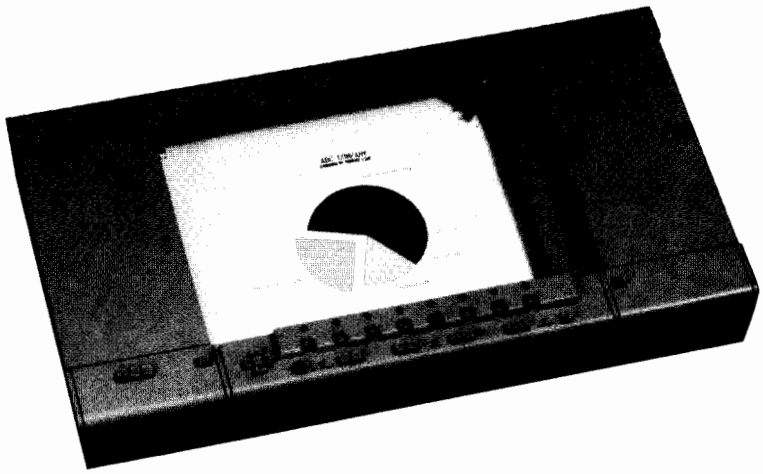
7220C Graphics Plotter and 7220T Graphics Plotter Operating and Programming Manual Using HP-GL Instructions

RS-232-C/CCITT V.24



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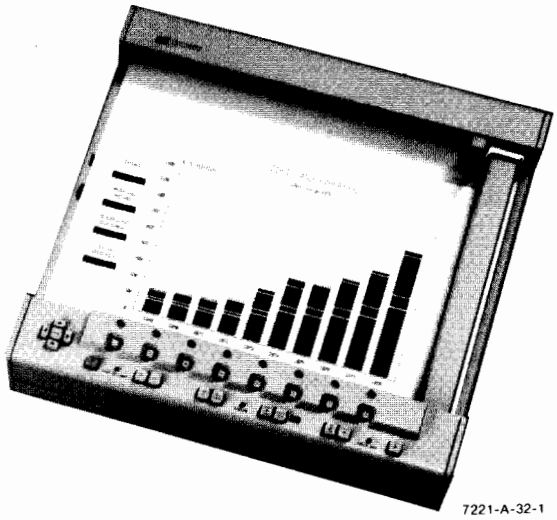
HP 7220T GRAPHICS PLOTTER



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HP 7220C GRAPHICS PLOTTER

16399 W. BARNARDO DRIVE, SAN DIEGO, CALIFORNIA 92127 February 1981

Manual Summary

Chapter 1: General Information

Provides information about setting up the plotter, checking normal operation, controls and indicators, periodic maintenance, and simple interface procedures.

Chapter 2: Handshake Protocol

Explains the function of handshake protocol and the four types of handshakes, together with the terms used in defining handshakes.

Chapter 3: Device Control Instructions

Describes the device control instructions used to establish the handshake protocol.

Chapter 4: General Programming Instructions

Introduces the 7220 HP-GL instruction set, the instruction syntax, and the Default and Initialize instructions.

Chapter 5: Scaling

Describes the plotting area, plotter and user units, and the instructions that enable you to scale the plotting area into user units.

Chapter 6: Plotting

Describes the instructions used in vector plotting. Included are pen control instructions, plot absolute or relative instructions, arc and circle instructions, and velocity control instructions.

Chapter 7: Plot Enhancement

Describes the instructions used to enhance plots. Included are instructions to draw X- and Y-axis tick marks, vary tick lengths, draw symbols in graph plots, and select line types.

Chapter 8: Lettering

Describes the character sets and how to select them. Included are instructions to vary the size, direction, and slant of characters and to create characters of your own design.

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Manual Summary (Continued)

Chapter 9: Additional Plotter Control

Describes additional plotter control instructions which provide for outputting information, defining the error mask, and the plotting area or "window."

Chapter 10: Digitizing

Describes the instructions that enable you to use the plotter as a digitizer.

Chapter 11: Automatic Paper Advance

Describes the instructions for the 7220T which enable you to advance and cut the paper.

Chapter 12: Putting The Commands To Work

Develops a complete plot using both escape code sequences and HP-GL instructions.

Chapter 13: Operating Configurations

Describes control line protocol, error transmissions, baud rates, and installation/operating instructions for using the plotter with host computers and terminals.

Appendix

Provides reference material on error messages, default conditions, instruction syntax, and ASCII character codes.

Table Of Contents

Chapter 1
General Information

Introduction

This manual contains interfacing and programming information for the Hewlett-Packard 7220C and 7220T Graphics Plotters. The manual is organized into thirteen chapters and an appendix as follows:

Chapter 1 – General Information
Chapter 2 – Handshake Protocol
Chapter 3 – Device Control Instructions
Chapter 4 – General Programming Instructions
Chapter 5 – Scaling
Chapter 6 – Plotting
Chapter 7 – Plot Enhancement
Chapter 8 – Lettering
Chapter 9 – Additional Plotter Control
Chapter 10 – Digitizing
Chapter 11 – Paper Advance Features – 7220T
Chapter 12 – Putting The Commands To Work
Chapter 13 – Operating Configurations
Appendix

NOTE

Throughout this manual, the term computer is used to denote a computer, controller or calculator with RS-232-C or CCITT V.24 I/O interface. All references to RS-232-C apply equally to the European standard CCITT V.24. Unless specified as applying to one model only, the term 7220 plotter is used to denote both the Model 7220C and 7220T Graphics Plotters. Chapter 11 explains the instructions unique to the 7220T.

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Before using this manual you should be thoroughly familiar with the computer you intend to interface with the 7220C or 7220T Plotters through an RS-232-C cable.

The following conventions apply to the HP-GL command syntax used within this manual:

DOT MATRIX – All items in dot matrix are required exactly as shown.

[ ] or ( ) – All items in brackets and/or parentheses are optional.

◯ – All items in circles are required keyboard entries either as the character shown or as the decimal equivalent value of that ASCII character.

The following conventions apply to the program listings contained in this manual:

DOT MATRIX – All characters in dot matrix must be sent to the plotter exactly as shown.

NORMAL FONT – All characters in normal font are either BASIC program lines – which are not sent to the plotter **or** represent variables and the punctuation delimiting them. Variables must be sent to the plotter in an acceptable format. Formatting statements are computer dependent and are not included in this manual.

Certain syntax conventions are used when discussing device control instructions. These syntax conventions are listed and explained below:

< > – Numeric values are shown between angle brackets. These can be the decimal equivalent of the ASCII character <ASC> or decimal integer values such as block data size or turnaround delay time <DEC>.

[ ] or ( ) – Optional parameters are shown between square brackets and/or parentheses.

{ } – Braces indicate parameters which may be repeated.

( ) . . . ( ) – Dots between pairs of parentheses indicate parameters which may be more than one character (i.e., a string of characters).

ESC . ◯ – The three character escape codes used to initiate all device control instructions. The ESC and . ASCII characters are used for all device control instructions. The ◯ ASCII character is an alphabetic, punctuation or sign character which identifies the specific device control instruction to be executed.

Description

The Hewlett-Packard 7220 is a microprocessor-based RS-232-C compatible plotter that produces high quality, multicolor graphic plots on any size chart up to 280 × 432 mm (ISO A3). The 7220 offers exceptional line and character quality with addressable moves as small as 0.025 mm (0.001 in.). Forty-seven different instructions are built in to equip the plotter with such capabilities as point digitizing, labeling, character sizing, arcs, circles and window plotting. You can connect the plotter to your RS-232-C compatible computer using a standard RS-232-C interface cable. Short, easily understood HP-GL commands and the RS-232-C interface enable you to start plotting with only a minimum of programming experience.

Trace identification is enhanced by the use of the 7220's automatic selection of any of eight pens through either program control or front panel pushbuttons. Seven different dashed-line fonts, symbol mode plotting, and user-defined characters aid in trace identification.

Faster, high quality plotting is another contribution of the 7220. The pen speed is programmable to any one of 36 speeds from 10 mm/s to 360 mm/s. This feature enables you to produce high quality graphics on standard chart paper as well as other media.

Annotation can be easily done using any of five character sets, including three European sets. Text can be written in any direction, with or without character slant, and in varying sizes. You can even design your own characters.

The 7220 is designed to be especially useful in the areas of business graphics, statistics, medicine, numerical control, surveying, and engineering design. Whether tabulated, measured, or computed data, the 7220 enables you to quickly prepare multicolor plots of excellent line quality and high resolution.

The 7220T, with automatic paper feed, cutting and plot stacking, allows full programmable unattended operation. Three added HP-GL instructions provide the program control of these additional features of the 7220T.

Unpacking and Inspection

WARNING

The 7220T is a large, heavy device (weight 66 lbs.). Do not attempt to unpack it or move it to a different location alone.

The 7220T plotter should be moved or unpacked by two people, one positioned at each end of the plotter. Each person should grasp the lower support bars of the plotter near the rubber feet and lift.

The individual parts of your plotter were thoroughly inspected before the unit was shipped to you, and the instrument should be in good operating order. Carefully inspect the plotter and accessories for any physical damage sustained in transit. Notify the nearest HP Sales and Service Office and file a claim with the carrier if the unit is received in a damaged condition.

Please check to ensure that you have received all of the items that should accompany the plotter. Refer to the table of Accessories Supplied and check that all accessories are present.

If you have any difficulties with the plotter, if it is not operating properly, or if accessories are missing, contact the nearest HP Sales and Service Office.

NOTE

Retain the original packing materials and carton. If the plotter must be shipped, this will save having to order new packing materials and a carton from HP.

Accessories Supplied

The following items are supplied with each 7220 plotter:

Item	Quantity	Part Number
Operating and Programming Manual	1	07220-90003
Pocket Guide	1	07220-90005
Power Cord (appropriate cord supplied based on destination of unit)		
Male-To-Male Interface Cable (RS-232-C/CCITT V.24)	1	8120-3258
Dust Cover 7220C or Dust Cover 7220T	1	9222-0742 9222-0741
Digitizing Sight	1	09872-60066
Paper Tray 7220T only	1	17072-60251
Supplies Kit* 7220C — includes:	1	
Plotter Paper, 8½ × 11 in. blank (pkg of 300 sheets)	1	9280-0517
Plotter Paper 11 × 16½ in., blank (pkg of 300 sheets)		9280-0518
Fiber Tip Pens, package contains:		
5 black pens, 0.3 mm line width	1	5060-6787
5 black pens, 0.7 mm line width	1	5060-6890
4 pens, 0.3 mm line width, 1 each of black, red, blue, and green	2	5060-6810
4 pens, 0.7 mm line width, 1 each of black, red, blue, and green	1	5060-6858
6 pens, 0.3 mm line width, 1 each of burnt orange, lime green, gold, turquoise, violet, and brown	1	5060-6894
6 pens, 0.7 mm line width, 1 each of burnt orange, lime green, gold, turquoise, violet, and brown	1	5060-6895
Supplies Kit* 7220T — includes: Same as 7220C Supplies Kit *except* Roll Paper (English), 200 ft., perforated at 11 in. replaces 8½ × 11 in. blank paper.	1	9280-0493

*Metric paper may be supplied with the plotter based on destination of unit. This will result in replacement of 8½ × 11 in. paper by A4 size 210 × 297 mm (9280-0519) and English roll paper by metric roll paper, 61 m perforated at 297 mm (9280-0494).

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Accessories Available

The following items are also available and can be purchased using the appropriate part number:

Item	Part Number
Plotter Pens, fiber tip	
Package of 5 red pens, 0.3 mm line width	5060-6784
Package of 5 red pens, 0.7 mm line width	5060-6893
Package of 5 blue pens, 0.3 mm line width	5060-6785
Package of 5 blue pens, 0.7 mm line width	5060-6891
Package of 5 green pens, 0.3 mm line width	5060-6786
Package of 5 green pens, 0.7 mm line width	5060-6892
Package of 5 black pens, 0.3 mm line width	5060-6787
Package of 5 black pens, 0.7 mm line width	5060-6890
Four-color Pack, 0.3 mm line width	5060-6810
1 each red, green, blue, black	
Four-color Pack, 0.7 mm line width	5060-6858
1 each red, green, blue, black	
Six-color Pack, 0.3 mm line width	5060-6894
1 each burnt orange, lime green, gold, turquoise, violet, brown	
Six-color Pack, 0.7 mm line width	5060-6895
1 each burnt orange, lime green, gold, turquoise, violet, brown	
Plotter Paper	
10 × 15 in. grid area, 10 grids/in., 100 sheets	9270-1004
7 × 10 in. grid area, 10 grids/in., 100 sheets	9270-1006
250 × 380 mm grid area, 1 grid/mm, 100 sheets	9270-1024
180 × 250 mm grid area, 1 grid/mm, 100 sheets	9270-1023
Semi-log:	
10 in. × 2 cycle plot area, 100 sheets	9280-0159
10 in. × 3 cycle plot area, 100 sheets	9280-0160
2 cycle × 15 in. plot area, 100 sheets	9280-0169
3 cycle × 15 in. plot area, 100 sheets	9280-0168
Log-log:	
2 cycle × 3 cycle plot area, 100 sheets	9280-0167
3 cycle × 2 cycle plot area, 100 sheets	9280-0165
3 cycle × 4 cycle plot area, 100 sheets	9280-0171
Blank, 100 sheets 11 × 16½ in.	9280-0180
Blank, 300 sheets 11 × 16½ in.	9280-0518
Blank, 300 sheets 8½ × 11 in.	9280-0517
Blank, 300 sheets ISO A4 (210 × 297 mm)	9280-0519
Roll: English 200 ft. (61 m) perforated for 11 in. width	9280-0493
Metric 61 m (200 ft.) perforated at 297 mm	9280-0494
Overhead Transparency Kit (includes)	17055A
Package of 4 pens, 0.3 mm line width, 1 each red, green, blue, black	5060-6818
Package of 4 pens, 0.6 mm line width, 1 each red, green, blue, black	5060-6819
Package of 4 pens, 0.3 mm line width, 1 each black, orange, brown, violet	5060-6834
Package of 4 pens, 0.6 mm line width, 1 each black, orange, brown, violet	5060-6835
Solvent 29.6 ml (1 fl. oz.)	5060-6828
100 sheets transparency film (kit includes two packages)	9270-0639

Accessories Available (Continued)

Item	Part Number
Overhead Transparency Pens, single color packages	
Package of 5 black pens, 0.3 mm line width	5061-5010
Package of 5 black pens, 0.6 mm line width	5061-5020
Package of 5 red pens, 0.3 mm line width	5061-5012
Package of 5 red pens, 0.6 mm line width	5061-5022
Package of 5 green pens, 0.3 mm line width	5061-5015
Package of 5 green pens, 0.6 mm line width	5061-5025
Package of 5 blue pens, 0.3 mm line width	5061-5016
Package of 5 blue pens, 0.6 mm line width	5061-5026
Soft Carrying Case 7220C only (not suitable for shipping)	1540-0480
Interface Cables, ROMs and Software (see your HP sales representative)	—
Service Manual 7220/7221C/T	07220-90004
2K Buffer Expansion Kit (includes 4 sockets, 4 RAMs and installation instructions)	07221-60600

Additional plotter supplies are available from your local Hewlett-Packard Sales and Service Office. Just ask for a copy of the Computer Supplies Catalog (5953-2450) which is a complete listing of supplies for Hewlett-Packard computers and plotters.

Grounding Requirements

To protect operating personnel, the National Electrical Manufacturers' Association (NEMA) recommends that the plotter be properly grounded. The plotter is equipped with a three-conductor power cable which, when connected to an appropriate power receptacle, grounds the plotter. To preserve this protection feature, do not operate the plotter from an ac power outlet which has no ground connection.

Power Requirements

The 7220 plotter has the following power requirements:

- Line Voltage: 100 V ~ +5%, −10%
  120 V ~ +5%, −10%
  220 V ~ +5%, −10%
  240 V ~ +5%, −10%
- Line Frequency: 48 to 66 Hz, single phase
- Maximum Line Current: 1.3 A @ 100 V
  1.1 A @ 120 V
  600 mA @ 220 V
  550 mA @ 240 V
- Consumption: 100 Watts maximum

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Operator Maintenance

Maintenance of the plotter is limited to a periodic cleaning of the external surfaces, electrostatic paper hold-down surface, pen stalls, and air filter. Cleaning intervals are determined by the type of operation, local air contamination, and climatic conditions.

WARNING

Disconnect the plotter from the power source prior to performing any maintenance. When cleaning, apply water using a lint-free tissue. DO NOT allow water to run onto electrical components and circuits or through openings in the enclosure as it may create a shock hazard.

Scratches or punctures in the electrostatic paper holddown surface may expose high voltage conductors. Plotters damaged in this manner should not be operated.

General Cleaning

Clean the outer surfaces as follows:

a. Blow away dust accumulation, using compressed air if available.

b. Clean the outer surface of the instrument with a damp sponge or cloth. Use a mild soap and water solution if necessary. Wipe dry after cleaning.

Electrostatic Paper Hold-down Surface Cleaning

Dust and other contaminants will lower the paper holding capability. Although pen ink will not affect hold-down performance, it may be desirable to remove ink stains as well.

Cleaning moderate contamination can be accomplished as follows:

a. Prepare a mixture of 50% isopropyl alcohol and 50% water by volume.

b. Apply the alcohol/water mixture to the surface using a lint-free tissue. Immediately wipe any moisture from the surface. Never let any liquid stand on surface as it may become permanently damaged.

If the surface cannot be easily cleaned with the alcohol/water mixture, cleaning can be accomplished as follows:

a. Select a clean, lint-free cloth that will not scratch the surface.

b. Remove transparency ink with solvent (HP 5060-6828) and dry thoroughly before continuing the cleaning process.

c. Dampen the cloth with warm water or alcohol and apply a light amount of cleanser such as Ajax® or Comet®.

d. Wipe the surface until it is clean, then rinse the cloth and wipe any remaining cleanser from the surface. Immediately wipe any moisture from the surface. Alcohol and water may be used to remove the remaining cleanser from the surface.

Pen Stall Cleaning

Before using overhead transparency pens, remove leftover ink from the boots in the pen stalls using a cotton swab and solvent. This will prevent the transfer of other inks to the plots.

Air Filter Cleaning

The air filter located on the rear panel should be cleaned approximately every three months or when dirt becomes visible on the filter surface, whichever happens first. Remove the filter and either hold it under running water, or wash it in warm, soapy water, followed by a rinse in clean water. Dry the filter thoroughly before replacing it.

Shipment

When the plotter is to be shipped, it is essential that the original packing materials and carton be used. If not available, packing materials and a carton may be ordered through your local Hewlett-Packard Sales and Service Office.

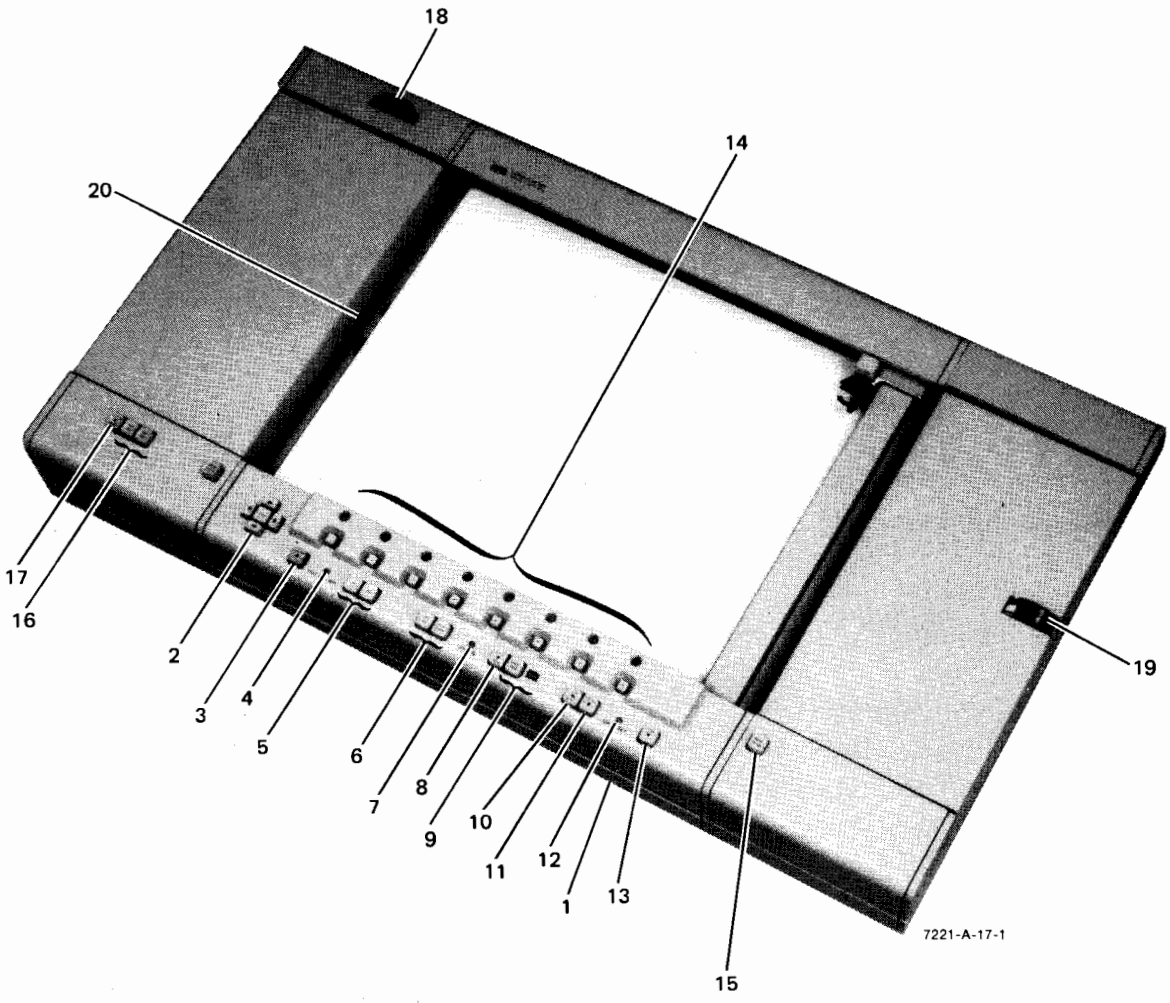
If the plotter is being returned to Hewlett-Packard for any reason, contact your local HP Sales and Service Office for shipping instructions. Attach a tag to the instrument including the following information:

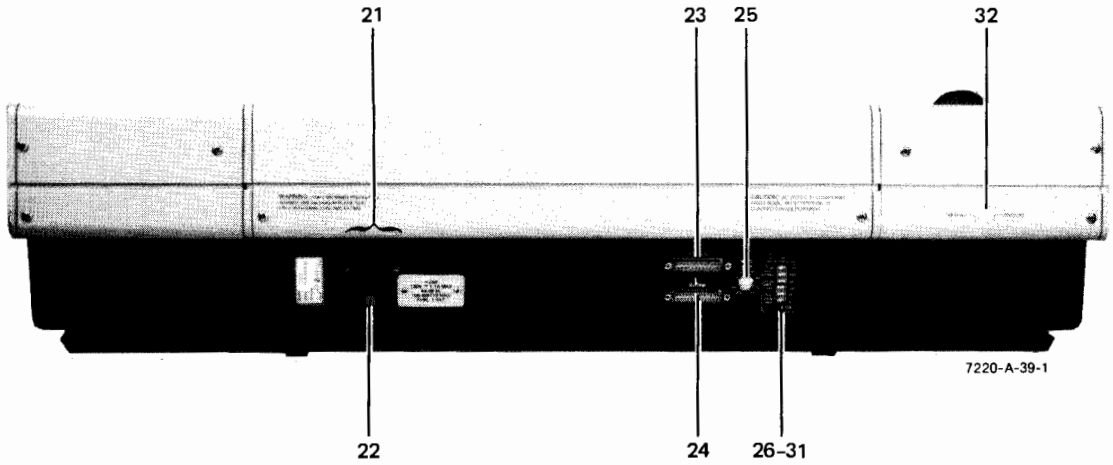
1. Your company name
2. Address
3. Telephone number
4. Name of person to contact
5. Description of problem and desired service
6. Model number and full serial number

Do not include the power cord or other operating accessories if returning the instrument to HP.

CAUTION

Before shipping remove all pens.





7220T Plotter Controls And Indicators

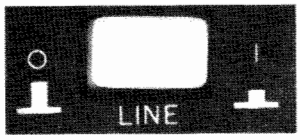
Controls And Indicators

A brief description of the 7220 controls and indicators, including their functions, follows. Those which apply to both the 7220C and 7220T are given first, followed by those that apply to the 7220T only.

WARNING

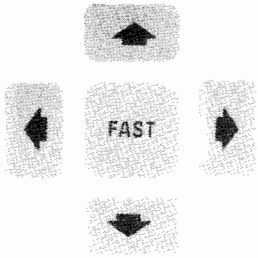
To avoid the possibility of injured fingers, always keep your hands away from the pen stable and plotter arm when operating the panel controls.

FRONT BASE

1. 

A pushbutton switch that controls application of power to the plotter. Power is on when depressed (set to I) and off when extended (set to O).

FRONT PANEL

2. 

Pushbuttons to move pen within the plotting area in the direction of the arrows at 4 mm/s. Two adjacent pushbuttons move pen diagonally in the indicated directions at 5.66 mm/s. When an arrow pushbutton is pressed together with [FAST], pen moves at approximately 90 mm/s and at 127 mm/s diagonally.

3. 

A multipurpose pushbutton with a lamp. It is used as follows:

a. Pushed before [CHART HOLD] to initialize plotter. The lamp in [ENTER •] blinks until [CHART HOLD] is pushed.

b. Used with [P1] and [P2] to establish scaling points. The lamp in [ENTER •] blinks until [P1] or [P2] is pushed.

c. Used to enter a point in the Digitize Mode. The lamp in [ENTER •] is on steady from receipt of digitize point command until [ENTER •] button is pushed.

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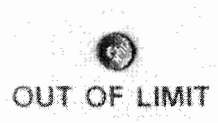
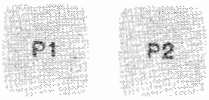
d. Used with the pen select buttons to store a pen.

e. The lamp in [ENTER] can be turned off by pushing any of the [▲] [◀] [▶] [▼] pushbuttons.

f. Used to suspend or resume execution of programmed graphic instructions from the front panel.

4. 

OUT OF LIMIT lamp lights when plotter is requested to plot outside window area or beyond limits of platen area. Lamp blinks if commanded position puts plotter in "lost" state. See Plot Absolute (Chapter 6) and Input Window (Chapter 9).

5. 

Pressing [P1] or [P2] raises the pen and moves it to the corresponding physical point, P1 or P2, on the platen. Pressing [ENTER], followed by [P1] or [P2] defines the current pen location as the scaling point P1 or P2. See Setting The Scaling Points (Chapter 5).

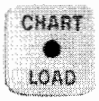
6. 

These pushbuttons raise or lower the pen. When held down during program execution, they override programmed pen control until released. [PEN DOWN] with [▲] [◀] [FAST] [▶] [▼] can be used to draw lines.

7. 

ERROR lamp lights when an RS-232-C related error occurs, or when an HP-GL related error occurs if the error mask has been set to flag that error. See ESC . E (Chapter 3) and Input Mask Instruction (Chapter 9).

Lamp also lights at end of confidence test until confidence test switch is turned off.

8. 

Pushbutton switch used to load chart paper. When pressed, the lamp in the pushbutton is turned on, the OUT OF LIMIT light is on steady, electrostatic paper hold-down is deactivated, execution of any plot data in the buffer is suspended, and the pen is moved to the upper right corner of the platen.

9. 

A pushbutton switch that activates electrostatic hold-down when sheet paper is used, and turns off the lamp in [CHART LOAD]. Execution of plot data in the buffer is suspended while the button is held down. Holding the button down for more than one second causes the pen to move to the upper right corner of the plotting area, with the pen raised. The pen returns to the original position and execution of plot data resumes when the pushbutton is released.

When pressed after pressing [ENTER], the plotter is initialized.

10. 

A pushbutton switch with lamp that may be used to place the plotter in On-Line Mode. The lamp indicates the mode of the plotter.

a. If the lamp in [ON LINE] is on steady, the plotter has not received a Plotter On instruction from the computer or front panel and is programmatically off. The plotter will not respond to received device control and graphics instructions, except Plotter On, in this state.

b. If the lamp in [ON LINE] is flashing, the plotter has received a Plotter On instruction from the computer or front panel and is programmatically on. The plotter responds to device control and graphics instructions in this state.

c. Repeatedly pressing [ON LINE] will toggle the plotter between programmed off and programmed on modes. Turning the plotter programmatically off will not terminate execution of instructions already in the buffer.

d. Plotter responses to output data requests are sent to the computer unless Monitor Mode is active. See Set Plotter Configuration in Chapter 3 for Monitor Mode explanation.

e. Data originating at the terminal is passed to the computer unless Monitor Mode is active. See Set Plotter Configuration in Chapter 3 for Monitor Mode explanation.

11. 

A pushbutton switch with lamp that is used to place the plotter in Local Mode. The following events occur in Local Mode:

a. After Local Mode is selected, the plotter is connected to the terminal and any further data from a host computer is ignored.

b. If the lamp in [LOCAL] is on steady, the unit has not received a Plotter On instruction from the terminal or front panel and is programmatically off. The plotter will not respond to incoming instructions, except Plotter On, in this state.

c. If the lamp in [LOCAL] is flashing, the plotter has received a Plotter On instruction from the terminal or front panel and is programmatically on. The plotter responds to all device control and graphics instructions in this mode.

d. Plotter responses to received output instructions are sent to the terminal.

e. Repeatedly pressing the local pushbutton will toggle the plotter between programmed off and programmed on modes.

f. When the plotter has been toggled off, or immediately after Local Mode is selected, execution of any graphics data in the plotter buffer continues uninterrupted until the buffer is empty.

12. 

The DATA SET lamp indicates the state of the modem or host computer when the plotter is connected into a computing system. The lamp is on steady when the Data Set Ready line from the modem or host computer is high.

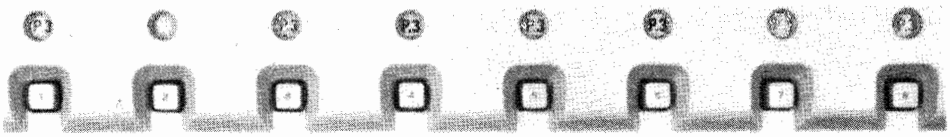
13. 

A pushbutton switch with lamp that is used to place the plotter in standby. The following events occur in the Standby Mode:

a. The lamp in [STBY] turns on steady.

b. Execution of buffered instructions in the plotter is halted, and unexecuted instructions in the buffer are purged.

c. The plotter passes data between the host computer and terminal using plotter microprocessor control, but without scanning for plotter instructions.

14. 

Eight pen-select pushbutton switches used to select, change or store plotting pens under the following conditions:

a. Pressing a pushbutton causes the pen in the pen holder to be stored in its original stall or, if that stall is occupied, in the lowest numbered empty stall. The pen in the stall associated with the pushbutton pressed is then loaded into the pen holder and the pen holder returns to the last graphic position and places the pen in its previous up/down state.

b. If the pen is moving when the pushbutton is pressed, the vector or character will be completed before the pen is changed.

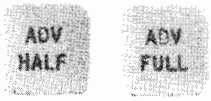
c. Execution of buffered data in the plotter is suspended while the plotter is changing pens.

d. If [ENTER •] is pressed before pressing a pen-select pushbutton, the light in [ENTER •] will flash, and the pen in the pen holder will be stored in the stall associated with that pen-select pushbutton if the stall is empty. The empty pen holder then returns to the last graphic position. If the stall associated with that pushbutton is full, the pen is stored in the lowest numbered empty stall. If all stalls are occupied, no pen holder movement occurs.

7220T ONLY

15. 

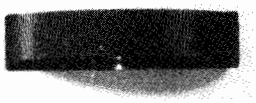
Pushbuttons to release cover on right and left paper supply module.

16. 

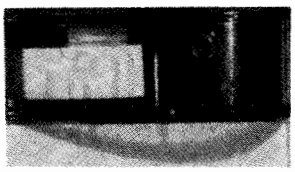
Pushbuttons to advance paper one full page or one half page from left margin of platen. The length of the advance depends on the setting of the English/metric switch on the rear panel. Will interrupt plotting and advance paper if pushed during program execution.

17. 

Pushbutton switch to enable/disable cutter. Lamp is on when cutter is enabled and off when disabled.

18. 

Paper advance thumbwheel to adjust tension on newly loaded roll paper or to advance paper manually.

19. 

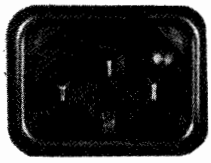
Paper gauge calibrated in quarters of a roll.

PLATEN AREA 7220C and 7220T

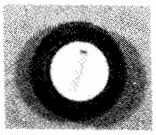
20. 

Paper stop. Should be recessed while roll paper is in use and raised when using sheet paper. Pushing upper part with a pencil point will raise stop.

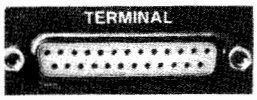
REAR PANEL 7220C and 7220T

21. 

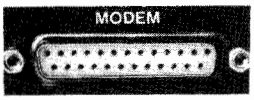
Power cord receptacle (refer to paragraph entitled Power Cords).

22. 

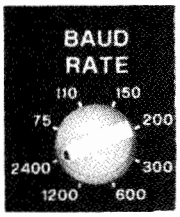
Fuseholder (refer to paragraph entitled Fuse).

23. 

The TERMINAL connector is a 25-pin, female type, RS-232-C connector and is used to interconnect the plotter and a terminal.

24. 

The MODEM connector is identical to the TERMINAL connector and is used to interconnect the plotter with a modem or host computer.

25. 

An eight-position selector switch that is used to set the plotter electronics for operation with data transmission rates of 75, 110, 150, 200, 300, 600, 1200 or 2400 baud as required by the system.

26. 

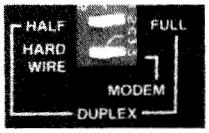
The confidence test (CONF TEST) switch is set to the OFF position during plotter operation. The switch is set to ON to test plotter circuits prior to operation. Refer to the "Confidence Test" discussion in this chapter for details concerning the use of this switch.

27. 

In the DTR BYPASS position, the modem or computer will receive the DTR signal from the terminal. In the NORM position, the modem will receive DTR from the plotter and the terminal DTR is ignored.

28 and 29. 

The parity ON/OFF and EVEN/ODD switches are effective only when the plotter is in the On-Line Mode and programmed on by a host computer (or front panel control), or when outputting data to the terminal in Local Mode. These switches set the parity checking and generation electronics for use with Odd or Even parity as established by system requirements. If parity is not used, the PARITY ON/OFF switch is set to OFF, and the setting of the EVEN/ODD switch is irrelevant.

30. 

The DUPLEX HALF/FULL switch is used only when the plotter is set for Local Mode or with Monitor Mode active during on-line operation. During Local Mode operation, the switch function is as follows:

a. When set to FULL, the plotter returns (echoes) data received from the terminal back to the terminal.

b. When set to HALF, the echo is suppressed.

During On-Line Mode operation, with Monitor Mode active, the DUPLEX switch function is as follows:

a. When set to FULL, and computer is working in an echoplex environment, all plotter output responses are echoed from computer, through plotter, to terminal.

b. When set to HALF, all plotter output responses are sent to both the computer and the terminal. All data received from the computer is also sent to the terminal.

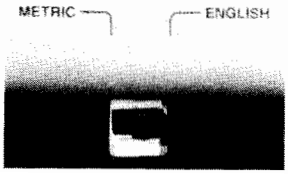
31. 

The MODEM/HARDWIRE switch is effective only at plotter power-on. This switch determines the initialized state of the "Hardwire Handshake" and "Enable Data Transmission" options of the Set Plotter Configuration instruction (refer to Chapter 3).

When the switch is set to MODEM, the "Hardwire Handshake" and "Enable Data Transmission" options are initialized to the "Off" state.

When the switch is set to HARDWIRE, the "Hardwire Handshake" and "Enable Data Transmission" options are initialized to the "On" state.

7220T ONLY

32. 

Metric/English paper switch to control length of paper advance and settings of scaling point P1 and P2 at power-up and initialization.

Setting Up The Plotter

Determining Pen Type

To obtain plots of the highest quality, it is important to use pens matched to your application. Pens are available for use on standard Hewlett-Packard plotting paper and transparency film. The top of each pen is marked, in a color which matches the pen's ink, with a two-character code. The first character is alphabetic and denotes the media on which the pen will draw or the ink type. The "P" is for paper and "T" for transparency.The second character is numeric and specifies in millimetres the approximate width of a line drawn with that pen.

Turning The Power On

After observing the proper power and grounding requirements and precautions previously specified, set the LINE switch to I (on). The following will then occur:

a. Pen moves to lower right corner with the pen up.

b. Chart hold is on. Chart hold is off if roll paper is loaded on a 7220T.

c. Certain parameters are set to their default values. For a description, see the DF instruction (Chapter 3).

Loading Pens

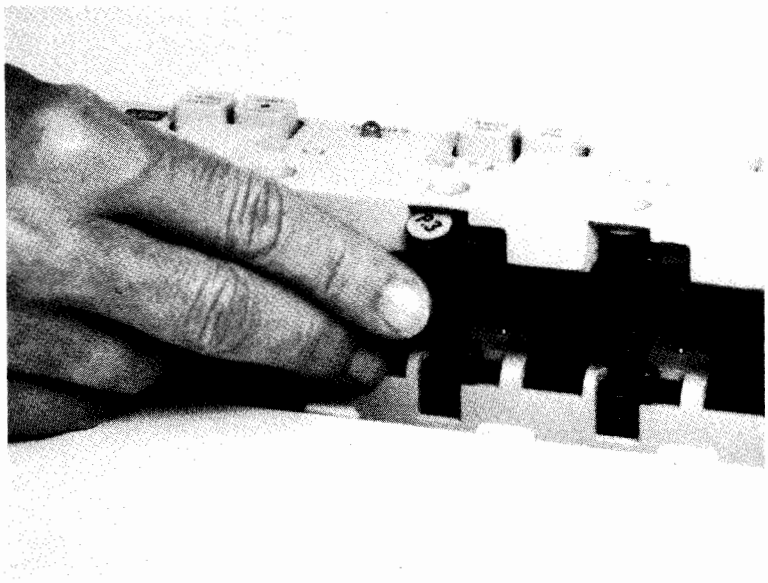
After the plotter's initialization process is complete and the plotter arm has stopped moving, you can install the pens. There are two methods of doing this. The first is to place the pen directly into the stable under the front panel; the second is to place each pen in the pen holder and store it using the front panel buttons.

Direct Stall Loading

WARNING

To avoid the possibility of injured fingers, always turn the plotter off when directly storing pens.

