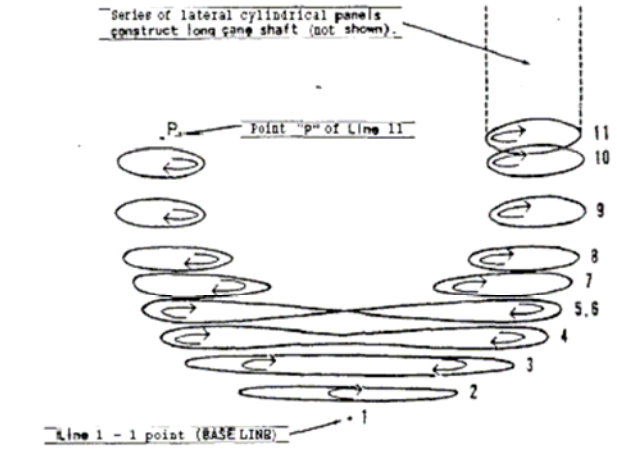

fig. 58

Line 6 is an INSERT LINE used to rearrange the plot order of Line 5 so that the next higher panel can be constructed of 2 subpanels (see Line 7, fig. 58).

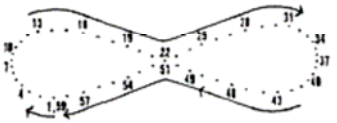

fig. 59 - line 5

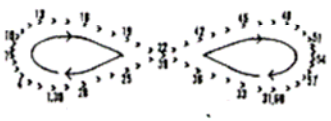

fig. 60 - line 6

Constructing the cane with the handle down demonstrates how to diverge two or more structures from a single structure and, also, how to terminate separate structures in space (see fig. 58). Notice, in this case, all the panels up to panel 4 (HIGH LINE 5, fig. 58) are single panels (i.e., no sub panel s) and are used to describe a single structure (the lower portion of the handle).

Line 6 is an INSERT LINE that serves to rearrange the order of the points of Line 5 so that the succeeding higher panels can be composed of two sub panel s. The use of two sub panel s makes it easier to describe the two upward protruding structures (the cane shaft and the cane handle-end). Notice, also, that one of the structures (the cane handle-end) is terminated at pt. P of Line 11.

Cane Model (Handle Down): Construction Steps

Read the steps below while referring to fig. 58.

1. Plot a 1-point BASE LINE to start the model. Use a series of panels to describe the lower portion of the handle (here, Lines 2 to 5, fig. 58) until the HIGH LINE of one of the panels (here, Line 5) touches itself in the center, roughly describing a figure "8".

2. Use an INSERT LINE for Line 6. Use the " > " (Advance/LOW LINE) and the' <" (Back/LOW LINE) keys, along with the V (Plot) key, to replot the points of Line 5 so that the order in which the points are plotted are rearranged from the single loop of Line 5 (figs. 58 and 59) to the double loop of Line 6 (fig. 60).

3. Construct a series of 2-sub panel panels upward to describe the curved handle and shaft of the cane (here, Lines 7, 8, 9,10 and 11). The last panel of this series should have only one point in the HIGH LINE of the sub panel of the structure to be terminated (here, pt. P of Line 11 -- the tip-end of the handle).

The final point of the handle (here, pt. P, Line 11) will show up, when constructing the next higher panel (Line 12), as an isolated point on the LOW LINE. In the cane model, as we have constructed it here, the final point of the handle will show up as the last point of the LOW LINE when constructing Line 11.

Generally, however, with other models the final point of a structure could fall anywhere on the LOW LINE of the next higher panel. This point must not be used by the next higher panel to construct visible triangles.

Eliminating the Final Point of a Structure •

To eliminate the final point of a structure and thereby terminate the structure, follow one of these 3 procedures when constructing the next higher panel:

A. If the final point of the structure to be terminated is the first point of the LOW LINE, position the cursor to the location desired to start the panel; then use a JUMP TRIANGLE to move the LEADING LINE off the 1st LOW LINE point. (Use the "L" (LOW LINE) key to construct the triangle.) Proceed to normal panel construction. This procedure uses a JUMP TRIANGLE to move the LEADING LINE off the point before starting the panel.

B. If the final point happens to be the last point of the LOW LINE, it can be ignored. The panel can be constructed without the necessity of using the last LOW LINE point.

