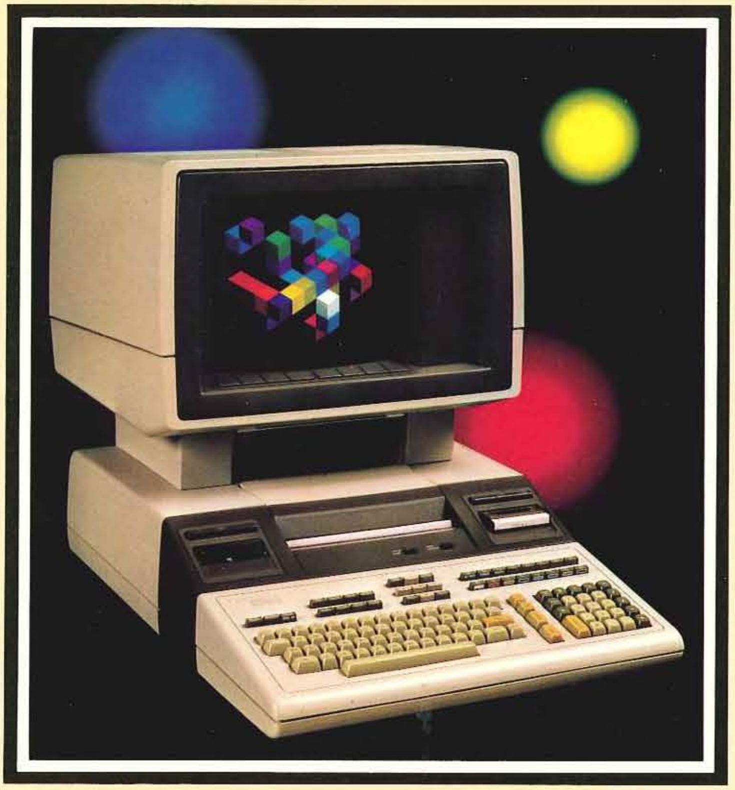
HP 9800 Computer Systems

Demo Guide
For the HP 9845C



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Warranty Statement

Demo Guide
System 45C
Desktop Computer

Important

The tape cartridge or disc containing the programs is very reliable, but being a mechanical device, is subject to wear over a period of time. To avoid having to purchase a replacement medium, we recommend that you immediately duplicate the contents of the tape onto a permanent backup tape or disc. You should also keep backup copies of your important programs and data on a separate medium to minimize the risk of permanent loss.

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Chapter 1
Introduction

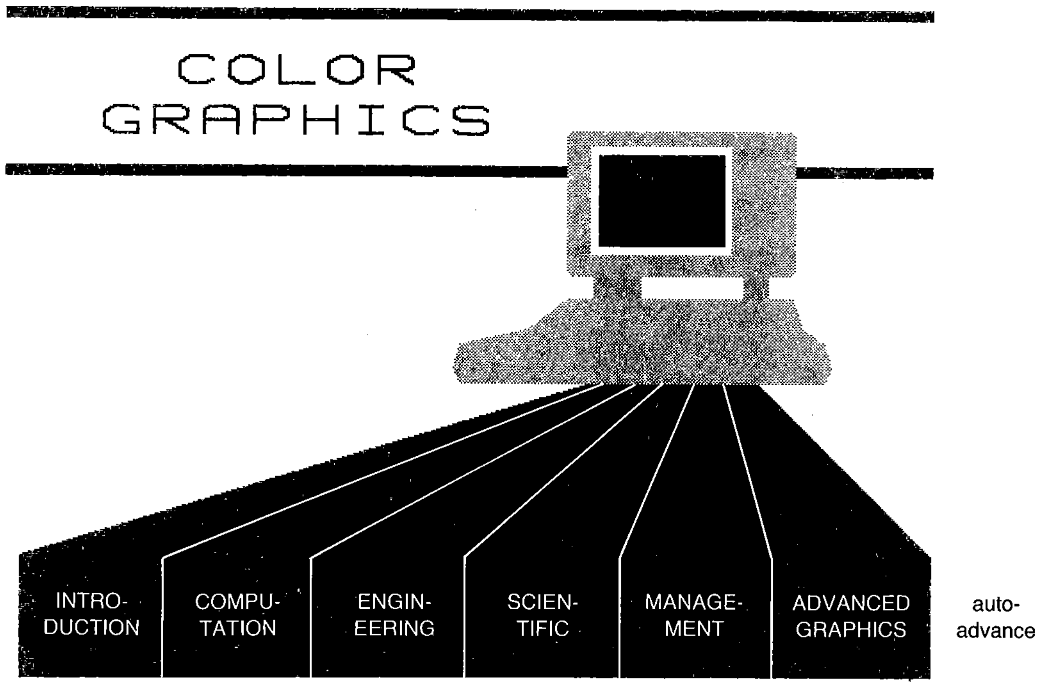
Loading the Demo Program

The System 45C Color Graphics Demo is stored on two tape cartridges. (Instructions for inserting the cartridges are found on page 206 of the Operating and Programming Manual.) Insert the cartridge marked "T14" in the left tape drive, and the cartridge marked "T15" in the right tape drive.

When running the demo initially, depress the AUTO START key (AUTO ST) on the keyboard before turning on your computer. When you then turn on the computer, it will automatically start reading the program from the "T15" cartridge. The program is over 4000 lines long, so it will take about two minutes to load into memory. The computer will start running the program automatically after the loading operation is complete. Even if you stop the program for any reason, it will still be in the computer memory, and will not need to be reloaded. (To restart, just press the STOP key, then the RUN key, and the program will begin again.) If for any reason you must reload the program while the computer is already turned on, press SCRATCH A, EXECUTE then LOAD "DEMO",EXECUTE. Then press the RUN key to start up the program.