Turn the plotter off. Select the pen to be placed in the first stall and remove the pen cap. Place the pen tip in the round boot at the base of the stall and press the pen down and in gently until the pen snaps into place. The pen code on the top of the pen will be centered under the hole in the front panel. Repeat this procedure for the remaining pens and turn the plotter back on.

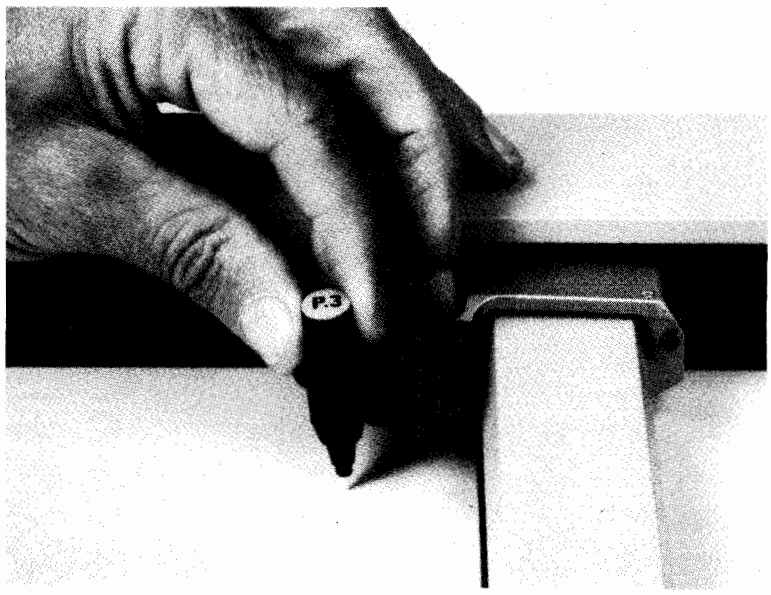


9872-A-166-1

With the plotter turned off for safety reasons, pens may be removed from a stable by depressing the lever to the right of the pen, grasping the pen between thumb and index finger and pulling gently.

Automatic Stall Loading

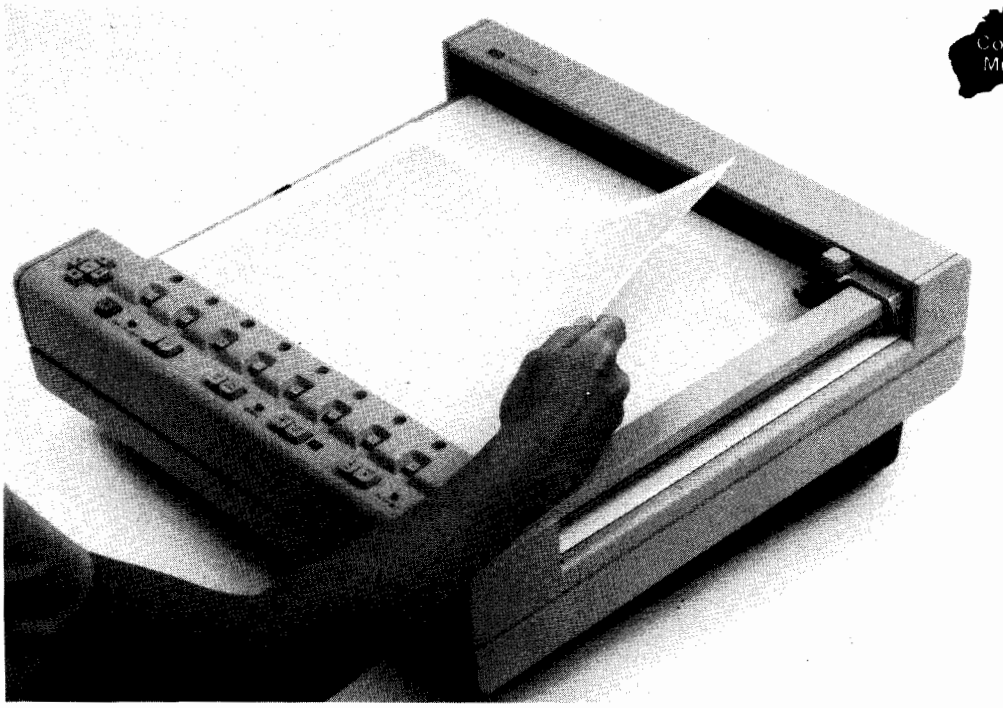
Select the pen that you want in pen storage location 1, remove the cap and place the pen in the pen holder as shown in the picture below. Note that the thick ring around the middle of the pen fits into the slot in the pen holder. Now press [ENTER •] and pen location button [1]. The plotter arm will put the pen in the first storage location. Repeat this procedure with up to seven more pens, substituting the appropriate pen location button for each one.



9872-A-165-1

Loading Sheet Paper

To load sheet paper, you first press CHART LOAD. This releases the paper hold-down mechanism and moves the plotter arm to the upper right corner of the platen. Raise the paper stop by pushing down the upper portion of the stop with a pencil or other pointed object. Make sure the paper is positioned squarely against the ridge at the bottom of the platen and against the paper stop on the left side of the platen. Starting from the lower left corner, smooth the paper with the back of your hand so that skin oil is not deposited on the paper. Now press CHART HOLD. This will activate the electrostatic hold-down mechanism and turn off the lamp in CHART LOAD. Smooth the paper again with the back of your hand.



Loading Sheet Paper

Loading Roll Paper (7220T)

WARNING

To avoid the possibility of injured fingers, always turn off the plotter before changing roll paper.

Store pens to avoid getting ink on the new paper. Turn off the plotter to avoid injury and to disable electrostatic hold-down. Depress the paper stop on the left side of the platen and open both left and right paper supply modules by pressing the door latch buttons. Grasping the roll of paper in your left hand continue loading as follows (see pictures):

a. Load roll between hubs in supply module with paper feeding across top of roll, aligning hub tabs with roll notches.

b. Feed paper across table and under arm.

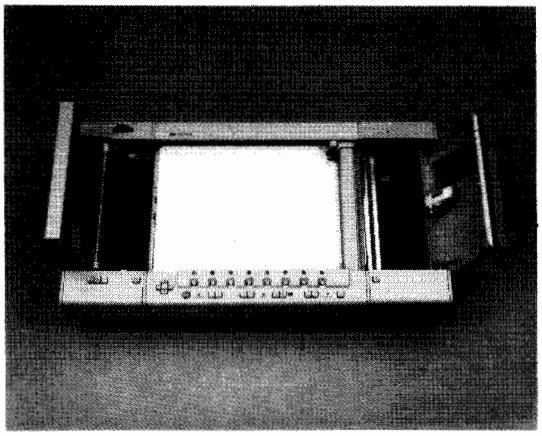
c. Engage paper sprocket holes and sprockets at each end of take-up roller. Hold paper on roller while closing door.

d. Close supply module door. Make sure paper is not on top of front edge guide.

e. Advance paper with thumbwheel until tensioned. Turn plotter on and advance paper at least once with front panel buttons.

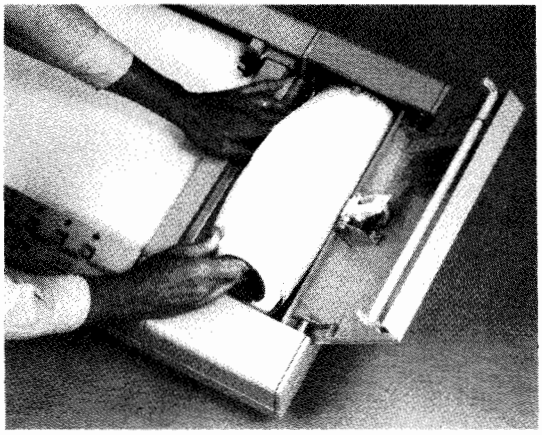
Successful loading of roll paper will turn the page advance option on. Electrostatic paper hold-down is disabled while roll paper is loaded.

Set the English/metric switch on the back of the paper take-up module to the desired position. Paper advance distances for both settings are specified under the AF and AH commands (Chapter 11).



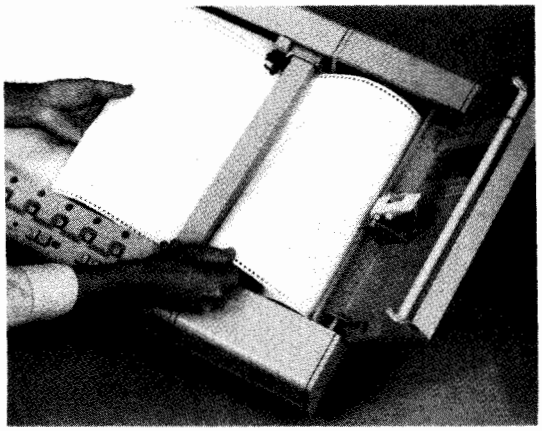
7220-A-20-1

Paper Modules Open



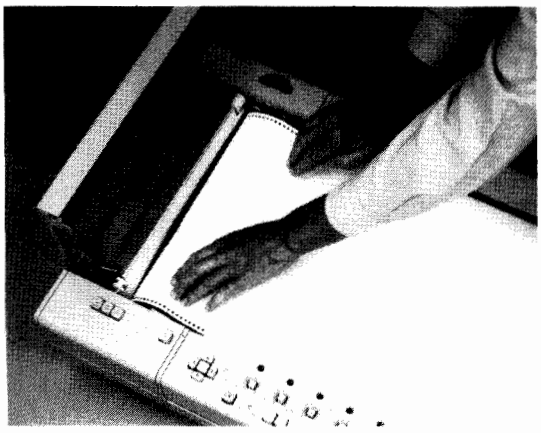
7220-A-21-1

Installing Paper Roll



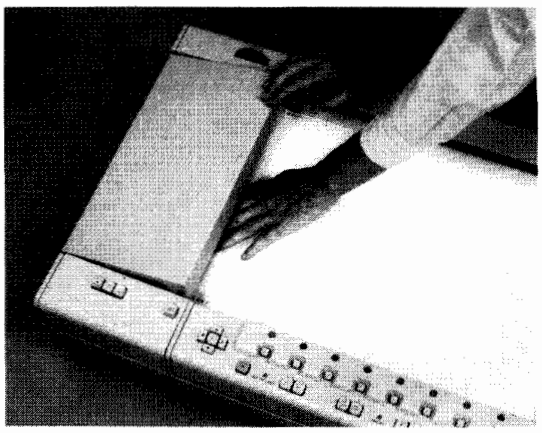
7220-A-22-1

Threading Paper Across Platen



7221-A-23-1

Engaging Paper on Sprockets



7220-A-23-1

Closing Take-up Module Door

Paper Loading 7220T

1

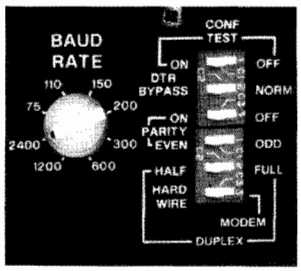
Running The Confidence Test

A confidence test is included in the plotter firmware to verify that the unit is operating correctly. Prior to the performance of this test, have a pen in the pen holder and paper located. Proceed as follows:.

a. Set the LINE switch off.

b. Connect the RS-232-C male-to-male interface cable (HP Part No. 8120-3258) supplied with the plotter between the rear-panel TERMINAL and MODEM connectors.

c. Make rear panel switch settings as follows:



CONF TEST	ON
DTR BYPASS/NORM	NORM
PARITY	OFF
EVEN/ODD	Irrelevant
DUPLEX	Irrelevant
BAUD RATE	Any
MODEM/HARDWIRE	Irrelevant

d. Set the LINE switch on.

The plotter performs an initialization sequence, then the confidence test runs and performs the following functions in sequence:

a. The lamps in DATA SET and [ON LINE] are on steady.

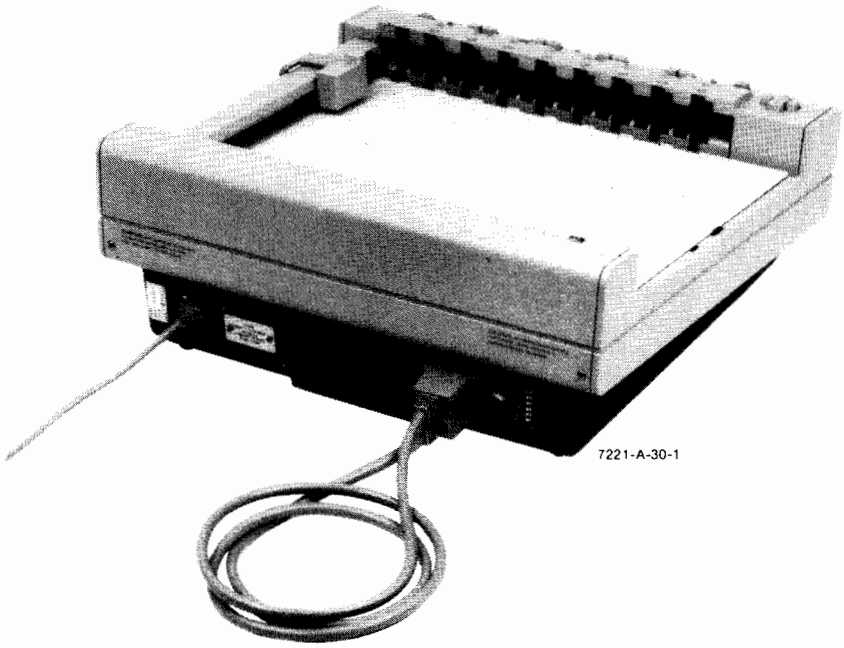
b. The plotting pen is moved to the lower right corner of the platen, then moves to the lower left corner.

c. The plotter performs a self-test of various internal circuits. During this time the plotting pen does not move. This portion of the test takes approximately 3 seconds and occurs simultaneously with d, e, and f.

d. The lamp in [ON LINE] turns off.

e. The lamp in [STBY] turns on steady.

f. DATA SET lamp flashes 3 times.



Plotter Confidence Test Connections

g. The plotter executes the confidence test plot illustrated on the next page.

h. The plotting pen returns to the lower left corner of the platen with the pen down.

i. The following lamps go on steady:

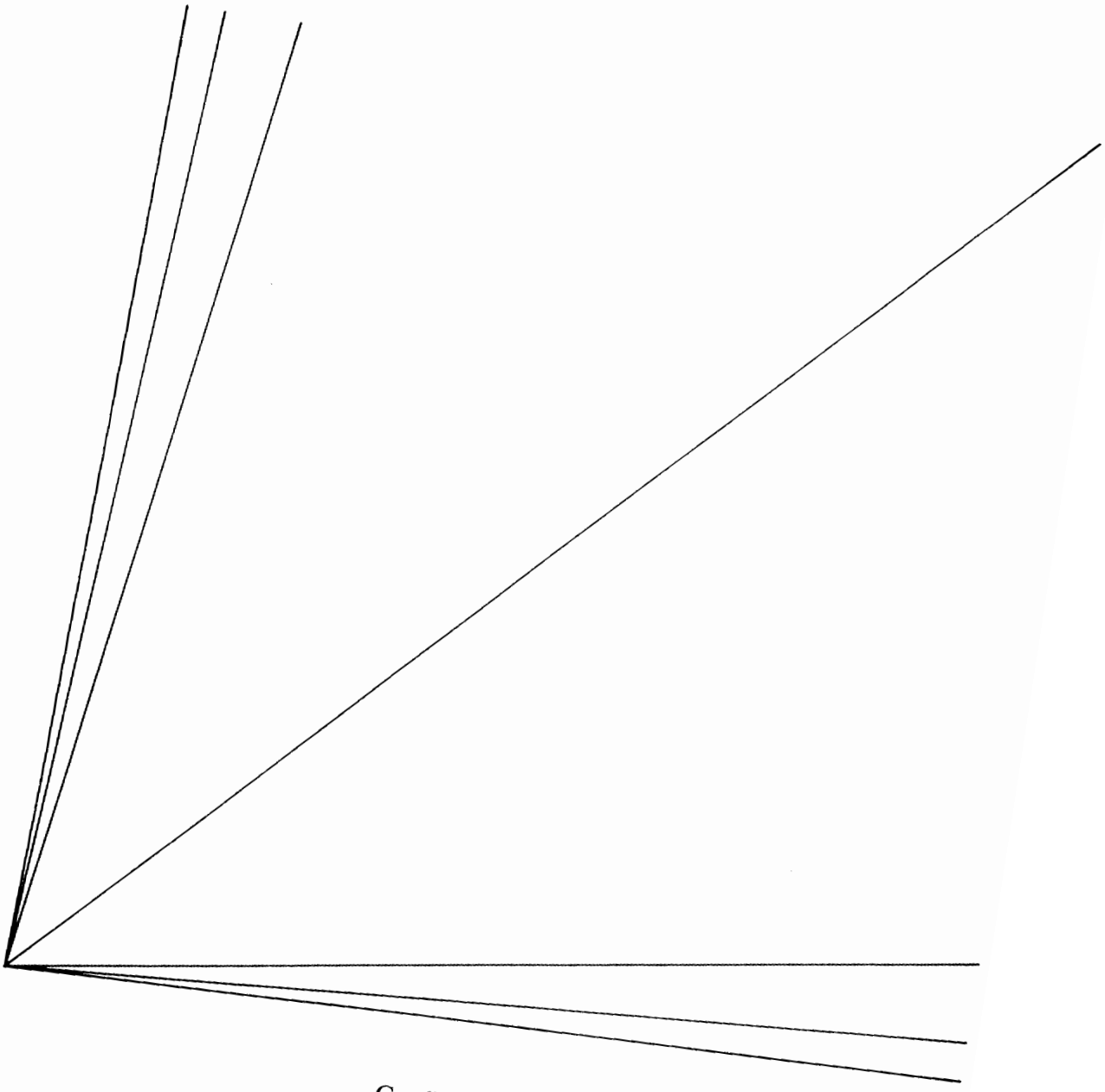
j. The following lamps are off:

NOTE

If a failure occurs while the confidence test is running, or if improper results are obtained, refer the problem to qualified service personnel.

This concludes the confidence test. Set the  and  switches off. Disconnect the RS-232-C cable from the TERMINAL and MODEM

1



Confidence Test Plot

Plotter Initialization

Initialization sets the plotter to a predetermined logical and mechanical state. After observing the proper power and grounding requirements and precautions, set the LINE switch to on (1). The following will then occur:

a. The pen arm moves toward the right of the platen until it encounters the far-right limit switch.

b. The pen holder moves down until it encounters the bottom limit switch in a stall adjacent to the pen stable.

c. The pen holder moves out of the limit switch stall and stops in the lower-right corner of the platen.

This completes plotter initialization, and internal graphic variables are set to their default values (values assumed by the plotter in the absence of an actual instruction). Refer to the Default instruction in Chapter 3 for a list of these default values.

Selecting A Pen

1

NOTES

If all pen stalls are full when a pen-select pushbutton is pressed, the pen holder moves to the stall adjacent to the pen stable in the lower right corner of the platen to sense if there is a pen in the pen holder. If there is, the pen holder moves back to the original position. With eight pens in the stable and one in the holder, pens cannot be interchanged.

If the stall associated with the pushbutton pressed is empty, no pen selection occurs and the pen holder remains stationary.

Front panel pen selection events occur as follows:

a. Press one of the eight pen-select pushbuttons.

b. Execution of graphic instructions in the buffer is suspended.

c. The pen in the holder is put into its original stall, if empty, or the lowest numbered vacant stall.

d. The pen in the stall associated with the pushbutton is loaded into the pen holder.

e. The pen holder moves back to its original position.

f. Execution of graphic instructions stored in the buffer resumes.

Storing A Pen

NOTE

If the stall associated with the pen-select pushbutton that was pressed is occupied, the pen holder will store its pen in the lowest numbered empty pen stall. If no stalls are empty, no movement will occur.

To store a pen, proceed as follows:

a. Press [ENTER •]. The lamp starts flashing.

b. Press the pen-select pushbutton for the stall in which you want to store the pen.

c. The pen in the pen holder is stored in the selected stall.

d. The pen holder is returned to its original position.

e. The lamp in [ENTER •] goes out.

Pen Up/Pen Down Controls

NOTE

The AP instruction defaults to the on state and automatically raises the pen after approximately 65 seconds with no new pen movement commands. See the description of the AP instruction in Chapter 6.

To raise the operating pen: Press [PEN UP].

To lower the operating pen: Press [PEN DOWN].

Pen Positioning

The arrow pushbuttons and [FAST] are used to manually position the plotting pen on the platen surface.

Pressing any one of the four arrow pushbuttons moves the pen in the direction of the arrow at 4 mm/s. Pressing [FAST] and any arrow pushbutton moves the pen in the direction of the arrow at 88 mm/s.

Pressing any two adjacent arrows moves the pen on the 45° diagonal between the two arrows. Diagonal moves are at 5.7 mm/s when only arrow pushbuttons are depressed, and 125 mm/s if [FAST] is also pressed.

Installation/Operation Of The Digitizing Sight

A digitizing sight (HP Part No. 09872-60066) is supplied with the plotter and is loaded and selected in the same manner as a pen. To use the digiting sight, proceed as follows:

a. Load the pen holder by pressing the pen-select pushbutton associated with the stall in which the digitizing sight is loaded.

b. Position the sight over the area to be viewed using the previously described pen positioning controls.

c. To accurately lower the sight onto the platen, press [PEN DOWN] and align the dot on the digitizing sight with the point to be digitized.

d. Press [ENTER •].

A description of digitizing can be found in Chapter 10.

Chapter 2
Handshake Protocol

Introduction

The 7220 Graphics Plotter provides RS-232-C compatible asynchronous data communications at rates up to 2400 baud. Since the rate at which data is transmitted may not equal the rate at which data is processed (i.e., plotting is executed), an input buffer has been included in the 7220 plotter. The standard buffer holds 928 bytes of data; an optional 2K buffer expansion kit can be used to expand input buffer capacity to 2976 bytes.

If data transfer is to be successful, the computer and plotter must transfer information in such a way that data will not be lost due to buffer overflow, and will not be misunderstood. The purpose of handshaking is to assure that data is transferred in a complete and understandable manner.

In all, the 7220 is capable of using any one of four handshaking methods to prevent buffer overflow and the resulting loss of data. The computer system's capabilities and requirements dictate which handshake method is appropriate. The four handshaking methods and terms used in handshaking are described briefly below. This is followed by a more detailed description of each handshake mode and a description of the device control instructions used to implement handshaking and to transfer information on the state of the plotter.

- Hardwire handshake: Can be used if the computer system can or does monitor pin 20 (DTR).

- Xon-Xoff handshake: Can be used if the computer system follows an Xon-Xoff protocol (control characters are transmitted from the peripheral to the computer).

- Enquire/acknowledge handshake: Can be used if the computer cannot use hardwire or Xon-Xoff handshake. (The enquire/acknowledge handshake method has less communications overhead than software checking.)

- Software checking handshake: Can be used on almost any computer system, but must be used if the system cannot implement any of the other three handshaking methods.

Once the handshake method is selected, the 7220 can be programmatically instructed to match the computer system requirements, implement the chosen handshake method, and function properly within the system-dependent communication environment. This is done by specifying certain variables in device control commands which are issued to the 7220 at the beginning of each computer session or graphics program. The variables which may be specified through the four handshake methods available to the 7220 are:

- Output Trigger Character: The output trigger character, when used, is the last character output by the computer when making a request of a graphics peripheral. Defining this character in a command tells the plotter, "Don't respond to my request until you receive this trigger character." This character is often a DC1 (decimal equivalent 17) or some other non-printing ASCII character.

- Turnaround Delay: The turnaround delay is the length of time the plotter will wait after receiving a computer request before it responds. The purpose of this time delay is to postpone the plotter's transmission of requested data until the computer is ready to receive and process it. Most systems require either a turnaround delay or a trigger character, but not both.

- Output Terminator: The output terminator is a one- or two-character terminator that the computer requires the plotter to send at the end of each response to a data request. The output terminator tells the computer "This completes my transmission." Often, computers expect a carriage return character CR (decimal equivalent 13) as the plotter's output terminator.

- Echo Terminate Character: Echoing is commonly found in full duplex systems. Use of the echo terminate parameter in a device control command tells the plotter that the computer will echo all responses and that this echoed data should be ignored (the plotter's data buffer should be closed) until an echo terminate character is received. When the plotter receives the echo terminate character, it reopens the data buffer to receive graphics data from the computer. Computers often use the line feed character LF (decimal equivalent 10) as the echo terminator. If the computer does not echo the peripheral's response, this variable must be a NULL character (decimal equivalent 0) or must be omitted.

- Intercharacter Delay: Some computers cannot process data as fast as the plotter can transmit it due to limited buffering in the I/O port. This can be compensated by delaying each transmission from the plotter for the period of time specified by the intercharacter delay variable. This intercharacter delay is added to a turnaround delay (if one has been specified) before the first character is sent by the plotter, and is also inserted before each subsequent character in a string being sent to the computer.

- Handshake Enable Character: In some systems, the computer sends a handshake enable character to ask the plotter if it has room for a block of data, thereby initiating the handshake process. If Xon-Xoff handshake mode is to be established, a NULL character (decimal equivalent 0) must be specified as the handshake enable character. If enquire/acknowledge handshake is to be established, an ENQ character (decimal equivalent 5) or any other ASCII character besides the NULL is used.

- Immediate Response String: Certain system environments require an immediate response from the plotter acknowledging the enquiry from the computer. Systems of this type include a computer that transmits data to the plotter after a certain time interval but before receiving a go-ahead signal from the plotter. If the plotter's buffer is full and the computer sends more data, the buffer will overflow. The immediate response string prevents this inadvertant transmission of data before the plotter is ready. It is transmitted by the plotter immediately after receipt of a handshake enable character and tells the computer, "Wait, I am here and checking my buffer space." The computer will wait indefinitely until it receives a handshake response string. Computers frequently require a DC3 character (decimal equivalent 19) for the immediate response.

- Handshake Response String: The handshake response string specifies the character or characters that the plotter will send to the computer when the plotter's input buffer has room for another block of data. Computers frequently require that an ACK character (decimal equivalent 6) be used for the handshake response string.

- Maximum Buffer Size: This variable establishes an artificial usable buffer size in the plotter.

- Data Block Size: This is the size of each data block the computer will transmit to the plotter.

- Data Terminal Ready (CD) Line Control: This variable sets the configuration of the plotter's Data Terminal Ready control line (pin 20) to enable or disable the hardwire handshake mode. Pin 20 is held on (+12 V) if hardwire handshake is disabled.

- Xoff Threshold Level: In the Xon-Xoff handshake mode this defines how full the buffer may get before the plotter will send the Xoff trigger character to the computer, telling it to stop sending data. The user should specify a value that equals the maximum buffer size (the actual size of 928 or 2976 minus the computer's data block size) using the Set Plotter Configuration instruction.

- Xoff Trigger Character: This specifies the character string the plotter will use to signal the computer to temporarily stop sending data while the plotter processes what it has already received. The DC3 character (decimal equivalent 19) is generally used for the Xoff trigger.

- Xon Trigger Character: This specifies the character string the plotter will use to signal the computer that there is sufficient space in the buffer to resume sending data. The DC1 character (decimal equivalent 17) is generally used for the Xon trigger.

The following discussion of the four handshake methods includes the pertinent variables and identifies the commands which will establish their values.

Hardwire Handshake

As the name implies, the hardwire handshake takes place in the hardwire rather than in the firmware or software. The plotter controls the data exchange sequence by setting the electrical voltage on one of the connecting lines (CD line) to the computer to signal the computer when to send another block of data. If there is enough room in the plotter's buffer to accept and store another block of data, the plotter sets the Data Terminal Ready (CD) line to a "high" state. If there is insufficient space, it sets the line low. By monitoring this line, the computer knows when it can or cannot safely transmit another block of data.

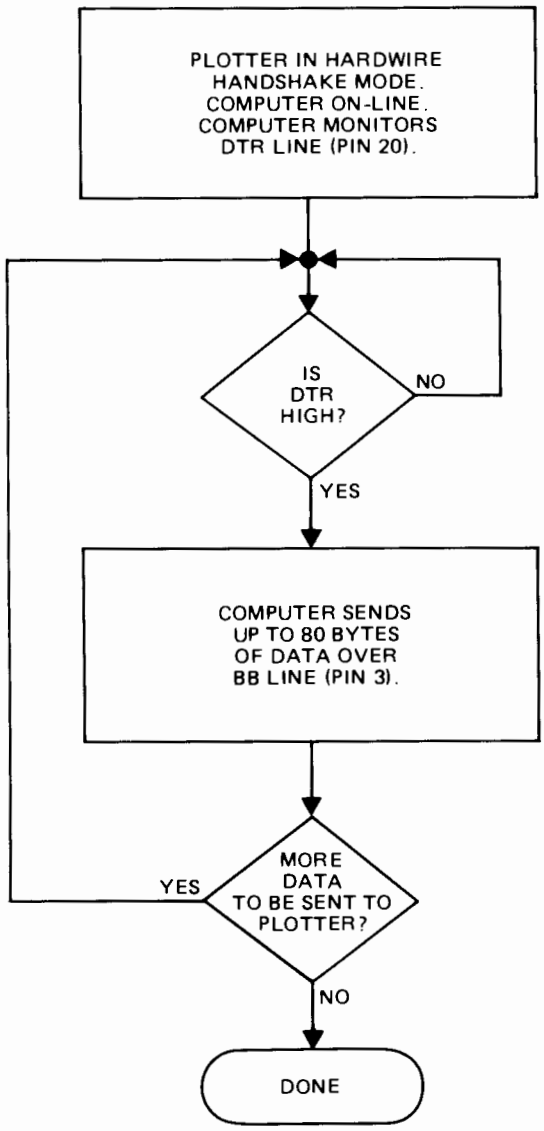
The following conditions may be specified for the hardwire handshake mode by using the appropriate parameters:

- Maximum buffer size (ESC . @ command)

- Data Terminal Ready (CD) line control (ESC . @ command)

The MODEM/HARDWIRE switch must be set to HARDWIRE at power-up or bit 0 must be set with the ESC . @.

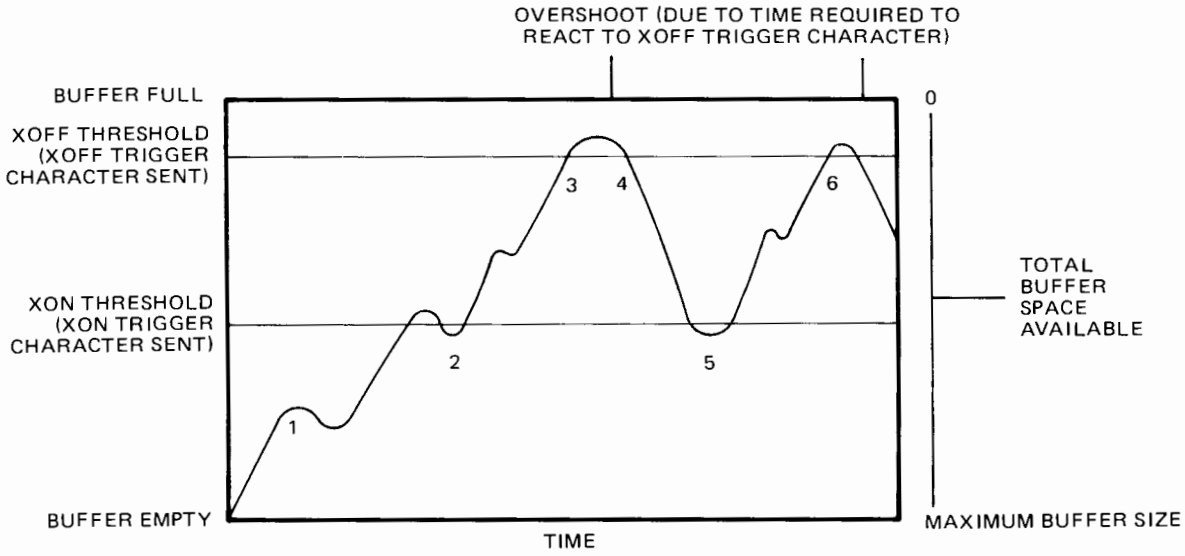
The following flowchart shows the steps involved in this very simple hardwire handshake mode of operation.



Flowchart of Simple Hardwire Handshake Mode

Xon-Xoff Handshake

With the Xon-Xoff handshake method the plotter controls the data exchange sequence by telling the computer when it has room in its buffer for data and when to shut off the flow. The plotter uses buffer threshold indicators (an Xon trigger character and an Xoff trigger character) to prevent buffer overflow.



Xon-Xoff Threshold Levels

As data is sent to the plotter by the computer, it is stored in the buffer and simultaneously is being acted on by the plotter. The preceding figure is representative of the way the Xon-Xoff handshake works:

1. Data enters the buffer faster than it can be acted on by the plotter and the buffer starts to fill.

2. The plotter begins processing the input data faster than the computer sends it and the buffer starts to empty.

3. The data enters the buffer at a faster rate than the plotter can process. The amount of data stored in the buffer reaches the Xoff threshold level at which point the plotter sends the Xoff trigger character, stopping the flow of data from the computer.

4. Due to a finite delay between the time the plotter sends the Xoff trigger character and the time it takes the computer to react, a slight overshoot may occur. For this reason, the Xoff threshold level should always be specified sufficiently less than the maximum buffer size to allow room for this overshoot.

5. When the amount of stored data drops to the Xon threshold level, the plotter sends the Xon trigger character to signal the computer to resume sending data. The Xon threshold level is automatically set at 50% of the total buffer size.

6. Data is again stored in the buffer until all the data is transferred or until the Xoff threshold level is exceeded again.

To match the requirements of the computer system, the following conditions can be specified for the Xon-Xoff handshake mode by using the appropriate command:

- Xon trigger character (ESC . I command)
- Xoff trigger character (ESC . N command)
- Xoff threshold level (ESC . I command)
- Intercharacter delay (ESC . N command)
- Handshake enable character (ESC . I command)
- Maximum buffer size (ESC . @ command)

Enquire/Acknowledge Handshake

With the enquire/acknowledge handshake, the computer initiates the data exchange process by querying the plotter about the availability of buffer space. The format of the exchange is dependent upon the requirements of the computer.

The following conditions can be specified for the enquire/acknowledge handshake mode by using the appropriate command:

- Turnaround delay (ESC . M command)
- Output trigger character (ESC . M command)
- Echo terminate character (ESC . M command)
- Output terminator (ESC . M command)
- Intercharacter delay (ESC . N command)
- Immediate response string (ESC . N command)
- Data block size (ESC . I or ESC . H command)
- Handshake enable character (ESC . I or ESC . H command)
- Handshake response string (ESC . I or ESC . H command)
- Maximum buffer size (ESC . @ command)

An example of the enquire/acknowledge handshake is found under the ESC . N command in the next chapter.

Software Checking

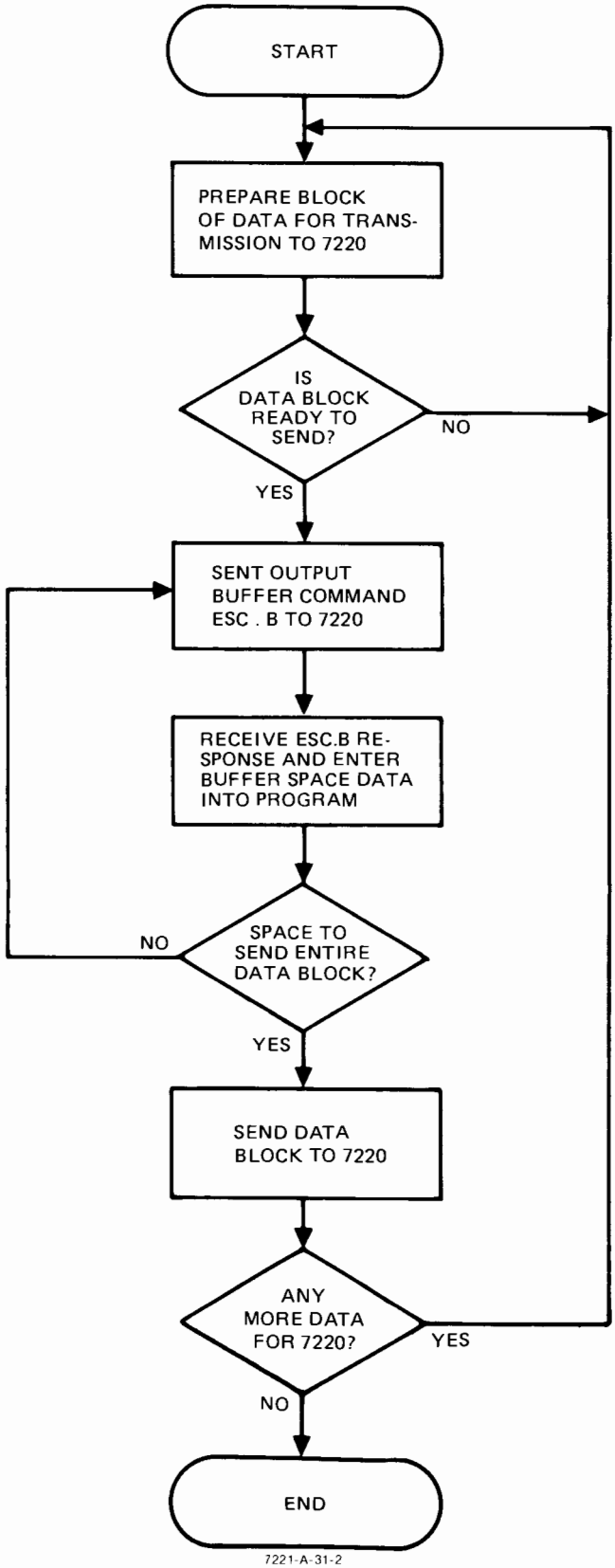
Software checking is a non-automatic handshake method in which the user's program repeatedly asks the plotter how many characters of empty space remain in the buffer. When the plotter response is bigger than the next block of data, the program will transmit the data block to the plotter.

Depending upon requirements of the computer, these variables or a subset of these variables may be specified for the software checking handshake mode by using the appropriate command.

- Maximum buffer size (ESC . @ command)
- Turnaround delay (ESC . M command)
- Output trigger character (ESC . M command)
- Echo terminate character (ESC . M command)
- Output terminator (ESC . M command)
- Intercharacter delay (ESC . N command)

The advantage of software checking is that it is independent of hardware and operating system abilities required to implement other handshake modes; therefore, it usually makes software transportable between computer systems. The limitation of this method of handshaking is that it uses up computer time.

The following flow diagram illustrates the functional elements of a typical software checking handshake mode within a user's program.



Software Checking

Chapter 3
Device Control Instructions

Introduction

Handshake protocol between the 7220 Graphics Plotter and computer is established by device control instructions. Device control instructions are acted upon immediately by the 7220 plotter, and are never stored in the data buffer.