C. If the final point falls somewhere between the first and last points of the LOW LINE, use one JUMP TRIANGLE to advance the LEADING LINE to the point and another JUMP TRIANGLE to advance the LEADING LINE back to the next point on the LOW LINE. (Use the "L' (LOW LINE) key twice to construct the triangles.) This procedure uses JUMP TRIANGLES to advance the LEADING LINE past the point.

4. Use a series of vertical cylindrical panels (not illustrated in fig. 58) to construct the remainder of the model (the cane shaft). The first panel of the series should use procedure "A" above to snip off pt. P from the LOW LINE. The last panel of the series should use a one-point HIGH LINE to end the cane shaft structure (in the same manner as pt. P ended the handle-end structure).

NOTE: In the above examples, the cane model was constructed vertically because it was a simple model for demonstrating how to start and terminate model structures in space. This model would be much easier to construct horizontally (as if the cane were laying naturally on the BASE LINE GRAPH). This time, we'll leave the construction details up to you. HINT: The BASE LINE must be plotted in the shape of a cane and it must double back on itself (i.e., following the same path) so that the last point of the BASE LINE falls on the first point.

Constructing Model Surfaces that Lie Parallel to the Plane of the BASE LINE GRAPH

There may be times when you must construct surfaces that project out (or in) from the model and that lie parallel to the plane of the BASE LINE GRAPH. For example, let's say you are constructing the exterior of a house and you want to construct a shelf that

projects out from a side of a wall. The shelf will have an underside surface, a top surface and outside-facing edges.

Follow the steps below to construct the shelf. The same technique can be used for almost all model surfaces that lie parallel to the plane of the BASE LINE GRAPH.

1. Make sure the HIGH LINE of the previous panel lies at the desired elevation of the underside surface of the shelf.

2. Follow the steps below to construct the underside surface of the shelf:

A. Select CONSTRUCT 3-D PANEL. Leave the same value in Z OF THIS LINE as in Z OF LAST LINE. (Set up as if to do an INSERT LINE.)

B. Use the "F" (Follow) key to advance the cursor around the LOW LINE to the point where the shelf is to begin.

C. Move the cursor away from the LOW LINE to the desired point for the outside lower corner of the shelf. Type V (Plot) to move one end of the LEADING LINE out to the point and then construct the underside surface of the shelf normally.

D. Position the cursor over the last point on the LOW LINE that was used to construct the underside surface of the shelf. Type the "." (Plot) key to move the end of the LEADING LINE back to the LOW LINE. Use the "F" (Follow) key to follow the LOW LINE completely around the model to finish the panel.

3. Construct the outside-facing edges of the shelf. This lateral panel is constructed normally. It runs completely around the model and around the outside edges of the shelf.

4. Construct the top surface of the shelf. The top surface of the shelf is constructed in a similar manner as the underside surface. The difference, of course, is that this time the HIGH LINE must follow the contour of the outside surface of the house whereas the LOW LINE follows the outside edge of the shelf. i

SECTION 9 - MUG MODEL

In most cases, before constructing large complicated sculptured surface models, you'll want to plan the model on graph paper before actually constructing it with the computer.

A standing mug was used as a demonstration model (see fig. 61). A mug has a handle that diverges out from the main body and then converges back into the main body at a higher elevation. A mug also has an inside surface. Planning and constructing a mug model uses many of the techniques covered in previous models.

A sculptured-surface mug, such as the one pictured in fig. 61, using 42 panels is a much more typical ChromaCAD model than the block letter models covered so far. By varying the shape of the contour lines and the number of panels used, the mug could be constructed in any shape desired, even with a sculptured relief such as a human face on the surface. If you understand how to plan and construct the mug, you should have no trouble planning and constructing any kind of 3-D model with any kind of surface configuration.

Mug Model: Using Graph Paper to Plan a Model

Fig. 61 depicts an excellent way of graphically planning a sculptured-suriace 3-D model before actually constructing it with the computer. Follow the steps below to plan the mug:

1. First sketch a cross-section side view of the model on a piece of graph paper (see fig. 61). (At this point, the dots in fig. 61 have not been added yet.) This sketch depicts the intersection of the model surfaces with the X,Z plane. (For this purpose, the graph paper is assumed to lie in the X,Z plan, not the X.Y plane.)

2. Assign a 0,0,0 point at the lowest point of the drawing (in this case, pt. A). (The 0,0,0 point will serve as a reference for constructing the model.)