When the program asks what type of thermal paper is in the printer, press the appropriate key just below the picture. If you aren't sure of the paper type, just select "BLUE (UN-PERF.)". If it turns out to be wrong, you can always restart with the STOP and RUN keys, and choose again.

After selecting the paper tape, you will be asked which graphic input device (Light Pen or Tablet) is going to be used. Make the proper selection by pressing the appropriate key just below the picture. In the descriptions that follow, "graphics input device" will refer to your selection. If this selection needs to be changed, press the STOP key, then the RUN key, and the program will begin again.



Demo Menu

Moving Around in the Demo

The Color Graphics Demo is made up of 36 examples that are accessed by a menu program. The menus let you move from one example to another in any order that you wish. The first menu you see is the master menu, entitled "COLOR GRAPHICS". From here, you may get to any of the demo examples in only two steps. The first step is to select one of the six topical menus, like "INTRODUCTION" or "ENGINEERING". The second step takes you to any of the six demo examples under that topic. You make your selections by pressing the keys directly under the picture.

These keys are called "soft keys", since their function can be redefined by the program or software. The computer stores the keystroke whenever you press a key, but before it can take appropriate action it must finish the current operation. Sometimes this takes a while, as with the planet-drawing subprogram for the space shuttle. Additional keystrokes won't help. The computer will faithfully save them ALL, usually with unintended results.

Each demo will re-label the soft keys according to their function within the example. In each case, the key labeled "RETURN" will take you back to the menu, and the "NEXT" key will take you directly to the next demo without returning to the menu. The last demo in each section (the one on the right side of the menu of six) is a graphics input device (light pen or tablet) example, as shown in the DEMO ROADMAP. (See next page.)

The "auto advance" mode, which can be selected from the "COLOR GRAPHICS" menu, automatically cycles through each of the examples except for the light pen demos. The complete cycle takes about an hour. You may leave the "auto advance" mode by pressing "RETURN".

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5.	Management	3-D Bar Chart	Prism Map	Area Color	Bar Chart	Pie Chart	Inter-active
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Demo Roadmap

Live Keyboard

The keyboard is live throughout the Color Graphics Demo. This means that you can still compute 2+2, for example, while the demo is running. (Press "2+2", then EXECUTE). You may also examine any part of the program listing. ("EDITLINE A3", EXECUTE, will show the color cube demo listing. CLEAR will make it go away again, along with any other alpha on the screen.) You can even change the program, using the editing facilities. (See the Operating and Programming Manual.)

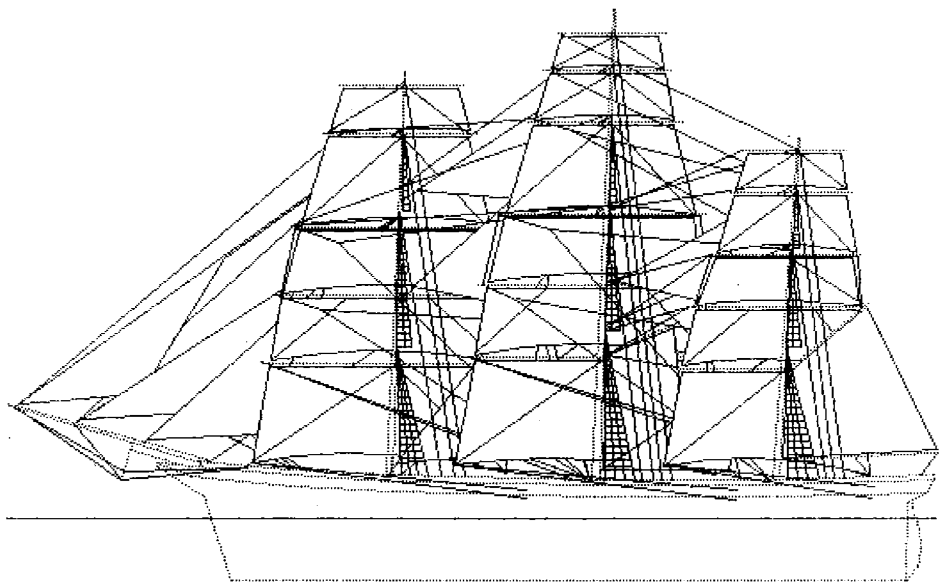
Obviously, some of the possibilities could be disastrous, but if the STOP and RUN keys won't fix it, STOPing the machine, pressing "SCRATCH A", EXECUTE and reloading the program will.

Running the Color Graphics Demo Examples

Short descriptions of the 36 Color Graphics Demo examples follow. Select the desired category from the six choices as previously described and proceed as explained. Notice that in addition to the written descriptions here, further explanation is presented on the screen as the various examples are accessed.

Chapter 2
Demo Examples

Introducing Color



Clipper Ship

(A1) Clipper Ship

This colored line drawing shows the rigging of the clipper ship "Cutty Sark". This ship has been restored and fully rigged, and may be viewed at its drydock in London.

If you wish to have a black and white copy of the picture, press the key labeled "DUMP", directly under the CRT. The graphics image will be output to the System 45C thermal printer. To see the sails identified, press the key under the label "SAILS".

The rigging of the Cutty Sark has been color coded as follows:

Cyan	=	Stays
Green	=	Halyards
White	=	Sheets
Yellow	=	Clewlines and Downhauls
Red	=	Course Sheets
Blue	=	Braces

(A2) 4913 Colors

When coloring areas, the System 45C uses groups of dots to create a large number of colors from the three primaries, red, green, and blue. The screen is divided into tiny 4 by 4 dot arrays, and any number of the dots can be turned on. If all 16 of the red dots are turned on, the color is a bright red. If only 4 of the 16 red dots are on, a much darker red results.