This device control instructions comprise two groups, I/O Control and Output, which are listed below and explained in detail in this chapter.

I/O Control Group

- Plotter On
- Plotter Off
- Set Output Mode
- Set Handshake Mode 1
- Set Handshake Mode 2
- Set Extended Output and Handshake Mode
- Abort Device Control Instructions
- Set Plotter Configuration

Output Group

- Output Buffer Size
- Output Buffer Space
- Output Extended Error
- Output Extended Status

NOTE

All device control instructions, initiated by the controller, must be three-character escape-code sequences. Any other combination of escape-code sequences will result in an RS-232-C error condition.

I/O Control Group Instructions

Plotter On Instruction

ESC . (or ESC . Y

Description

Beginning with the next character, the plotter will accept incoming data and interpret it as plotter instructions. If the plotter is already in the Plotter On state, it will ignore this instruction.

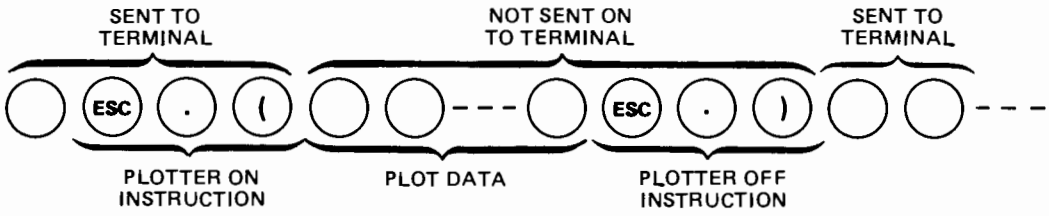
Plotter Off Instruction

ESC .) or ESC . Z

Description

Beginning with the next character, the plotter will assume a passive state and remain in that state until a Plotter On instruction is received or until ac power to the plotter is removed and restored.

At the time that a Plotter Off instruction is received by the plotter, any HP-GL instructions remaining in the buffer are executed. However, no additional HP-GL instructions will be accepted by the plotter.



Plotter On And Plotter Off Instruction Routing, On-Line Mode

The <DEC> And <ASC> Format

The next five instructions (Set Output Mode, Set Handshake Mode 1, Set Handshake Mode 2, Set Extended Output and Handshake Mode, and Set Plotter Configuration) have parameters which are strings of decimal <DEC> or ASCII <ASC> encoded digits separated by semicolons. Each of these instructions is terminated by a colon which may occur after any number of parameters. Also, any parameter may be omitted by sending only the semicolon which normally delimits if from the next parameter. Omitted parameters are set to their default values. Where the <ASC> format is used to specify the ASCII decimal equivalent of an input/output character, a "0" (the ASCII equivalent of NULL) generally indicates the associated function is not to be used. The following examples of the <ASC> format define valid and invalid conditions.

Valid Formats

ESC . M <DEC> :	All but first parameter defaulted.
ESC . M <DEC> ; ; <ASC> :	Second parameter and last parameter defaulted.
ESC . H :	All parameters defaulted.

Invalid Formats

ESC . H SPACE :	Embedded space.
ESC . I <DEC>	No terminating colon.
ESC . I <DEC> <ASC> :	Missing semicolon delimiter.

Set Output Mode Instruction

ESC . M [<DEC> ; <ASC> ; <ASC> ; <ASC> ; <ASC>] :

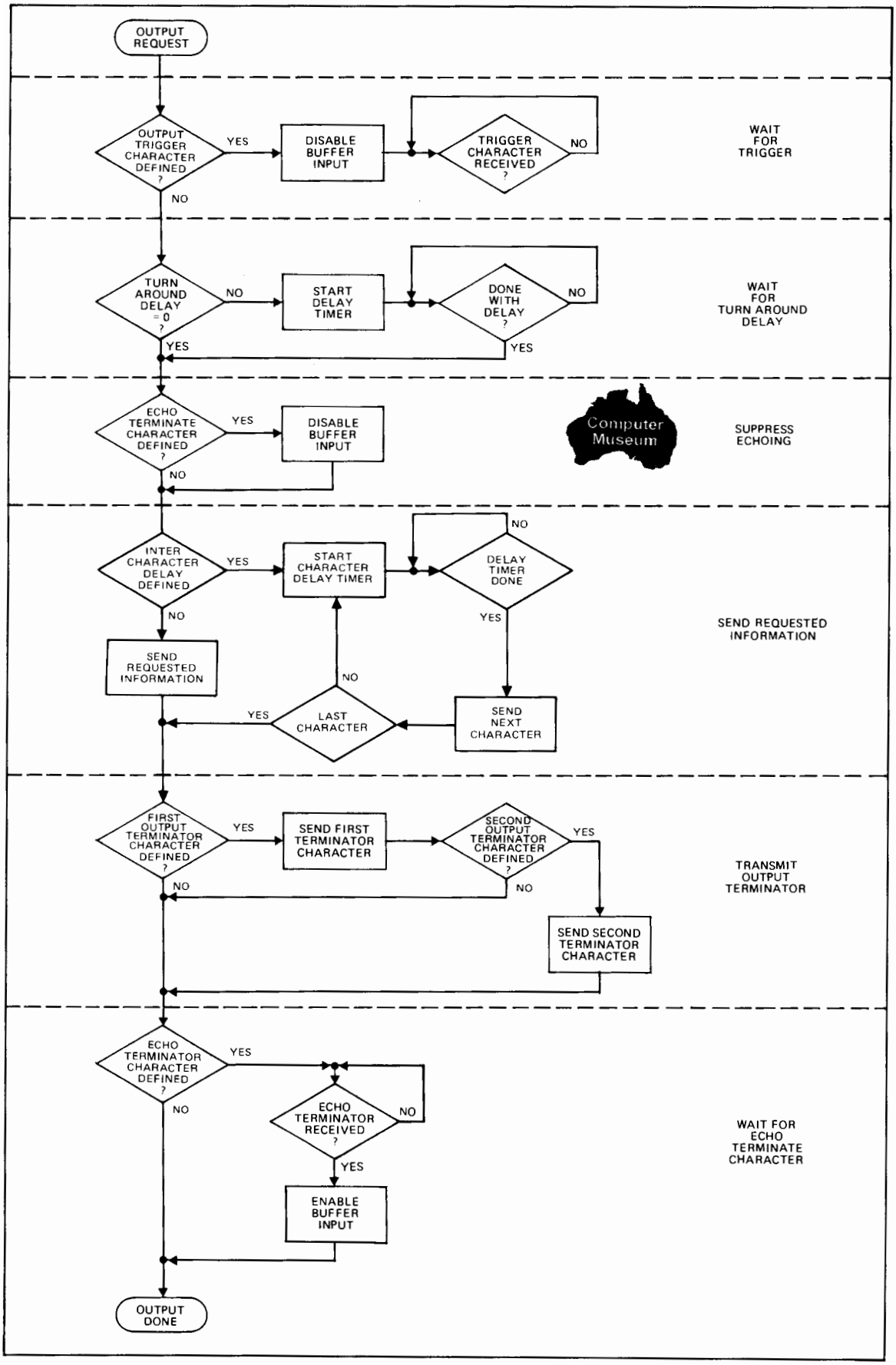
<DEC>	Turnaround delay (0 to 9999 milliseconds). Default: 0 milliseconds (no delay).
<ASC>	Output trigger character; ASCII decimal equivalent (0 to 126). Default: 0 (no trigger character).
<ASC>	Echo-terminate character; ASCII decimal equivalent (0 to 126). Default: 0 (no echo-terminate character).
<ASC> <ASC>	Output terminator; 1 to 2 characters; ASCII decimal equivalents (0 to 127). Default: 13;0 (single character, carriage return as output terminator).
DEFAULT:	ESC . M : is
the same as	ESC . M 0 ; 0 ; 0 ; 1 3 ; 0 :

3

ESC . M

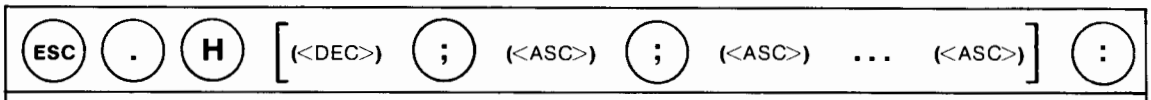
General Description

The Set Output Mode instruction establishes the nature of plotter outputs, providing compatibility with a wide variety of computer protocols. The flowchart on the following page illustrates the sequence for a plotter output operation upon receipt of a Set Output Mode instruction.



Plotter Output Operations

Set Handshake Mode 1 Instruction

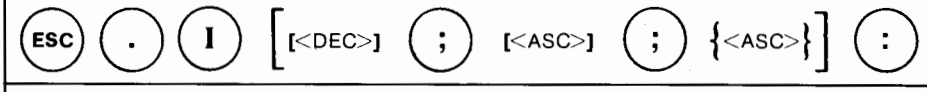


For parameter description, see Set Handshake Mode 2 Instruction (ESC . I).

General Description

The Set Handshake Mode 1 instruction is used to establish the data block size, the handshake enable character, and the handshake response string when the computer requires that the four conditions specified or defaulted in the Set Output Mode instruction be satisfied on each response. In this mode, the handshake string is transmitted in accordance with the conditions established by the Set Output Mode (ESC .M) and Set Extended Output and Handshake Mode (ESC . N) instructions, which may include turnaround delay, character delay, trigger character, echo terminate character, and output terminate character. Parameter descriptions are the same as for the Set Handshake Mode 2 instruction (ESC . I).

Set Handshake Mode 2 Instruction



<DEC>

For Xon-Xoff Handshake Mode:

Sets Xoff threshold level. (This is expressed in terms of the number of empty bytes remaining in the buffer.) The value must be less than the maximum buffer size. (Since the Xon threshold level is automatically half the maximum buffer size, the Xon threshold level will be reset to one byte less than the Xoff level if the Xoff level is specified at > half the buffer size.)

Default: Xoff threshold level is 80 bytes.

For Enquire/Acknowledge Handshake Mode:

Sets block size (0 to 9999 bytes).

Default: 0 bytes (80 bytes when bit 0 of the second parameter of the Set Plotter Configuration instruction (ESC . @) is set equal to 1).

<ASC> Handshake enable character (ASCII decimal equivalent 0 to 126).

Default: 0 (NULL character).

For Xon-Xoff Handshake Mode:

Omit the parameter (include only the semicolon) or enter the value 0 (ASCII NULL character) to specify the Xon-Xoff handshake mode. To enable Xon-Xoff, the next parameter, an Xon trigger character, must also be specified.

For Enquire/Acknowledge Handshake Mode:

Any value other than 0 enables the enquire/acknowledge handshake mode. However, the value 5 (enquire character ENQ) is generally used.

{<ASC>} Handshake string of 1 to 10 characters separated by semicolons (ASCII decimal equivalent 0 to 127).

Default: All 0 (ASCII equivalents of NULL).

For Xon-Xoff Handshake Mode:

Xoff trigger character(s).

For Enquire/Acknowledge Handshake Mode:

Handshake response string. The value 6 (acknowledge character ACK) is generally used.

DEFAULT: (ESC) (.) (I) (:) is

the same as (ESC) (.) (I) (0) (;) (0) (;) (0) (:) if

MODEM/HARDWIRE switch is set to MODEM at plotter power-on and enquire acknowledge handshake is being used, and is

the same as (ESC) (.) (H) (8) (0) (;) (0) (;) (0) (:) if

MODEM/HARDWIRE switch is set to HARDWIRE at plotter power-on or Xon-Xoff handshake is being used.

General Description

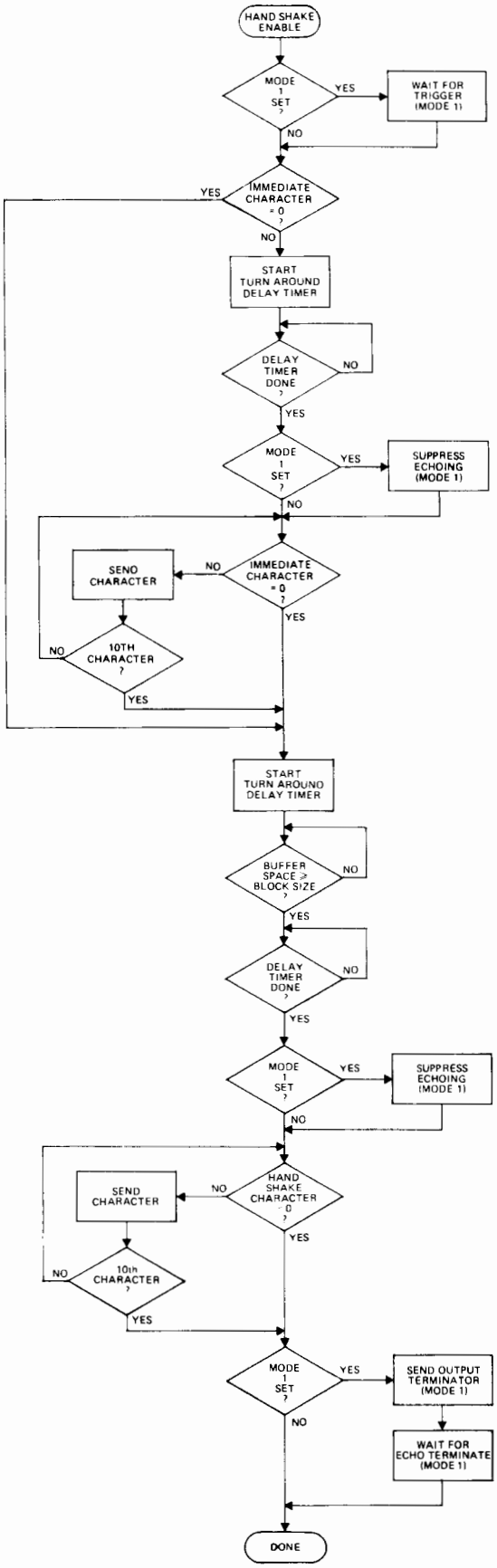
The Set Handshake Mode 2 command is used to set parameters for either Xon-Xoff or enquire/acknowledge handshake protocol. For the enquire/acknowledge protocol, it establishes the data block size, the handshake enable character, and the handshake response string when the computer requires that none or only certain ones of the ESC .M formatting parameters be specified. Any parameters which are specified but not required will be ignored, except for turnaround delay.

In this mode, transmission of the handshake string is not subject to the trigger character, echo-terminate character, and output terminate character conditions established by the Set Output Mode instruction. The handshake string is transmitted as soon as buffer space is available, but after the character delay, turnaround delay, and immediate response string, if specified.

For enquire/acknowledge handshake mode, unless otherwise specified by modes 1 or 2, the receipt of an ENQ control character causes transmission of an ACK character. This is an automatic "dummy" handshake which is not dependent on buffer space and will only occur if a received ENQ character is not used for some other function.

The two handshake modes, 1 and 2, are mutually exclusive. Specifying either mode will disable the other mode such that only one mode is in effect at a time.

The handshaking process is diagrammed in the following figure.



Plotter Handshake Mode Flowchart

Set Extended Output And Handshake Mode Instruction

ESC . N [(<DEC>) ; (<ASC> ... <ASC>)] :

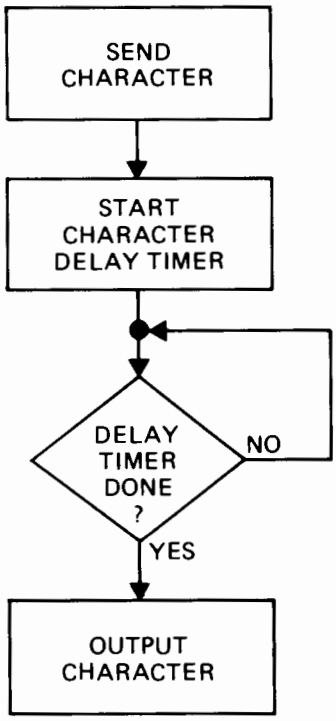
<DEC>	Intercharacter delay. Default: 0 milliseconds (no delay).
(<ASC>) ... (<ASC>)	String of 1 to 10 characters separated by semicolons (ASCII decimal equivalents 0 to 127). Default: No characters are sent.
	For Xon-Xoff Handshake Mode: Xoff trigger character(s).
	For Enquire/Acknowledge Handshake Mode: Immediate response string.
DEFAULT:	ESC . N : is
the same as	ESC . N 0 ; 0 :

General Description

The first parameter of the Set Extended Output and Handshake Mode establishes a delay prior to the output of each character. If an intercharacter delay is specified, each "SEND CHARACTER" block shown in the flowchart on page 51 is expanded to reflect the flowchart shown below.

When the Xon-Xoff handshake is being used, the second parameter specifies the Xoff trigger character(s).

In enquire/acknowledge handshake mode, the second parameter of the Set Extended Output and Handshake Mode identifies an immediate response string which is transmitted in accordance with the conditions established by either Set Handshake Mode 1 or Mode 2 as diagrammed in the flowchart on page 51.



Character Delay Flowchart

Using The Handshake Modes

The Set Extended Output and Handshake Mode instruction establishes a procedure in conjunction with Set Handshake Mode 1 or Mode 2 that can be followed to permit blocks of graphic instructions to be transferred from the host computer to the input buffer of the plotter. This instruction can also be used to inject a 0 to 10 second (approximate) delay prior to each character that is output from the plotter.

The following example and figure illustrate the use of the Set Extended Output and Handshake Mode instruction. The plotter is asked to accept a specified size data block. After a specified turnaround delay and a specified output character delay, the plotter acknowledges.

First, the Set Output Mode instruction is sent to specify a two second turnaround delay with default values for Output Trigger, Echo Terminator, and Output Terminator as follows:

Procedure

Send (ESC) (.) (M) (2) (0) (0) (0) (:) Set Output Mode instruction with parameters.

Second, the Set Handshake Mode 2 instruction is sent to specify data block size, handshake enable, and handshake string characters.

Procedure

Send (ESC) (.) (I)	Set Handshake Mode 2 instruction.
(8) (0)	Data block byte size.
(;)	Delimiter.
(5)	Handshake enable; decimal equivalent of ASCII character ENQ.
(;)	Delimiter.
(7) (1) (;) (7) (9)	Handshake string; decimal equivalent of ASCII characters GO.
(:)	Terminator.

Next, the Set Extended Output and Handshake Mode instruction is sent to specify a five second delay prior to each plotter output character and also the immediate response string.

Procedure

Send (ESC) (.) (N)	Set Extended Output and Handshake Mode instruction.
(5) (0) (0) (0)	Plotter intercharacter delay.
(;)	Delimiter.
(1) (9)	Immediate response string; decimal equivalent of ASCII character DC3.
(:)	Terminator.

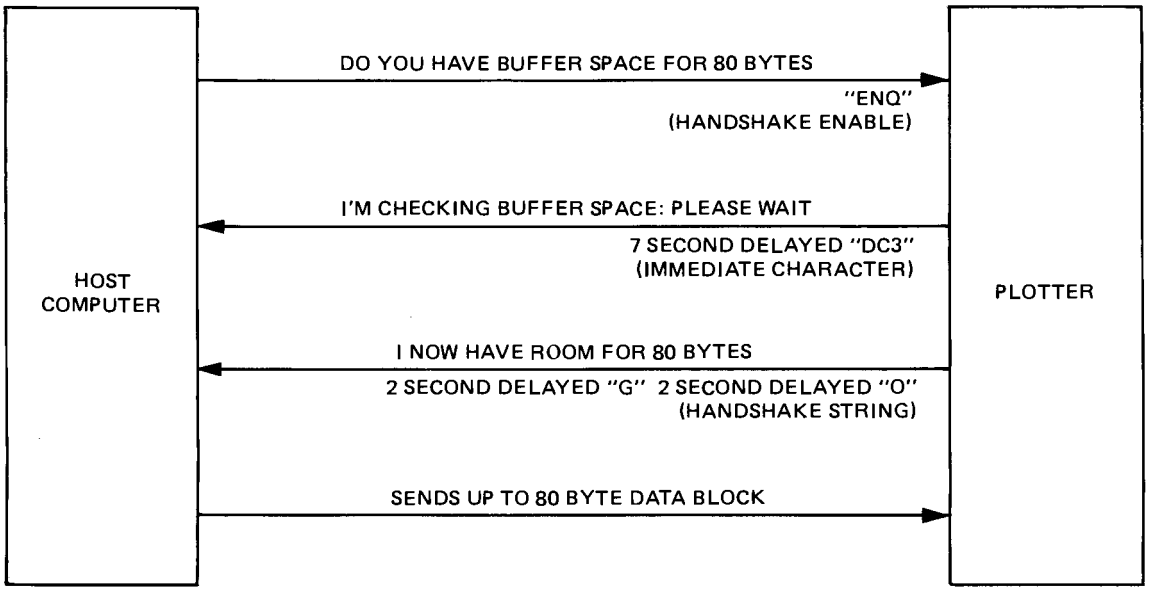
Then, as shown in the figure, the plotter is asked to check its buffer space and transmit the immediate response string, followed by the handshake string when the buffer can accommodate a data block. Note that the immediate response character output is delayed a total of seven seconds, two seconds as specified in the Set Output Mode instruction and five seconds as specified by the Set Extended Output and Handshake Mode instruction. Also, note that each subsequent output character is delayed five seconds as specified by the Set Extended Output and Handshake Mode instruction.

Procedure

Send (ENQ)	Keyboard equivalent of the ASCII character ENQ.

Result

Plotter transmits DC3 indicating "wait" followed by GO indicating buffer has space for a data block of 80 bytes. The handshake procedure has been completed and the host computer can now send a data block.



Example Of The Set Extended Output And Handshake Mode

NOTE

The delay injected prior to the output of each character can be used to compensate for those computers that cannot process output data as fast as the data is normally sent by the plotter.

Set Plotter Configuration Instruction

ESC . @ [<DEC> ; <DEC>] :

<DEC> Set maximum buffer size (0 to 9999 characters).

Default: Maximum actual buffer in the plotter.

<ASC> Set configuration options character — ASCII decimal (0-15), the equivalent of a 4-bit word. ASCII decimals 0-127 will be accepted. However, the three most significant bits of the binary equivalent are not used.

Default: Initialized only at plotter power-on. Bit 0 and bit 1 determined by position of MODEM/HARDWIRE switch: MODEM = 0, HARDWIRE = 1, Bit 2 and bit 3 = 0.

DEFAULT: ESC . @ : is

the same as ESC . @ 9 2 8 ; 0 : if MODEM/HARDWIRE switch is set to MODEM, and is

the same as ESC . @ 9 2 8 ; 3 : if MODEM/HARDWIRE switch is set to HARDWIRE.

General Description

The Set Plotter Configuration instruction is used to establish different configuration options. These configuration options are determined by two parameters. The first parameter specifies a maximum available buffer size. The second parameter specifies four binary bits as desired to establish Hardwire Handshake, Enable Data Transmission, Data Indicator and Monitor Mode options.

The initialized state of the second parameter is set only at plotter power-on, and the state of bit 0 and bit 1 is determined by the position of the MODEM/HARDWIRE switch. If the MODEM switch position is selected, all four bits will be initialized to 0. If the HARDWIRE switch position is selected, bits 0 and 1 will be set to 1 and bits 2 and 3 will be set to 0. Subsequent states for these four bits can only be changed programmatically.

The first parameter of this instruction sets the apparent maximum buffer size. The actual buffer size and space are unchanged, but the plotter's response to an output request for buffer size or buffer space is restricted to a value equal to or less than the value specified by the first parameter of this instruction. The second parameter establishes configuration options as defined by the bit pattern described in the following paragraphs and summarized in the table which follows.

Hardwire Handshake (Bit 0)

In a hardwired environment, where the RS-232-C Data Terminal Ready (CD pin 20) control line is not normally used for protocol purposes, bit 0 of the Set Plotter Configuration instruction can be used in lieu of the Set Handshake Mode instructions ESC . H, ESC . I, and ESC . N to establish a "Buffer Available Flag." Handshaking is accomplished when the host computer monitors the "high" or "low" state of control line (CD). While this configuration option is active, the plotter sets control line (CD) "high" when the existing buffer space is > = the current data block size. The default block size for this configuration option is 80 bytes, as established by the ESC . H or ESC . I instruction. The Hardwire Handshake option is normally used in conjunction with the Enable Data Transmission option described in the following paragraph.

ESC . @ Enable Data Transmission (Bit 1)

This configuration option will normally be used in a hardwired environment (no modems) to enable data transmission on the Transmitted Data (BA) and Received Data (BB) lines that is independent of conditions normally required by control line protocol. This configuration allows the plotter to be operated in a 3-wire hookup in which the only lines present are Transmitted Data (BA), Received Data (BB), and ground.

Data Indicator (Bit 2)

This data indicator is available when the plotter is programmed "on" in an On-Line Mode. When bit 2 is turned on (set to 1), on the front panel of the plotter the light in STBY will flash if a character has been sent to the plotter within the last one-quarter second. This option is intended as a debugging aid in programming. (See the table.)

Monitor Mode (Bit 3)

The Monitor Mode is available only when the plotter is programmed "on" in the On-Line Mode, and when active, allows all data that is received or transmitted by the plotter to be displayed on the terminal. This configuration option is primarily intended to be used as a "debugging" aid for program development. Since operating environments vary, data are transmitted to the terminal in different ways as follows: (1) all data which are sent to the MODEM connector from the computer are also seen at the TERMINAL connector; (2) all plotter output responses are sent to both the computer and terminal if the DUPLEX switches on the plotter and terminal are set to HALF; and (3) when the computer is working in an echo-plex environment and the DUPLEX switches on the plotter and terminal are set to FULL, all plotter output responses are echoed from the computer, through the plotter, to the terminal. "Echo-plex environment" is one in which data received from the sending device are "echoed" backed to the sending device. All data that the terminal sends to the plotter, except "break," are ignored while the Monitor Mode is active.

Set Configuration Options Bit Definition

Bit No.	Logic State	Description
0	0 (off)	**Hardwire Handshake** Sets RS-232-C Data Terminal Ready (CD) control line to high (on) at MODEM connector as required for normal control line protocol.
	1 (on)	Establishes "Buffer Available Flag" at MODEM connector on RS-232-C Data Terminal Ready (CD) control line, where CD is not normally used in a hardwired environment. CD is set high (on) if buffer space $\geq$ current block size. The block size is established by the Set Handshake Mode 1 or Mode 2 instructions, and unless otherwise specified, the block size will default to 80 bytes when bit 0 of this instruction is set to 1 or if the MODEM/HARDWIRE switch was set to HARDWIRE at plotter power-up. CD is set low (off) if buffer space $<$ current block size.

Set Configuration Options Bit Definition (Continued)

Bit No.	Logic State	Description
1	0 (off)	**Enable Data Transmission** Implements "Disable Data Transmission." Normal control line protocol must be observed in order for data transmission to occur.
	1 (on)	Enables data transmission that is independent of the RS-232-C Data Set Ready (CC) and Clear To Send (CB) control line conditions.
2	0 (off)	**Ongoing Communications Indicator** Allows indicator lamp in [STBY] to be lit only when the plotter is in Standby Mode.
	1 (on)	Causes indicator lamp in [STBY] to flash if a character has been sent to the plotter within the last 1/4 second. This visual indication that data is being sent to the plotter is available only when programmed "on" in the On-Line or Local Mode.
3	0 (off)	**Monitor Mode** Allows plotter to operate normally, as specified for the On-Line programmed "on" mode.
	1 (on)	Enables all data that are received or transmitted by the plotter to be viewed on the terminal. This is called Monitor Mode and is active only when the plotter is programmed "on" in the On-Line Mode. All data which the terminal sends to the plotter (except "break") are ignored while in Monitor Mode.

Abort Device Control Instruction

ESC . J

Description

This instruction aborts any device control instructions that may be partially decoded or executed. Unspecified parameters of partial instructions are defaulted. All pending or partially transmitted output requests are immediately terminated including handshake and output instructions. Intermediate output operations, such as turnaround delay and echo suppression, are aborted and buffer input is enabled. Only the specified execution of an output operation is aborted. The handshake and output modes remain as specified.

Abort Graphic Instruction

ESC . K

Description

This instruction aborts any partially decoded graphic instructions but permits instructions being executed to finish. All pending graphic instructions in the buffer are discarded, leaving the buffer empty. The currently executing vector is allowed to be completed; however, all other scheduled vectors are aborted.

NOTE

This condition is most obvious when executing Label, Arc, and Circle instructions or plotting with a dashed line type.

Output Group Instructions

Output Buffer Size Instruction

ESC . L
Response: <bytes>
Response Description: <bytes> Number of bytes allocated to buffer use; 928 bytes, if the buffer size has not been changed by an ESC . @ instruction.

Description

The response will not be transmitted until the buffer is empty and ready to start another graphic instruction.

NOTE

The plotter's buffer may be expanded with a 2K buffer expansion option. This will change the response to 2976 bytes unless an ESC . @ instruction was previously executed in which case the response will equal the buffer size specified by the ESC . @ instruction.

Output Buffer Space Instruction

ESC . B
Response: <bytes>
Response Description: <bytes> Number of bytes of buffer space that are currently available for storing received graphic instructions (0 to 928 bytes or 0 to 2976 bytes with expanded buffer).

Description

The response is the number of currently available bytes in the buffer and equals the buffer size minus the number of bytes occupied by the graph instructions yet to be executed.

Output Extended Error Instruction

(ESC) (.) (E)
Response: <DEC>
Response Description: <DEC> A zero or decimal number of 10 through 16 indicating the type of RS-232-C related error that has occurred.

Description

A zero response indicated that no RS-232-C related error has occurred. If the plotter ERROR light is on and an (ESC) (.) (E) instruction results in a response of 0, HP-GL instruction OE should be executed to determine what type of graphic instruction error has occurred. (Refer to Chapter 9 for a complete description of this OE instruction and related graphic error indicators.)

A decimal 10 through 16 response indicates that some type of RS-232-C related instruction error has occurred. Refer to the following table for a listing of these error indicators and their meanings.

Table of Error Indicators

Type	Description
10	Output instruction received while another output instruction is executing. The original output instruction will continue normally while the one in error will be ignored.
11	Invalid byte received following the (ESC) (.) in a device control instruction.
12	Invalid byte received while parsing a device control instruction. The device control parameters from the parameter where the invalid byte was received to the end of the instruction will be defaulted. The invalid byte will then be parsed.
13	Parameter out-of-range (too big, too small, or an illegal value).
14	Too many parameters received for a device control instruction. Additional parameters beyond the proper number are ignored and the parsing of the device control instruction ends when a colon (normal exit) or the first byte of another instruction is received (abnormal exit). **NOTE** The receipt of something other than another parameter, a semicolon, or a colon will result in an error type 12 overwriting error type 14.
15	A transmission error has been detected. These are errors generated by the Universal Asynchronous Receiver/Transmitter (UART) (framing error, parity error, or overrun error).
16	The input buffer memory has overflowed. This indicates improper handshaking. As a result of the overflow, one byte of data has been lost and therefore eventually an HP-GL error will probably occur.

Output Extended Status

ESC . O
Response: <status>
Response Description: <status> Decimal equivalent of a status word response in the range of 0 to 7.

3

ESC . O

Description

This instruction response provides the status of the 7220T paper advance option using the bit pattern listed in the bit definition and description table that follows. When the instruction is sent to the 7220C, 0 is always 0, and the plotter will respond with a 6 or 2.

NOTE

This instruction can be used at the beginning of a plotting sequence to determine if a paper advance operation is necessary and feasible before plotting commences and to check for an out-of-paper condition resulting from the paper advance. When requesting Output Extended Status after a paper advance operation, it is necessary to ensure that the paper advance instruction is actually executed before requesting the extended status. The following sequence suggests one way to accomplish this.

Send ESC . L Not executed until buffer is empty. All HP-GL instructions will have been executed.

ESC . O Bit 2 (paper advance instruction status) reset to 0. Test to see if paper has been written on and roll paper loaded. Even response means roll paper not loaded. Response of 3 or 7 means paper has been written on.

AF; HP-GL instruction that will cause a full page paper advance if paper is present.

ESC . O Look for a response of 5 (bits 0 and 2 set to 1) indicating paper advance completed. If response is 1 (bit 2 set to 0), execute a second ESC . O to assume sufficient time has elapsed for the paper advance instruction to be completed.

Output Extended Status Response Bit Definition And Description

Bit No.	Logic State	Description
0	0	Paper advance "off" (roll paper is not loaded — 7220T).
	1	Paper advance "on" (roll paper is loaded — 7220T).
1	0	Set only after an advance has happened and "paper" is sensed.
	1	Current page not clean. Set under the following conditions: a. At plotter power-on. b. Each time pen is moved with the pen down. c. Each time "no paper" is sensed after a front panel paper advance. d. Each time "no paper" is sensed before a programmatic paper advance attempt or after a programmatic paper advance.
2	0	Indicates no paper advance instruction was completed or executed since the last ESC . O instruction (i.e., no AF, AH, PG or PG1 has been executed). This bit is reset to 0 by the ESC . O instruction.
	1	Indicates that a paper advance instruction has been executed/completed (AH, AF, PG or PG1).

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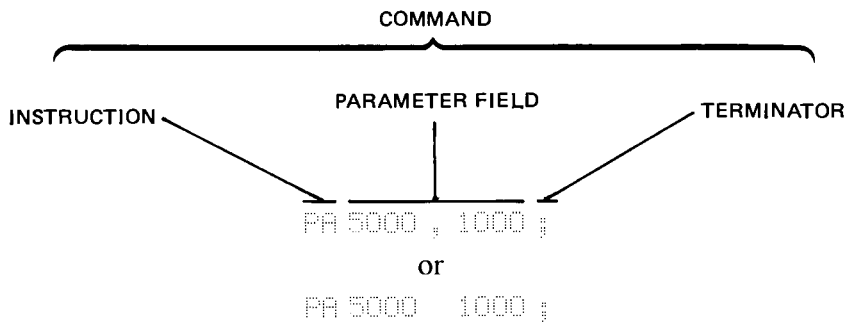
Chapter 4
General Programming Instructions

This chapter introduces the 7220 plotter's HP-GL (Hewlett-Packard Graphics Language) instruction set and defines parameter ranges and the instruction syntax that is used throughout the manual. General instructions that establish default and initialize parameters are also defined.

The 7220 HP-GL Instruction Set

The Hewlett-Packard Graphic Language (HP-GL) instruction set for the 7220 plotter consists of 50 instructions which fall into 9 basic groups. A command is defined as an instruction followed by its parameter field and a terminator shown in the following example:



NOTE

In addition to these 47 HP-GL instructions, three more HP-GL instructions unique to the 7220T are described in Chapter 11 of this manual. These instructions control paper advance and cutting operations associated with the 7220T.

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Each instruction is a two-letter mnemonic which can be either upper or lower case. The parameter field can be of three types:

1. Integer Format: Free field integers maximum range is −32767 and +32767; parameters of some instructions are limited to a narrower range. If no sign is specified, the parameter is assumed to be positive. All decimal fractions are truncated.

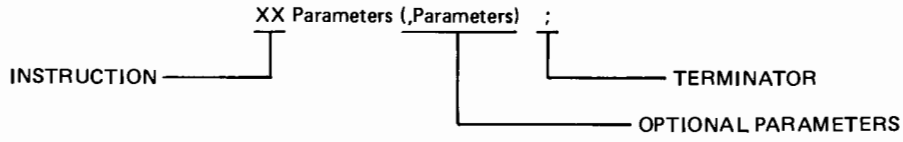
2. Decimal Format: Numbers between ±127.999 with an optional decimal point. Fractional inputs between −0.004 and +0.004 are interpreted as zero. If no sign is specified, the parameter is assumed to be positive.

3. Label Fields: Any combination of text, expressions, or string variables. Refer to the "Label Instruction LB" in Chapter 8 for a complete description.

A terminator must be sent at the end of the parameter field for all instructions. For all instructions, except LB, the terminator must be a semicolon. The syntax used throughout this manual is (;).

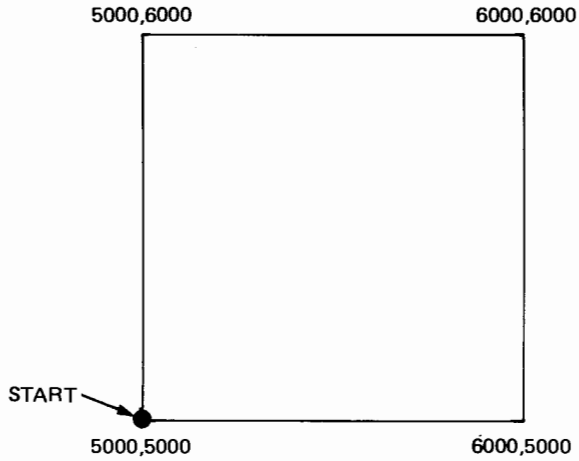
The Label instruction LB requires a special terminator (see Chapter 8, "Lettering").

Certain instructions (such as PA or PR) may have multiple parameters. These parameters must be separated by commas or spaces and must conform to a particular syntax. The syntax is listed under the respective instruction definition in the following chapters and will take the general form:



The following string of HP-GL instructions, when sent to the plotter, will cause a square to be drawn as shown below.

```
IN;SP5;PA5000,5000;PD;
PR0,1000,1000,0,0,-1000,-1000,0;SP0;
```



Steps:

1. The IN instruction initializes the plotter.
2. The SP instruction selects pen 5.
3. The PA sends the pen to the absolute plotter position of X = 5000, Y = 5000.
4. The PD instruction puts the pen down.
5. The string of PR instruction pairs (0,1000,1000,0 etc.) moves the pen to the respective absolute plotter coordinates X = 5000, Y = 6000, X = 6000, Y = 6000, X = 6000, Y = 5000 and finally X = 5000, Y = 5000.
6. The SP0 instruction puts the pen away.

Note the use of the terminator (;) between commands. The terminator is necessary at the end of the parameter field even though no further commands follow. The HP-GL instruction set for the 7220 plotter is summarized in the following table.