3. Decide how many computer units you will use (or each graph square. (Here, it was decided that 16 units would be used for each large square. The distance from pt. A to pt. B, therefore, is 72 units.)

4. Decide how many 3-D PANELS will be used to construct the model and the elevations of the HIGH LINES of each of the panels.

Place dots on the drawing where the HIGH LINES of the panels will intersect the X,Z plane. (Here it was decided to use a 1-point BASE LINE (pt. A) and 42 3-D PANELS. In this step, it's important to pay careful attention to the curved surfaces of the model on the X,Z plane and to use more panels where the curves are sharpest.

Fig. 61 depicts the final X,Z graphing of the mug model.

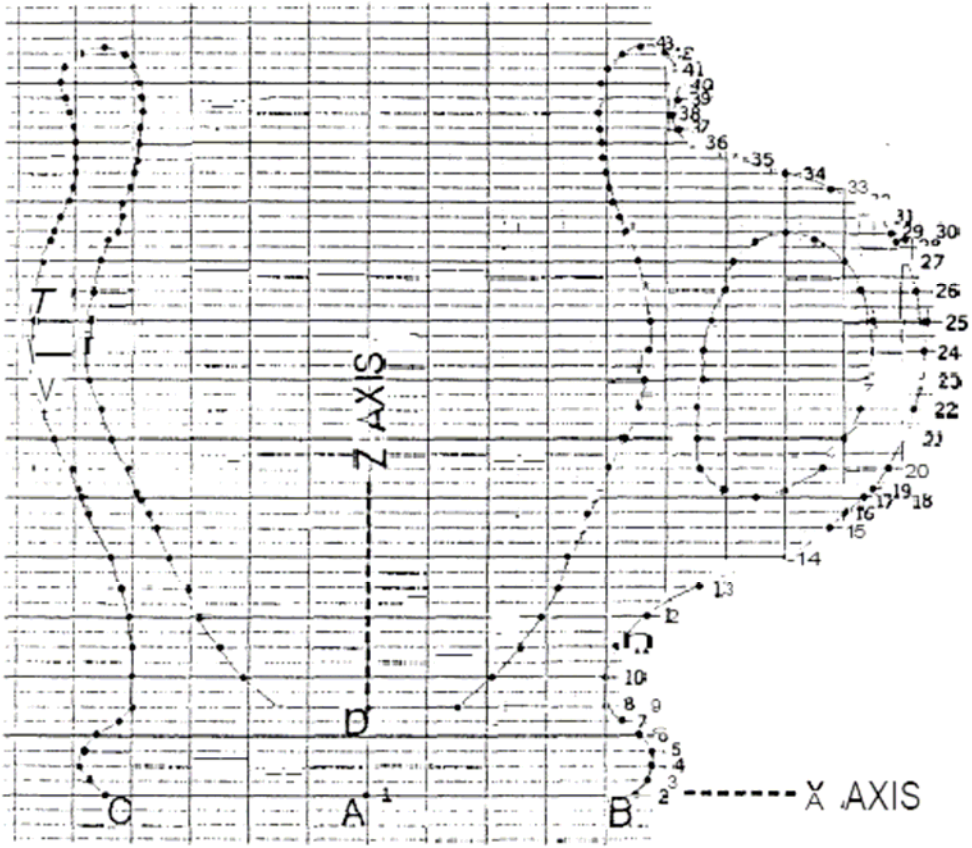

fig. 51

Mug Model: Constructing the Model

Once the mug model is graphed the actual computer construction of the model can proceed quickly. Once a model is graphed on the X,Z plane, it becomes easier to establish the locations of the HIGH LINE points because the X,Y points of at least two points of each HIGH LINE are known. For example, in fig. 61, pt. B of the undersurface panel is at X = 72, Y = 0 and pt. C is at X = *-72,* Y = 0. These two points can be used to reference the other HIGH LINE points of that panel.

Read the steps below, used In constructing the mug mode!, while referring to fig. 61. The numbers running up the right side of the model In fig. 61 represent the line numbers of the model.

NOTE: Your view of the mug on the monitor screen as it is being constructed will be, as usual, down the Z axis onto the XY graph. In the case of the mug, the view will be down into the interior of the mug with the handle orientated toward the right side of the monitor screen (+X side).

Line 1. The model *is* started with a 1-point BASE LINE (pt. A).