Including black, or no dots on, there are 17 steps available for each primary color. Mixing all three primaries gives 17x17x17, or 4913 colors.

(A3) Color Cube

The AREA INTENSITY statement directly controls the number of dots turned on for each of the primary colors in the tiny 4x4 arrays. For example, the statement "AREA INTENSITY 12/16, 4/16, 0/16" would turn on 12 red dots, 4 green dots, and no blue dots, out of the 16. This would result in an orange color.

To specify color in this way, it's helpful to picture a cube of colors, with each of the primaries along an edge of the cube. To save time in drawing the color cube, this demo will use only nine steps for each primary, showing 729 of the 4913 colors available.

(A4) Color Cylinder

The AREA COLOR statement allows you to specify color the way an artist does, without concern for the mixture of the primaries that make it up.

There are three fundamental attributes of color: hue, saturation, and luminosity.

The first attribute, hue, can be measured as the dominant wavelength. As a color changes from red to orange to yellow, it is varying in hue.

The second attribute is saturation, which is measured as purity of the color. As a color is changing from yellow to cream to white, the saturation is decreasing from 1 to .5 to 0.

The third attribute is luminosity, which is measured as the amount of light. To the eye, a pink cube maintains the same hue, red, and the same saturation, about .5, whether it is seen in bright sunlight or deep shade. As the color gets lighter or darker, its luminosity is changing.

On the color cylinder, hue goes circularly around the cylinder. Saturation varies from 0 at the center axis of the cylinder, to maximum 1, at the rim. Luminosity is the vertical axis, running from 0, or black, at the bottom, to 1, or full luminosity at the top.

(A5) Color Shading

Subprograms are very handy for doing repetitious tasks. Since they are independent entities, they may be called by different main programs, or even other subprograms, without worrying about whether variable names have been duplicated, etc.

This demo calls a subprogram to draw shaded boxes. Essentially the same box-making subprogram is used in the 3-D bar chart example, and in the architectural rendering example.

Each time the subprogram is called, the main program passes it some values to work with. In this demo, the size and location of the box, and its color are the passed parameters. The subprogram then computes the perspective, and draws the box.

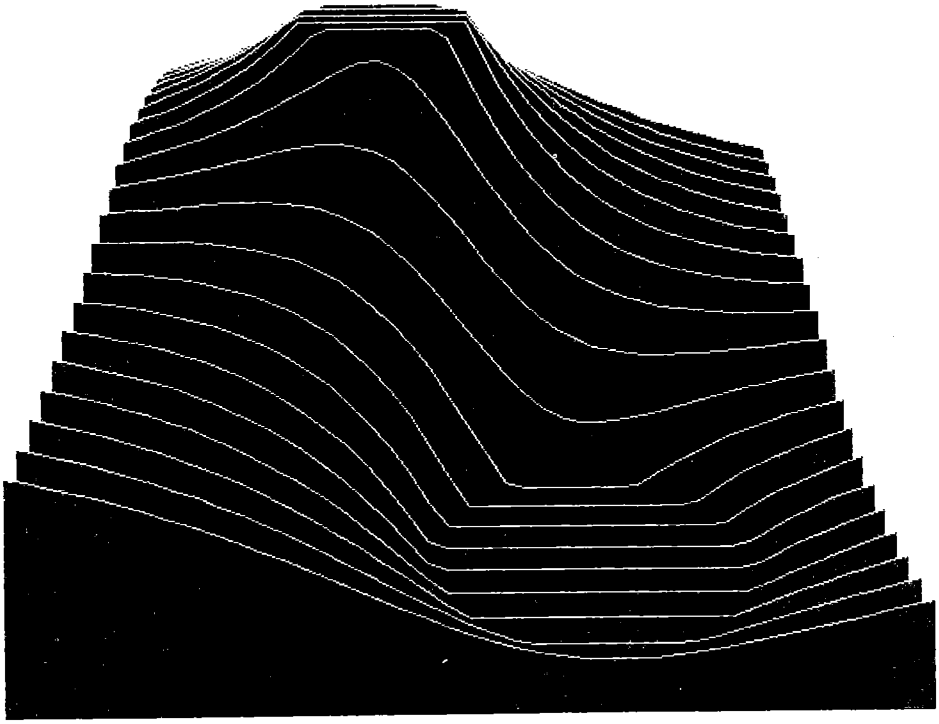
(A6) Mixing Light

From playing with our childhood watercolors, we know that mixing a yellow paint with a "turquoise" or cyan paint results in a green color. It is not so obvious that the paint is subtracting colored light before it reaches the eye.

The cells in our eyes respond only to the red, green, and blue content of colored light. (This is why a color TV set can create a satisfactory picture out of only these three primary colors.) The yellow paint is absorbing the blue light, and the cyan paint is absorbing the red light, leaving only the green to get to the eye.

In this demo, you can mix colored light directly, changing the amount of the red, green and blue primaries. You can demonstrate that what the eye sees as yellow is made up of lots of red, lots of green, and no blue.

Computing with Color



Opaque Planes

(B1) Colored Line

In this section, each of the examples uses a different technique to portray the values of the same function:

U=MAX(−.17,MIN(.21,((X−.9) ↑ 2+Y ↑ 2) ↑ .1−((X−.5) ↑ 2+(Y−.7) ↑ 2) ↑ .1))

In each case the expression is evaluated for every step in X and Y, and all computations are real-time.