Plotter Instruction Set

Instruction		Definition
VECTOR GROUP		
PA	x,y(,x,y(,...))	Plot absolute
PD		Pen down
PR	x,y(,x,y(,...))	Plot relative
PU		Pen up
CHARACTER GROUP		
CA	n	Designate alternate set n
CP	spaces, lines	Character plot
CS	m	Designate standard set m
DI	run, rise	Absolute direction
DR	run, rise	Relative direction
DT	t	Define terminator t
LB	c....c	Label ASCII string
SA		Select alternate character set
SI	width, height	Absolute character size
SL	tan θ	Absolute character slant (from vertical)
SR	width, height	Relative character size
SS		Select standard character set
UC	(pen,)x,y,pen(,x,y)(,....)	User defined character
LINE TYPE GROUP		
LT	t(,l)	Designate line type and length
SM	c	Symbol mode
SP		Select pen
VA		Adaptive velocity
VN		Normal velocity
VS	v(,n)	Select velocity v for pen n
DIGITIZE GROUP		
DC		Digitize clear
DP		Digitize point
OD		Output digitized point & pen status

Plotter Instruction Set (Continued)

Instruction	Definition
AXES GROUP	
TL tp(,tn)	Tick length
XT	X-axis tick
YT	Y-axis tick
SET-UP GROUP	
IP P1x,P1y,P2x,P2y	Input P1 and P2
IW Xlo,Ylo,Xhi,Yhi	Input window
OP	Output P1 and P2
SC Xmin,Xmax,Ymin,Ymax	Scale
CONFIGURATION AND STATUS GROUP	
AP	Automatic pen pickup
DF	Set default values
IM e(,s(,p))	Input e, s, and p masks
IN	Initialize
OA	Output actual position and pen status
OC	Output commanded position & pen status
OE	Output error
OF	Output factors
OI	Output identification
OO	Output options
OS	Output status
CIRCLE GROUP	
AA x,y, arc angle (,chord angle)	Arc absolute
AR x,y, arc angle (,chord angle)	Arc relative
CI radius (,chord angle)	Circle
PAPER ADVANCE GROUP –7220T ONLY	
AF or PG or PG1	Advance full page
AH	Advance half page
EC	Enable cutter

The following two commands set the plotter to a predefined state.

The Default Instruction DF

The Default instruction DF sets certain plotter functions to a predefined state.

Syntax:

DF ;

No parameters are used. However, the terminator ; must be included to complete the command.

A DF command sets the following plotter functions to the conditions shown:

Default Conditions

Function	Conditions
Relative character direction	Horizontal (DR1,0)
Line type	Solid line
Line pattern length	4% of the distance from P1 to P2
Input window	Mechanical limits of plotter 0,0,16000,11400
Relative character size	Width = 0.75% of $\lvert P2_X - P1_X \rvert$, Height = 1.5% of $\lvert P2_Y - P1_Y \rvert$
Automatic pen pickup	on
Pen velocity	36 cm/s
Adaptive pen velocity	off
Symbol mode	off
Tick length	tp = tn = 0.5% of $\lvert P2_X - P1_X \rvert$ for Y-tick and 0.5% of $\lvert P2_Y - P1_Y \rvert$ for X-tick
Standard character set	Set 0
Alternate character set	Set 0
Character slant	0°
Mask value	223
Digitize clear	on
Scaling	off
Label terminator	ETX

In addition, P1 and P2 are not changed and the current pen location is not changed. The state of the cutter and the status of the paper check bit are not changed on the 7220T.

The Initialize Instruction IN

The Initialize instruction IN returns the plotter to the initial power-on state under program control.

Syntax:

IN ;

No parameters are used. However, the terminator (;) must be included to complete the command.

The Initialize command sets the plotter to the same conditions as the Default command and sets these additional conditions.

The pen is moved to the lower right corner of the platen.

The scaling points P1 and P2 are set to the points P1 = (520, 380) and P2 = (15720, 10380) on the 7220C or the 7220T with sheet paper loaded. For the 7220T with roll paper loaded the settings are P1 = (520, 1020), P2 = (15760, 11180) in English mode and P1 = (520, 1140), P2 = (15720, 11140) in metric mode.

All errors are cleared and bit position 3 of the output status word is set true (1).

The cutter is enabled and the paper check bit is set to 1 on the 7220T.

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Chapter 5
Scaling

This chapter describes the plotting area, plotter and user units, and the instructions that enable you to scale the plotting area into user units. Procedures for setting the scaling points manually and programmatically are described. The following instructions are included in this chapter:

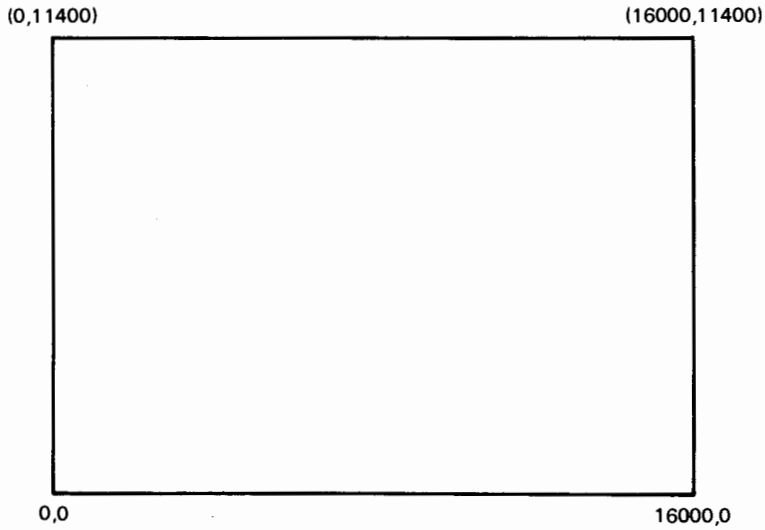
Input P1 and P2 (IP)
Output P1 and P2 (OP)
Scale (SC)

A discussion of scaling without using the SC command is contained in the appendix.

The Plotting Area

The absolute plotting area is established by the mechanical limits of pen motion while the pen is down. This plotting area is part of the platen area, the platen being the white flat surface area of the plotter. The physical size of the plotting area on the platen is 285 × 400 mm (11.2 × 15.75 in.). The plotting area is divided into plotter units where one plotter unit = 0.025 mm (0.001 in.).

The absolute plotting area is shown below (the coordinates of the mechanical limits are shown in absolute plotter units).



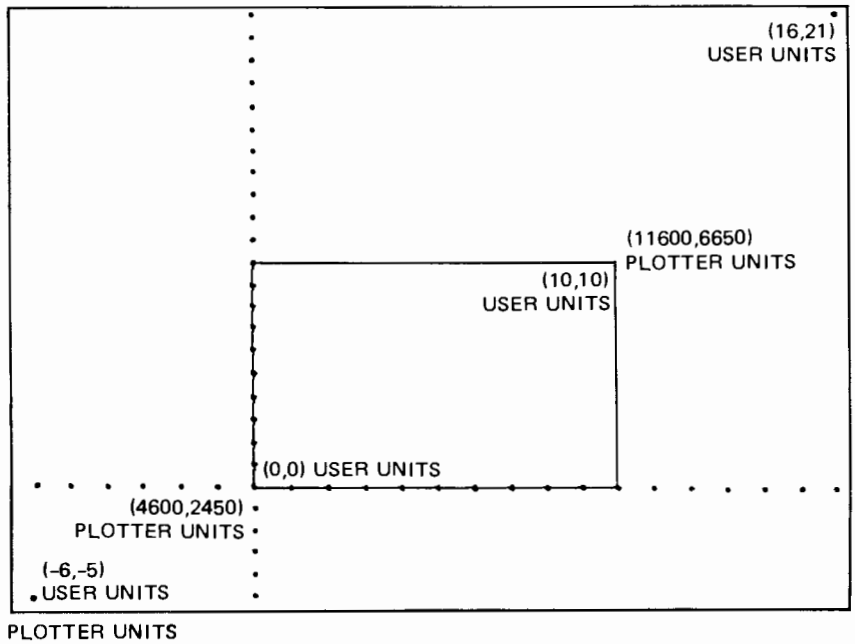
When the plotter is initialized by power-up, front panel controls, or use of the IN instruction, scaling points P1 and P2 are set, as shown in the following table.

Plotter	$P1_X$,$P1_Y$	$P2_X$,$P2_Y$
7220C or 7220T, no paper or sheet paper	520,380	15720,10380
7220T, roll paper loaded, paper switch set to metric	520,1140	15720,11140
7220T, roll paper loaded, paper switch set to English	520,1020	15760,11180

User Units

The size of a user unit is determined by the parameters of the Scale instruction (SC) and the setting of the scaling points, P1 and P2. The scaling point P1 is assigned the value Xmin, Ymin, while the scaling point P2 is assigned the value Xmax, Ymax. The larger the range of parameters in an SC command and the closer together the scaling points, the smaller the size of a user unit. The total plotting area (including not only the platen area, but also "nearby" and "faraway" areas described under the PA command in Chapter 6) is scaled into units of this size. Thus, if P1 is not 0,0 plotter units, and/or P2 is not 16000,11400 it is possible to physically plot to a point outside the rectangle defined by P1 and P2.

In the following illustration, the scaling points are set to 4600,2450 and 11600,6650. Assigning a value of 0,0 to P1 and 10,10 to P2, the platen is divided into user units as shown below. The minimum value that can be plotted on the platen surface is −6,−5 and the maximum value is 16,21. Notice that a user unit is not necessarily the same size on the X-axis as it is on the Y-axis and that the scaled area extends beyond the rectangle established by P1 and P2.



Setting The Scaling Points Using Front Panel Controls

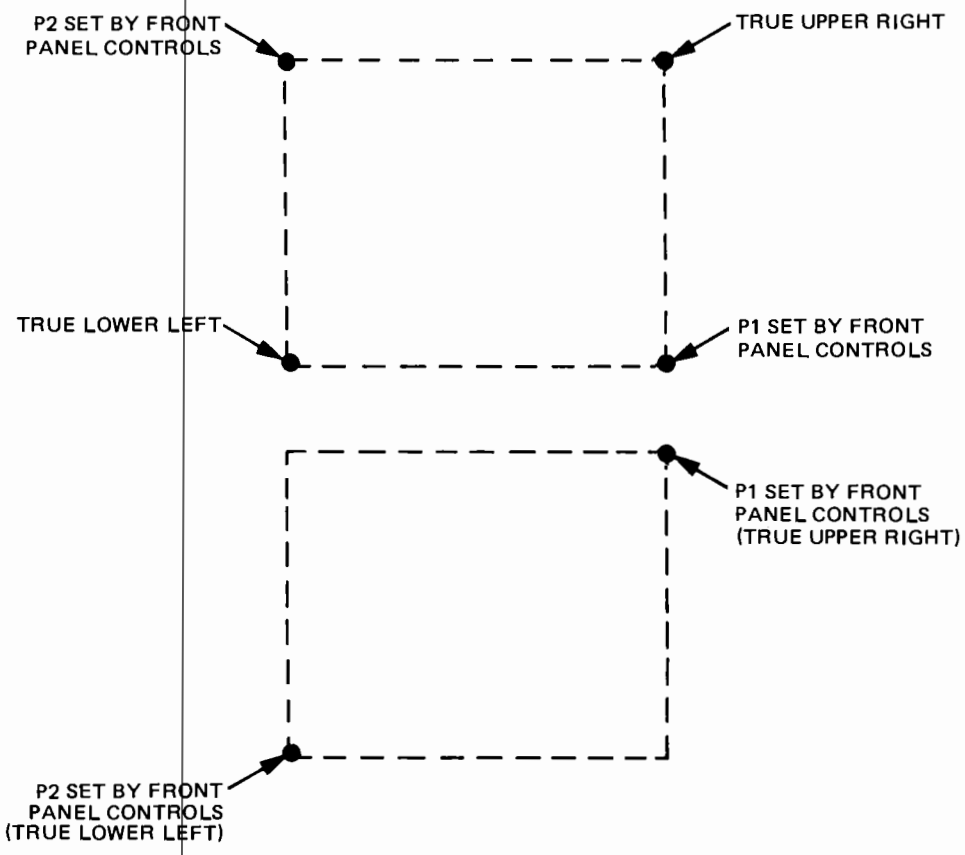
Scaling points may be set using front panel controls [ENTER •] [P1] and [ENTER •] [P2]. When the plotter is turned on, default scaling points are set as described earlier in this chapter. The default scaling points for the 7220C or 7220T with roll paper loaded are shown in the following illustrations.

Scaling points can be relocated using plotter front panel controls as follows:

Position the pen at the new location using [◄] [FAST] [►] [▲] [▼].

When the pen is at the desired location, press [ENTER •] and either [P1] or [P2] according to the point that is to be located there.

P1 and P2 as set by the plotter front panel controls do not need to have a true lower left/upper right relationship. They may occupy opposite corners of any desired plotting area. Refer to the following examples for clarification:



Scaling points may also be set programmatically by executing an IP instruction as described in the next section.

The Input P1 And P2 Instruction IP

The Input P1 and P2 instruction IP relocates the scaling points P1 and P2 through program control.

Syntax:

IP $P1_X$,$P1_Y$,$P2_X$,$P2_Y$ (;)

The new coordinates of P1 and P2 are specified in the order shown above, must be in absolute plotter units, and also within platen maximum range X = 0,16000, Y = 0,11400.

Upon receipt of a valid IP command, bit position 1 of the output status word is set true (1). A command IP with no parameters (IP;) will default to the values shown in the following table:

Plotter	$P1_X$,$P1_Y$	$P2_X$,$P2_Y$
7220C or 7220T, no paper or sheet paper	520,380	15720,10380
7220T, roll paper loaded, paper switch set to metric	520,1140	15720,11140
7220T, roll paper loaded, paper switch set to English	520,1020	15760,11180

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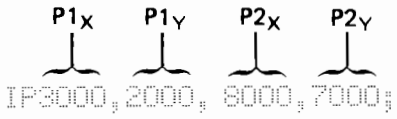
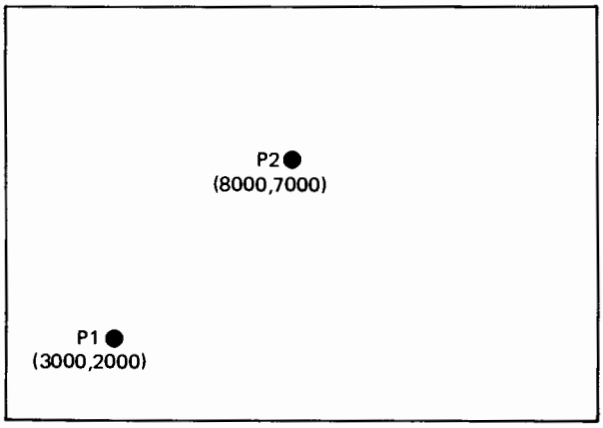
IP

Upon initialization, character size is set relative (SR) to the locations of P1 and P2. Unless an SI command has been entered as part of the program, the character size will be directly affected by the IP command.

The following example relocates the scaling points P1 and P2 to the positions shown on the figure.





The Output P1 And P2 Instruction OP

The Output P1 and P2 instruction OP makes the current coordinates of the scaling points P1 and P2 (in absolute plotter units) available for output to the computer.

Syntax:

OP ;

No parameters are used. However, the terminator (;) must be included to complete the command.

When requested, the coordinates will be output as four ASCII integers as follows:

$P1_X$, $P1_Y$, $P2_X$, $P2_Y$ CR*

Upon completion of output, bit position 1 of the output status word is cleared.

*Default output terminator is CR. The terminator defined by the ESC . M command currently in effect will be used.

The Scale Instruction SC

The Scale instruction SC assigns user unit values to scaling points P1 and P2, and thus maps user units onto the whole plotting area.

Syntax:

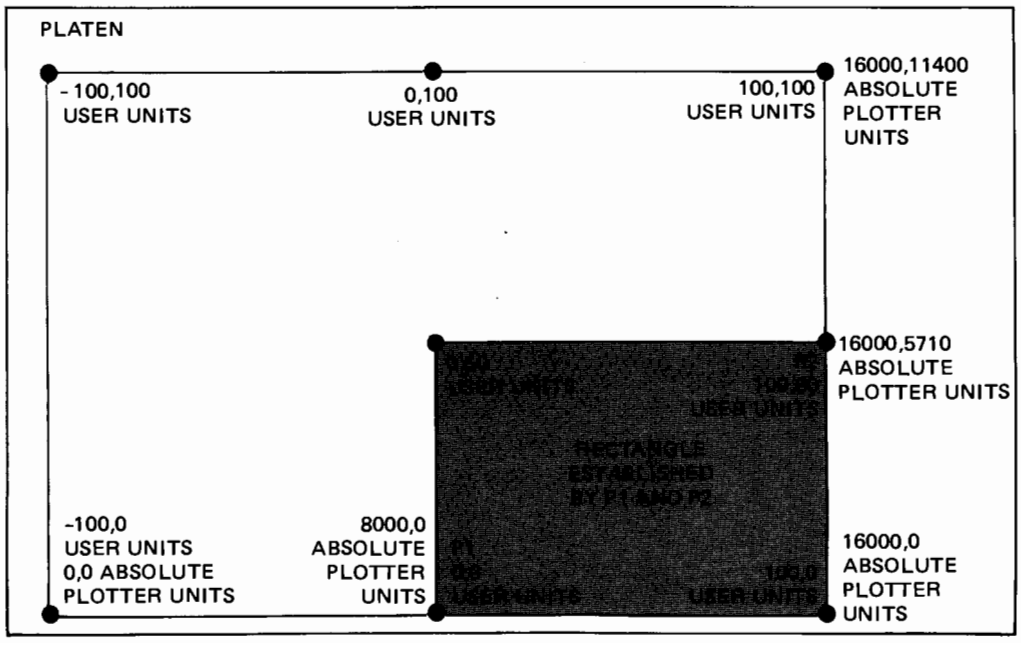
SC Xmin, Xmax, Ymin, Ymax (;)

An SC command with no parameters (SC;) returns the plotter to unscaled mode in which parameters of plot commands are interpreted as absolute plotter units.

When parameters are used, all four parameters are required and must be integers in the range ±16383. Xmax must be greater than Xmin and Ymax greater than Ymin. The Xmin,Ymin values are assigned to the scaling point P1 and the Xmax,Ymax values are assigned to the scaling point P2. Execution of an SC command with valid parameters places the plotter in scaled mode in which parameters of plot commands are interpreted as user units.

The whole plotting area, including the platen area, and the nearby and faraway areas beyond the platen (see "Plot Absolute Instruction PA," Chapter 6), are scaled into user units. Thus, scaling extends beyond the rectangle established by P1 and P2. The size of a user unit depends on both the range of the scaling parameters and the X- or Y-distance between P1 and P2. The illustration below shows the absolute plotting area (mechanical limits) which results from the following statements.

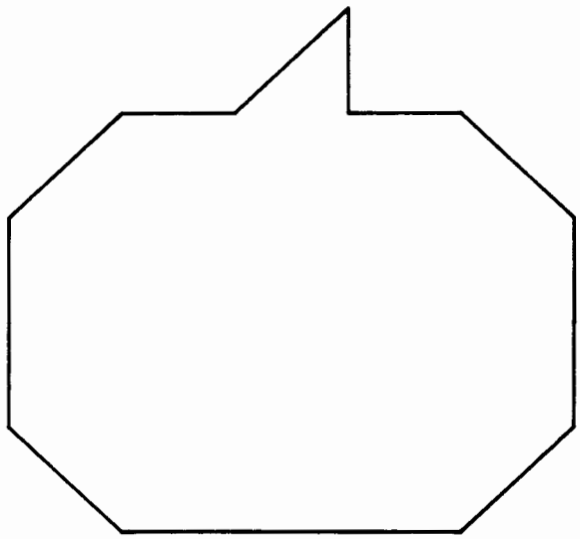

```
IP8000,0,16000,5710;
SC0,100,0,50;
```



Let us now assume we have scaled an area of the platen into 25 × 18 user units. With integer scaling, plotting is only possible to coordinates with integer values. It is only possible to plot to a finite number of points on the platen, in the current example 26 × 19 (X-coordinates 0 to 25, Y-coordinates 0 to 18). You cannot draw to the location 2.2,3.7; the line must be drawn to 2,3 or 2,4. When trying to plot functions where the fractional portion of the function's value is significant, truncation or rounding that is performed to send integer values as parameters of plot commands produces some unexpected and unsatisfactory results. The following two programs illustrate the problem and its solution.

The first program is an attempt to draw a circle in the center of the plotting area. The constants, 12.5 and 9, in lines 3 and 4 center the circle in the plotting area. Since line 5 must be formatted to send integer values, significant fractional parts are lost, and the result is an undiscernable plot. The scaling 0 to 25, and 0 to 18 does not allow plotting to enough points, and results in a circle of poor resolution.

```
  LINE 1. IN;SCO,25,0,18;SP1;
■LINE 2. FOR T=0 TO 2*PI STEP PI/20
■LINE 3. X=2.5*COS(T)+12.5
■LINE 4. Y=2.5*SIN(T)+9
★LINE 5. PA X,Y;PD;
■LINE 6. NEXT T
  LINE 7. SPO;
```

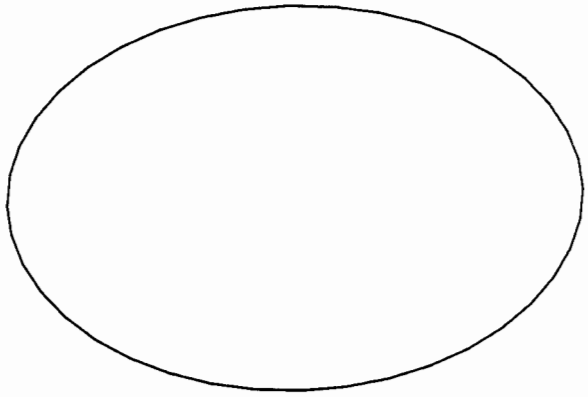


■BASIC Statement. Do not send to plotter.

★A controller-dependent format statement may be required for this statement to be accepted by the plotter.

In the second example, a constant of 1000 is used in both the scaling and the values of X and Y. Note the constants that center the circle have changed to correspond with the SC command (lines 3 and 4). The use of the multiplier 1000 solves the resolution problem.

```
  LINE 1. IN;SCO,16000,0,16000;SP1;
■LINE 2. FOR T=0 TO 2*PI STEP P1/20
■LINE 3. X =2.5*1000*COS(T)+8000
■LINE 4. Y=2.5*1000*SIN(T)+8000
★LINE 5. PA X,Y;PD;
■LINE 6. NEXT T
  LINE 7. SPO;
```



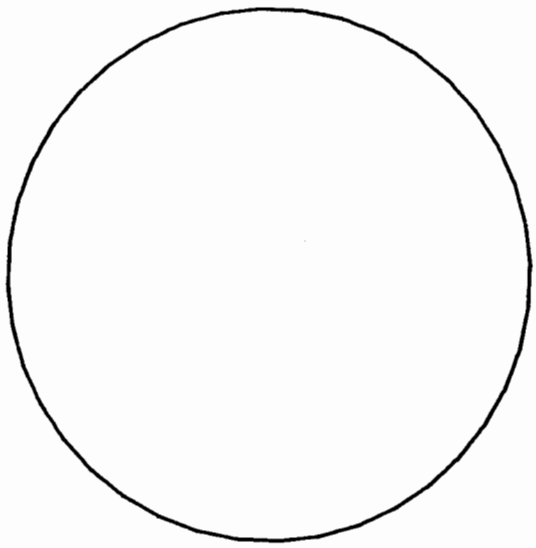
Notice that the plot is not a perfect circle. This is a result of the aspect ratio of the plotter ($|P1_X-P2_X| \neq |P1_Y-P2_Y|$) and the parameters of the SC command. In the preceding example, which has been slightly reduced, P1 and P2 were the default values for a 7220C or a 7220T without roll paper.

There are two ways to compensate for this distortion. The first is to define P1 and P2 so that the plotting area is square and scale the area alike in X and Y.

■BASIC Statement. Do not send to plotter.

★A controller-dependent format statement may be required for this statement to be accepted by the plotter.

```
LINE 1. IN;IP1000,1000,10000,10000;SP1;
LINE 2. SCO,16000,0,16000;
■LINE 3. FOR T=0 TO 2*PI STEP PI/20
■LINE 4. X=2.5*1000*COS(T)+8000
■LINE 5. Y=2.5*1000*SIN(T)+8000
★LINE 6. PA X,Y;PD;
■LINE 7. NEXT T
LINE 8. SPO;
```



We now plot a perfect circle.

The second method of solution is to use any scaling points, but compensate for the aspect ratio either in the Scaling instruction, or the calculation of the variables X and Y.

Program 1

```
LINE 1. IN;IP520,1140,15720,11140;SP1;
LINE 2. SCO,1520,0,1000;

■LINE 3. FOR T=0 TO 2*PI STEP PI/20
■LINE 4. X=100*COS(T)+760

■LINE 5. Y=100*SIN(T)+500
★LINE 6. PA X,Y;PD;
■LINE 7. NEXT T
LINE 8. SPO;
```

Line 1 sets P1 and P2.
Line 2 — 1 scaled unit = 10 plotter units.

Offsets 760 and 500 in lines 4 and 5 center circle in plotting area.

■BASIC Statement. Do not send to plotter.
★A controller-dependent format statement may be required for this statement to be accepted by the plotter.

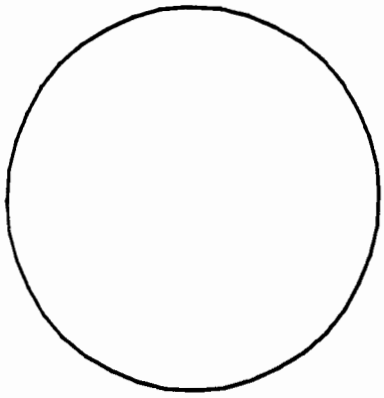
If the Scale command sets an equal number of user units in the X- and Y-axes, the values of X or Y must be adjusted to correspond with the aspect ratio when the plotting area is not square. Both programs plot the same circle, but the pen used is differently.

Program 2

```
LINE 1. IN;IP520,1140,15720,11140;SP2;
LINE 2. SC0,1000,0,1000;
■LINE 3. FOR T=0 TO 2*PI STEP PI/20
■LINE 4. X=65.78947*COS(T)+500
■LINE 5. Y=100*SIN(T)+500
★LINE 6. PA X,Y;PD;
■LINE 7. NEXT T
LINE 8. SP0;
```

Line 1 sets default P1 and P2 so
$|P1_X - P2_X| = 15200$
$|P1_Y - P2_Y| = 10000$

$10000/15200 = 65.78947/100$



5

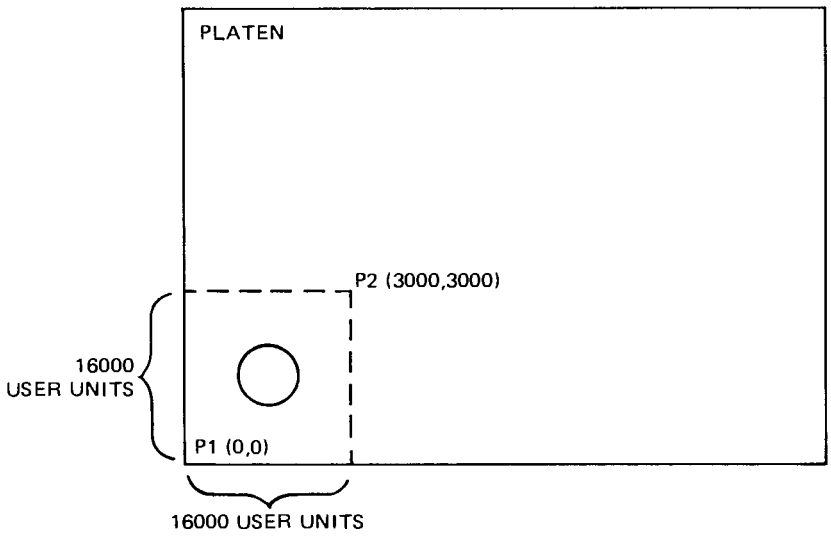
SC

Changing P1 and P2 with an IP command can move the plot to a different area of the platen and can change the plot size. If geometrically accurate plots are desired, it is always necessary to adjust for a new P1 and P2 by changing the Scale (SC) command, or by scaling the values of X and Y with a multiplier. The following listing plots a small circle in the lower-left-hand corner of the platen.

■BASIC Statement. Do not send to plotter.

★A controller-dependent format statement may be required for this statement to be accepted by the plotter.

```
LINE 1. IN;IP0,0,3000,3000;SP1;
LINE 2. SC0,16000,0,16000;
■LINE 3. FOR T=0 TO 2*PI STEP PI/20
■LINE 4. X=2.5*1000*COS(T)+8000
■LINE 5. Y=2.5*1000*SIN(T)+8000
★LINE 6. PA X,Y;PD;
■LINE 7. NEXT T
LINE 8. SP0;
```



Algebraic formulas may be used to convert from user to plotter units. Some users may wish to do this to compute desired window parameters without using output commands, to cope with non-integer data where it is difficult to figure a convenient multiplier, or to enable use of user units beyond the limits ±16384. This method of scaling is covered in the appendix of this manual.

5

SC

■BASIC Statement. Do not send to plotter.

★A controller-dependent format statement may be required for this statement to be accepted by the plotter.

5

Chapter 6
Plotting

This chapter describes the HP-GL instructions that enable you to control the pen and to perform all plotting movements. Plotting moves can be made to an absolute set of coordinates, or relative to the given pen position with any of the 8 pens. In addition, you can raise or lower the pen before or after the move and control the pen-down velocity. Plotting moves can be specified in absolute plotter units (when no Scale instruction has been executed) or user-defined integer units (when a Scale instruction has been executed).

The Pen Select Instruction SP

The Pen Select instruction SP selects a pen through program control.

Syntax:

SP pen stall number (;)

The pen stall number should be an integer in the range of 0 through 8. Decimal fractions are truncated. SP commands with integer pen numbers < 0 or > 8 are ignored. When the command SP is executed, the pen arm raises the pen it is currently holding (if any) and returns it to the position from which it was originally fetched. The new pen designated by the SP command is then fetched and the pen arm returns to its last position prior to the SP command.

A pen stall number of 0 or no parameter directs the pen arm to return the pen it is currently holding to its stall, then the pen arm returns to its last position prior to the SP command.

If the specified pen stall is empty, or if all of the pen stalls are full and there is a pen in the arm, then no pen change occurs.

If the stall from which the pen was originally fetched has since become occupied, the currently held pen is placed in the lowest numbered vacant stall.

Plotter front panel select controls can override the program command.

The Pen Instructions PU And PD

The Pen Up instruction PU raises the pen without moving it to a new location. The Pen Down instruction PD lowers the pen without moving it to a new location.

Syntax:

PU ;

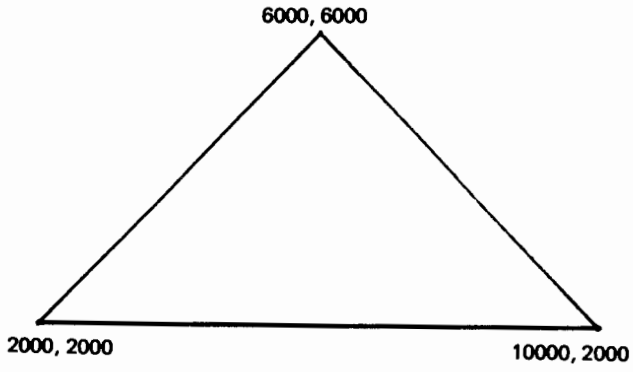
or

PD ;

Neither instruction requires or permits any parameters. Both instructions require the terminator ; to complete the command. Front panel pushbuttons on the plotter will override these commands.

The following string of HP-GL instructions, when sent to the plotter, will cause a triangle to be drawn with pen 4 as follows:

```
IN;SP4;PA2000,2000;PD;PR4000,4000,4000,-4000,-8000,0;SP0;
```



The Plot Absolute Instruction PA

The Plot Absolute instruction PA moves the pen to the point specified in plotter or user units by the X- and Y-coordinate parameters that complete the command.

Syntax:

PA X_1 coordinate, Y_1 coordinate (, X_2 coordinate, Y_2 coordinate, . . . , . . . , X_n coordinate, Y_n coordinate) ;

A PA command requires that both the X-and Y-coordinates be specified (coordinate pair). The X-coordinate parameter specifies the absolute X location in plotter units to which the pen is to move. The Y-coordinate parameter specifies the absolute Y location in plotter units to which the pen will move.

Any number of coordinate pairs, separated by commas or spaces, can be listed after the PA instruction. The pen will move to each point in the order given.

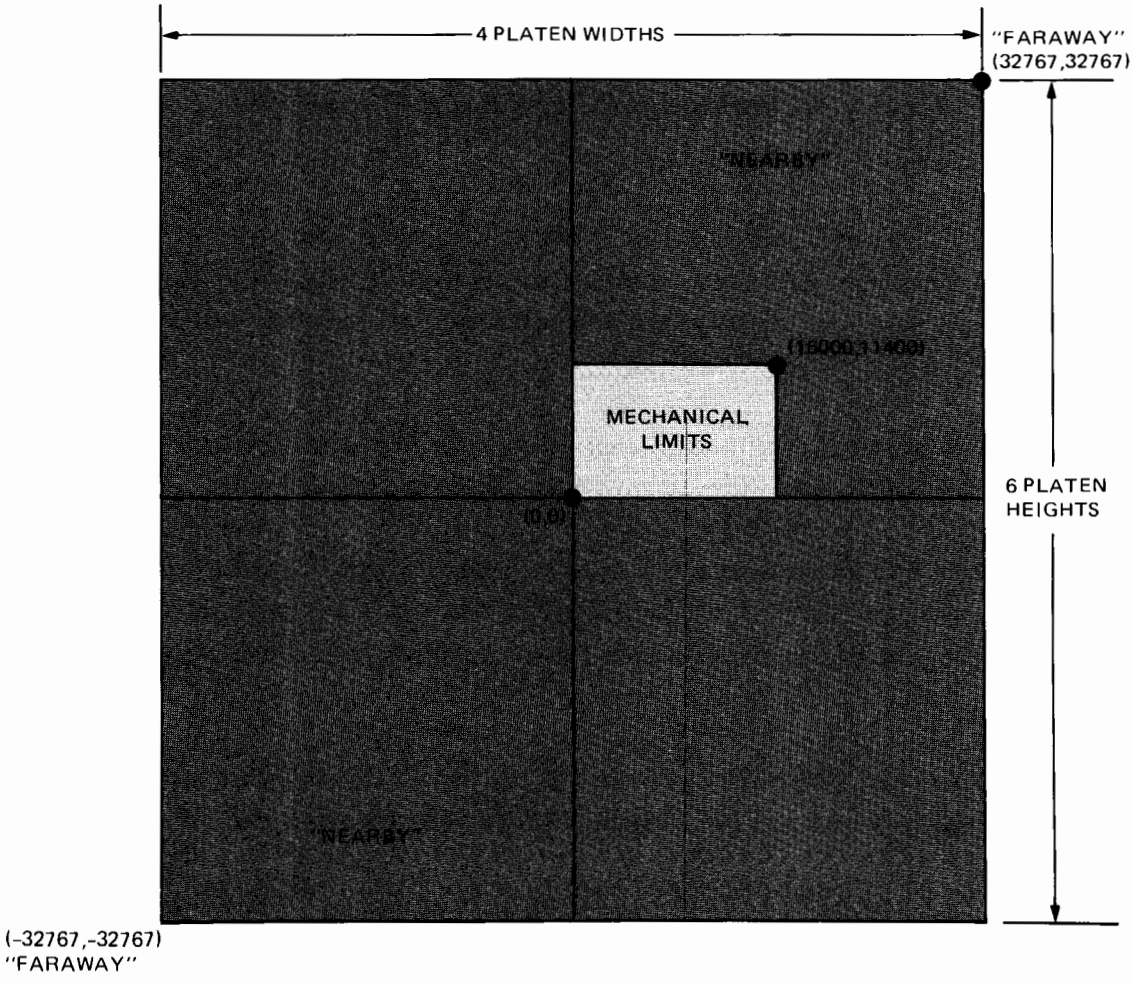
Using the PU or PD instruction, a pen control command can be placed before or after the PA command, raising (PU) or lowering (PD) the pen. If no pen control command is specified, the pen will assume the pen state (pen up or pen down) of the previous statement.

Plotting is done only within the currently defined "window" area on the platen. Refer to "Input Window Instruction IW," Chapter 9 for further information.

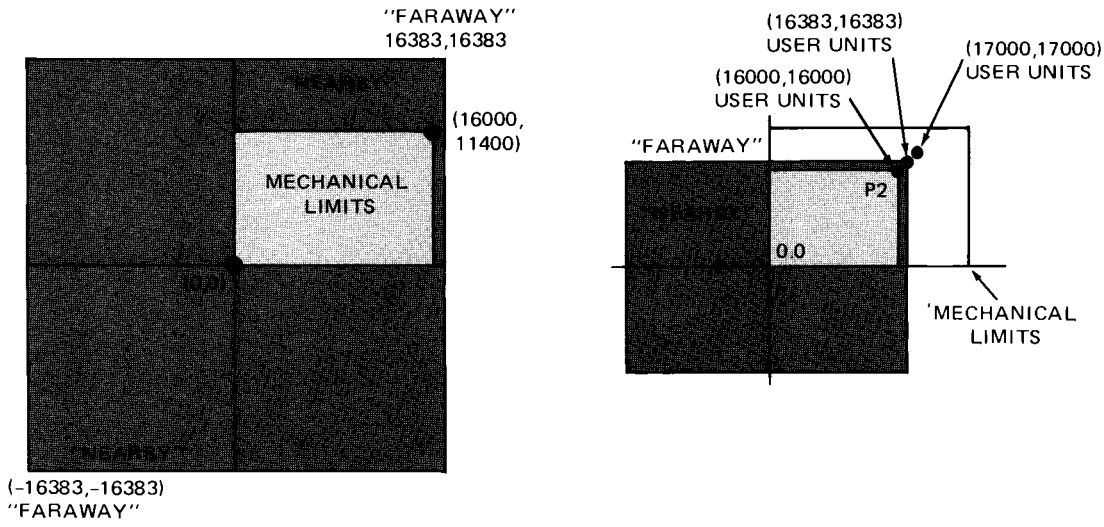
If the point specified by a PA command lies off the platen surface but within the "nearby" area: a line is drawn to the platen limit; the pen is raised; the OUT OF LIMIT light will turn on. The pen remains raised until a point on the platen is specified.

If the point lies off the platen and in the "faraway" area, the OUT OF LIMIT light will blink, but the pen will not move from its present position in the plotting area.

The following figure identifies the absolute plotter unit limits of "nearby" and "faraway" areas. In the figure, the platen area is lightly shaded and the "nearby" area is shaded darker. The "faraway" area is white.



When scaling is on, "nearby" and "faraway" areas change considerably as can be seen in the following diagram. When scaling is on, a point is "faraway" if any parameter is more negative than −16383 or greater than +16383, or if its plotter unit equivalent is not between ±16383.



Scaling On

The leftmost diagram represents the maximum "nearby" area when scaling is on. In that diagram, you are limited by the plotter unit equivalents being beyond the acceptable range. Consider, however, the rightmost diagram showing the case where P2 is set to some point in the center of the plotting area. Now, if scaling is set at 0 to 16000 on both X- and Y-axis, you will be in the "faraway" area if you plot the point 17000, 17000, yet that would lie within the platen area.