Line 2. Line 2 constructs a circular under-surface panel. (HIGH LINE runs in the clockwise direction.) Line 2 intersects the X,Z plane at pts. B (X = 72, Y = 0) and C (X = *-72,* Y = O). A circle with a radius of 72 is used for the under-surface panel (16 computer units per large square).

Lines 3-8. Lines 3 to 8 construct lateral panels that describe the outside curved contour at the base of the mug. Each panel is 4 units high. An EXTRA POINT (pt. D) is added at the center of the mug at Line 8. *(This* EXTRA POINT will start construction upward of the inside surface of the mug.)

Line 9. Line 9 has the same elevation as Line 8. First, the "F" (Follow) key is used to plot a line of EXTRA POINTS directly on the points of Line 8 around the outside perimeter of the mug. (This line will be used by the next panel to continue the upward construction of the outside surface of the mug.) Second, the EXTRA POINT left by Line 8, in the center of the mug (pt. D), is used to construct a circular upward-facing surface. This surface will be the bottom surface of the inside of the mug. (A radius of 24 was used for this

surface.) The HIGH LINE points of this inside-facing surface should run in a counter-clockwise direction. (This circle of points will be used by the next panel to start the upward construction of the inside surface of the mug.)

Lines 10-17. Lines 10 to 17 construct a series of 2-sub panel panels upward until the hole in the mug handle is reached. For each panel, the outside-facing sub panel describes the contours of the outside surface of the mug within the elevation range of the panel. Similarly, the inside-facing sub panel s run in a counter-clockwise direction and describe the inside-facing surface of the mug. (These panels are similar in construction to sub panel s A and B, fig. 50, "O" model.)

Line 18. Line 18 is an INSERT LINE that serves to rearrange the single loop of points of the outside-facing sub panel to two separate loops so that higher panels can construct the mug handle using one outside-facing sub panel and the mug body using a separate outside-facing sub panel (similar to the rearrangement illustrated by figs. 59 and 60).

Lines 19-29. Lines 19 to 29 construct a series of 3-sub panel panels. Each panel has one inside-facing sub panel that describes the inside surface of the mug and two outside-facing sub panel s that describe the outside surface of the mug body and the outside surface of the mug handle.

Line 30. Line 30 is another INSERT LINE that serves to rearrange the double loop of points used for the two outside-facing sub panel s to a single loop of points so that the remaining outside surface of the mug can be constructed of only one outside-facing sub panel (similar to the rearrangement illustrated by figs. 56 and 57).

Lines 31-42. Lines 31 to 42 construct a series of 2-sub panel panels that are used to describe the inside-facing and outside-facing surfaces of the top of the mug. These panels all have the same height and provide convenient surface triangles for logos, words, designs, etc. around the outside surface of the mug (or, if desired, on the inside surface). Of course, designs, words, etc. can always be placed anywhere on the mug by carefully positioning and coloring the surface triangles of appropriate panels to form the design desired. Sometimes, you may want to add extra panels just for the purpose of making a design.

Line 43. Line 43 is used to round off and close the top lip of the mug. The circular HIGH LINES of the inside-facing and outside facing sub panel s of Lines 40,41 and 42 come closer together with each higher panel. At Line 43, the HIGH LINES of the sub panel s touch (are superimposed) to dose and finish the model.

NOTE: You can also construct this model without using the INSERT LINES at Line 18 and Line 29. As the main body of the mug is being constructed, use two JUMP TRIANGLES, where necessary, to jump to the handle and, when the handle sub panel is finished, use two more JUMP TRIANGLES to jump back to finish the main body.

Intentionally left blank

SECTION 10 - 2-D MODELS

2-D models are constructed in the same way as 3-D models, except that all triangles of all the panels of the model lie on the BASE LINE GRAPH (see fig. 62). 2-D models require less computer memory and can be displayed in less time than 3-D models. You can use them as backgrounds for 3-D models or as foreground models to add objects to a scene. You can also use them to add words, numbers, logos, shadows, etc. to a scene.

Constructing 2-D Models

Fig. 62 depicts the "L" model constructed as a 2-D model using two panels. The "L" was constructed by using the PAINT NUMBER and SHADING TINT registers to selectively paint and shade individual triangles as each panel was being constructed. The entire model was done on the BASE LINE GRAPH. The Z OF THIS LINE register of every panel of a 2-D model is always set to "0". Notice also that the RIGHT HAND RULE indicates that the visible surface of both panels face upward.