In this, the first of these demos, the value of U is plotted by both the "altitude" of the line and the line color. By pressing the "NO COLOR"-"RESTORE COLOR" key, you can easily see how much more readable the color image can be, particularly in complex plots.

(B2) Cross-Sections

In this example, the same function is displayed by progressive cross-sections.

Each cross-section is somewhat like a bar chart, in that it is made up of small rectangles which vary in height and color according to the computed value of U.

Extensions of this technique, using very tiny rectangles, are especially valuable for the interactive interpretation of the extremely complex data found in oil exploration.

(B3) Opaque Planes

This example shows a very quick and easy solution to a common plotting problem: how to display a function plot without showing confusing hidden lines.

This method uses opaque planes of color simply to cover up what is behind them without doing any time-consuming "hidden-line" computation. For each plane, the expression is evaluated, and the area under the curve is filled with a solid color. Then the picture is re-scaled to bring the next plane a little closer, and the process is repeated as necessary.

(B4) 3-D Surfaces

Although the computation takes a little longer, a full 3-D perspective warped surface can be portrayed from any desired viewpoint. Just be sure to start plotting from the furthest part of the surface.

In this demo, the surface is viewed from below, which would not have been possible in the preceding example.

(B5) 3-D Prisms

The same function is here portrayed by the color and height of prismatic solids.

The "CHANGE COLOR" key switches the color combinations without re-plotting the image. This is accomplished by changing the colors assigned to each graphic memory plane. Ordinarily, memory #1 is assigned to "RED", memory #2 to "GREEN", and memory #3 to "BLUE". These assignments can be changed, however, without affecting any of the information being plotted into the graphic memory planes.

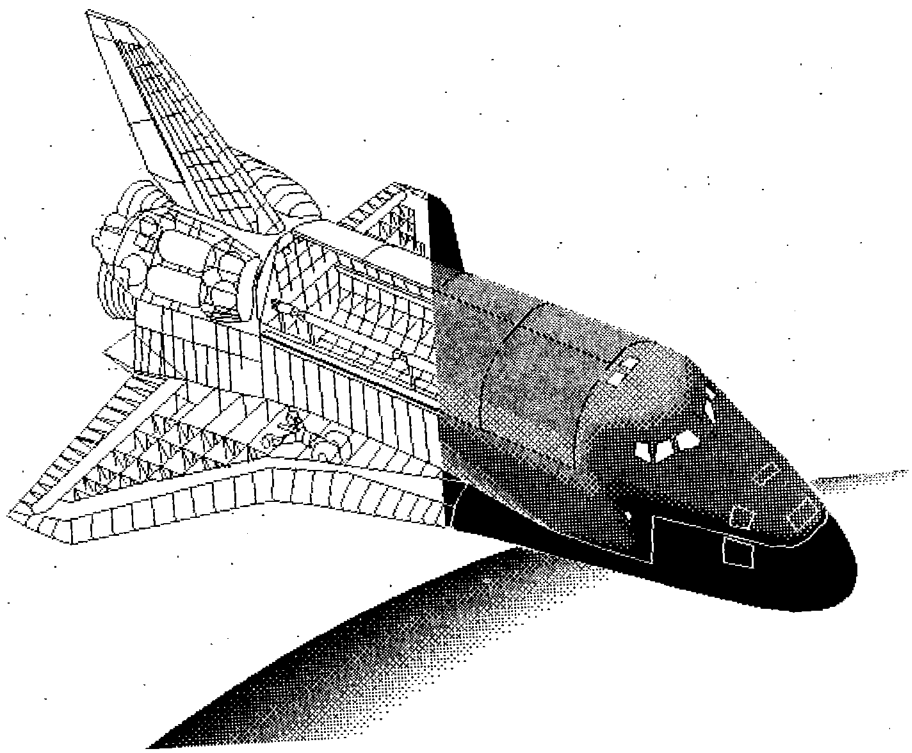
(B6) Color Plots

In this example, the results of the function are shown only by the color for each position of X and Y. Color plots of this kind are especially useful for rapidly exploring the effects of varying different parameters in a complex system of equations.

As in this demo, you can get a quick look to see if the current results are in the ball park. If so, you can use the graphics input device to select areas to be plotted in greater detail.

The more difficult the analysis and the more complex the data, the greater the advantage in using the eye's natural ability to quickly understand a vast quantity of graphic information.

Engineering Applications



Space Shuttle

(C1) Space Shuttle

Note

When the SPACE SHUTTLE demo is selected from the menu, there will be a noticeable pause before the menu is erased, due to the number of subprograms being initialized. Remember not to press the "SPACE SHUTTLE" key again during this interval, because the computer would log the keystroke, and service it later.

The internal structure is shown in the aft portion of the space shuttle, with components drawn in different colors to aid in identification. Press the "LABEL" key if you would like to see the component callouts. Pressing the "CLEAR" key will erase the callouts, but not the picture.

The plotting of the aft section has been slowed down for viewing. To see the maximum line plotting speed, select "FAST PLOT".

In the forward section of the shuttle, color is used to display the maximum re-entry temperatures for different portions of the spacecraft. Pressing the "TEMPS" key will display the corresponding temperature callouts. These are also erased by the "CLEAR" key.

(C2) 3-D Rotation

In this example, real-time computation of 3-D perspective uses the powerful matrix handling extensions of System 45C BASIC.

Mathematically, moving and rotating an object in space can be modeled by a series of matrix multiplications of four dimensional arrays. Perspective is added by dividing by the distance from the viewer, so things that are twice as far away will appear half as big.