"Faraway" is that area in which the plotter is in its lost state. Another way of describing it is to say the coordinates are out-of-range. Coordinates within the platen area and "nearby" area are in-range. When scaling is off, in-range coordinates are defined as both X- and Y-parameters being integer plotting units having values in the range of −32768 and +32767. When scaling is on, in-range coordinates must have both X- and Y-parameters in the range of ±16383 and, when converted to plotter units, must also be in the range of ±16383. When out-of-range parameters are given, the plotter will enter its lost state. The OUT OF LIMIT light will blink. However, the ERROR light will not turn on.

The Plot Relative Instruction PR

The Plot Relative instruction PR moves the pen relative to its current location by the number of plotter or user units specified by the X- and Y-parameters that complete the command.

Syntax:

PR X_1 increment, Y_1 increment (, X_2 increment, Y_2 increment, . . . , . . . , X_n increment, Y_n increment) (;)

Parameters are interpreted as plotter units if scaling is off and as user units if scaling is on.

The X-increment parameter specifies the number of plotter or user units that the pen is to move horizontally.

The Y-increment parameter specifies the number of plotter or user units that the pen is to move vertically.

The signs of the increment parameters determine the relative direction that the pen moves; a positive value moves the pen in a positive direction and a negative value moves the pen in a negative direction.

Any number of coordinate pairs, separated by commas or spaces, can be listed after the PR instruction. The pen will move relative to the previous point in the order given.

A pen control command can be placed before or after the PR command, raising (PU) or lowering (PD) the pen. If no pen control command is specified, the pen will assume the pen state (pen up or down) of the previous statement.

In-range coordinates with scaling off are defined as:

1. Both X- and Y-parameters being integer plotter units having values between −32768 and +32767.

2. Each succeeding X- and Y-increment, when added to the current X- and Y-coordinate, does not exceed ±32767 plotter units when referenced from the point 0,0.

In-range coordinates with scaling on are defined as:

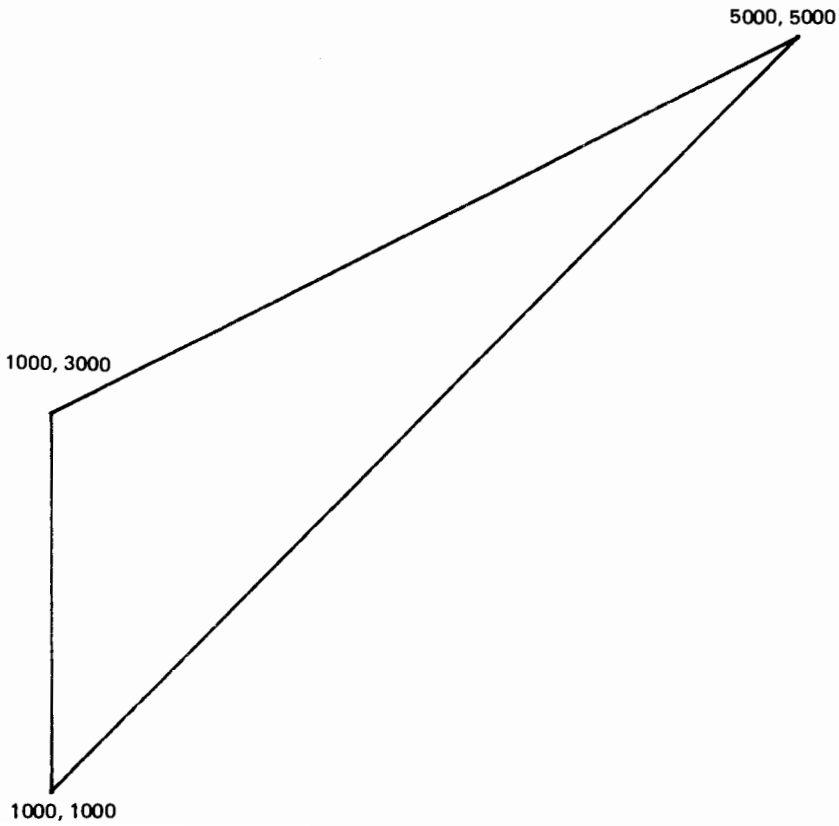
1. Both X- and Y-parameters being integer user units have values between ±16383.

2. Each succeeding X- and Y-increment, when added to the current X- and Y-coordinate, is not less than −16383 or greater than +16383 user units, and when converted to plotter units does not exceed ±16383 plotter units when referenced from 0, 0.

If a PR command specifies a point off the platen in the "nearby" area as described under the PA instruction, the pen draws a line to the limit of the platen and stops with the pen raised. The OUT OF LIMIT light turns on steady. The plotter recognizes subsequent PR commands while in this area. If a PR command specifies a point in the "faraway" area, the pen is raised and does not move. The OUT OF LIMIT light blinks and the plotter does not recognize subsequent PR commands until a PA command with valid parameters or pen movement with front panel controls moves the pen to the "nearby" area or within the platen area.

The following string of HP-GL instructions, when sent to the plotter, will cause a triangle to be drawn as follows:

```
IN;SP2;PR1000,1000;PD;PR0,2000;
PR4000,2000,-4000,-4000;SP0;
```



Plotting With Variables

In many plotting applications it is necessary to plot using variables rather than fixed numbers to define the X- and Y-coordinate values. The values of all HP-GL statement parameters have the same restrictions (integer or decimals in a valid range) when sent as variables as when sent as literals (fixed numbers). The terminators and delimiters of HP-GL statements must be sent to the plotter too. The method of defining output format and variable precision varies from computer to computer. Refer to your computer manual for the appropriate format statements that may be needed in your program.

The following example illustrates the use of variables in plotting. Quotation marks are used by many computers to define the literal characters that are to be sent. Note the comma in line 6 which is part of the HP-GL statement and is sent to the plotter. Here it is sent as a literal in quotes.

```
  LINE 1. IP0,0,7544,7544;SP1;
  LINE 2. SC0,10,0,10;
■LINE 3. FOR T=0 TO 2*PI STEP PI/20
■LINE 4. X=1.5*COS(T)+5
■LINE 5. Y=1.5*SIN(T)+3
★LINE 6. "PA".X.",".Y.";PD;"
■LINE 7. NEXT T
  LINE 8. PU;
```

This statement causes the plotter to move to the integer value defined by the X and Y variables and lower the pen. The HP-GL mnemonics, delimiters, and terminators are sent as literals in quotes on some computers. The comma enclosed in quotes is included here to delineate the variables X and Y.

6

■BASIC Statement. Do not send to plotter.

★A controller-dependent format statement may be required for this statement to be accepted by the plotter.

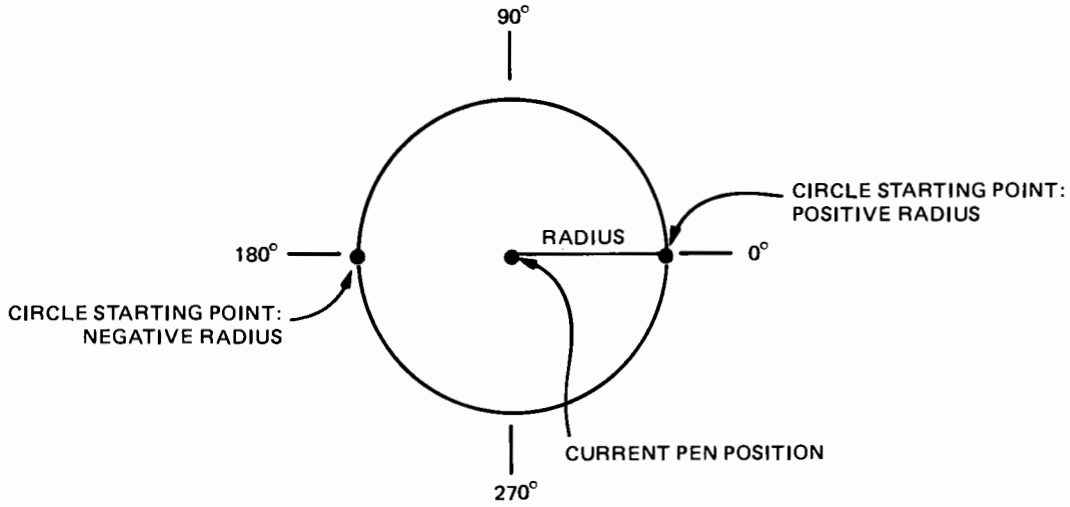
Three instructions in the 7220 instruction set increase the ease with which arcs and circles can be drawn. These three instructions are the Circle instruction CI, the Arc Absolute instruction AA, and the Arc Relative instruction AR.

The Circle Instruction CI

The Circle instruction CI draws a circle with a specified radius and chord angle.

Syntax:

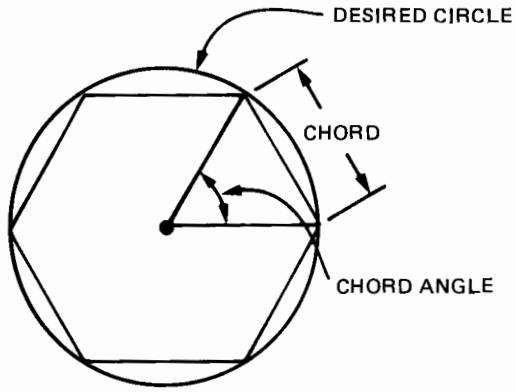
CI radius (,chord angle) ;



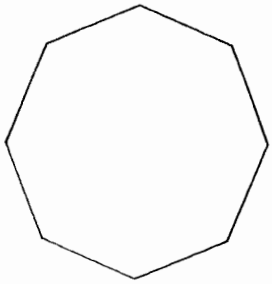
The radius can be a positive or negative number in the presently defined units with the sign defining the starting point of the circle: positive numbers start at the 0-degree point; negative numbers start at the 180-degree point. The current pen position is the center of the circle.

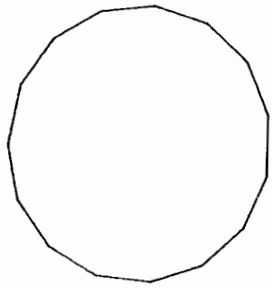
The chord angle is the angle, in degrees, through which a chord is drawn representing the shortest straight line segment along the circle. The chord angle can be a positive or negative number. The default chord angle is 5 degrees.

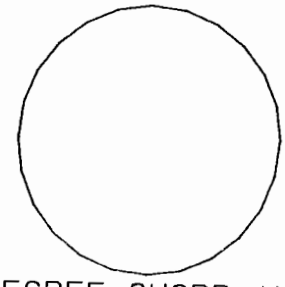
A circle is actually made up from a series of straight line segments, or chords, as shown below:

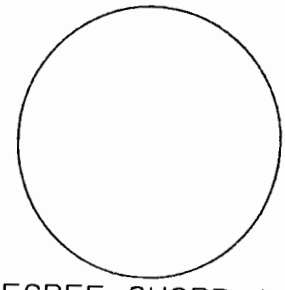


Increasing the number of chords by decreasing the chord angle generates a smoother circle. Decreasing the chord angle, however, increases the length of time required to draw a circle. The effect of different chord angles is shown in the following circles.


45 DEGREE CHORD ANGLE


25 DEGREE CHORD ANGLE


15 DEGREE CHORD ANGLE


5 DEGREE CHORD ANGLE

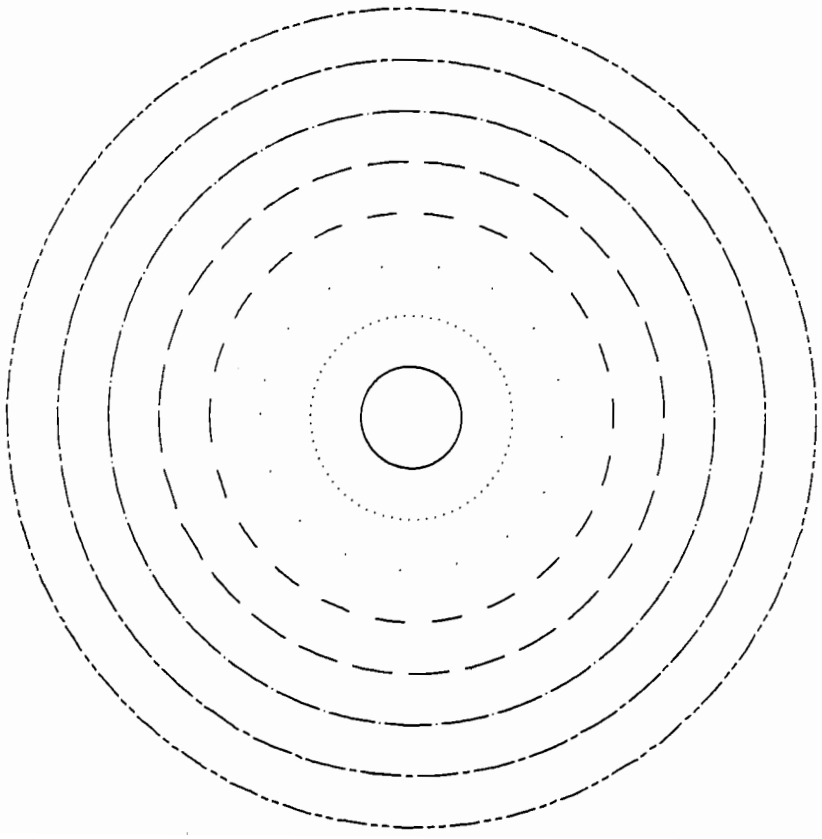
The Circle instruction does not require a Pen Down command since circles are drawn regardless of pen status. The pen lifts (if it was down), moves to the circle starting point, draws the circle, then returns to the center of the circle. After drawing the circle, the pen assumes the pen status (up or down) held prior to the Circle command. The PEN UP pushbutton, if pressed and held down, will override the automatic pen down feature of the Circle command.

Circles are drawn within the plotting area established by the Input Window instruction IW, with clipping occurring outside the window limits. If no window has been established through a programmed instruction, the default window is in effect.

Circles are drawn using the presently defined line type.

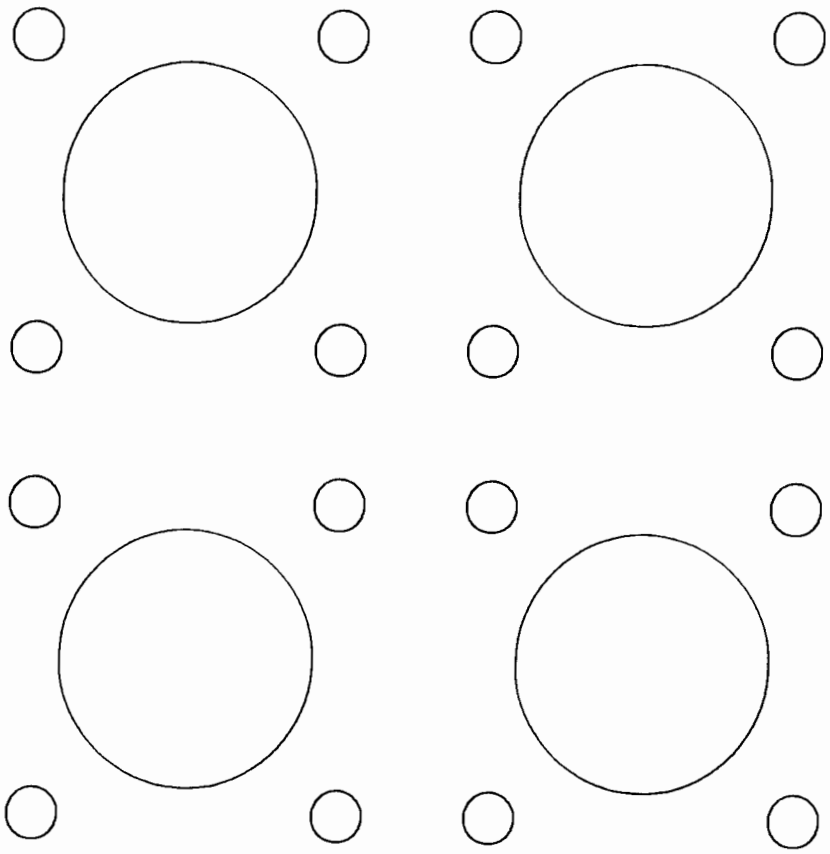
To demonstrate some of the features of the Circle instruction, the following HP-GL instructions, when sent to the plotter, draw various circles with different line types, radii, and starting points.

```
LINE 1. IP200,200,8000,8000;
LINE 2. SC-1000,1000,-1000,1000;
LINE 3. PA0,0;LT;CI100,5;LT0;CI200,5;LT1;CI300,5;
LINE 4. LT2;CI400,5;LT3;CI500,5;LT4;CI600,5;LT5;
LINE 5. CI700,5;LT6;CI800,5;
```



The Circle instruction can also be used to define a series of holes that must be repeated in a particular pattern as shown below:

```
  LINE  1. IP200,200,8000,8000;
  LINE  2. SC-1000,1000,-1000,1000;
  LINE  3. SP2;PU;PA-800,-800;
■LINE  4. GOSUB12
  LINE  5. PA-800,100;
■LINE  6. GOSUB12
  LINE  7. PA100,100;
■LINE  8. GOSUB12
  LINE  9. PA100,-800;
■LINE 10. GOSUB12
■LINE 11. GOTO16
  LINE 12. CI50;PR600,0;CI50;
  LINE 13. PR-300,300;CI250;
  LINE 14. PR-300,300;CI50;
  LINE 15. PR600,0;CI50;
■LINE 16. RETURN
```



■BASIC Statement. Do not send to plotter.

Explanation of Preceding Example

1. The IP instruction and SC instruction define the plotting area and perform user unit scaling.

2. The SP instruction selects a pen, the PU instruction lifts the pen, and the PA instruction moves the pen to the center of the first hold pattern.

3. GOSUB12 sends the program to the subroutine that draws the circles.

4. The subroutine draws the pattern. First a 50-unit radius circle is drawn, followed by a relative move of 600 units in the X direction where another 50-unit radius circle is drawn. A move of −300 units in X and +300 units in Y locates the center of the 250-unit radius circle. The last two 50-unit radius circles are then located and drawn with their respective moves.

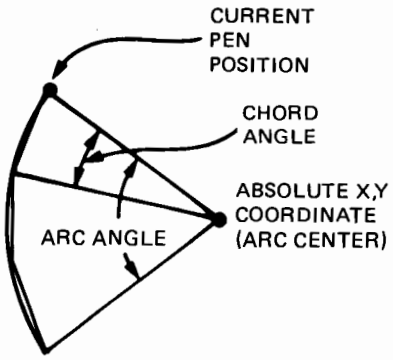
5. The RETURN statement returns the program to the next instruction in the main program and the pattern is repeated.

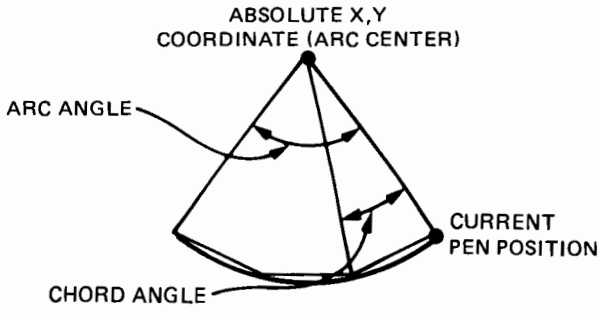
The Arc Absolute Instruction AA

The Arc Absolute instruction AA draws an arc with the center point located at a specified point and the starting point of the arc at the current pen position. The arc can be drawn clockwise (CW) or counterclockwise (CCW), through the specified arc angle with the chord angle optionally specified.

Syntax:

AA X-coordinate, Y-coordinate, arc angle (, chord angle) (;)





The AA instruction requires that both X- and Y-coordinates be specified (coordinate pair). They are interpreted as plotter units when scaling is off and as user units when in scaled mode. The X- and Y-coordinates locate the center of the arc and may be located on or off the platen. The distance from the current pen position to the specified coordinates becomes the radius which is not therefore directly specified.

The arc angle must be specified and is the angle, in degrees, through which the arc is drawn: a positive arc angle draws CCW from the current pen position; a negative arc angle draws CW from the current pen position.

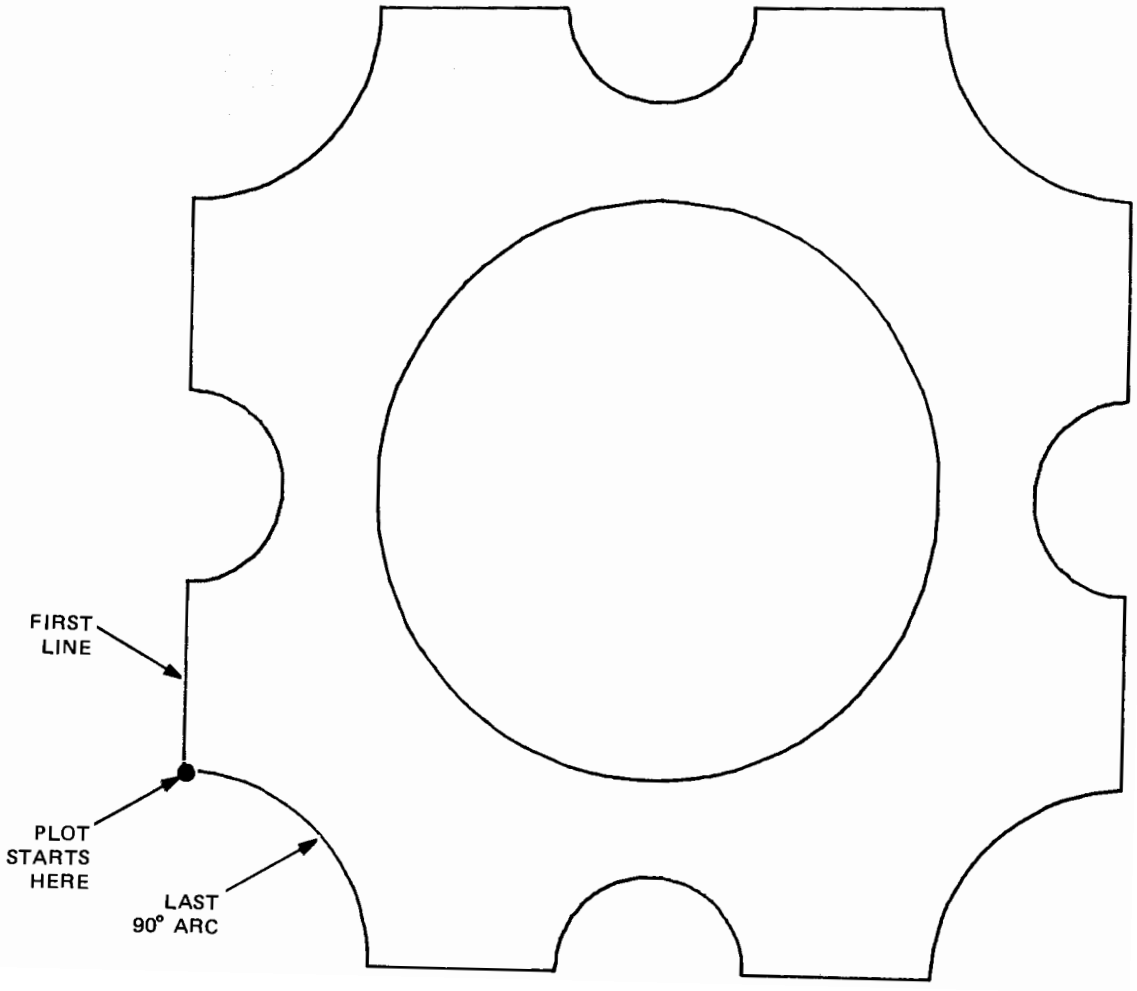
The chord angle is the angle, in degrees, through which a chord is drawn representing the shortest straight line segment along the arc. The chord angle can be a positive or negative number. The default chord angle is 5 degrees. As discussed under the Circle instruction, since an arc is also made up from a series of chords, increasing the number of chords by decreasing the chord angle generates a smoother arc.

The AA command uses the previously commanded pen status and line type. If no pen status has been commanded since initialization, pen up is assumed. If no line type has been commanded, a solid line is drawn.

Arcs are drawn within the plotting area established by the Input Window instruction IW, with clipping occurring outside the window limits. If no window has been established through a programmed instruction, the default window is in effect.

The following HP-GL instructions and the resulting figure below demonstrate the use of the AA instruction:

```
LINE  1. IP200,200,7200,7200;
LINE  2. SC0,700,0,700;PU;SP2;
LINE  3. PA100,200;PD;PA100,300;
LINE  4. AA100,350,180;PA100,500;
LINE  5. AA100,600,90;PA300,600;
LINE  6. AA350,600,180;PA500,600;
LINE  7. AA600,600,90;PA600,400;
LINE  8. AA600,350,180;PA600,200;
LINE  9. AA600,100,90;PA400,100;
LINE 10. AA350,100,180;PA200,100;
LINE 11. AA100,100,90;PU;PA350,350;
LINE 12. CI150;
```



Explanation of Preceding Example

1. The IP, SC, and SP instructions define the plotting area and perform user unit scaling and select a pen.

2. The string of PU, PA, and PD instructions moves the pen to the starting point and draws the first line.

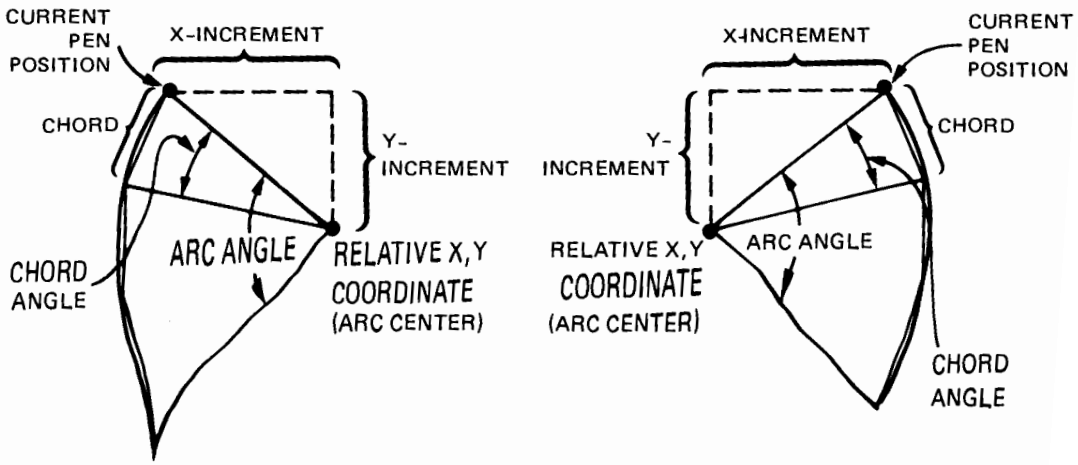
3. The series of AA and PA strings draws 90° or 180° arcs and associated straight lines.

4. When the last 90° arc is drawn, the pen is raised (PU) and moved to the center of the circle which is then drawn by the CI instruction.

the current pen position which is the ... clockwise (CW) or counterclockwise (CCW) through the specified arc angle with the chord angle optionally specified.

Syntax:

AR X-increment, Y-increment, arc angle (, chord angle) ;



The AR instruction requires that both X- and Y-increment parameters (coordinate pair) and arc angle be specified. Increment parameters are in plotter units when in nonscaled mode or user units when in scaled mode. The X- and Y-increment parameters locate the center of the arc with respect to the current pen position. The signs of the increment parameters determine the relative direction of the location of the center of the arc. A positive value locates that parameter in a positive direction and a negative value locates that parameter in a negative direction.

The arc center can be located on or off the platen. The arc angle is the angle, in degrees, through which the arc is drawn: a positive arc angle draws CCW; a negative arc angle draws CW.

The chord angle is the angle, in degrees, though which a chord is drawn representing the shortest straight line segment along the arc. The chord angle can be a positive or negative number since the 7220 uses only the absolute value in computations. The default chord angle is 5 degrees. As discussed under the Circle instruction, since an arc is also made up from a series of chords, increasing the number of chords by decreasing the chord angle generates a smoother arc.

Arcs are drawn using the previously commanded pen status and line type. If no pen status has been commanded since initialization, pen up is assumed. If no line type has been specified, a solid line is used.

As described under the Arc Absolute instruction, arcs are drawn within the plotting area established by the Input Window instruction IW.

The Automatic Pen Pickup Instruction AP

The Automatic Pen Pickup instruction AP causes the plotter to automatically raise the pen whenever it has been down without motion for 65 seconds.

Syntax:

AP (integer) ;

An AP command with no parameters (AP;) enables automatic pen pickup. Pickup enabled is the default condition.

An AP command with a valid parameter disables automatic pen pickup. Decimal fractions are truncated. Using AP0 is recommended.

An AP command with invalid parameters has no effect on pickup.

The Velocity Select Instruction VS

The Velocity Select instruction VS specifies in centimetres per second the pen speed for plotting and lettering operations.

Syntax:

VS pen velocity (, pen number) ;

The pen velocity parameter should be an integer between 1 and 36 and represents pen speed in cm/s. If the optional pen number (1 to 8) is specified, the speed will apply only to that pen. If a pen number is not specified, the speed applies to all pens. Decimal fractions in either parameter are truncated.

When the plotter is initialized, the pen velocity defaults to 36 cm/s. A VS command with no parameters (VS;) also defaults the pen velocity to 36 cm/s.

A VS command with an invalid velocity parameter turns on the ERROR light and pen velocity does not change. A VS command with a valid velocity parameter but an invalid pen number will be ignored (no error, no velocity change).

A VS command remains in effect until another valid VS command is executed or the plotter is reinitialized or set to default conditions.

The Adaptive Pen Velocity Instruction VA

The Adaptive Pen Velocity instruction VA provides the means to adapt the pen-down speed automatically to approximate the rate at which the computer sends coordinate data to the plotter.

Syntax:

VA (;)

No parameters are used. However, the terminator (;) must be included to complete the command. A VA command with parameters turns on the ERROR light but does not alter the velocity mode. A VA command remains in effect until a VN (see "Normal Velocity Instruction VN" in this chapter) is executed or the plotter is initialized or set to default values. This mode provides a smoother plot than the normal velocity mode when plotting coordinates that are generated by a relatively slow program routine (fewer than 15 coordinates per second). The maximum pen speed will not exceed the speed selected by the previous VS command.

If the time required to complete a plot is a consideration, care should be taken when including the VA command in a program, since the VA command slows the plotter down to the computer data rate. If the data creates long vectors, plotter movement will be very slow and should the data rate increase, it will take a few data points and a significant period of time before the plotter is again up to data speed.

UN ;

No parameters are used. However, the terminator (;) must be included to complete the command.

After receipt of a VN command, the pen returns to the velocity specified by the previous VS command or default velocity if no VS command has been executed.

A VN command with parameters will turn on the ERROR light and adaptive velocity mode will not be canceled.

Chapter 7
Plot Enhancement

This chapter describes the instructions that enable you to enhance the plotted data with axes, with tick marks, and with special symbols; and to select tick lengths and line types.

The Tick Instructions XT And YT

The Tick instruction XT draws a vertical X-tick at the current pen location. The Tick instruction YT draws a horizontal Y-tick at the current pen location.

Syntax:

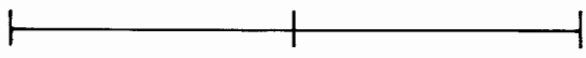
XT (;)
or
YT (;)

Neither instruction requires any parameters. Both instructions require the terminator (;) to complete the command.

The tick length is specified by the Tick Length command (see "Tick Length Instruction TL" in this chapter). If no tick length is specified, the default length for tp and tn is 0.5% of $|P2_X - P1_X|$ for a Y-tick and 0.5% of $|P2_Y - P1_Y|$ for an X-tick.

The following string of HP-GL instructions, when sent to the plotter, draws a horizontal line 8000 plotter units long, and places X-ticks at the end points and at 4000 plotter units.

```
SP2;PA1000,4000;PD;XT;PR4000,0;XT;PR4000,0;XT;SP0;
```



Ticks are always drawn no matter whether the current pen status is up or down.

The Tick Length Instruction TL

The Tick Length instruction TL specifies the length of the tick marks drawn by the plotter. The tick lengths are specified as a percentage of the horizontal and vertical distances between the scaling points P1 and P2.

Syntax:

TL tp, tn (;)

The up and right tick length (tp) determines the length of the upward portion of the tick marks drawn along the X-axis and the right-side portion of the tick marks drawn along the Y-axis. This value is specified as a percentage of the vertical scale length, $|P2_Y - P1_Y|$.

The down and left tick length (tn) determines the length of the downward portions of the tick marks drawn down along the X-axis and the left-side portion of the ticks marks drawn along the Y-axis. The value is specified as a percentage of the horizontal scale length, $|P2_X - P1_X|$.

The plotter, when initialized, automatically sets the tick length values to 0.5% of the scaling lengths ($|P2_Y - P1_Y|$ and $|P2_X - P1_X|$). A TL command with no parameters (TL;) will default to the same values.

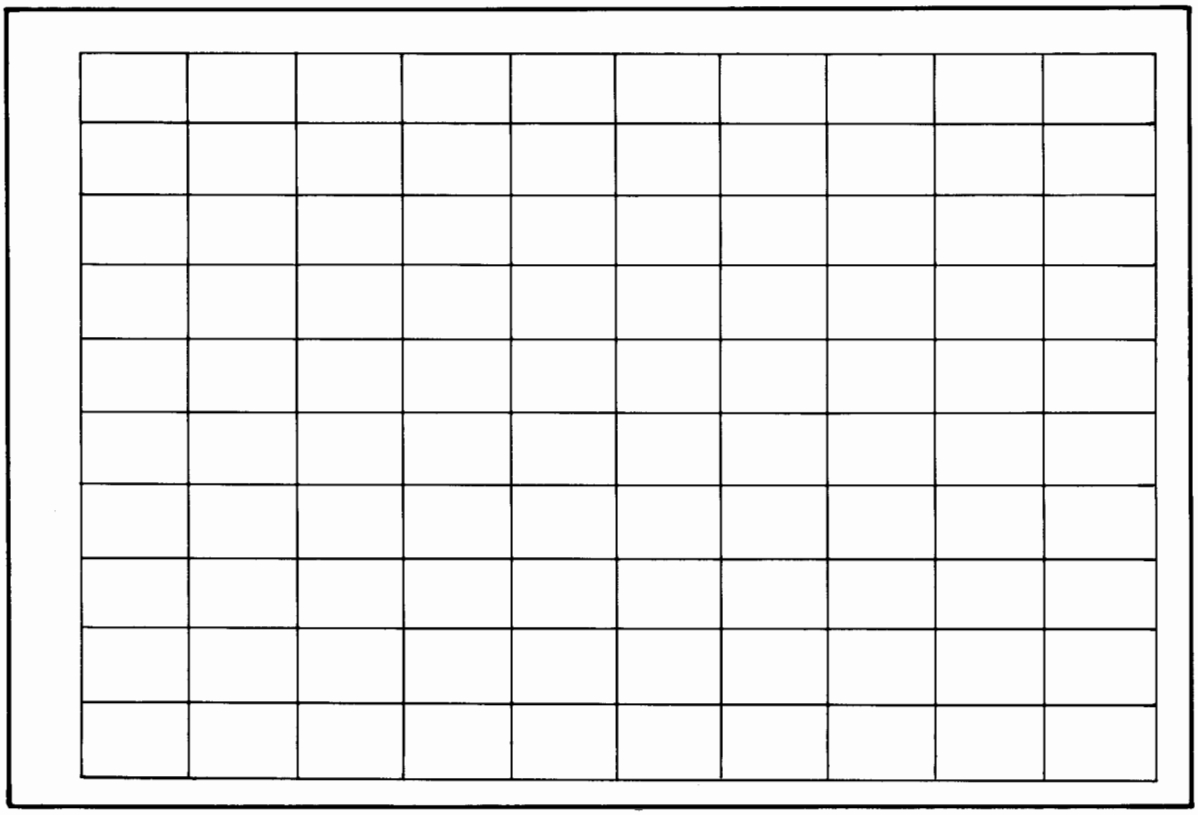
The following HP-GL instructions, when sent to the plotter, draw a 10 × 10 grid on the plotter defined within the points P1 = 520,380 and P2 = 15720, 10380. Note that only the up and right tick length parameter is specified since only the area above the X-axis and to the right of the Y-axis is being used.

```
  LINE 1. IN;PU;PA520,380;PD;TL100;XT;
■LINE 2. FOR I=1 TO 10;
  LINE 3. PR1520,0;XT;
■LINE 4. NEXT I;
  LINE 5. PU;PA520,380;PD;YT;
■LINE 6. FOR J=1 TO 10;
  LINE 7. PR0,1000;YT;
■LINE 8. NEXT J;
  LINE 9. PU;
```

7

TL

■BASIC Statement. Do not send to plotter.



Tick Length Example

Syntax:

SM character ;

The symbol is limited to a single character and may be any printing character except ASCII 59 or ASCII 44.

The PA and PR commands function as described in Chapter 6, except that the specified character is drawn at the end of each vector and is centered on the plotted point. The character will be drawn at the end of the vector whether the pen is up or down.

The character is drawn according to the character set currently selected when the SM instruction is executed. Once selected, the character is independent of character set changes later in the program and can only be changed by a new SM command.

If a character is not specified (SM;) or an invalid parameter is used, the Symbol Mode is canceled. The size (SI and SR), Slant (SL), and direction (DI and DR) commands affect the character drawn. An SM command remains in effect until another SM command is executed or the plotter is initialized or set to default conditions.

NOTE

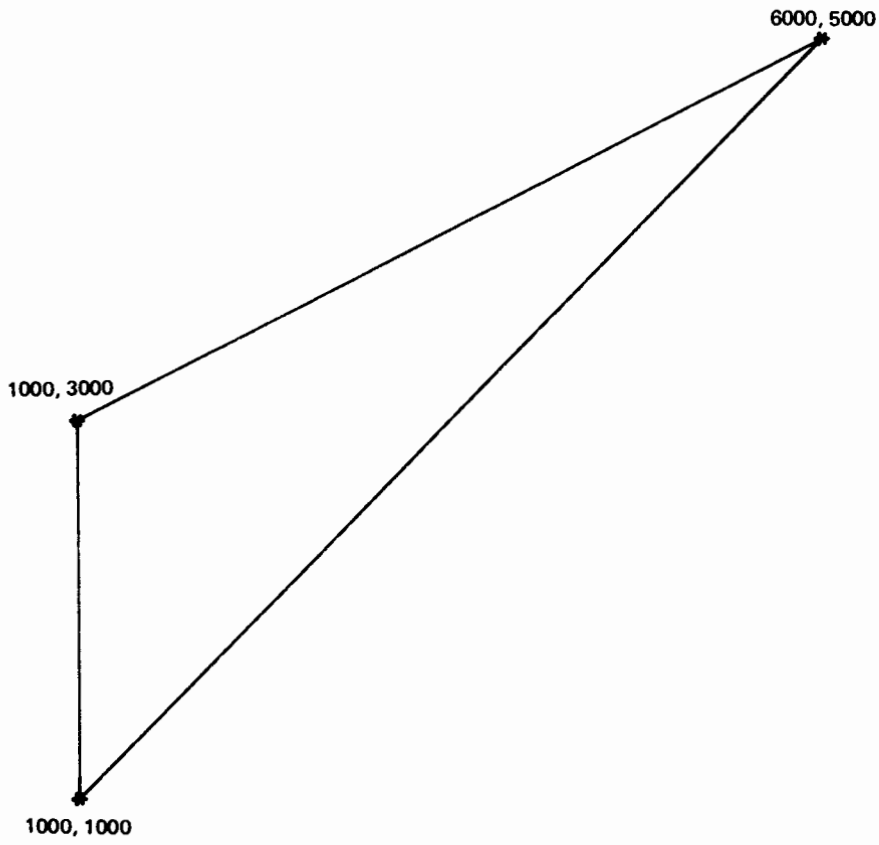
If a space is inserted before the character, the space is ignored by the plotter.