You can simulate a 3-D effect by using the SHADING TINT register to selectively shade triangles of 2-D models. For example, in fig. 62, if triangles 1., 2L and 6. of panel #1 and triangle 7L of panel #2 were all shaded with a 50% tint, and the remaining (simulated top surface) triangles were all shaded with a 30% tint, a simulated 3-D shaded block letter "L", similar to the illustration, would be produced when the model is displayed with the SURFACE SHADER XE program.

You can use JUMP TRIANGLES to jump between visible triangles of 2-D models. Notice in fig. 63, triangles 5. and 6L of panel #1 and triangles 4. and 5L of panel *#2* serve only to jump the gap between the stem and the dot. By making these triangles invisible JUMP TRIANGLES, the "CONTROL V" multi-model display option can be used to overlay this model on other 2-D or 3-D models without unnecessarily obscuring any background model. (This is a little like drawing an illustration on clear acetate and then overlaying it on another illustration.)

You can also use 2-D models for background scenes. For example, a 2-D model could be constructed of sky and mountains with the intention of placing other 2-D and 3-D models in the foreground. Usually, background 2-D models are rectangular in shape and

contain no JUMP TRIANGLES. 2-D background models are usually the first models plotted when using the "CONTROL V" multi-model option and usually fill the entire screen area.

You can copy a picture or graphic by measuring the features of the graphic and then constructing a 2-D, shaded, colored model of the graphic. For this, it's handy to use a transparent graph grid to overlay and measure the graphic. The accuracy of the reproduction will depend on the number of triangles used per panel and the number of panels used per model (i.e., the scale of the model).

2-D models are displayed using the same procedure as is used in displaying 3-D models. The BASE LINE of the model is loaded in the MODEL BASE LINE register of a 3-D MENU and the model is displayed using the "V" (View) or 'CONTROL V" multi-model option. For more information on the many uses of 2-D models, see the SURFACE SHADER XE manual.

MARKED POINT Register (GRAPH MENU): Marking a LOW LINE Point

When you do 2-D models (or designs and lettering on 3-D models), it's often necessary to continue the color scheme of the design from one panel to the next. Since only one panel can appear on the drawing graph at a time, it's important to be able to easily locate the point on the LOW LINE where a color change has occurred on the previous panel.

For example, Triangle 3. of panel #1 in fig. 63 would usually be assigned the same PAINT NUMBER and SHADING TINT values as triangle 3L of panel *#2* because both triangles are used to describe portions of the same surface (the top of the lower stem). It would make it easier, when constructing panel #2, if Pt. A of the LOW LINE were marked as a reminder to change the value in the PAINT NUMBER and SHADING TINT registers prior to constructing triangle 3L. A marker has been provided for marking LOW LINE points.

To set this marker, follow the steps below:

1. Access the GRAPH MENU by typing the "P" (Paint Number) or "S" (Shading Tint) keys. Drop the cursor down to the MARKED POINT register.

2. Load the sequential order number of the desired LOW LINE point into MARKED POINT; then return to the graph.

When you return to the graph, the indicated LOW LINE point will be marked with a large "X". When you do designs that span many panels, it's a good idea to keep track of the HIGH LINE points where PAINT NUMBER or SHADING TINT changes occur and then use the LOW LINE MARKER described above to mark those points when the next higher panel is being constructed.

After the LEADING LINE reaches each marked point and the PAINT NUMBER or SHADING TINT change is made, advance the marker to the next point on the LOW LINE where a PAINT NUMBER or SHADING TINT change must be made.