If you wish to see the object in this demo displayed from a particular viewpoint, press "INPUT #", and then input the desired angles. When you exit this demo, the computer could be completing a large matrix multiplication. If so, it may be several seconds before it can respond to the keystroke.

(C3) Field Strength

This plot displays the relative field strength of a particular configuration of a two element dipole antenna array. This field pattern varies both with azimuth, running from 0 degrees around the compass to 360 degrees, and with elevation, plotted from 90 degrees at the zenith to 0 degrees at the horizon.

As shown by the key, color portrays the field strength, with the strongest signal shown as white. All computation is real-time.

(C4) Stress Analysis

The diagram shows three kinds of load applied to a beam fixed at both ends: a point load, a distributed load, and an applied moment. By using the appropriate keys, you can see the effects of each load separately, or the sum of all three. In each case, the deflection of the beam is plotted in yellow, the shear in red, and the moment in blue.

You may also change the value of any of the given parameters by pressing the "INPUT" key. When the changes are complete, select "INPUT FINISHED", and the diagram will be re-drawn with the new values. The results of the new loadings will now be computed in response to the corresponding keys.

(C5) IC Wafer Yields

In the production of integrated circuits, graphic analysis is an effective method of improving wafer yields. The first step of the analysis is the tabulation of the raw data, in this case from a run of 18 wafers. The number of successful chips (0-18) at each location is mapped. By pressing the "NO COLOR"-"RESTORE COLOR" key, see how helpful color is in sorting out the yield pattern.

The "RAW DATA (COLOR)" key will display the same information by color only.

A crucial part of the analysis is distinguishing the wafer zones subject to improvement from the locations that will never yield good chips due to flaws in the mask. The "SMOOTHED (PERCENT)" key will display the average of all the non-zero yields immediately surrounding each location, expressed as a percentage.

The same information shown by color only, as with the "SMOOTHED (COLOR)" key, clearly shows the zonal information desired. To an experienced analyst, these patterns are diagnostic of the wafer-making processes.

(C6) Floor Plan

This demo shows some of the ways you can interact with an office floor plan using the graphics input device.

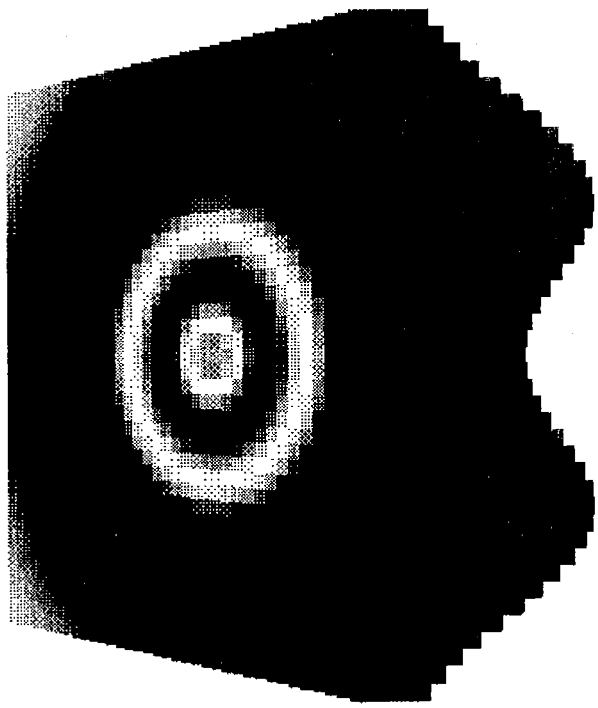
It will display the basic floor plan, modular grid, lighting plan, and furniture layout as requested from the menu. You may also digitize the lower left and upper right corners of areas to be displayed at a larger scale.

In the "ADD FURN." mode, another menu will enable you to select a type of furniture, and then pick a suitable location for it on the plan. If, for example, a chair isn't oriented in the right direction, select "ROTATE", and all the source pieces will be rotated 90 degrees.

If it weren't for the limitations of keeping all 35 other demos in memory at once, this example could be expanded to include moving and deleting furniture, "dragging" furniture around with the graphics input device, rotations of any angle, and positioning furniture at large scale.

Other helpful extensions of this program would be electrical, heating, and air conditioning layouts, and automatic inventory and pricing of existing and required furniture.

Scientific Applications



Hydrogen Atom

(D1) Hydrogen Atom

The desktop computer is a powerful tool for the interactive analysis of scientific data. Color graphics are particularly suitable for portraying complex functions in a way that can be quickly and clearly understood.

This three-dimensional color plot illustrates one technique for visualizing complex scientific data. In this case, the charge density of an excited state of the hydrogen atom is given by the function f(R)=R ↑ 2★(27 − 18★R + 2★R ↑ 2) ↑ 2★EXP(− 2★R/3) where R=SQR(X ↑ 2+Y ↑ 2). By stepping through the values of X and Y, the computer calculates the result of this expression for each step.

In addition to the numeric output, this example portrays the results by the color and length of the bars. As each cross-sectional slide is completed, the drawing is re-scaled so that the next layer will appear a little closer.

(D2) Acid Rain

Even without numbers, these maps would immediately communicate the dramatic increase of the acidity of rainfall in the Eastern United States. The acids dissolved in the rain are largely from sulfur and nitrogen oxides emitted into the atmosphere by fossil fuel combustion and industrial processes. In spite of efforts to curb emissions, the problem is expected to get worse with increasing reliance on coal as a source of energy.

These maps were input using the 9874 digitizer. On the System 45C, the plotting instructions can be saved in an array, and quickly re-plotted at any time.