An SM command with an invalid parameter will cause Symbol Mode to be canceled.

An SM command remains in effect until another valid SM command is executed or the plotter is reinitialized or set to default values.

The following string of HP-GL instructions, when sent to the plotter, causes the plotter to draw a triangle with an asterisk (ASCII 42) drawn at each vector.

```
IN;PU;PA1000,1000;SM*;PD;PA1000,3000;PA6000,5000;
PA1000,1000;PU;
```



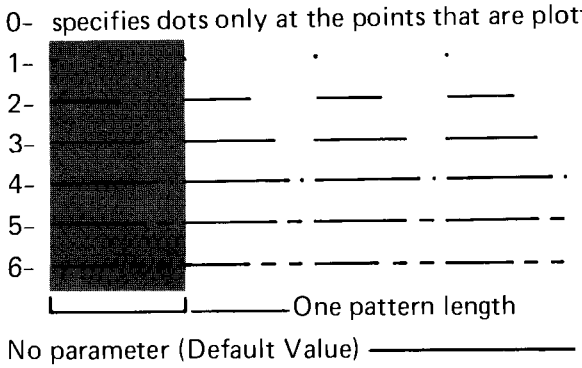
The Line Type Instruction LT

The Line Type instruction LT specifies the type of line that will be used with PA and PR commands.

Syntax:

LT pattern number (,pattern length) ;

Shown below are the line patterns and their pattern numbers.



The shaded portion of each of the line patterns above is one complete segment of the pattern.

The pattern number parameter is truncated to an integer. Parameters ≥ 7 set the error condition and the LT statement is ignored.

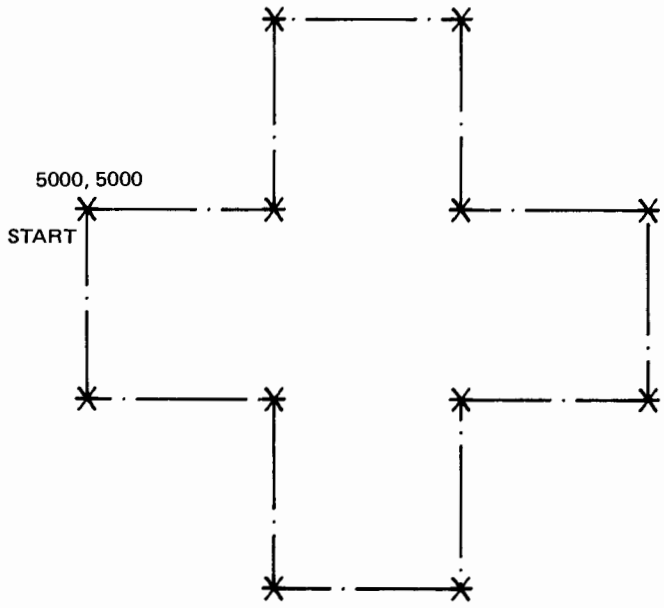
The optional pattern length parameter specifies the length of one complete segment of the pattern and is expressed as a percentage of the diagonal distance between the scaling points, P1 and P2. If a pattern length parameter is not specified, the last value received is used. If no pattern length has ever been specified, a length of 4% is used. Valid pattern length parameters are between .004 and +127.999. A pattern length of 0 will turn on the ERROR light and the pattern length will not change. Useful values for pattern length with default P1 and P2 are between 0.5 and 5 and depend somewhat on the pattern number.

After this command, all subsequent vector commands with the pen down will cause the specified pattern to be drawn. Any portion of the pattern which is not used will be carried over into the next vector.

An LT command with no parameters (LT;) will default the line type to a solid line.

The following HP-GL instructions, when sent to the plotter, plot a cross using line type 4, and draws the symbol * at each corner.

LINE 1. `IN;PA5000,5000;PD;LT4;SM*;PR1000,0,0,1000;`
LINE 2. `PR1000,0,0,-1000,1000,0,0,-1000,-1000,0;`
LINE 3. `PR0,-1000,-1000,0,0,1000,-1000,0,0,1000;PU;`



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Chapter 8
Lettering

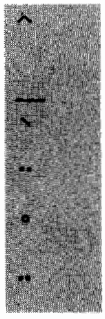
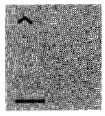
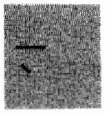
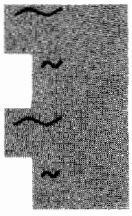
This chapter describes the instructions that allow you to label the plot with alphanumeric characters and symbols using the plotter's internal character sets. Included are instructions to specify the size, slant, direction, and positioning of labels, as well as the instruction which enables you to design your own characters or symbols.

Plotter Character Sets

The plotter has the capability of lettering with any of five internal character sets. Each of the character sets has identical alphabetic characters, but the symbols available vary from set to set. The plotter, when initialized, automatically sets both the "standard" set and the "alternate" set to the ANSI ASCII character set 0, which follows:

```
CHARACTER SET 0
 ! "#$%&' () *+, -./0123456789: ; <=>?
@ABCDEFGHIJKLMNOPQRSTUVWXYZ [\] ^_
`abcdefghijklmnopqrstuvwxyz {| } ~
```

Shown next are the symbols in the various character sets that are changed from set to set. The plotter will perform an automatic backspace before drawing any of the shaded symbols. Therefore, when an accented letter is required, the letter should be entered first, followed by the accent.

Decimal Value	Set 0 Standard ASCII	Set 1 9825 ASCII	Set 2 French/German ASCII	Set 3 Scandinavian ASCII	Set 4 Spanish/Latin American ASCII
35	#	#	£	£	¿
39	'	'		'	
91	[	[	[	Ø	[
92	\	√	Ç	Æ	¡
93	]	]	]	ø	]
94	^	↑		æ	
95	_				_
96	`			`	`
123	{	π			
124	|	⊢			
125	}	→			
126	~				

The Designate Standard Character Set Instruction CS

The Designate Standard Character Set instruction CS designates one of the five character sets (0 through 4) as the standard character set.

Syntax:

CS character set number (;)

The character set number must be an integer in the range 0 through 4. The character set designated is used for all labeling and lettering operations when the standard set is selected. Character set 0 is automatically specified as the standard character set whenever the plotter is initialized.

A CS command with no parameters (CS;) defaults to set 0.

A CS command with invalid parameters will turn on the ERROR light and the character set designated as standard will not change.

The Designate Alternate Character Set Instruction CA

The Designate Alternate Character Set instruction CA designates one of the five character sets (0 through 4) as the alternate character set.

Syntax:

CA character set number (;)

The character set number must be an integer in the range 0 through 4. The character set designated is used for all labeling and lettering operations when the alternate character set is selected. Character set 0 is automatically specified as the alternate character set whenever the plotter is initialized.

A CA command with no parameters (CA;) defaults to set 0.

A CA command with invalid parameters will turn on the ERROR light and the character set designated as alternate will not change.

The Select Standard Character Set Instruction SS

The Select Standard Set instruction SS selects the standard set as the character set to be used for all labeling and lettering.

Syntax:

SS (;)

No parameters are used. However, the terminator (;) must be included to complete the command.

This command is automatically selected when the plotter is first turned on or initialized. If the SS command is to be used to select the standard set, it is recommended the dummy string CP0,0; immediately precede the SS command. The standard set can be selected within a Label command by sending the ASCII control character for shift-in (decimal 15).

The Select Alternate Character Set Instruction SA

The Select Alternate Character Set instruction SA selects the alternate set as the character to be used for all labeling and lettering.

Syntax:

SA (;)

No parameters are used. However, the terminator (;) must be included to complete the command.

This command should be executed prior to executing a labeling statement whenever the alternate character set is to be used. If the SA command itself is to be used to select the alternate set, it is recommended the dummy string CP0,0; immediately precede the SA command. The alternate set can be selected within a Label command by sending the ASCII control character for shift-out (decimal 14).

The following example using CS, CA, the ASCII control character for shift-out, and the SS command writes two character sets where the character "_" is printed with and without any backspace.

```
CS0;CA4;SS;LBS_E_T_0[14]S_E_T_4[3]
```

Result:

S_E_T_0 SET4

The Label Instruction LB

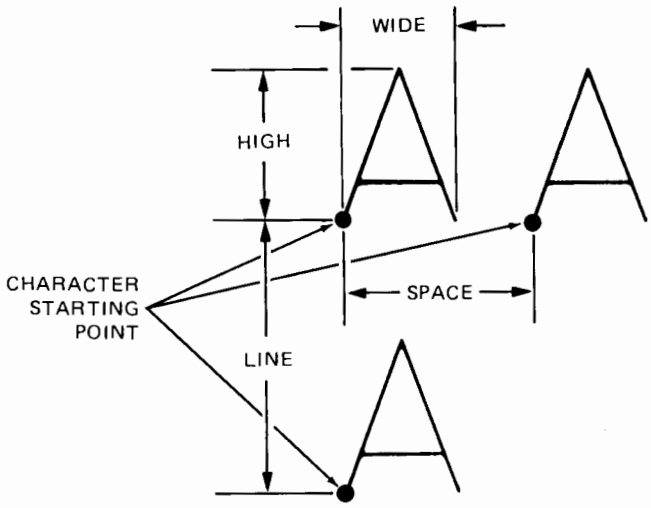
The Label instruction LB provides the means to letter text, expressions, or string variables on the plotter.

Syntax:

LB character string <ASC>

The label mode must be terminated by sending an ASCII character (parameter <ASC> above) which has been established by a previously executed DT instruction (see "Define Terminator instruction DT" in this chapter). If a DT instruction has not been previously executed, the label terminator is defaulted to the ASCII character ETX (a decimal equivalent of 3).

Before using a Label command, the pen should be moved to the location where labeling is to begin by using one of the plot commands (PA, PR, CP) or by using the four direction controls on the plotter front panel. This point will be the lower-left corner of the first character space. After lettering a character, the pen stops at the lower-left corner of the next character space as shown on the next page. For a further explanation of character spacing, refer to "Spacing Between Characters And The Character Grid" in this chapter. The pen will assume the pen up/down status in effect prior to the Label command. To avoid placing a dot at the end of the label, the pen should be raised before the Label command is executed.



Direction, size, and slant of the characters being lettered are as specified by the commands using DI, DR, SI, SR, and SL, or default values if not specified. The character set used is specified by the commands using SA or SS, and CA or CS. If not specified, the default character set is set 0.

The following string of HP-GL instructions is an example of plotting text using an LB instruction.

```
IN;PA5000,3000;
LB I AM A 7220 PLOTTER ETX
```

I AM A 7220 PLOTTER

The Define Terminator Instruction DT

The Define Terminator instruction DT specifies the character to be used as the label terminator.

Syntax:

DT (t) (;)

where (t) is the label terminator

The label mode can only be terminated by sending a label terminator at the end of the character string. Decimal characters 1 through 31 and 127 (ASCII control characters) can be defined as the label terminator and will not print when invoked, although the function performed by the character will be performed (i.e., 13 will terminate but will also cause a carriage return). Decimal characters between 33 and 126 can be defined but will be printed at the end of the character string.

The 7220 defaults to a label terminator of ETX. An ETX is the ASCII character equivalent to a decimal 3.

NOTE

A DT command with no parameter (DT;) does not establish a default terminator. The (;) is interpreted as the label terminator just as any other (t) parameter.

Labeling With Variables

In some applications, it is necessary to label the plot using variables rather than literals to define the label string. Many different conventions are used on computers to define variable length and the character field format in which these variables will be printed. To avoid unexpected placement of the labels defined by variables, refer to your computer manual for a definition of the conventions used to define the output character field.

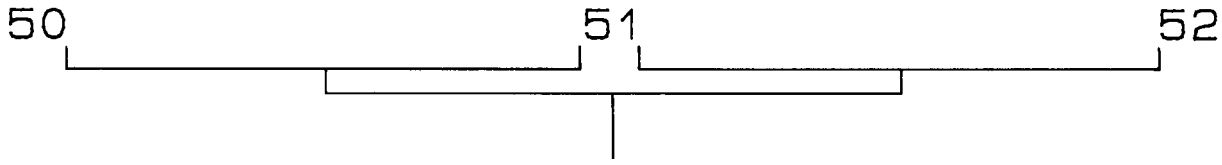
Quotation marks are used by many computers to define the literal characters that are to be sent, but variables are not included within quotation marks. The comma is used as a delimiter between variables or literals by some computers to cause the output to be left justified in a specific character field width. The unused positions in this field are normally sent as blank spaces in order to establish fixed spacing between label strings. For close spacing of the label strings, the blank spaces can normally be suppressed by using a semicolon as the delimiter between variables or literals.

The following example illustrates the use of the comma as a delimiter when using variables for labeling. HP-GL mnemonics, literals, and terminators are enclosed in quotation marks.

■LINE 1. X=50
★LINE 2. " "LB" ", X, X+1, X+2, " "$_{E_X}$" "

This statement causes the plotter to label the integer, integer +1, and integer +2. Blank spaces between the printed integers vary from computer to computer and normally include the sign space. A computer may or may not print positive signs.

Result:



Number of blank character field spaces may vary with different computers.

■BASIC statement. Do not send to plotter.
★A controller-dependent format statement may be required for this statement to be accepted by the plotter.

The following example illustrates use of the semicolon as a delimiter when using variables for labeling:

■LINE 1. X=50
★LINE 2. ""LB"";X;X+1;X+2;"" E_x ""

The semicolons between the variables cause suppression of blank spaces. The space between the printed integers varies with different computers, but normally includes the sign space.

Result:

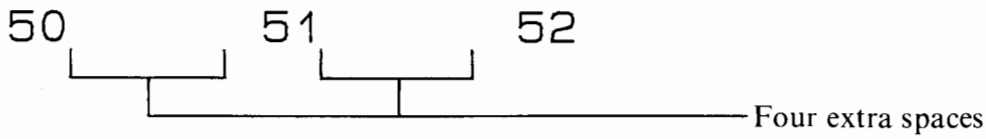
50 51 52

Any spaces required to fit into the context of the item being labeled must normally be sent enclosed in quotes. The following example labels the same variables as above, but with four extra spaces between each of the integers.

■LINE 1. X=50
★LINE 2. ""LB"";X;"" "";X+1;"" "";X+2;"" E_x ""

Note that four spaces enclosed in quotes are sent between each variable; but the semicolon suppresses unwanted blank spaces.

Result:



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■BASIC statement. Do not send to plotter.
★A controller-dependent format statement may be required for this statement to be accepted by the plotter.

The Absolute Direction Instruction DI

The Absolute Direction instruction DI specifies the direction in which characters are lettered.

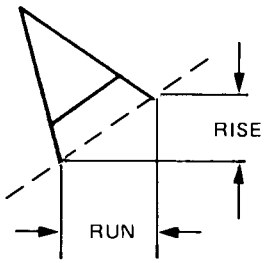
Syntax:

DI run, rise ;

Run and rise are in decimal format between ±127.999 and specify the direction according to the relationship:

$$\frac{\text{rise}}{\text{run}}$$

where:



A change of scaling points P1 and P2 will not affect the direction of lettering.

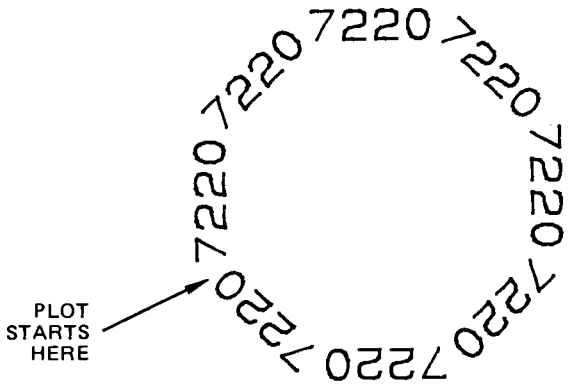
A DI command with no parameters (DI;) will default to the values DI 1,0 (horizontal).

A DI command with a rise parameter of zero will produce horizontal labeling. A DI command with a run parameter of zero will produce vertical labeling. At least one parameter must be effectively nonzero ($|\text{parameter}| \geqslant 0.004$). A DI command with invalid parameters will turn on the ERROR light and the direction of labeling will not change.

A DI command remains in effect until another DI or DR command is executed, or the plotter is initialized or set to default conditions.

The following HP-GL instructions, when sent to the plotter, will cause the expression 7220 to be lettered clockwise in an octagon pattern.

```
LINE 1. IN;PA5000,3000;
LINE 2. DI0,1;LB7220 E
LINE 3. DI1,1;LB7220 E
LINE 4. DI1,0;LB7220 E
LINE 5. DI1,-1;LB7220 E
LINE 6. DI0,-1;LB7220 E
LINE 7. DI-1,-1;LB7220 E
LINE 8. DI-1,0;LB7220 E
LINE 9. DI-1,1;LB7220 E
```



The Relative Direction Instruction DR

The Relative Direction instruction DR specifies the direction in which characters are to be lettered relative to the scaling points P1 and P2.

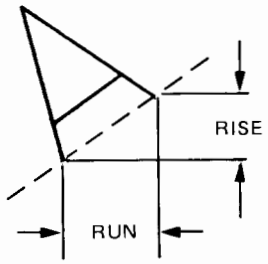
Syntax:

DR run, rise ;

Run and rise are decimal numbers and specify the direction according to the relationship:

$$\frac{\text{rise}}{\text{run}}$$

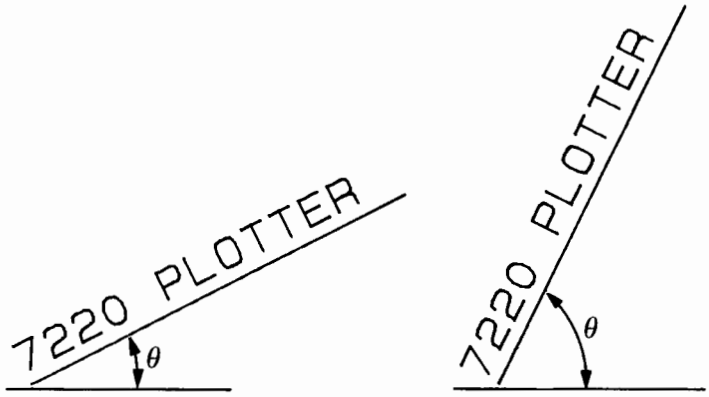
where:



Run is the desired percentage (0 to ±127.999) of $|P2_X - P1_X|$. Rise is the desired percentage (0 to ±127.999) of $|P2_Y - P1_Y|$, and P1 and P2 are the scaling points.

Note in the following example that even though a DR 100,100 is chosen for each set of scaling points P1 and P2, the direction of lettering changes.

```
LINE 1. IN;
LINE 2. IP1000,1000,3000,2000;PU;
LINE 3. PA1000,1000;PD;PA3000,2000;PU;
LINE 4. PA1000,1000;DR100,100;SI;CP0,.25;
LINE 5. LB7220 PLOTTER ETX
LINE 6. IP3500,1000,4500,3000;
LINE 7. PA3500,1000;PD;PA4500,3000;PU;
LINE 8. PA3500,1000;DR100,100;CP0,.25;
LINE 9. LB7220 PLOTTER ETX
```



The Absolute Character Size Instruction SI

The Absolute Character Size instruction SI specifies the size of characters and symbols in centimetres.

Syntax:

SI width, height (;)

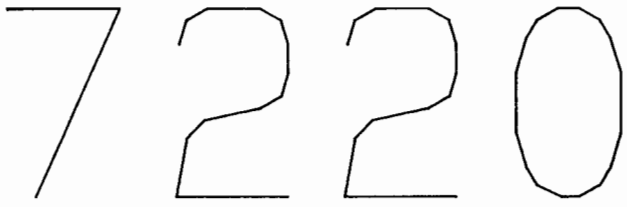
The defined width and height must be in decimal format and may have any value between −87.042 and +40.957 (0 however, is not allowed). An SI command with no parameters (SI;) will default to the values 0.285 cm wide by 0.375 cm high.

Negative parameters cause the character to be reflected about the axes. A negative width parameter causes rotation about the Y-axis; a negative height parameter causes rotation about the X-axis. Two negative parameters cause rotation about both axes. If the labeling direction has been changed to other than horizontal, the line of direction of labeling should be thought of as the effective X-axis in the above description.

The current pen position, the sign and magnitude of the width and height parameters, and the character to be labeled, together determine whether the character will fit in the plotting area. With positive parameters, default horizontal direction, and the pen at P1; at most one character will fit on the plotting area.

The following string of HP-GL instructions, when sent to the plotter, letters the word 7220 at a specified width of 1.5 cm and height of 2.5 cm.

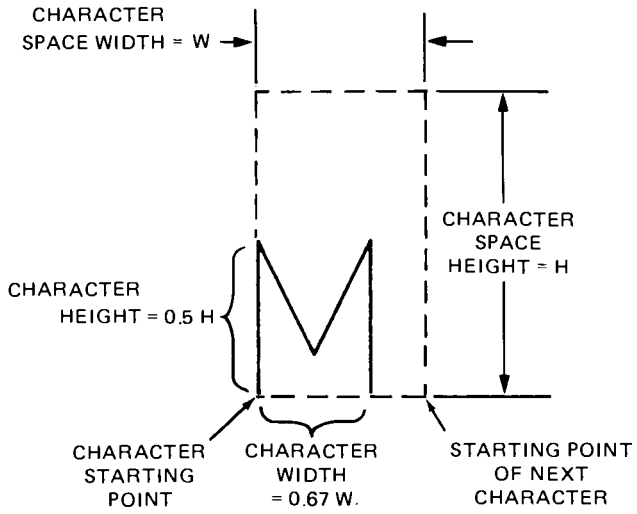
```
IN;PA5000,6000;
SP1;SI1.5,2.5;LB7220
```



A specified SI command will stay in effect until another valid SI or SR command is executed by the plotter, until the plotter is reinitialized, set to default values by turning ac power off and on again, or through program control.

Spacing Between Characters And The Character Grid

Character spacing and line spacing are functions of character size. In the diagram below, you can see the relative position of a character, in this case "M," within the character-space field. The character-space field is set indirectly by the SI command, since the character space height is twice the character's height and the character space width is 1½ times the character width. The space above and beside a character becomes the spacing between lines and characters.



When you specify the height of a character in an SI or SR command, however, you should specify the character height and not the height of the character-space field.

The Relative Character Size Instruction SR

The Relative Character Size instruction SR specifies the size of characters and symbols as a percentage of the distance between scaling points P1 and P2.

Syntax:

SR width,height(;)

The width is the desired percentage (−128.000 to +127.999) of $|P2_X - P1_X|$. The height is the desired percentage (−128.000 to +127.999) of $|P2_Y - P1_Y|$, and P1 and P2 are the scaling points.

Negative parameters will cause rotation about the axes. Large parameters (above 25) will create characters too large to fit in the plotting area (see "Absolute Character Size Instruction SI" in a previous section of this chapter).

Zero parameters are invalid and will cause the ERROR light to illuminate. If this happens, the plotter assumes the last valid SI or SR command parameters or the default parameters, if no previous SI or SR command has been executed.

Note the character size will vary as P1 and P2 are changed. Character and line spacing are functions of character size. Refer to "Spacing Between Characters And The Character Grid" in this chapter.

An SR command with no parameters included (SR;) will default to the same values as SR .75, 1.5.

An SR command remains in effect until another valid SR or SI command is executed, the plotter is initialized or set to default values, or the power is turned off and then on again.

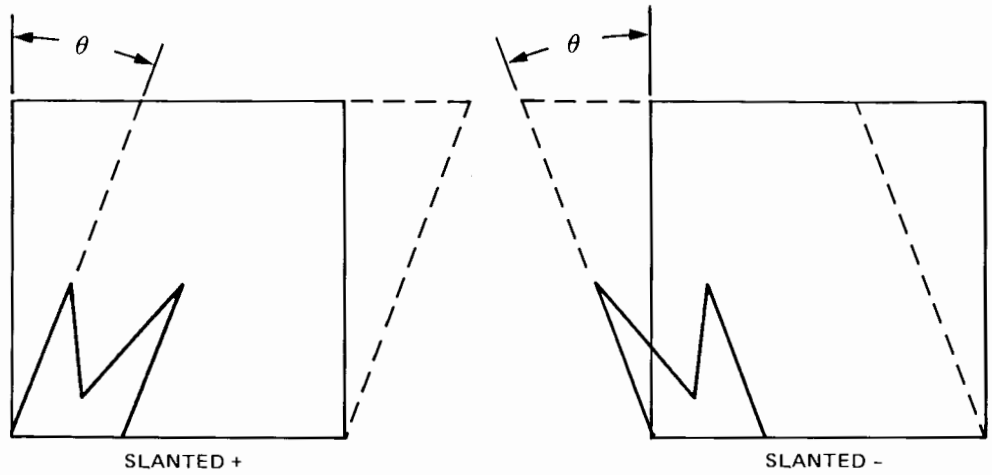
The Character Slant Instruction SL

The Character Slant instruction SL specifies the slant with which characters are lettered.

Syntax:

SL tan θ (;)

The degree of slant is a decimal number between ±127.999 and is equivalent to the tangent of the angle θ from vertical as follows:



The useful parameter range is ±0.5 to ±2 when using default absolute character size and up to ±3.5 for large letters.

A change in scaling points P1 and P2 will not affect the angle θ.

An SL command with no parameters (SL;) will default to the same values as SL0 (no slant). An SL command with invalid parameters will turn on the ERROR light and default to the last valid SL instruction, or if none to SL0. An SL command remains in effect until another valid SL command is executed or the plotter is initialized or set to default conditions.

The following string of HP-GL instructions, when sent to the plotter, letters the number 7220 at a slant of +45°.

```
IN;PA5000,3000;
SP1;SL1;LB7220
```

7220

The Character Plot Instruction CP

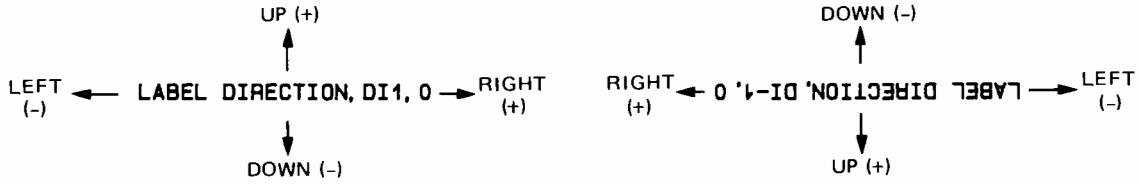
The Character Plot instruction CP moves the pen the specified number of character-space fields.

Syntax:

CP # of character-space field widths, # of character-space field heights ;

If no parameters are specified, a CP command (CP;) performs a carriage return and line feed operation by moving one character-space field height down and returning to the margin defined by the last point to which the pen was sent by either a PA command, PR command, the plotter front-panel controls, or the pen position at the last DI or DR command.

When parameters are specified, the CP command moves the pen the specified number of character-space field widths to the right (a positive value), or to the left (a negative value), and the number of character-space field heights up (a positive value), or down (a negative value). Note that right, left, up, and down are relative to the label direction as shown below:

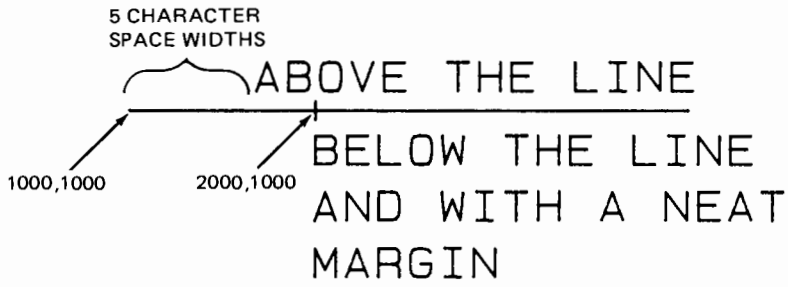


The pen's position (raised or lowered) does not change when a CP command is executed. The parameters must be within the range of −128.000 to +127.999. However, since there are approximately 90 character-space field widths and 40 character-space field heights on the platen surface (assuming default sizing), the effective parameter range that will not invoke an out-of-limit condition is considerably less, depending on the pen position at the given time.

The CP; command is useful to produce lettering with alignment along a left-hand margin, while a CP command with small decimal parameters enables lettering along a line, but not on top of it. This is illustrated in the following program.

```
LINE 1. PA1000,1000;PD;PR3000,0;PU;PR-3000,0;
LINE 2. CP5,.35;LBABOVE THE LINE␃
LINE 3. PA2000,1000;XT;CP0,-.95;LBBELOW THE LINE␃
LINE 4. CP;LBAND WITH A NEAT␃CP;LBMARGIN␃
```

The CP instruction in line 2 moves the label slightly above the line. The CP instruction in line 3 moves the label slightly below the line and the two CP instructions in line 4 perform a carriage return line feed to the margin established by the plot command in line 3.



The User Defined Character instruction UC

The User Defined Character instruction UC draws characters of your own design.

Syntax:

UC (pen control parameter,) X-increment, Y-increment,
(pen control parameter,) (X-increment, Y-increment,) . . . . ;

Each segment of the character is drawn according to the three parameter values as follows:

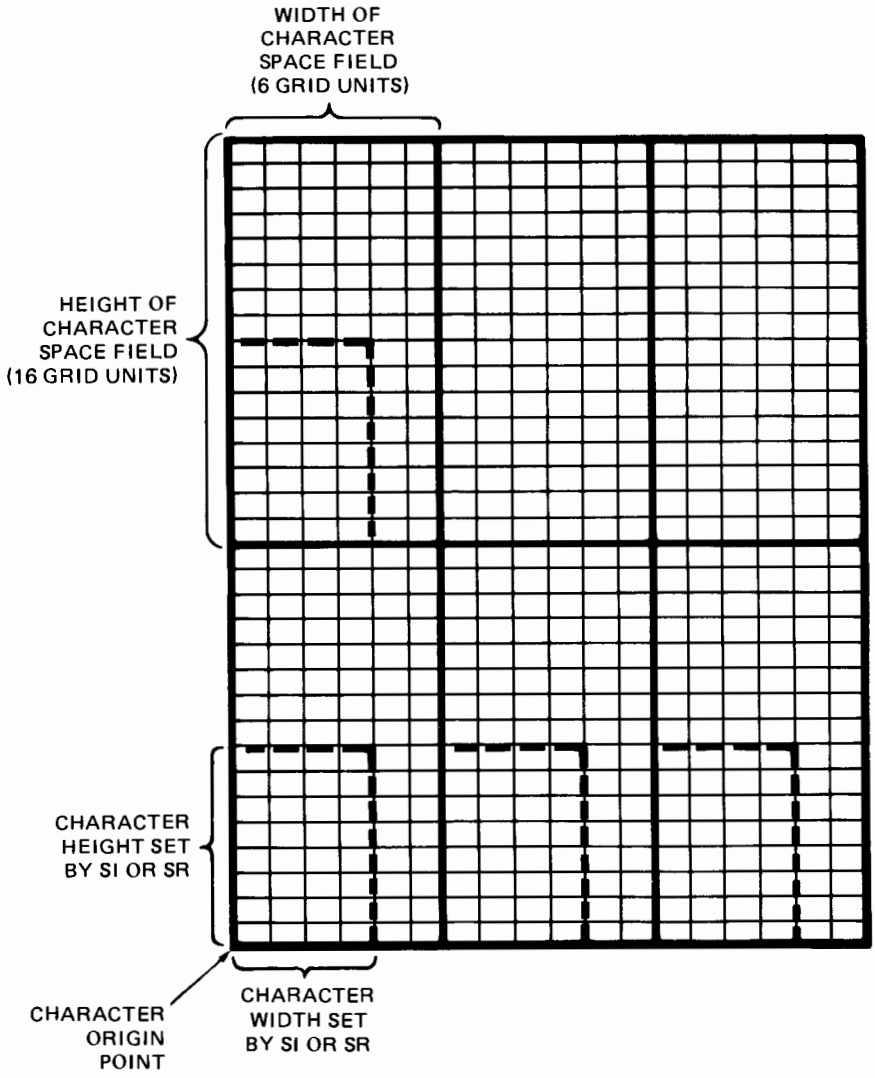
Pen control parameter (integer) +99 up to +32767 = pen down and −99 down to −32768 = pen up (+99 and −99 are commonly used).

X-increment – specifies the number of character grid units that the pen will move horizontally. A positive value moves the pen to the right, and a negative value moves it to the left. The increment value should be an integer and can range from ±98 grid units. Decimal values are truncated.

Y-increment – specifies the number of character grid units that the pen will move vertically. A positive value moves the pen up and a negative value moves it down. The increment value must be an integer and can range from ±98 grid units. Decimal values are truncated.

The optional pen control parameter does not have to be repeated between X- and Y-increments unless a different pen state is required. That is, once a pen down (+99) has been sent, the pen will remain down for the following X- and Y-increments until a pen up (−99) has been sent.

The character grid units are scaled by the current size command (SI or SR) as shown below. Each character block contains 6 horizontal units and 16 vertical units.



Note that the character block width is 1½ times the character width as set by the size command and twice the character height as set by the size command.

Each character starts from the character block origin point. When the character is completed, the pen moves to the next character block origin (6 horizontal grid units from the initial starting point). This may not be a valid starting point if the new character was larger than a normal character. One of the plot commands (PA, PR, or CP) may be needed to properly position the pen for the next character, if any, to be lettered.

A user defined character is drawn with the current character slant, size, and direction.

At the start of the UC instruction, the pen is automatically up. Each UC command must have at least one pen down parameter ($\geq +99$) in order to draw anything. A UC command without a pen down will result in a pen movement of one character-space field horizontally.

Plot commands (PA, PR, CP, AA, AR) which follow a UC command will be made using the pen status set by the previous PU or PD command.

The following HP-GL instructions, when sent to the plotter, draw in two different sizes and labels the letter **E.** To demonstrate that user defined characters can take more than one character space, the Σ has first been drawn almost twice as large as the labeled **E**'s. The second Σ, created by dividing each X- and Y-parameter of the previous UC command by 2, is the same size as the labeled **E.** In order to draw a character the same size as a character created with a Label command, the UC character must have a width of 4 grid units and a height of 8 grid units.

```
LINE 1. IN;SP1;SI.5,.8;PU;PA4000,9000;
LINE 2. UC-99,8,14,99,0,2,-8,0,4,-8,-4,-8,8,0,0,2;
LINE 3. CP;LBEE ETX CP;
LINE 4. UC-99,4,7,99,0,1,-4,0,2,-4,-2,-4,4,0,0,1;
```

8

Chapter 9
Additional Plotter Control

Described in this chapter are the plotter instructions which enable it to output the pen position, HP-GL error, plotter status, and to define the limits of pen motion.

The Output Actual Positon And Pen Status Instruction OA

The Output Actual Position and Pen Status instruction OA instructs the plotter to make the X- and Y-coordinates and pen status (up or down) associated with the actual pen position available for output.

Syntax:

OA (;)

No parameters are used. However, the terminator (;) must be included to complete the command.

The OA command can be used with scaling on or off. (Use OD when in digitize mode).

After receipt of an OA command, the pen position and status are made ready for output to the computer as ASCII integers in the following form:

X , Y , P CR*

where:

X is the X-coordinate in absolute plotter units,
Y is the Y-coordinate in absolute plotter units,
P is the pen status (0 = pen up, 1 = pen down).

The range of the X- and Y-coordinates is the mechanical limits of the plotter ($0 \leqslant X \leqslant 16000$, $0 \leqslant Y \leqslant 11400$). When the pen has been moved by program control, the range of the X- and Y-coordinates is the current window.

*CR is the default output terminator. The currently defined output terminator will be sent.

The Output Commanded Position And Pen Status Instruction OC

9

OC

The Output Commanded Position and Pen Status instruction OC makes the X- and Y-coordinates and pen status (up or down) associated with the last valid pen position instruction available for output to the computer.

Syntax:

OC ;

No parameters are used. However, the terminator (;) must be included to complete the command.

The OC command outputs user defined unit coordinates if operating in the scaled mode, and absolute plotter units if operating in the unscaled mode.

The pen position and status will be output to the computer in ASCII as follows:

X , Y , P CR*

where:

X is the X-coordinate in absolute or user defined plotter units,
Y is the Y-coordinate in absolute or user defined plotter units,
P is the pen status (0 = pen up, 1 = pen down).

When scaling is off, the range of the X- and Y-coordinates is ±32767. When scaling is on, the range of the X- and Y-coordinates is −16384 to +16384, except when the plotter is in the lost state, then 32767 will be output for both X and Y.

*CR is the default output terminator. The currently defined output terminator will be sent.

The Output Error Instruction OE

The Output Error instruction OE makes the decimal equivalent of the last error (if any) available for output to the computer.

Syntax:

OE ;

No parameters are used. However, the terminator (;) must be included to complete the command.

When an OE command is received, the plotter converts the last error to a positive ASCII integer and makes it available for output in the form:

error number CR*

The error numbers are defined as follows:

Error Number	Meaning
0	No error
1	Instruction not recognized
2	Wrong number of parameters
3	Bad parameter
4	Not used
5	Unknown character set
6	Position overflow
7	Not used
8	Out of roll paper (7220T)

After the error code is output to the computer, bit position 5 of the output status byte is cleared, and the ERROR light (if lit) is turned off.

*CR is the default output terminator. The currently defined output terminator will be sent.

The Output Factors Instruction OF

The Output Factors instruction OF instructs the plotter to make the number of plotter units per millimetre in each axis available for output.

9

OF

Syntax:

OF (;)

No parameters are used. However, the terminator (;) must be included to complete the command.

The 7220 will always output two positive ASCII integers in the form:

40 , 40 CR*

This indicates that there are 40 plotter units per millimetre in the X-axis and 40 plotter units per millimetre in the Y-axis on the 7220 plotter.

*CR is the default output terminator. The currently defined output terminator will be sent.

The Output Identification Instruction OI

The Output Identification instruction OI commands the plotter to make an identifier available for output.