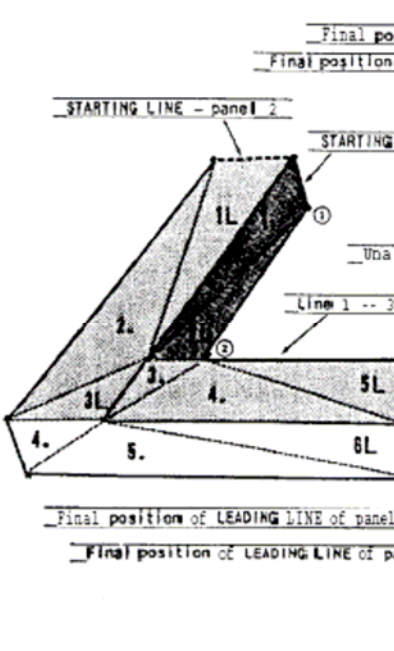

fig. 62

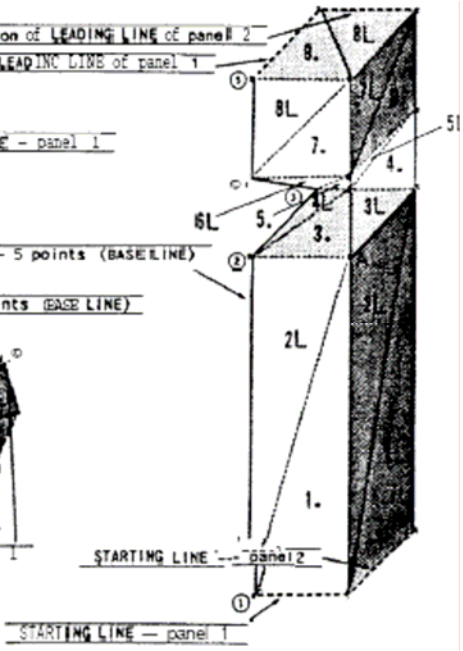

fig. 63

The " ↑ " (Advance/Marker) and" ↓ " (Back/Marker) Keys (HIGH LINE GRAPH Mode): Moving the Marker to a Particular LOW LINE Point

If you need the point number of a particular LOW LINE point while in the HIGH LINE GRAPH mode, you can scroll the marker to the point in question by using the" ↑ " (Advance/Marker) and" ↓ " (Back/Marker) keys. Once the marker is marking the point, you can access the GRAPH MENU and read the point number in the MARKED POINT register of the GRAPH MENU.

REGISTER RANGE APPENDIX

3-D MENUS (Registers used In this program)

THIS MENU NO. 0 to 9
MENU DISPLAY ORDER 1 to 10
MODEL BASE LINE Any Current Model BASE LINE Number
PITCH ANGLE -18010+180
YAW ANGLE - 18010+180
ROLL ANGLE -18010+180
DISTANCE -32767 to +32767
X OFFSET -32767 to +32767
Y OFFSET -32767 to +32767
Z OFFSET -32767 to +32767
ANGLE OF VIEW 10 to 90

GRAPH MENU

Z OF THIS LINE number in "Z OF LAST LINE" to +32767
PAINT NUMBER 0 to 127
SHADING TINT 0 to 100 (in increments of 2)
X OF CURSOR -32767 to +32767
Y OF CURSOR -32767 to +32767
MARKED POINT 0 to sequential number of last point recorded

DRAW MENU

NO. OF POINTS 2 to 360
RADIUS 1 to 32767
AXIS RATIO 0 to 10000
XDRAW -32767to+32767
Y DRAW -32767 to +32767
ROTATE ANGLE -180 to +180
LINE (1) CURVE (0) 1 or 0

""DANGER" zone coordinates outside -18918 to +18918

ERROR NUMBER TABLE

1 You attempted to save a line to disk but the maximum number of lines permitted was already stored on the disk.

2 You attempted to plot two consecutive line points at the same location.

3 You attempted to plot a point (or construct a panel triangle) that would have exceeded the maximum amount of space permitted for a line.

4 You attempted to erase a plotted point but no points were available to be erased. (Either no points were plotted or the first point plotted was already erased.)

5 You attempted to form a LOW LINE triangle but no LOW LINE point was available. (All LOW LINE points were already used.)

6 You attempted to construct panel triangles without first forming a panel STARTING LINE. (You must first use the"." (Plot) key to form a STARTING LINE before proceeding to panel construction.)

7 You attempted to store a non-existent BASE LINE or 3-D PANEL to disk. Either the line was never constructed or the line was accidentally destroyed. (NOTE: the use of any MAIN MENU option other than STORE 3-D MENUS TO DISK, LOAD DEFAULT VALUES or LIST MODEL BASE LINES will destroy resident BASE LINES or 3-D PANELS.)

8 You attempted to jump the cursor back to the location of the previous LOW LINE point when the cursor was already at the first LOW LINE point.

9 You attempted to return to a non-existent BASE LINE or 3-D PANEL. Either the line was never constructed or was accidentally destroyed. (NOTE: the use of any MAIN MENU option other than STORE 3-D MENUS TO DISK, LOAD DEFAULT VALUES or LIST MODEL BASE LINES will destroy resident BASE LINES or 3-D PANELS.