(D3) X-Ray Astronomy

This "false-color" plot shows the intensity of x-radiation in the region surrounding the giant elliptical galaxy, M87. X-ray observations must be made above the atmosphere, and in this case the data was returned by a rocket-borne x-ray telescope. The more intense the measured radiation, the brighter the color in this plot. The visible galaxy is located in the center of the picture, and is enveloped by a vast xray-emitting cloud, about a million light-years in diameter.

(D4) Jupiter Data

Jupiter is the largest planet in the Solar System, and the Great Red Spot is one of its most prominent features. The visible surface of Jupiter is not a solid surface at all, but is the top of opaque cloud systems circling the planet in colored belts and zones. The Great Red Spot can be likened to a massive, nearly permanent hurricane, larger in diameter than the Earth.

As the unmanned Voyager spacecraft flew by Jupiter, they transmitted a wealth of data recorded by many instruments. One of the experiments resulted in these temperature cross-sections through the region of the Great Red Spot.

By using the soft keys, you can examine the cross-sections in several combinations. Temperatures are in degrees Kelvin, as shown in the color key. The Great Red Spot is at the intersection of the two planes, and can be seen to be considerably cooler than the surrounding atmosphere.

(D5) Ice Movement

As part of a joint US and Canadian research program to explore arctic ice dynamics, a group of unmanned drifting buoys were tracked by the Interrogation, Recording, and Location Subsystem on the Nimbus-4 weather satellite. As the data is plotted, sudden changes in the velocity of individual buoys show the ice being driven by storm winds. The overall clockwise rotation traced by the cumulative tracks reveals the existence of a circular Arctic Ocean current, the Beaufort Gyral Stream.

This example uses the System 45C's multiple plotter capability to create the updating display. Ordinarily, the three graphic memories are storing the red, green, and blue information to generate the color CRT picture. In this case, however, each memory is designated as a separate plotter, and assigned its own display color (one of eight colors possible).

The first plotter is turned on, assigned the color "cyan", and given the instructions to draw the permanent base map. Then this plotter is turned off, so that it will not be affected by any subsequent drawing instructions.

The second plotter is assigned the color "yellow", and is turned on at each update in order to add to the cumulative track. It is then turned off again.

The third plotter is assigned the color ''red'', and is used to portray only the current buoy positions and velocities at each update. The first step is to turn on the plotter and erase the old buoy positions. (Since the other two plotters are turned off, they will not respond to the erase instruction). Then the new positions are drawn, and this plotter is turned off to complete the cycle.

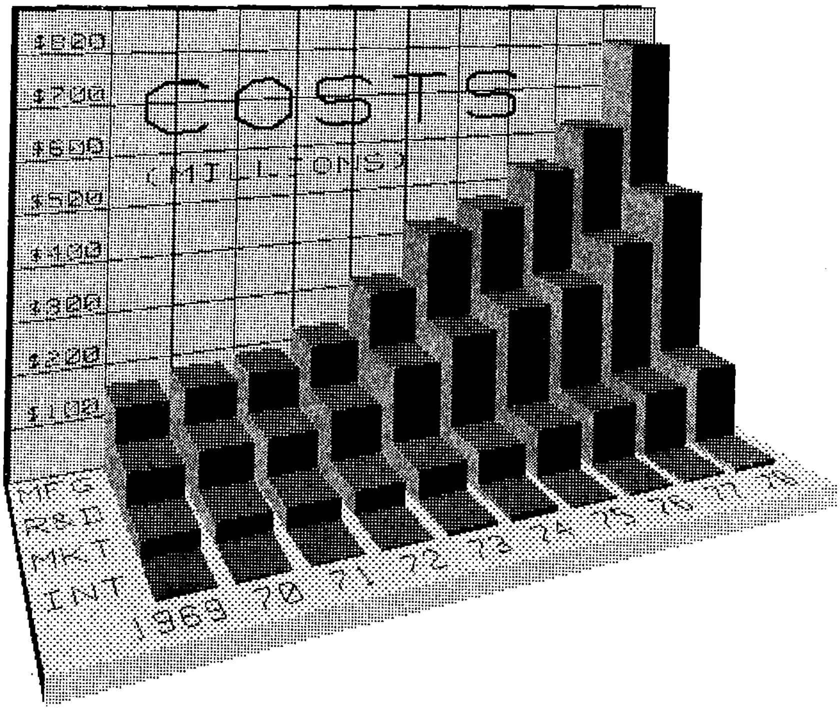
Variations of this technique are useful in many applications. Each plotter can be independently scaled, and made visible or invisible. It is even possible to draw on a plotter while it is invisible, or ''black'', and then instantly assign a visible color. Thus, one memory plane could show an aircraft wing structure, while the other two could alternate in showing the positions of a retracting landing gear.

(D6) Light Pen/Tablet Orrery

You may have heard it said that all of the planets will be on the same side of the sun in 1982. The statement is sometimes accompanied by speculation that California will fall into the sea.

The light pen/tablet orrery reveals that having all the planets on the same side of the sun is a far cry from having all the planets lined up in a row. While it cannot predict the future of California, the orrery does show that the Earth has survived far more spectacular planetary alignments in the past.

Management Graphics



3-D Bar Chart

(E1) 3-D Bar Chart

This three-dimensional bar chart uses solid blocks of color to portray the data. The program looks up the data for each block, and computes the perspective for a block of the proper height. There are four rows of ten blocks, and the corresponding values are stored in four DATA statements in the program. If you are adventurous, you can alter the program to portray your own data by using the following procedure. (While you will alter the program in the computer memory, the original version will still be on the tape. If you find that you need to re-load the program, press the STOP key,"SCRATCHA",the EXECUTE key, then LOAD "DEMO", and finally the EXECUTE key.)