Syntax:

OI ;

No parameters are used. However, the terminator (;) must be included to complete the command.

When the plotter is instructed to talk and the computer to listen, the 7220C always returns:

7220C CR*

The 7220T returns:

7220T CR*

*CR is the default output terminator. The currently defined output terminator will be sent.

The Output Options Instruction OO

The Output Options instruction OO commands the plotter to make the decimal equivalent of eight option parameters available for output.

9

OO

Syntax:

OO ;

No parameters are used. However, the terminator (;) must be included to complete the command.

The plotter will always respond to the instruction with a message consisting of eight ASCII integers in the form:

C, 1, 0, 0, 1, 0, 0, 0 CR*

The value of C is 0–3 as described in the chart below. The first 1 means the plotter has pen select capability. The second 1 means that arc and circle instructions are included.

C	Paper Check Bit	Advance Option
0	clear (0)	off (0)
1	clear (0)	on (1)
2	set (1)	off (0)
3	set (1)	on (1)

A 7220C will always output a value of C = 2.

On a 7220T, the advance option is set if the roll paper is present and properly installed. The paper check bit is set at power-up or initialization, and anytime the pen is put down under either program or front panel control. It is also set anytime the out of paper switch indicates no paper before or after a paper advance or attempt to advance. The paper check bit is cleared to zero after any successful advance. This instruction can be used on the 7220T to ascertain whether the plotter is loaded with roll paper and the plot area is clear; if this is true, C = 1. The OO instruction should be sent before an IN instruction since the IN instruction will set the paper check bit to 1 and paper may be wasted.

*CR is the default output terminator. The currently defined output terminator will be sent.

The Output Status Instruction OS

The Output Status instruction OS makes the decimal equivalent of the output status byte available for output.

Syntax:

OS ;

No parameters are used. However, the terminator ; must be included to complete the command.

Upon receipt of the OS command, the internal eight-bit status byte is converted to an ASCII decimal integer between 0 and 255. The decimal integer is output in the form:

status CR*

The status byte bits are defined as follows:

Bit Value	Bit Positon	Meaning
1	0	Pen down
2	1	P1 or P2 change or change attempted; cleared by OP
4	2	Digitized point available; cleared by OD
8	3	Initialized; cleared by OS
16	4	Ready for data
32	5	Error; cleared by OE
64	6	Not used
128	7	Not used

Upon power-up, the status is decimal 24, the sum of 8 (initialized) and 16 (ready for data). Upon output of the status byte after an OS command, bit position 3 is cleared.

*CR is the default output terminator. The currently defined terminator will be sent.

The Input Mask Instruction IM

The Input Mask instruction IM specifies the conditions under which an error message, require service message, and positive parallel poll response will occur.

9

IM

Syntax:

IM E-mask value ;

E-mask specifies the decimal equivalent of the bit values of the plotter error numbers that will set the error bit (bit 5) of the plotter status byte and turn on the ERROR light on the plotter front panel.

E-Mask Bit Value	Error Number	Meaning
1	1	Instruction not recognized
2	2	Wrong number of parameters
4	3	Bad parameters received
8	4	Not used
16	5	Unknown character set
32	6	Position overflow
64	7	Not used
128	8	Out of roll paper (7220T)

For example, the default E-mask value 223 (1 + 2 + 4 + 8 + 16 + 64 + 128) will specify that all error numbers except 6 can set the error bit in the status byte and turn on the ERROR light whenever they occur. Error 6, however, will not set the error bit or turn on the ERROR light if it occurs since it is not included in the E-mask value. Note an E-mask value of 151 would result in identical plotter behavior since errors 7 and 4 are not used on the 7220 plotter.

An IM command with no parameters (IM;) will set the E-mask value to 223.

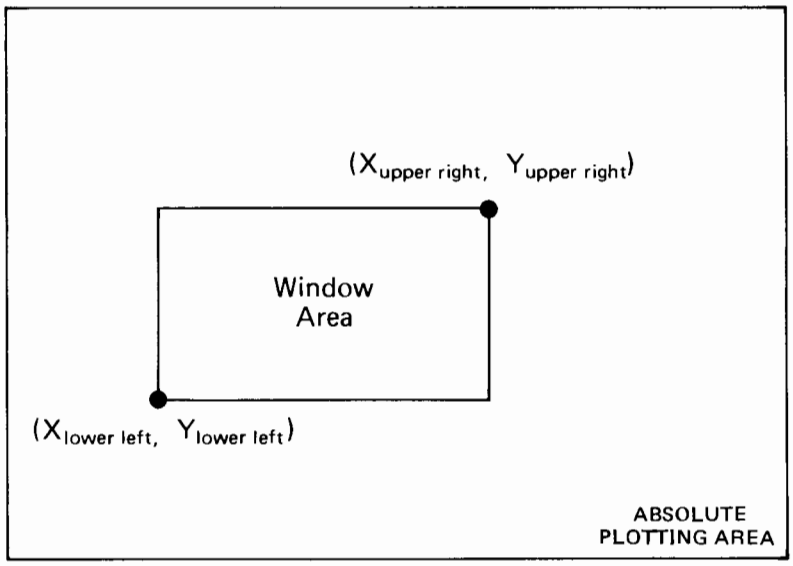
The Input Window Instruction IW

The Input Window instruction IW restricts the programmed pen motion to a specific rectangular area on the platen. This area is called the "window."

Syntax:

IW $X_{lower\ left}$, $Y_{lower\ left}$, $X_{upper\ right}$, $Y_{upper\ right}$ (;)

The four parameters specify, in absolute plotter units, the X- and Y-coordinates of the lower-left and the upper-right corners of the window area as shown below. The parameters should be positive and less than 16000 for X and 11400 for Y. Parameters between −32767 and 0 are set to 0 and parameters larger than the absolute plotting limits, but less than 32768 are set to the plotting limits (16000 for X and 11400 for Y). Parameters beyond ±32767 will cause an error and the window will not change.



At power-on, upon execution of a DF or IN command, or if executed without parameters (IW;), the window is automatically set at the mechanical limits of the plotter. The OUT OF LIMIT light will come on, after execution of an IW command with parameters, if the current pen position is outside the area specified by the four parameters.

At this point, the reader may wish to review the concept of "nearby" and "faraway" as described under the "Plot Absolute Instruction PA," Chapter 6.

There are seven types of vectors that can be developed from a given "last point" to some "new point" as follows:

Last Point		New Point
1. Inside window area	to	inside window area
2. Inside window area	to	outside but "nearby"
3. Inside window area	to	outside but "faraway"
4. Outside window area but "nearby"	to	inside window area
5. Outside window area but "nearby"	to	outside but "nearby"
6. Outside window area but "faraway"	to	inside window area
7. Outside window area "faraway"	to	outside window area but "nearby"

In type 1, the pen will move as programmed from the last point to the new point with the pen up or down as commanded.

In type 2, the pen will move as programmed from the last point toward the new point. At the intersection of this move and the window limit, the pen will stop and lift, and the OUT OF LIMIT light will come on steady.

In type 3, the pen will be raised, but not moved, and the plotter will assume out-of-range condition (enter lost state). The OUT OF LIMIT light will come on blinking.

In type 4, the OUT OF LIMIT light is on steady at the start of the vector. The pen will move (pen up) to the intersection of the current vector and the window limit. At this point, the OUT OF LIMIT light will go out, the pen will be under program control, either pen up or down as instructed, and will move to the new point.

In type 5, the pen is raised and the OUT OF LIMIT light is on steady at the start of the vector. If part of the vector is in the window area, the plotter will move with the pen up to the intersection of the current vector and the window limit nearest the last point. The light will go out and pen will be moved under program control to the intersection of the vector and the other window limit. The pen will then stop and lift and the OUT OF LIMIT light will come on steady. If the vector from the last point to the new point does not intersect the window area, no move will be made. However, X-and Y-coordinates of the current pen position are updated.

In type 6, the pen will move with pen up to the new point and the OUT OF LIMIT light will go out and the out-of-range mode (lost state) will be exited. Upon leaving the new point the pen will be under the control of the previous pen up or pen down instruction.

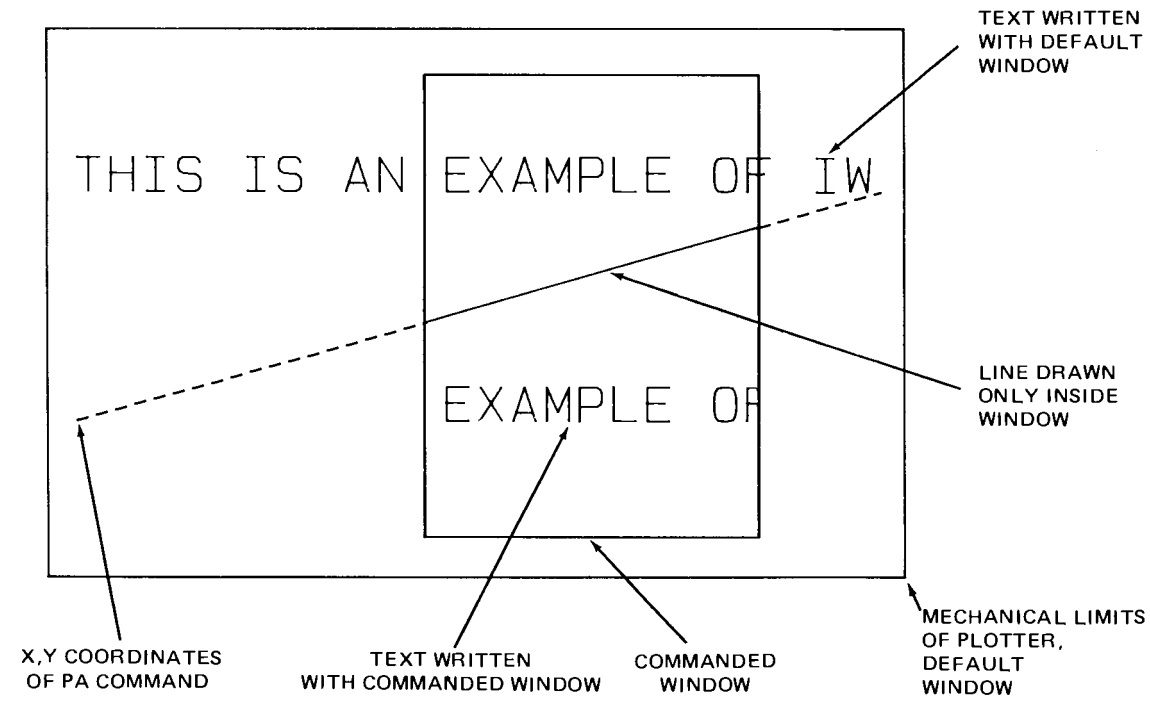
In type 7, the OUT OF LIMIT light will come on steady. If part of a vector from the last physical pen position to the new point is within the window area, the pen will move across the window with pen raised. If the vector from the last physical pen position to the new point does not intersect the window area, no move will be made.

In scaled mode a point will be within a window area, or outside but "nearby" or "faraway" if the plotter unit equivalents of the scaled parameters are within or outside that area.

The illustration below shows the effect of a window on text and plotted lines. The upper text is written with the default window (mechanical plotter limits) in effect. An IW command defining the rectangular area shown is executed. The pen is commanded to plot with the pen down to a point near the lower-left corner. Only the portion of the line inside the window is drawn. When a Label command to write the same text is given, only that portion within the window is written.

The following example of the IW instruction will be helpful in explaining how the plotter behaves when a window is specified. This string of HP-GL instructions, when sent to the plotter, will cause the following plot to occur.

```
DF;PA1219,5342;SI.5,.75;LBTHIS IS AN EXAMPLE OF IW ETX
IW4271,2290,7294,6374;PD;PA1219,3317;LBTHIS IS AN EXAMPLE OF IW ETX
```



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Chapter 10
Digitizing

This chapter describes the instructions used when the plotter is functioning as a digitizer.

The Digitize Point Instruction DP

The Digitize Point instruction DP provides the means to digitize points on the plotter.

Syntax:

DP ;

No parameters are used. However, the terminator (;) must be included to complete the command.

When a DP command is received by the plotter, the ENTER light turns on indicating that a point can be entered. When the ENTER pushbutton is pressed, the X- and Y-coordinates of the current pen position and pen up/down status are stored for retrieval by the Output Digitized Point and Pen Status command. Pressing the ENTER pushbutton also turns off the ENTER light and sets bit position 2 of the output status word.

The digitizing sight provided with the plotter should be used when digitizing. When digitizing, the pen should be down.

The Digitize Clear Instruction DC

The Digitize Clear instruction DC terminates the digitize mode.

Syntax:

DC ;

No parameters are used. However, the terminator (;) must be included to complete the command.

10

DC

This command enables you to terminate a digitize mode without entering coordinate values through the ENTER pushbutton. The ENTER light is turned off (if it was on).

The Output Digitized Point And Pen Status Instruction OD

The Output Digitized Point and Pen Status instruction OD makes the X- and Y-coordinates and pen status (up or down) associated with the last digitized point available for output.

Syntax:

OD ;

No parameters are used. However, the terminator (;) must be included to complete the command.

The OD command is used only when a digitized point has been stored, as indicated by receipt of the output status byte with a true (1) condition on bit position 2 (see "Output Status Instruction OS," Chapter 9).

When requested by the computer, the pen position and status will be output to the computer as ASCII integers in the form:

X , Y , P CR*

where:

X is the X-coordinate in absolute plotter units,
Y is the Y-coordinate in absolute plotter units,
P is the pen status (0 = pen up, I = pen down).

The ranges of the X- and Y-coordinates are the mechanical limits of the plotter, i.e., $0 \leqslant X \leqslant 16000$, $0 \leqslant Y \leqslant 11400$.

Upon receipt of the OD command by the plotter, bit position 2 of the output status byte is cleared and the ENTER light is turned off (if it was on).

*CR is the default output terminator. The currently defined output terminator will be sent.

Digitizing With The 7220

The plotter can be used as a digitizer as well as a plotter since digitizing is basically the inverse of plotting. Instead of sending the coordinates of a point to the plotter and the plotter then moving the pen to that point, you move the pen to a point on the plotter (typically by using the front panel controls), enter the point, then send the coordinates of that point to the computer. A special digitizing sight provided with the plotter allows you to visually position the pen over the point to be digitized. The sight is loaded like a pen and is used in the pen down position.

10

In general, the DP command is used with the OS and OD commands. The output status command OS is explained in Chapter 9. A generalized program flow for the digitize mode is listed below.

1. Allocate in your program storage for the number of points to be digitized for the variables X, Y, and P.
2. Develop a FOR-NEXT loop with the total number of points digitized.
3. Enter the digitize mode using the DP instruction, output the status byte, and monitor bit position 2 of the status byte for a true (1) condition. The true condition indicates that the ENTER pushbutton has been pressed.
4. Output the digitized point to the computer using the OD instruction.
5. Continue the loop for all digitized points; then print or display the values for each digitized point if desired.

The following subroutine monitors bit position 2 of the status byte. Executing successive divisions of a number by two and checking for an odd or even integer answer, is a common way of monitoring bits without converting the number to binary form. This subroutine, if called after a Digitize Point (DP) command, would accomplish steps 3 and 4 of the previous paragraph.

```
  LINE 1. OS;
  LINE 2. (using a suitable input statement, read the status byte into the
          variable named Status)
■LINE 3. Status=INT(Status/2)
■LINE 4. Status=INT(Status/2)
■LINE 5. Status=Status MOD 2
■LINE 6. IF Status=0 THEN Line1
  LINE 7. OD;
■LINE 8. RETURN
```

■BASIC statement. Do not send to plotter.

Chapter 11
Automatic Paper Advance – 7220T

The instructions in this chapter pertain only to the 7220T plotter which has automatic paper advance.

The Advance Full Page Instruction AF

The Advance Full Page instruction AF causes the paper to advance one full page.

Syntax:

AF ; or PG ; or PG1 ;

No parameters are used (PG1 is the only exception). However, the terminator ; must be included to complete the command.

When the advance option is off, executing this instruction causes an error condition to be set (error 8). The advance option is off if sheet paper is being used, roll paper is not properly loaded, or the plotter is a 7220C.

When the advance option is on, the paper advances one full page, measured from the left edge of the platen at the time the advance command was initiated. This is 432 mm (17 inches) in English mode or 420 mm in metric mode.

If the cutter is on, the paper is cut along what was the left edge of the platen at the time the advance command was initiated. Lack of paper at the completion of an AF command will set the error condition (error 8). PG and PG1 are included to maintain compatibility with other Hewlett-Packard systems.

The Advance Half Page Instruction AH

The Advance Half Page instruction AH causes the paper to advance one-half page.

Syntax:

AH ;

No parameters are used. However, the terminator ; must be included to complete the command.

When the advance option is off, executing this instruction causes an error condition to be set (error 8). When the advance option is on, the paper advances one-half page measured from the left edge of the platen at the time the advance command was initiated. A half page is 216 mm (8½ inches) in English mode or 210 mm in metric mode.

If the cutter is on, the paper is cut along what was the left edge of the platen at the time the advance command was initiated. Lack of paper at the completion of an AH command will set the error condition (error 8).

The Enable Cutter Instruction EC

The Enable Cutter instruction EC turns the cutter on and off.

Syntax:

EC (int) ;

An EC command with no parameter (EC;) turns the cutter on and the lamp in the front panel CUTTER ENABLE switch is turned on.

An EC command with integer parameter turns the cutter off and the lamp in the switch goes off. Zero is the recommended parameter to disable the cutter.

If the cutter is already on, the EC command with no parameters has no effect.

Chapter 12

Putting The Commands To Work

This chapter demonstrates the use of the 7220 commands to develop and label plots. Previous programs have purposely been kept to a less-advanced level in order to clearly demonstrate the command usage.

Creating A Complete Graph

This example is a problem encountered in an engineering environment — the response of a system to a step input. However, the 7220 also provides excellent graphics for business applications as well as many other areas. Following the example provided should help you visualize the steps needed to prepare your finished plot.

Problem:

Scale, draw, and label X- and Y-axes in user units and plot the function

$$d = 1000\ (1 - e^{-100t} \cos\ 300t).$$

Then, varying the line type, plot the function

$$d = 1000\ (1 - e^{-60t} \cos\ 300t)$$

over the limits $0 \leqslant t \leqslant 0.05$, $0 \leqslant d \leqslant 1600$.

Finally, from a file of test data, again varying the line type, plot the test data on the same graph for comparison with the ideal curves.

Solution:

A. Turn the plotter logically on and position the plot.

The 7220 has a range of $0 \leqslant X \leqslant 16000$ plotter units and $0 \leqslant Y \leqslant 11400$ plotter units. Allowing an additional 10% beyond the default P1 and P2 settings for the 7220C or the 7220T with chart advance off (P1 = 520,380 and P2 = 15720,10380) for labeling below the X-axis and to the left of the Y-axis, we set the scaling points to P1 = 2000,1400 and P2 = 14200,9300 using the IP instruction.

LINE 1. (ESC) (.) (()

LINE 2. IN;IP2000,1400,14200,9300;

Line 1 turns the plotter logically on. The Initialize command (IN;) in line 2 resets parameters to their default values. Either IN; or DF; should be included in all programs, avoiding unexpected results caused by parameters inherited from a previously run program.

B. Scale the plotting area.

Although we could plot in plotter units, an easier method is to use the Scale instruction SC to scale the plotting area into integer user units. We choose the scaling so as to cover the range of X- and Y-values expected from our computations and give sufficient resolution to our plot.

We know our data will cover the range $0 \leqslant X \leqslant 0.05$ and $0 \leqslant Y \leqslant 1600$. Had we not known this, we would have to make an educated guess about the range and perhaps revise the program after we saw a sample plot. Since the 7220 can only plot integers, we need to use a multiplier to convert the data to integers and to achieve sufficient resolution to obtain a smooth plot. We break the X-axis into 500 units and the Y-axis into 1600 units with the SC instruction below:

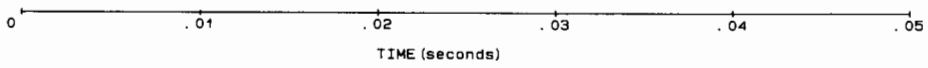
LINE 3. SC0,500,0,1600;

Since $10000 \times 0.05 = 500$ (the maximum scaled range) our X-multiplier to be used in calculations is 10000. No Y-multiplier is necessary since our results fall into the scaled range.

C. Draw, label, and title the X-axis.

To draw and label the X-axis, we use a FOR-NEXT loop. The loop contains plot instructions, tick instructions, label instructions, and the CP instruction to position the label. Because we want our output to read in hundredths of seconds to match our test data, we divide the user-unit position by our multiplier when writing the label. The title is written by line 10 after completion of the FOR-NEXT loop.

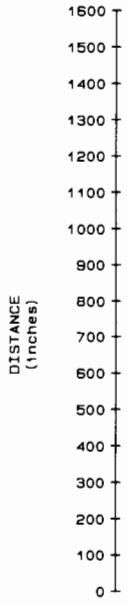
```
  LINE  4. PAO,0;SP1;PD;
■LINE  5. FOR X=0 TO 500 STEP 100
★LINE  6. PAX,0;XT;PU;
★LINE  7. CP-2.4,-.9;LB,X/10000,Ex
★LINE  8. PAX,0;PD;
■LINE  9. NEXT X
  LINE 10. PU;PA 200,-125;LBTIME (seconds)Ex
```



D. Draw, label, and title the Y-axis.

The Y-axis drawing and labeling is very similar to that of the X-axis, except that, since we will plot in integer units compatible with the results of our equations, there is no need to alter the label parameter before writing it.

```
  LINE 11. PAO,0;PD;
■LINE 12. FOR Y=0 TO 1600 STEP 100
★LINE 13. PAO,Y;YT;PU;
★LINE 14. CP-4.9,-.3;LB,Y,Ex
★LINE 15. PAO,Y;PD;
■LINE 16. NEXT Y
  LINE 17. PU;PA-55,600;DIO,1;LBDISTANCE CR LF (inches)Ex
```



■BASIC statement. Do not send to plotter.

★A controller-dependent format statement may be required for this statement to be accepted by the plotter.

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E. Plot the function.

To define a smooth curve, the step size for t in the equation has been set to 0.0005, establishing 100 intervals along the X-axis. With the SC instruction used earlier, we could make the step size one-fifth this size, but this is not necessary to create a smooth plot with this particular equation. The equation of the function must be written in a form acceptable to your computer. The following instructions plot the equation:

$$d = 1000\,(1-e^{-100t}\cos 300t)$$

```
LINE 18. PA0,0;SP2;PD;
■LINE 19. FOR T=0 TO .05 STEP .0005
■LINE 20. Y=1000*(1-EXP(-100*T)*COS(300*T))
■LINE 21. X=T*10000
★LINE 22. PA X, Y;
■LINE 23. NEXT T
```

The pen moves to the locations defined by X and Y. Changing the pen and line type for trace differentiation, the following instructions plot the equation:

$$d = 1000\,(1 - e^{-60t}\cos 300t)$$

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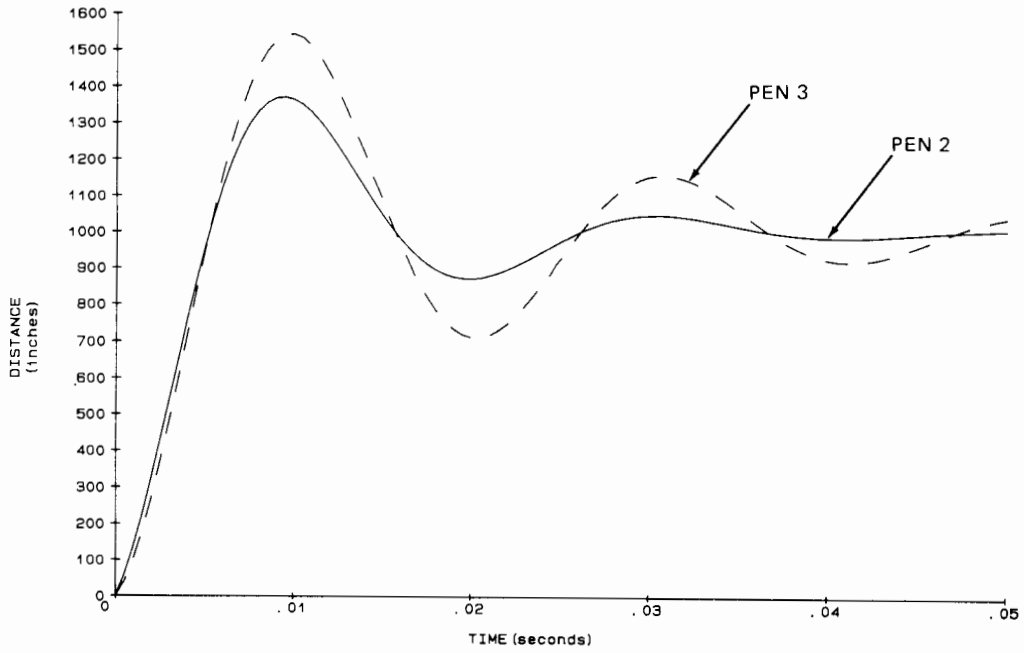
```
LINE 24. PU;PA0,0;SP3;PD;LT2;
■LINE 25. FOR T=0 TO .05 STEP .0005
■LINE 26. Y=1000*(1-EXP(-60*T)*COS(300*T))
■LINE 27. X=T*10000
★LINE 28. PA X, Y;
■LINE 29. NEXT T
```



■BASIC statement. Do not send to plotter.

★A controller-dependent format statement may be required for this statement to be accepted by the plotter.

F. Add the test data.

The test data can be plotted on the same graph for comparison with the ideal curves.

NOTE

Test data could be stored on a mass storage device. Accessing stored test data varies depending on the type of storage device and your computer. Refer to your computer operating and programming manual for specific instructions for loading test data into your computer.

The following steps illustrate plotting test data by incrementing the T-value in fixed steps and reading the corresponding test value from DATA statements. Line 30 specifies plotting the data in a different pen and line type for ease of comparison with the ideal curves.

The test data as given in the DATA statements had been divided by 10000. To restore it to the original range, it is multiplied by 10000 in line 33 to give the Y-parameter for the plot. The T-values are multiplied by the appropriate multiplier to obtain the X-parameters for the plot.


```
  LINE 30. PU;PA0,0;SP4;PD;LTB;
■LINE 31. FOR T=0 TO .05 STEP .0005
■LINE 32. READ Ydata
■LINE 33. Y=Ydata*10000
■LINE 34. X=T*10000
★LINE 35. PA X,Y;
■LINE 36. NEXT T
  LINE 37. SPO;
■LINE 38. DATA 0..005..013..022..033..043..054..064..078
■LINE 39. DATA .088..099..109..111..117..12..132..13..14
■LINE 40. DATA .143..131..14..14..128..127..13..128..114
■LINE 41. DATA .12..114..11..109..1..1..098..091..087
■LINE 42. DATA .092..089..085..082..087..085..084..092
■LINE 43. DATA .093..091..088..097..093..1..093..099..102
■LINE 44. DATA .098..1..098..107..1..103..101..103..1..109
■LINE 45. DATA .1..108..106..103..102..105..097..104..103
```

■BASIC statement. Do not send to plotter.

★A controller-dependent format statement may be required for this statement to be accepted by the plotter.

■LINE 46. DATA .096,.096,.095,.103,.098,.103,.103,.101
■LINE 47. DATA .094,.1,.099,.099,.095,.101,.097,.094,.095
■LINE 48. DATA .102,.094,.098,.099,.099,.104,.102,.099
■LINE 49. DATA .097,.098,.101,.102
LINE 50. (ESC) (.) ( )
■LINE 51. END

G. The following shows the completed effort.

The whole program which plots the ideal and actual data is given below. Note that using different line types and pens for the three lines makes the plotted results easy to read.

LINE 1. (ESC) (.) (
LINE 2. IN;IP2000,1400,14200,9300;
LINE 3. SC0,500,0,1600;
LINE 4. PA0,0;SP1;PD;
■LINE 5. FOR X=0 TO 500 STEP 100
★LINE 6. PA X,0;XT;PU;
★LINE 7. CP-2.4,-.9;LB X/10000. ETX
★LINE 8. PA X,0;PD;
■LINE 9. NEXT X
LINE 10. PU;PA200,-125;LBTIME(seconds) ETX
LINE 11. PA0,0;PD;
■LINE 12. FOR Y=0 TO 1600 STEP 100
★LINE 13. PA0,Y;YT;PU;
★LINE 14. CP-4.9,-.3;LB Y. ETX
★LINE 15. PA0,Y;PD;
■LINE 16. NEXT Y
LINE 17. PU;PA-55,600;DIO,1;LBDISTANCE CR LF (inches) ETX
LINE 18. PA0,0;SP2;PD;
■LINE 19. FOR T=0 TO .05 STEP .0005
■LINE 20. Y=1000*(1-EXP(-100*T)*COS(300*T))
■LINE 21. X=T*10000
★LINE 22. PA X,Y;
■LINE 23. NEXT T
LINE 24. PU;PA0,0;SP3;PD;LT2;
■LINE 25. FOR T=0 TO .05 STEP .0005
■LINE 26. Y=1000*(1-EXP(-60*T)*COS(300T))
■LINE 27. X=T*10000
★LINE 28. PA X,Y;
■LINE 29. NEXT T

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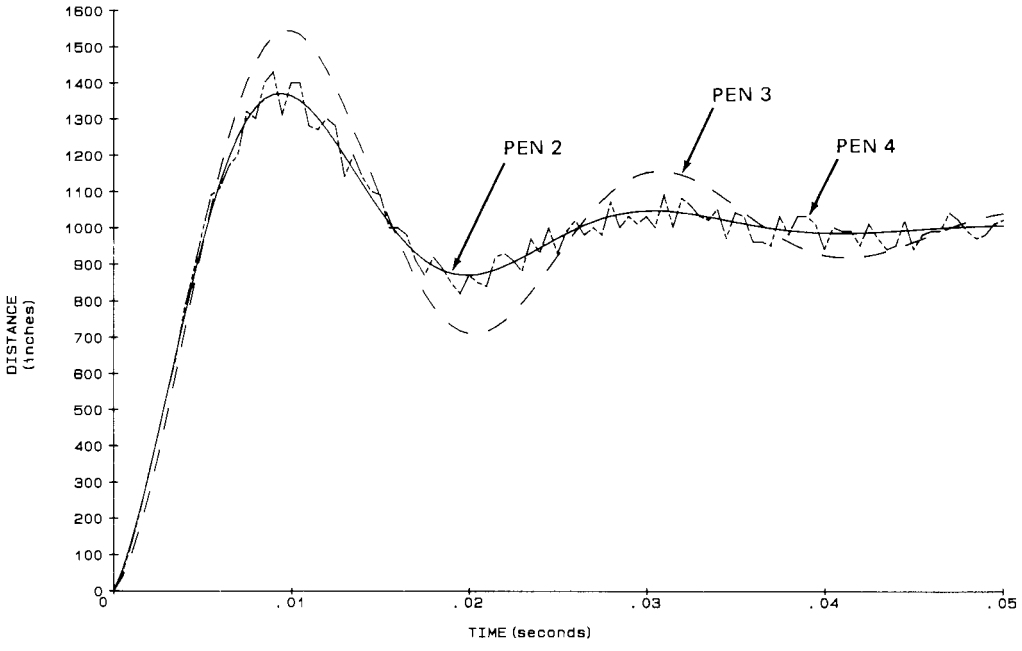
■Basic statement. Do not send to plotter.
★A controller-dependent format statement may be required for this statement to be accepted by the plotter.

LINE 30. PU;PA0,0;SP4;PD;LT6;
■LINE 31. FOR T=0 TO .05 STEP .0005
■LINE 32. READ Ydata
■LINE 33. Y=Ydata*10000
■LINE 34. X=T*10000
★LINE 35. PA X, Y;
■LINE 36. NEXT T
LINE 37. SP0;
■LINE 38. DATA 0,.005,.013,.022,.033,.043,.054,.064,.078
■LINE 39. DATA .088,.099,.109,.111,.117,.12,.132,.13,.14
■LINE 40. DATA .143,.131,.14,.14,.128,.127,.13,.128,.114
■LINE 41. DATA .12,.114,.11,.109,.1,.1,.098,.091,.087
■LINE 42. DATA .092,.089,.085,.082,.087,.085,.084,.092
■LINE 43. DATA .093,.091,.088,.097,.093,.1,.093,.099,.102
■LINE 44. DATA .098,.1,.098,.107,.1,.103,.101,.103,.1,.109
■LINE 45. DATA .1,.108,.106,.103,.102,.105,.097,.104,.103
■LINE 46. DATA .096,.096,.095,.103,.098,.103,.103,.101
■LINE 47. DATA .094,.1,.099,.099,.095,.101,.097,.094,.095
■LINE 48. DATA .102,.094,.098,.099,.099,.104,.102,.099
■LINE 49. DATA .097,.098,.101,.102
LINE 50. ESC .)
■LINE 51. END



■BASIC statement. Do not send to plotter.
★A controller-dependent format statement may be required for this statement to be accepted by the plotter.

Suggested Programming Practices

Certain programming practices will assure more effective use of the plotter. Among these are:

1. Initialize the plotter with the IN or DF command at the beginning of each program to assure no unwanted parameters are in effect from a prior plot. The use of IN will set P1 and P2 to default conditions and will enable cutter on 7220T only. The use of DF will not alter P1 or P2 or assure that cutter is enabled.

2. When operating the 7220T from a remote terminal, use the Output Option command OO to ascertain if paper advance is on and if paper has been written on. Advance the paper at the completion of your plot to assure no other user draws over your plot.

3. Select a pen before the first plot command to assure plot is actually recorded on the paper.

4. Lift the pen before changing colors to avoid a dot of the new color at the termination of the last vector.

5. Store the pen (SP0) at the completion of a plot so pens do not dry out.

6. When using A3 or 8½ × 11 inch paper, reset P1 and P2 manually or programmatically to points inside the paper area. Default P2 will scale the plot beyond the limits of 8½ by 11 inch paper.

7. When setting up the 7220T for unattended operation you may wish to load your plotter with a new set of pens. Pens have sufficient ink to draw 140 "typical" full page plots (1 roll) where each plot consists of 10 linear feet of writing per pen (axes, labels, and lines). If your plots differ from this norm you may wish to change pens more or less frequently.

Chapter 13
Operating Configurations

The 7220 can be operated in a wide variety of configurations. The two RS-232-C connectors on the back of the 7220 provide flexibility to allow the plotter to be interfaced to a computer and terminal in a modem or hardwire environment. This chapter describes the installation and operation considerations for these various configurations.

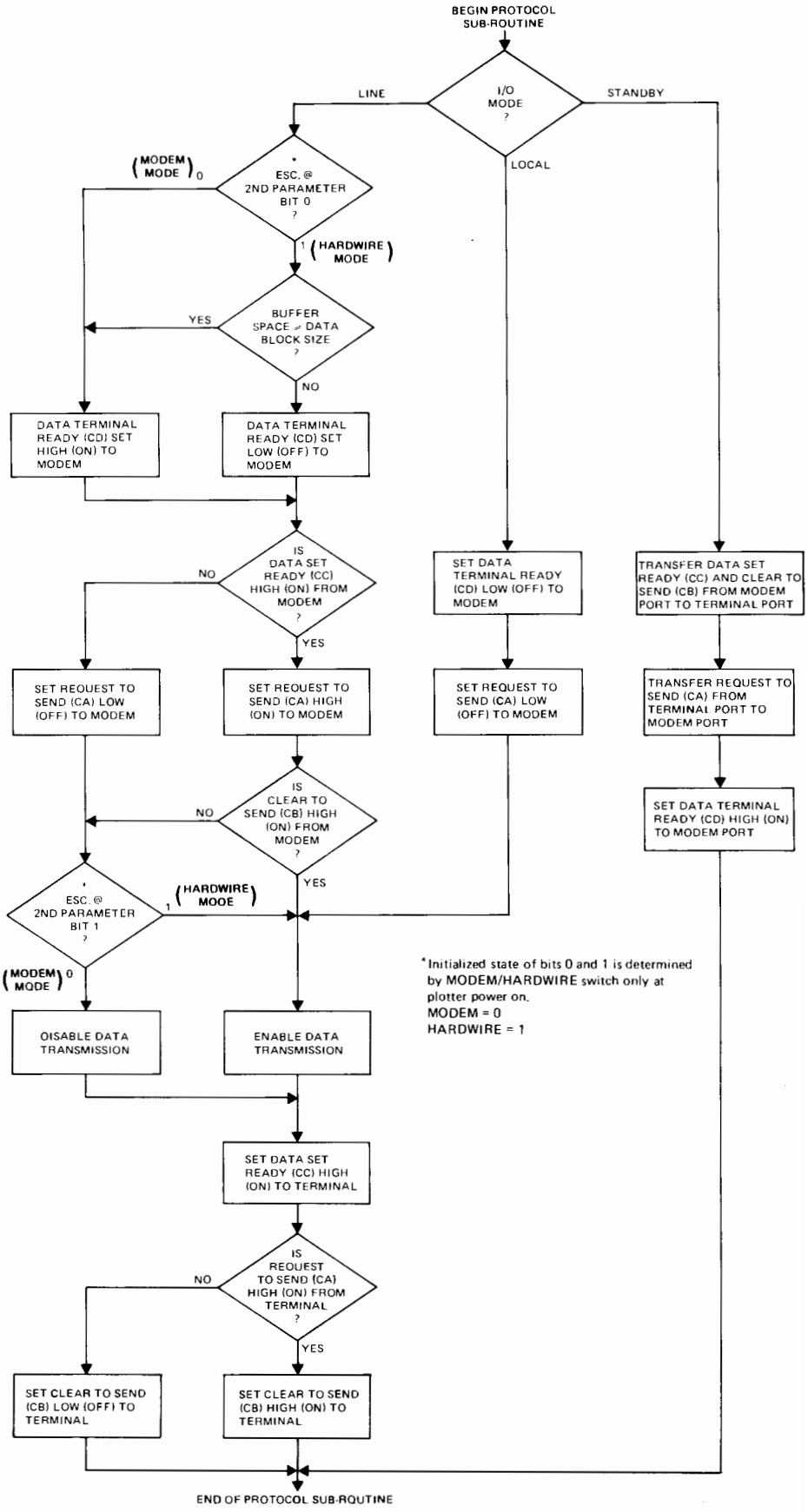
Control Line Protocol

It should be noted that in the On-Line Programmed-On Mode, all data generated by the plotter is routed to the modem. Data generated by the terminal is routed through to the modem on a non-interference basis so that data being transmitted by the plotter will not be interrupted by terminal data. However, all data generated by the host computer (and passed through the modem) is intercepted by the plotter and is not passed on to the terminal.

NOTE

The above data routing is true unless Monitor Mode is active. Refer to "Set Plotter Configurations" in Chapter 3 for a definition of Monitor Mode.