10 You attempted to construct a 3-D PANEL before drawing a BASE LINE.

11 The MODEL BASE LINE register of a 3-D MENU will only accept BASE LINES that have been used to construct a model. You must use the BASE LINE to construct at least one 3-D PANEL before the BASE LINE will be accepted by a MODEL BASE LINE register.

12 You attempted to draw a BASE LINE when the last line stored to disk was another BASE LINE. (You must either use the stored BASE LINE to construct a model or erase the stored BASE LINE before drawing another BASE LINE.)

13 You attempted to call a 3-D MENU to plot and display a model but did not load a BASE LINE number in the MODEL BASE LINE register of the 3-D MENU called.

14 You attempted to erase the last line stored to disk but no line has yet been stored.

15 You attempted to jump the cursor to the location of the first HIGH LINE point plotted but no point has yet been plotted.

16 You attempted to jump the cursor forward to the location of the next LOW LINE point when the cursor was already at the location of the last LOW LINE point.

17 You attempted to jump the marker forward to the location of the next LOW LINE point when the marker was already at the location of the last LOW LINE point.

18 You attempted to jump the marker back to the location of a previous LOW LINE point when the marker was already at the first (off screen) location.

19 You attempted to construct a straight line of suggested plot points but did not have at least one point plotted. (The line of suggested plot points always begins from the last point plotted.)

20 While tracing back the triangles of a 3-D PANEL, you attempted to trace a previous triangle when the first triangle of the panel had already been traced.

HARDWARE SPECIFICS APPENDIX

Disk Sectors Available

ChromaCAD contains its own built-in disk filing system. The number of disk sectors available for model storage depends on the disk drive and format used. All disks to be used for model storage should be formatted using the DOS provided with the disk drive. Disks formatted single density can utilize up to 720 sectors for model storage. Disks formatted enhanced density using the 1050 or XF551 drives can utilize up to 1040 sectors.

STORE LINE TO DISK Option (Main Menu)

When using the MODEL BUILDER program to store a model contour line to disk, always check the number displayed after the "STORE LINE TO DISK" option of the MAIN MENU. This number displays the total number of disk sectors that would be required if the current line in memory were saved to disk. (This includes the number of disk sectors already used plus the number of sectors that would be needed for the current line.) If this number would exceed your disk sector capacity (720 or 1040 depending on the format), do not attempt to store the line.

If an attempt would be made to store a line that would exceed the maximum capacity of the disk, no line storage would occur. For example, if only 3 disk sectors remained for storage and an attempt would be made to store a 5-sector line, no partial storage of the line would occur -- the attempted storage will be rejected and there would still be 3 disk sectors available for storage.

Colors and Shading Tints Available -- Atari Operating System

Users of the MODEL BUILDER program can "paint" up to 127 different surface paint numbers (1 to 127) on model surfaces at the time of construction. The Atari operating system, however, can only display three colors plus background color in highest resolution (192X160) color mode. (ChromaCAD "pushes" this a little by flipping screens to get six image colors plus separate background and border colors for a total of eight colors on the screen at once.) When the SURFACE SHADER XE program is used to display a model, any of 16 actual colors can be assigned to surfaces painted "1", "2" or "3" (see the SURFACE SHADER XE program manual for

the exact colors). Surfaces painted "4" will automatically be colored with a blend of the colors assigned to surfaces painted "1" and "2". Surfaces painted "5" will be colored with a blend of the colors assigned to surfaces painted "1" and "3", and surfaces painted "6" will be a blend of the colors assigned to surfaces painted "2" and "3". For example, when red, blue and yellow are assigned to paint numbers "1", "2" and "3" respectively, model surfaces painted "4", "5" and "6" will be displayed in purple, orange and green respectively.

In addition, at the time of construction, users can directly shade model surfaces with any of 50 shading tints. (The SURFACE SHADER XE program automatically shades 3-D models when they are displayed. This direct user shading feature is primarily used when building 2-D models.)

The SURFACE SHADER XE program uses up to 22 tonal values when displaying models on a monitor or TV. (The 50 shading tints that are used when constructing 2-D models, are scaled down, at display time, to 22 values that are practical for the Atari operating system. 3-D models are calculated to more than 48,000 tonal values by the program before being scaled down to the 22 values.)