Finding the Data Statements

To get the picture out of the way, type "EXIT GRAPHICS", then press the EXECUTE key. Next, type "EDITLINE E1", and EXECUTE. You are now looking at the actual program listing, and the line in the middle of the screen that starts "E1: SUB" is the first line of the 3-D bar chart subprogram. About seven lines below "E1:" are four lines that begin with the DATA statement. Press the up-arrow key that is just above the HOME key, and the display will scroll up. Because the program listing is so long, it will scroll quite slowly. Continue to scroll until you have the first DATA statement in the middle line with the flashing underline cursor at the right.

Note

While in the program editing mode, avoid pressing the DELETE LINE key, (DEL LN), unless you want a program line to immediately disappear.

Altering the Data

With the DATA line in the middle, you can use the left- and right-arrow keys to move the cursor under any number you wish. You may then type a new number over it. Or, you can move the cursor to the left, and retype the entire line. Just be sure that there are exactly ten numbers to the right of the DATA statement, separated by nine commas. Spacing doesn't matter, as spaces are ignored. This program assumes that the values range from 0 to about 850, so for numbers outside that range, you're on your own. If you have made a mistake, and want the original program line back, you can still get it. Simply use the arrow keys to scroll down and back up one line.

Storing the New Data Line

When you are satisfied with your new DATA line, press the STORE key. Unless the computer calls your attention to an error, it will place YOUR line in the program, and scroll the display up one line. Remember, if you haven't pressed the STORE key, the computer won't know that you want the new line to go into the program.

Leaving Editing Mode

When you have stored all four new DATA lines, press the CLEAR key. To get the picture back, type "GRAPHICS", and press EXECUTE. Although your new data is in the program it hasn't yet been used to redraw the picture. Pressing the "RETURN" soft key will return you to the menu. If you now select "3-D BAR CHART", the picture will be redrawn, with the height of the plotter bars corresponding to YOUR data.

(E2) Prism Map

The SCALE statement is very helpful in creating three-dimensional prism maps, like this one showing electronic equipment markets in Europe.

The SCALE statement specifies the horizontal and vertical scales of a plot. For example, "SCALE 1972,1980,0,5000" would show that the plot extended from 1972 on the left to 1980 on the right, and from 0 at the bottom to 5000 at the top.

In this case, a standard map of Europe was quickly input on the digitizer, and the SCALE statement was used to compress the vertical dimension, giving the illusion of a perspective map. The statement again comes in to play when the picture is drawn, to give the illusion of a vertical stack for each country. For each layer, the program changes the values in the SCALE statement, inching the drawing a little higher on the CRT. The data is then checked, to see whether to redraw the country at this "altitude", adding another layer to the stack.

(E3) Area Color

This chart uses areas of color to plot the data. If you wish, you may modify the DATA statements in this example, using the procedure outlined in section (E1), the 3-D bar chart. In this case, however, type "EDITLINE E3", and press EXECUTE.

(E4) Bar Chart

A standard two-dimensional bar chart is readily plotted using a pair of BASIC statements. The first is a MOVE to the desired location, expressed in your own scaled units. To draw the first bar on this chart, the simplest statement would be: "MOVE 69,0". (Meaning across to 1969, and up to the zero line.)

The second statement is RECTANGLE, which either draws a rectangular outline in the current PEN color, or fills it in with the current AREA COLOR. The width of the rectangle is specified first, then the height. The statement "RECTANGLE 1,Data,FILL" would create a colored bar one year wide, with its height determined by the value of the data.

(E5) Pie Chart

As unlikely as it may seem, this pie chart is drawn using the POLYGON statement. The circle is approximated by a polygon of many sides, usually 60 or more. If you wish to work directly in degrees, you can even use a 360 sided polygon, although it will be considerably slower. There is an excellent explanation of circle, polygon, and pie chart techniques on page 40 of your System 45C Color Graphics Manual.

(E6) Interactive Bar Chart (Graphics Input Device Example)

In this example, you will be able to create a high quality bar chart in about one minute, using the graphics input device.

First, use the graphic input device to select "BASE COLOR" from the menu, and the CRT will fill with horizontal bands of color. To indicate your choice, place the tip of the light pen or the tablet cursor on the color desired, and press the key on the light pen (or the tip switch on the stylus).

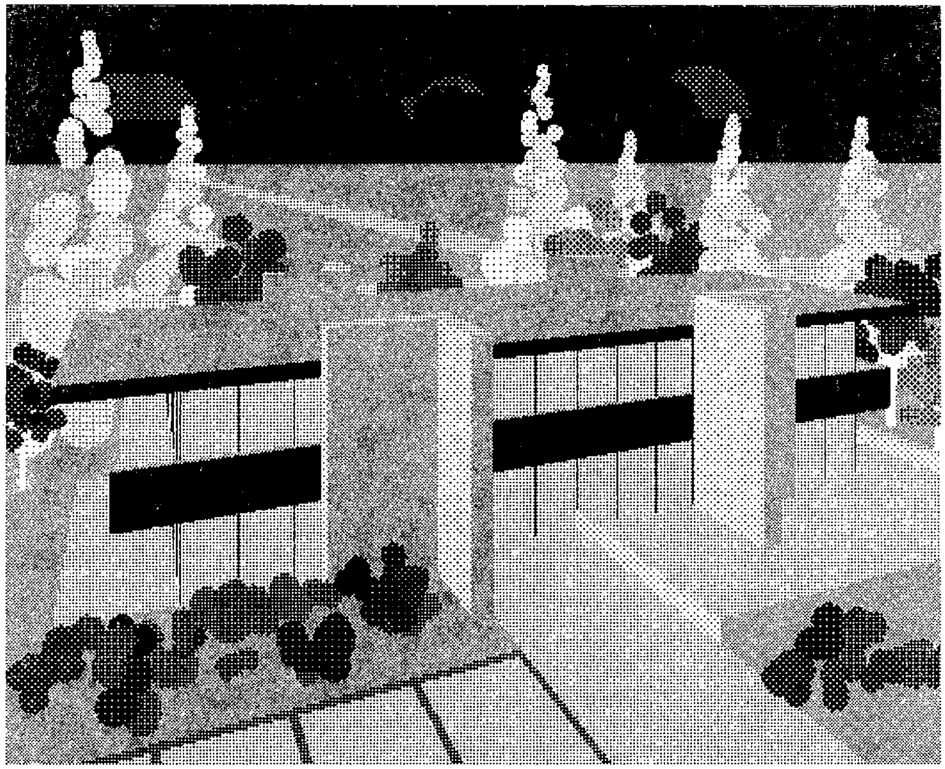
Next, select "COLOR RANGE" from the menu. Six color ranges, each beginning with your previously selected base color at the bottom, appear in vertical groups. Select the group of your choice by placing the light pen or tablet cursor on any color of the group.