When the SURFACE SHADER XE program displays models that have surfaces painted with paint numbers higher than "6", the program divides the number by 6 and uses the remainder as the paint number unless the remainder is 0, in which case, "6" is substituted. The same 6 colors are, therefore, rotated when the model is displayed on a monitor or T.V.

ChromaCAD permits the use of paint numbers greater than "6" and user shading values greater than "22" because, in the future, other output devices (other computers, color printers, slide makers, "TIFF" files etc.) with a larger range of colors and shades may be supported. When other output devices are supported, 3-D models designed on the Atari will be capable of being displayed (or printed) with up to 127 colors and up to 48,000 shading tones.

KEYSTROKE COMMANDS APPENDIX

EDIT 3-D MENUS Mode

"CONTROL Q" Key-combination (Used with the MENU DISPLAY ORDER Registers): Calling the 3-D MENUS To Display Multiple Views of the Test Pattern on One Screen 18,19
"CONTROL V" Key-combination (Used with the MENU DISPLAY ORDER Registers): Calling The 3-D MENUS To Display Multiple Views of Models on One Screen 66
"DELETE' Key (While viewing the SPACE SCREEN): Stopping the Screen Drawing Of a Model 65
Numbers Keys: Displaying the Corresponding 3-D MENU 3
"Q" (Quick) Key : Calling a 3-D MENU to Display the Test Pattern 8
"V" (View) Key : Calling a 3-D MENU to Display a Model 63, 64, 65

PLOT BASE LINE Mode ...(Accesses the BASE LINE GRAPH)

"." (Plot) Key: Plotting a Point 22
Number Keys: Calling the SPACE SCREEN for a 3-D View 34
Red Button, joystick: Scrolling the Screen 24, 25
"A" (Advance/Draw) and "B" (Back/Draw) Keys: Jumping the Cursor to Successive Line Points Suggested By the DRAW MENU 29, 96
"D" (Draw) Key: Accessing the DRAW MENU 27,28,95
"E" (Erase) Key: Erasing The Last Point Plotted 27
"G" (Graft) Key: Grafting the Curved Line Of Points Suggested By The DRAW MENU to the Current Line of Plotted Points 97,98
"H" (Hop Screen) Key: Hopping the screen to the Cursor 26
"J" (Join) Key: Sending the Cursor to the Location of the First Point Plotted 33
"M" (Menus) key: Going Directly to the 3-D MENUS from the Graph....34
"X" (X OF CURSOR) Key: Accessing the GRAPH MENU 23

CONSTRUCT 3-D PANEL Mode .....{Accesses the HIGH LINE GRAPH)

" > " (Advance/LOW LINE) and the" < " (Back/LOW LINE) Keys: Positioning the Cursor Directly over LOW LINE Points 55, 56,106
" ↑ " (Advance/Marker) and" ↓ " (Back/Marker) Keys: Moving the Marker to a Particular LOW LINE Point 126
"." (Plot) Key: Plotting a HIGH LINE Point And Either Forming the STARTING LINE or a New Triangle of a 3-D PANEL 38, 43
Number Keys: Calling the SPACE SCREEN for a 3-D View 34
Red Button, joystick: Scrolling the Screen 24, 25
"A" (Advance/Draw) and "B" (Back/Draw) Keys: Jumping the Cursor to Successive Line Points Suggested By the DRAW MENU 29, 96
"D" (Draw) Key: Accessing the DRAW MENU 27, 28, 95
"E" (Erase) Key: Erasing the Last Triangle Constructed 46
"F" (Follow) Key: Jumping the Cursor over the Next Unused LOW LINE Point and Forming Two Triangles 56, 57
"G" (Graft) Key: Grafting the Curved Line Of Points Suggested By The DRAW MENU to the Current Line of Plotted Points 97, 98
"H" (Hop Screen) Key: Hopping the screen to the Cursor 26
"J" (Join) Key: Sending the Cursor to the Location of the First Point Plotted 33
"L" (LOW LINE) Key: Using the Next Point on the LOW LINE to Construct a New Triangle 42
"M" (Menus) key: Going Directly to the 3-D MENUS from the Graph 34
"P" (PAINT NUMBER) Key: Setting the PAINT NUMBER of Triangles 40,41
"R" (Rectangle) Key: Combining the V (Plot) and "L" (LOW LINE) Keys 54
"S" (SHADING TINT) Key: Setting the SHADING TINT of Triangles 40,41
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