Now you are ready to specify the "TYPE COLOR", again from the menu. This time, another menu will appear, showing the different colors available for the labels. Again, choose with the graphics input device.

Here's the fun part - entering the data with the graphics input device. Select "MAKE BAR" from the menu, and the program will draw a blue grid on the right. Whenever you bring the light pen or tablet cursor near the blue grid, your coordinates will be displayed. This is a twelve-month bar chart, so JAN is to the left, DEC to the right. The numbers, (in millions), are lower toward the bottom, and higher toward the top. See if you can find the point for JAN, 4.3 million. If it misses as you press the light pen button or stylus tip switch, just do it again. The date for a full year can be entered in a remarkably short time. When you are done, select "FINISHED".

Finally, select "PLOT ALL" from the menu, and your bar chart will be drawn to order. If you want to change your base color, color range, or type color, you may do so without having to re-make the bars. Just make the new color selections, and "PLOT ALL" again. With a little practice, you will be able to complete the whole process, from beginning to end, in less than a minute.

Advanced Graphics



Architecture

(F1) Architecture

This program draws a three-dimensional architectural rendering. To avoid "hidden surface" computation, it starts drawing with the most distant objects, and works closer. Unlike the building contractor, it will have to plant the trees in back before it can begin constructing the building.

In essence, the program calls for a pine tree at 40 feet north and 70 feet east, etc. The building is built up of boxes of different sizes and colors. Even the roads and walks are boxes, of zero height.

Since the data base is three-dimensional, the site plan can be drawn from different viewpoints. (Press the "SECOND VIEW" key.)

In more complex views, such as interiors, it may be difficult for a program to evaluate which of two objects is in front of the other. With an interactive computer, a quick solution is to have the program make a guess, and have the operator tell it if it has made a mistake.

(F2) CIE Diagram

The chromaticity diagram is a map of the color response of an idealized human eye. Any color that the eye can see has a location on the map within the oddly shaped curve. The vertical coordinate is the percentage response of the eye's green receptor, and the horizontal coordinate is the response of the red receptor.

The chromaticity coordinates of the System 45C red, green and blue CRT phosphors form the vertices of a triangle. Each of the 4913 colors that can be mixed from these primaries is shown at its proper location within the triangle.

(F3) Computer Mapping

This computer map of the Chincoteague salt-marsh complex in Virginia was produced from data transmitted by Earth Resources Technology Satellites.

The data was evaluated by an algorithm for automatic classification of vegetation using the ERTS ANALYSIS system at the Goddard Space Flight Center.

Computer mapping techniques are also being applied to land use surveys, mineral exploration, environmental monitoring, and agricultural, forestry and rangeland management.

(F4) 3-D Wire Frame

This wire frame drawing of a piping schematic is composed of 400 lines, and is drawn in full three-dimensional perspective.

The moves and rotations are accomplished by a series of matrix multiplications. Additional matrix multiplications could be performed on portions of a data base, to portray the movements and rotations of subcomponents. Thus, even the complex articulation of a retractable landing gear reduces to a series of matrix operations.

In this example, the viewpoint is being changed for each drawing, and all computation is performed real-time.

(F5) Topography

The topography of a mountainous terrain is modeled here by a warped surface made up of many small triangles. The slope of each triangle is computed, real-time, from the data base altitudes, and a color shade is assigned according to the direction of the light source. If the bottom surface is showing, it is colored blue.

The data base was prepared by entering the elevations shown on topographic maps, sampled on a rectangular grid.

(F6) Gravity Game

Space Station X is counting on you, and you have only 15 supply capsules on board. Can you find a route through the complex gravity field surrounding these planets?

To pick a launch direction, first acquire the tracking cross with the graphics input device. Move it with the pen or stylus until it is some distance from your space ship, and press the key on the light pen or stylus tip switch. A tiny white cross will mark the position of your aiming point.

Although the supply capsule will be launched at your aiming point, it will be pulled this way and that by the gravitational fields of all the planets. It can go a little ways off the screen and still return, but if it leaves the system or impacts a planet you will hear it, and the tracking cross will reappear over your ship.

Your objective is to land a capsule at Space Station X, and not crash one into your own ship.

Actually, some experienced players reverse the game, and take turns trying to return a capsule to the launch ship without hitting the space station. This is usually difficult, and sometimes impossible, as it may require looping around several planets.

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