The flowchart that follows is a representation of the subroutine protocol the plotter observes for On-Line, Local and Standby Modes of operation. The following table shows the state of the various lines during the above modes of operation.



Interface Protocol Flowchart

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Plotter Modes and Line States

Plotter Mode	Data Set (Modem) Port Signal Lines		Terminal Port Signal Lines	
	Receive Lines	**Driven Lines**	**Receive Lines**	**Driven Lines**
Standby	Data Set Ready (CC) turns front panel data lamp on.	With DTR Normal Bypass in normal sets Data Terminal Ready (CD) High (ON) to modem.		Received Line Signal Detector (CF).
Local	Data Set Ready (CC) turns front panel data lamp on.	Sets to Low (OFF) state: Data Terminal Ready (CD). Request to Send (CA). Transmitted Data (BA).	Request to Send (CA) is monitored.	Sets to High (ON) state: Data Set Ready (CC). Clear to Send (CB) if Request to Send is High (ON). Received Line Signal Detector (CF.)
On-Line	Data Set Ready (CC) turns front panel data lamp on. Clear to Send (CB) is monitored if Data Set Ready (CC) is High (ON). Received Data (BB) is routed to plotter if plotter is programmed "ON" and through plotter if "OFF."	Data Terminal Ready (CD) is set High (ON). Request to Send (CA) is set High if Data Set Ready (CC) is High (ON). Transmitted Data (BA) is allowed to be set High (ON) if Data Set Ready (CC) and Clear to Send (CB) are High (ON).	Request to Send (CA) is monitored. If a Break Signal is received on transmitted data (BA) plotter generates a 200 millisecond break on modem Transmitted Data (BA) line. Data received is sent to host com puter if no output from plotter is pending or in progress.	Sets to High (ON) state: Data Set Ready (CC). Clear to Send (CB) if Request to Send (CA) is High (ON). Received Line Signal Detector (CF).

Transmission Errors

Depending upon its operating mode, the plotter upon receiving either a framing error or a parity error responds as follows:

RECEIVED FROM MODEM

With the plotter programmed-on, the defective byte is dropped from the buffer and is replaced by the DEL (127_{10}) ASCII character. The ERROR light is turned on steady when the delete character is encountered in the buffer. The plotter, when interrogated, will indicate an output error 15.

RECEIVED FROM TERMINAL

With the plotter either programmed-off or in the Standby Mode, the defective byte is dropped from the buffer and replaced by the DEL ASCII character.

The response of the plotter upon receipt of a framing error is the same as its response to a break signal. The break signal aborts output instructions but does not affect the plotter buffer. The plotter is turned programmatically off.

A buffer overflow error occurs when more bytes are received by the plotter than the available buffer space causing the overflowing data to be lost. In this event, an error marker character overlays the last byte received by the buffer which, when decoded, causes error 16 to be set and increments the error counter. Typically, this occurs when the handshake mode has not been set.

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Stop Bits

The plotter automatically verifies/generates two stop bits at the 75 and 110 baud rates and one stop bit at baud rates greater than 110.

NOTE

Two stop bits can be selected at all baud rates. Procedures for doing so are found in the 7220/7221C/T Service Manual, P/N 07220-90004.

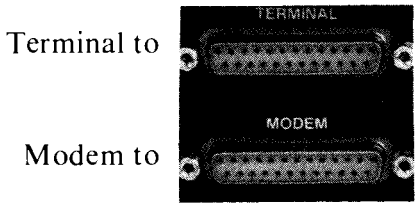
Output Baud Rate

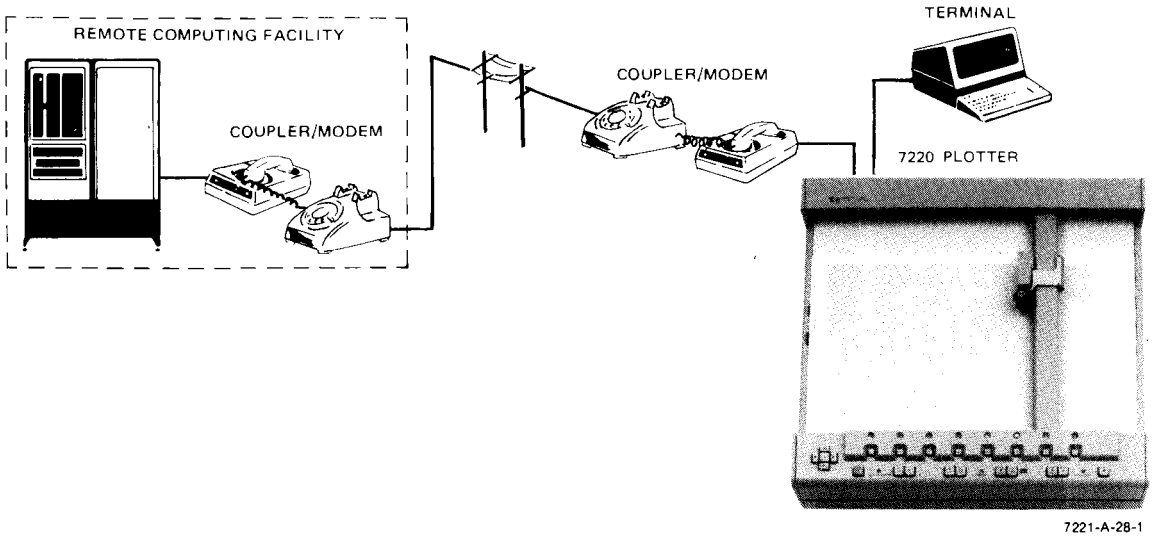
When the plotter responds to an output instruction, its transmission will be at the baud rate set by the rear BAUD RATE switch.

Installation/Operation In A Modem And Terminal Environment

Installation

The 7220 plotter can be connected to a remote computing facility through a data set (modem) and hardwired to a terminal to complete an operating system. In this type of installation, the plotter is connected in series between the modem and terminal as shown in the following figure. Rear panel connections are made as follows:





Plotter Interconnection With A Terminal And Remote Facility Using Modems

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Modem Considerations

When the plotter is installed in a plotting system using certain modems (such as those meeting the Bell 212 specifications), it is necessary to set the DTR BYPASS/NORM switch to DTR BYPASS. This avoids problems caused by the modem disconnecting from the computer when short interruptions occur in the DTR line of the plotter. When the switch is set to DTR BYPASS, the terminal controls the DTR line and it remains high as long as the terminal is turned on.

Operation

Six modes of operation are available when the plotter is connected in this type system. The modes and control settings are as follows:

Power-Off Mode

In this mode the plotter passes data between the host computer and terminal using relay closures. Plotter front and rear panel control settings are irrelevant.

Standby Mode

In this mode the plotter passes data between the host computer and terminal under plotter control, but all other plotter circuits are passive. Front and rear panel control settings are:

Front panel

On (set to 1)

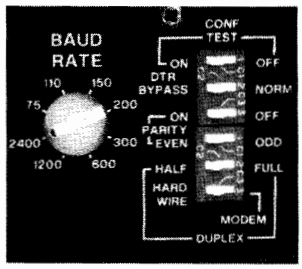
On and lamp on steady

Off and lamp off

Off and lamp off

On steady if the Data Set Ready line from the modem is high (active)

Rear panel



CONF. TEST: OFF

DTR BYPASS/NORM: Dependent on modem (See "Modem Considerations" in this chapter.)

PARITY ON/OFF: Irrelevant

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PARITY ODD/EVEN: Irrelevant

DUPLEX: Irrelevant

HARDWIRE/MODEM: As required

BAUD RATE: Same as host computer/terminal

On-Line Programmed-Off Mode

In this mode the plotter passes data between the host computer and terminal under plotter control. The plotter automatically enters this mode when power is applied to the unit, and remains in this mode until a Plotter On instruction is received from the host computer or by pressing the [ON LINE] pushbutton on the front panel of the plotter.

Front panel

[LINE] On (Set to 1)

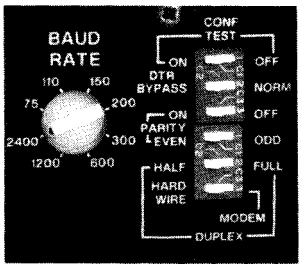
[STBY] Off and lamp off

[LOCAL] Off and lamp off

[ON LINE] On and lamp on steady

DATA SET On steady if modem's Data Set Ready line is high

Rear panel



CONF. TEST: OFF

DTR BYPASS/NORM: Dependent on modem (See "Modem Considerations" in this chapter.)

PARITY ON/OFF: Irrelevant

PARITY ODD/EVEN: Irrelevant

DUPLEX: Irrelevant

HARDWIRE/MODEM: MODEM

BAUD RATE: Same as host computer/terminal

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On-Line Programmed-On Mode

The plotter enters this mode from the On-Line Programmed-Off Mode upon receipt of a Plotter On instruction from the host computer or by pressing the [ON LINE] pushbutton on the front panel of the plotter. In this mode the plotter responds to the device control and graphic instructions from the computer, and passes data from the terminal to the computer including "breaks." Receipt of a break from the terminal aborts all plotter instructions and returns the plotter to the On-Line Programmed-Off Mode. Front and rear panel settings are:

Front panel

[0 LINE 1] On (set to 1)

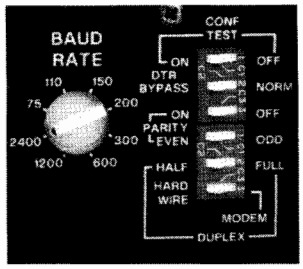
[STBY] Off and lamp off

[LOCAL] Off and lamp off

[ON LINE] On and lamp flashing upon receipt of Plotter On

DATA SET On steady if modem's Data Set Ready line is high

Rear panel



CONF. TEST: OFF

DTR BYPASS/NORM: Dependent on modem (Refer to "Modem Considerations" in this chapter.)

PARITY ON/OFF: Off for no parity; on for odd or even parity

PARITY ODD/EVEN: Same as host computer

DUPLEX: Irrelevant

HARDWIRE/MODEM: MODEM

BAUD RATE: Same as host computer/terminal

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Local Programmed-Off Mode

In this mode, the plotter ignores all data from the host computer and remains in a passive state awaiting a Plotter On instruction from the terminal or pressing the LOCAL pushbutton switch on the front panel of the plotter. Front and rear panel control settings are:

Front panel

On (set to 1)

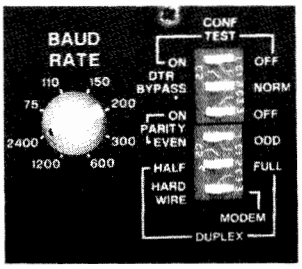
Off and lamp off

On and lamp on steady

Off and lamp off

On steady, if connected to a modem, and the modem's Data Set Ready line is high

Rear panel



CONF. TEST: OFF

DTR BYPASS/NORM: Irrelevant

PARITY ON/OFF: Irrelevant

PARITY ODD/EVEN: Irrelevant

DUPLEX: FULL for echo return to terminal; HALF for echo suppression

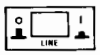
HARDWIRE/MODEM: MODEM

BAUD RATE: Same as terminal

Local Programmed-On Mode

The plotter enters this mode from the Local Programmed-Off Mode, upon receipt of a Plotter On instruction from the terminal. In this mode, the plotter responds to device control and graphic instructions from the terminal. All data from the host computer is ignored. Front and rear panel settings are:

Front panel



On (set to 1)

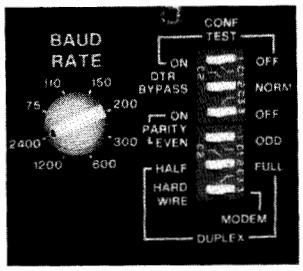
Off and lamp off

On and lamp blinking upon receipt of Plotter On

Off and lamp off

On steady if connected to a modem and the modem's Data Set Ready line is high

Rear panel



CONF. TEST: OFF

DTR BYPASS/NORM: Irrelevant

PARITY ON/OFF: Off for no parity; on for odd or even parity

PARITY ODD/EVEN: Same as terminal

DUPLEX: FULL for echo return to terminal; HALF for echo suppression

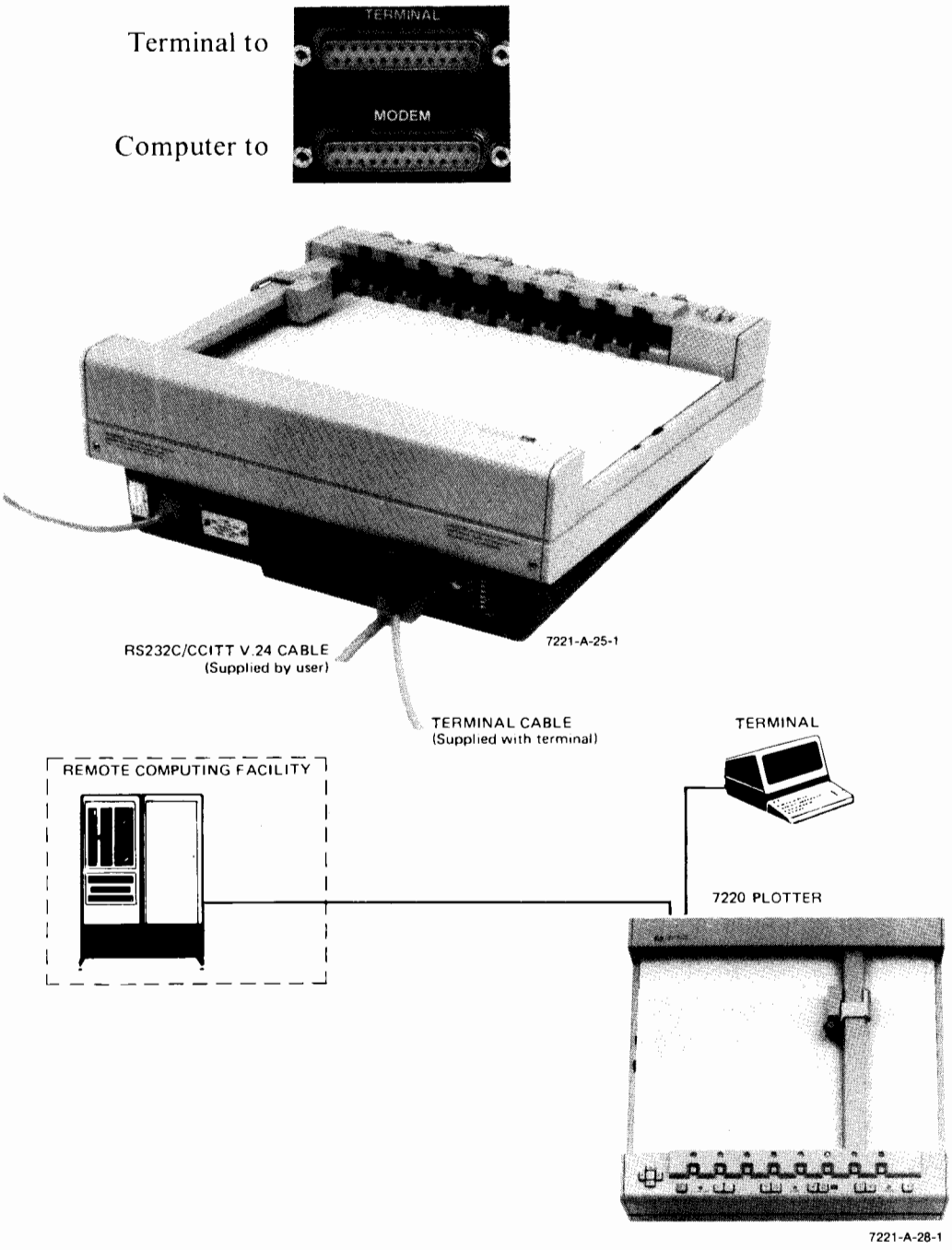
HARDWIRE/MODEM: MODEM

BAUD RATE: Same as terminal

Installation/Operation In A Hardwire Computer And Terminal Environment

Installation

A second type system installation connects the plotter with a computer and terminal by direct cabling. The plotter is connected in series between the computer and terminal as shown below. Rear panel connections are as follows:



Plotter Interconnection With A Terminal And Remote Facility
Using RS-232-C/CCITT V.24 Cabling

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Operation

System operation in this type installation is identical to operation with a modem and terminal, except that Data Set Ready is controlled by the host computer. The MODEM/HARDWIRE switch is set to HARDWIRE and the DTR BYPASS/NORM switch is set to NORM unless the system uses the terminal to control the DTR line. Refer to operating procedures for the following six modes as discussed in "Installation/Operation With A Modem And Terminal":

- **Power-Off Mode**
- **Standby Mode**
- **On-Line Programmed-Off Mode**
- **On-Line Programmed-On Mode**
- **Local Programmed-Off Mode**
- **Local Programmed-On Mode**

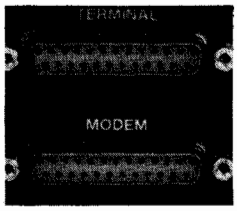
Installation/Operation With A Computer Mainframe

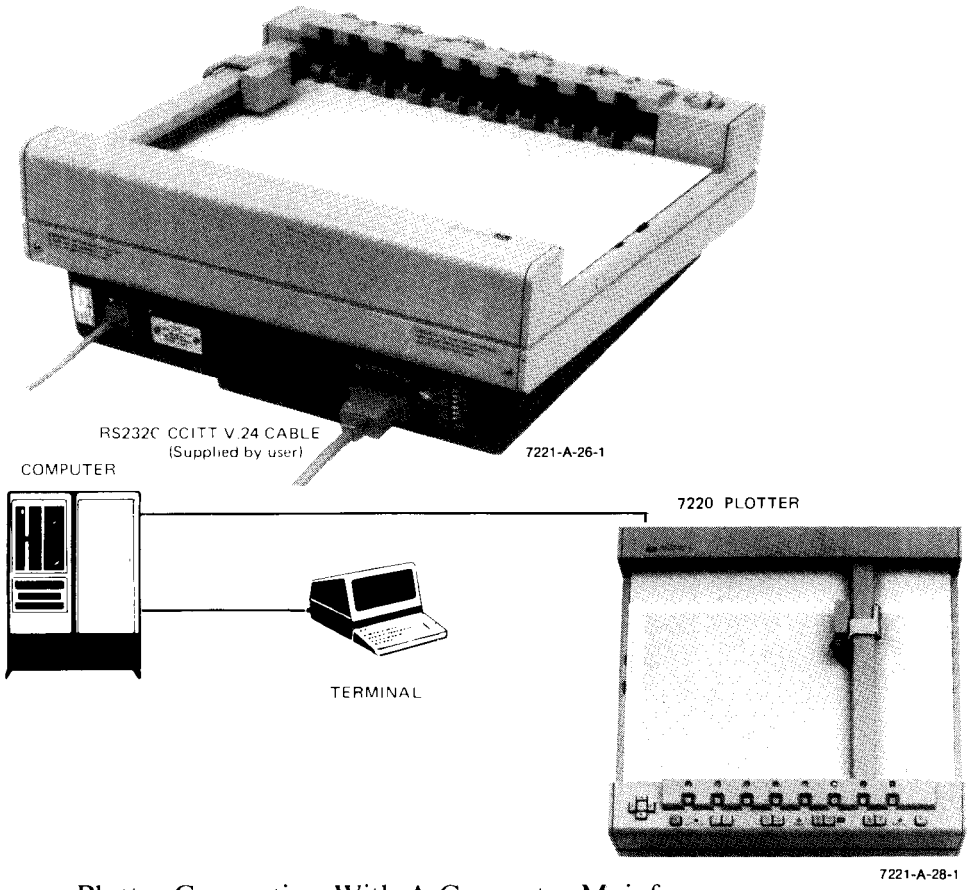
Installation

In this type system the plotter is adjacent and connected directly to a computer. Plotter activity is under program control of the computer; however, entry to the computer by a terminal is through a separate port rather than through the plotter. A figure on the next page illustrates the system installation, and rear panel connections.

Not connected

To computer





Plotter Connection With A Computer Mainframe

Operation

Operation with this type installation is confined to the three modes listed below and discussed in "Installation/Operation With A Modem And Terminal":

- **On-Line Programmed-Off Mode**
- **On-Line Programmed-On Mode**
- **Standby Mode**

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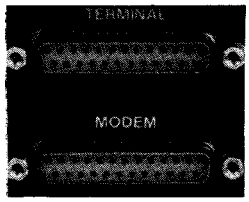
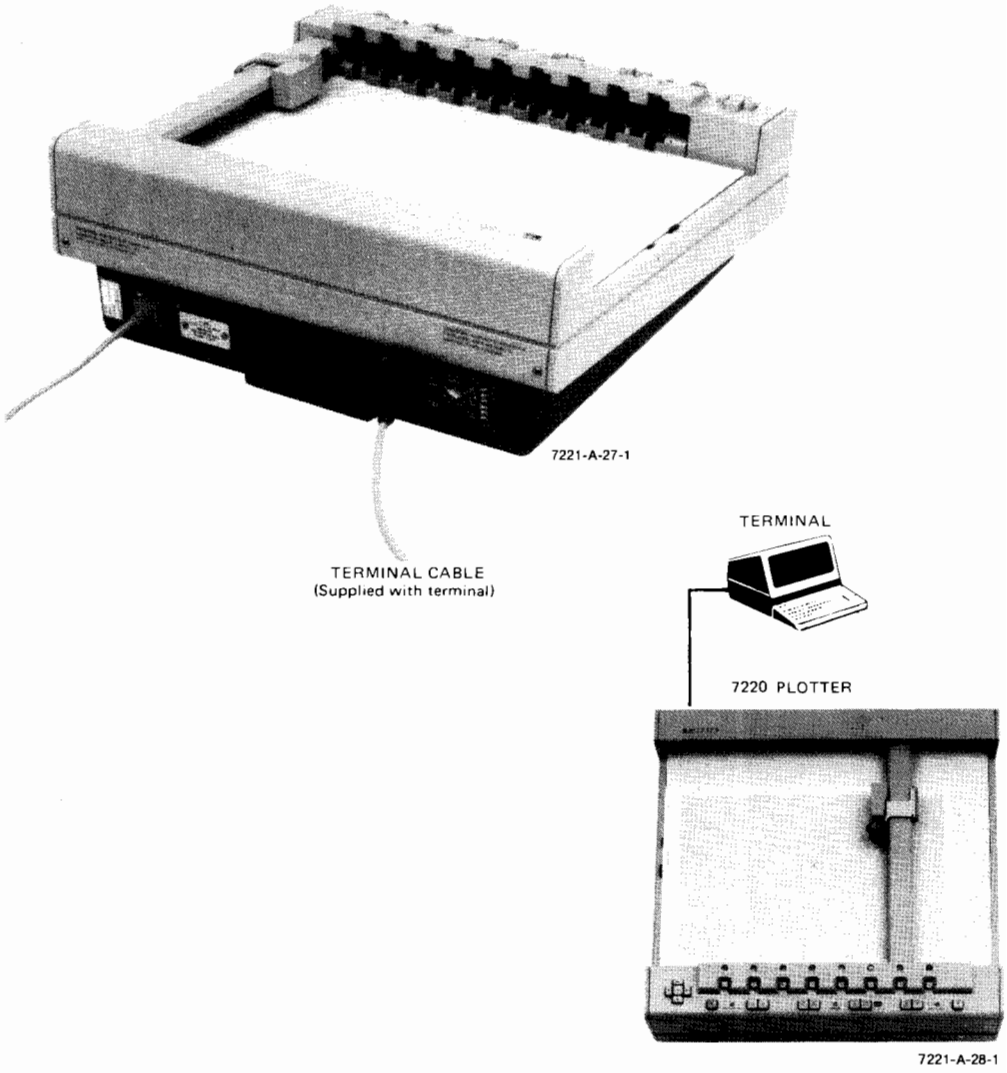
Installation/Operation In A Terminal Only Environment

Installation

In this type system the plotter is adjacent and connected to a terminal. This type installation is used for off-line labeling and data point digitizing. The following figure illustrates this installation, and rear panel connections.





Plotter Connection With A Terminal

Operation

Operation with this type installation is confined to the three modes listed below and described in "Installation/Operation With A Modem And Terminal":

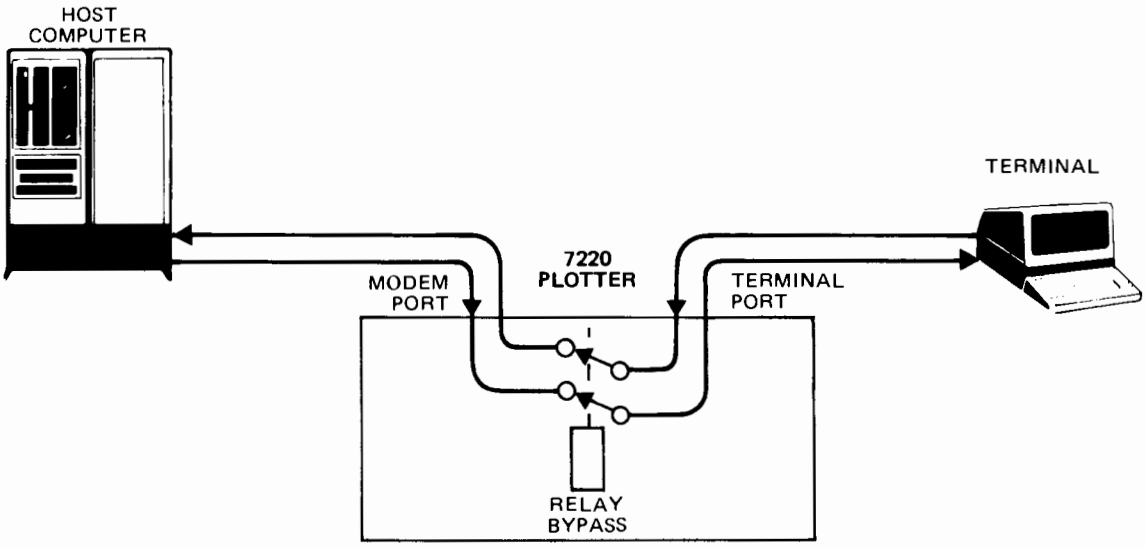
- **Local Programmed-Off Mode**
- **Local Programmed-On Mode**
- **Standby Mode**

Various Operating Modes

The plotter generally operates in series between a host computer and a terminal in the six modes described in the following paragraphs.

Power-Off Mode

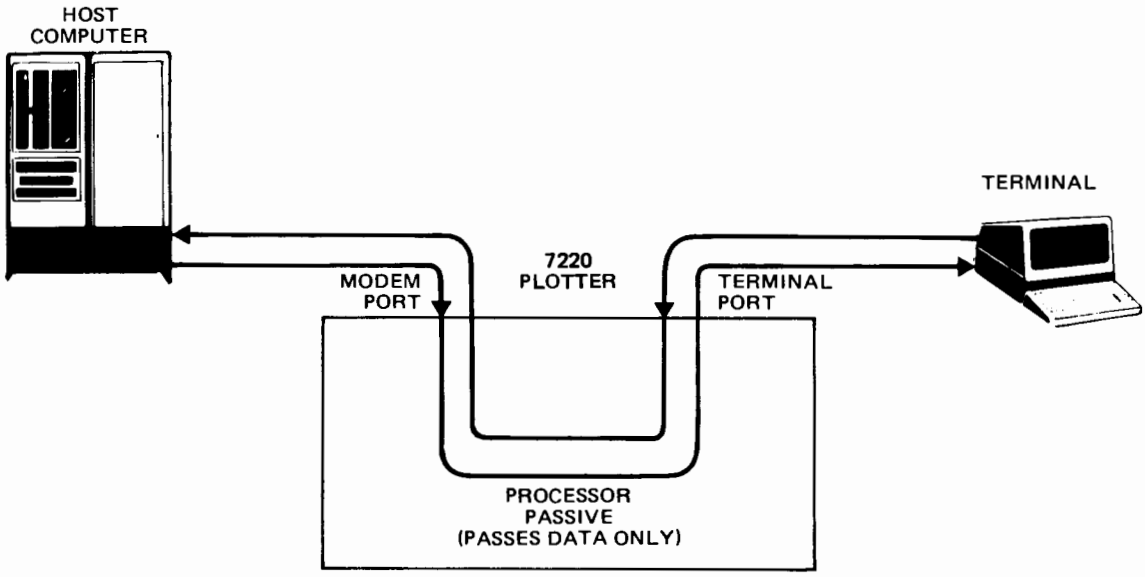
When the plotter is connected in a communication channel with a host computer and terminal, and the plotter LINE switch is off, the computer and terminal communicate through a hardwired relay connection in the plotter as shown below. The plotter responds to no instructions in this mode.



Plotter In Power-Off Mode

Standby Mode

The plotter is placed in a Standby Mode by setting the LINE switch on and pressing the front panel [STBY] pushbutton. In this mode, the [STBY] pushbutton lamp is on steady and the plotter processor passes data between the host computer and terminal as shown in the figure below. The plotter responds to no instructions in this mode.



Plotter In Standby Mode

On-Line Programmed-Off Mode

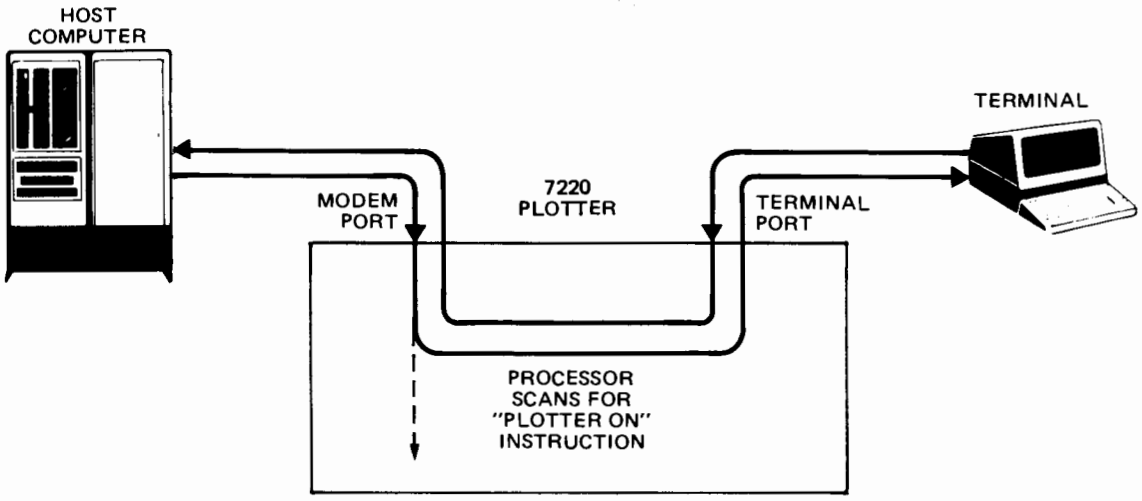
The plotter is placed on-line in a programmatically off state by one of the following actions:

a. Initially setting the plotter LINE switch on.

b. Being in On-Line Programmed-On Mode and receiving a Plotter Off instruction from the computer.

c. Switching from Standby Mode to On-Line Mode using the front panel [STBY] and [ON LINE] pushbuttons.

In this mode, the [ON LINE] pushbutton lamp is on steady and the processor passes data between the host computer and terminal as shown below. The plotter will respond only to a Plotter On instruction.



Plotter In On-Line Programmed-Off Mode

On-Line Programmed-On Mode

The plotter is switched from On-Line Programmed-Off Mode (the [ON LINE] pushbutton lamp is on steady) to On-Line Programmed-On Mode when a Plotter On instruction, ESC . (or ESC . Y, is received from the host computer or the front panel [ON LINE] push-button switch. When this mode is established, the [ON LINE] lamp starts flashing and the plotter operates in response to instructions received from the host computer as shown on the following page. The plotter also provides the following outputs when the computer requests the information:

a. Plotter identification (OI)
b. Status (OS)
c. Buffer size (ESC . L)
d. Buffer space (ESC . B)
e. Current graphic limits (OP)
f. Current pen position (OC or OA)
g. Error identification (OE)
h. Digitized point (OD)
i. Options (OO)
j. Plotter unit size (OF)

The communication channel from the terminal to the host computer through the plotter is maintained to provide operator entry into the computer. The communication channel from the plotter terminal port to the terminal is used in this mode of operation only if Monitor Mode is active. Refer to "Set Plotter Configuration" in Chapter 3.

The plotter processor monitors the communication channel from the terminal to the computer for a terminal-generated break signal (a series of space bits). This break signal causes the plotter to return to the On-Line Programmed-Off Mode. Any in-process plotter outputs are aborted, incoming data is halted, and plotting continues until stored buffer data is completed. A new Plotter On instruction from the computer or front panel is required to resume plotting operations.

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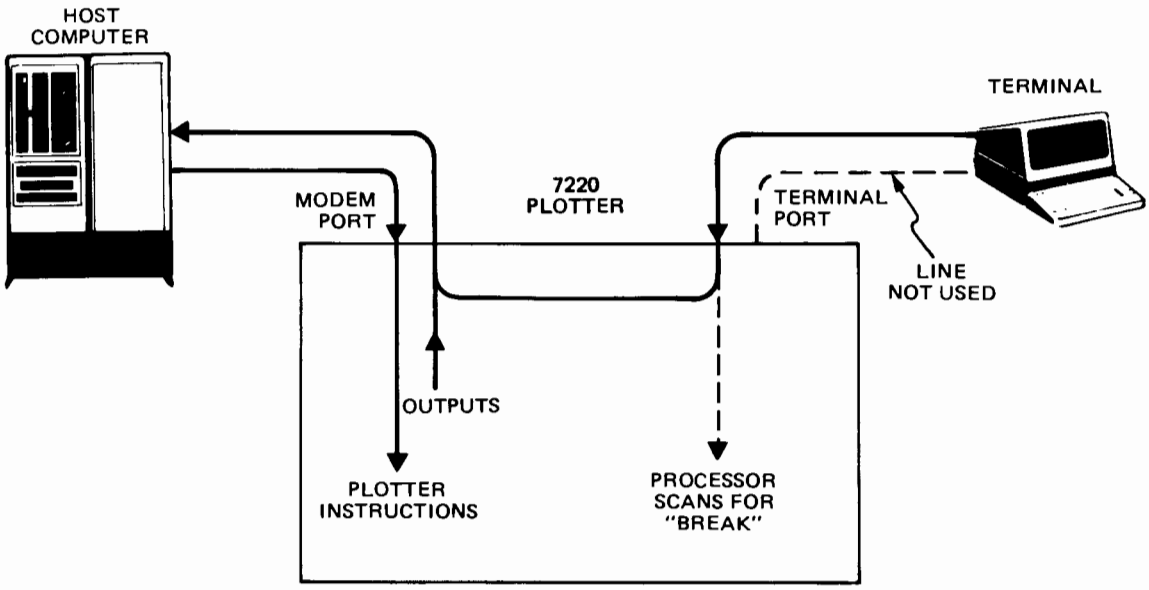
NOTE

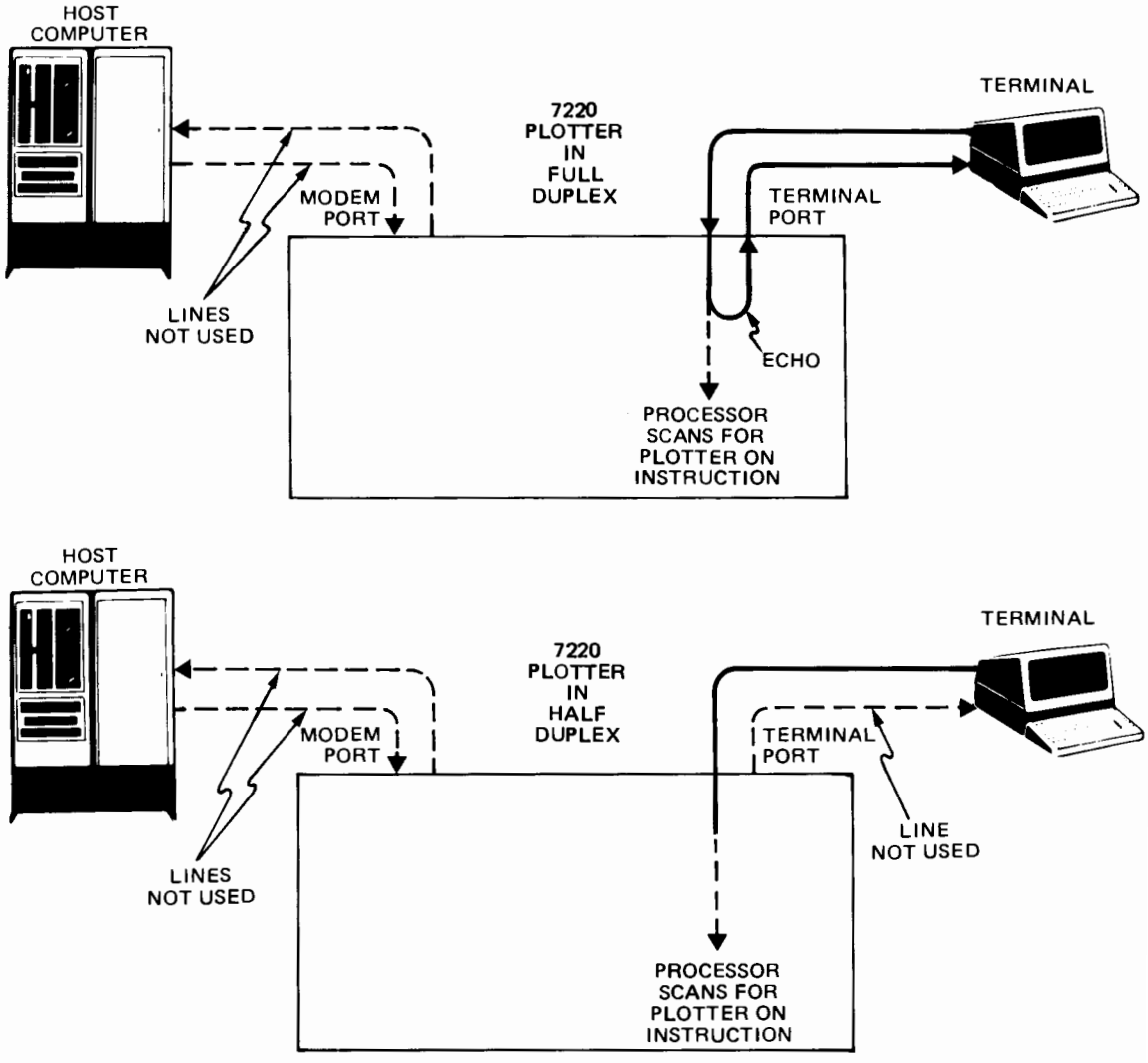
Pressing the [STBY] pushbutton will flush all graphics from the buffer.



Plotter In On-Line Programmed-On Mode

Local Programmed-Off Mode

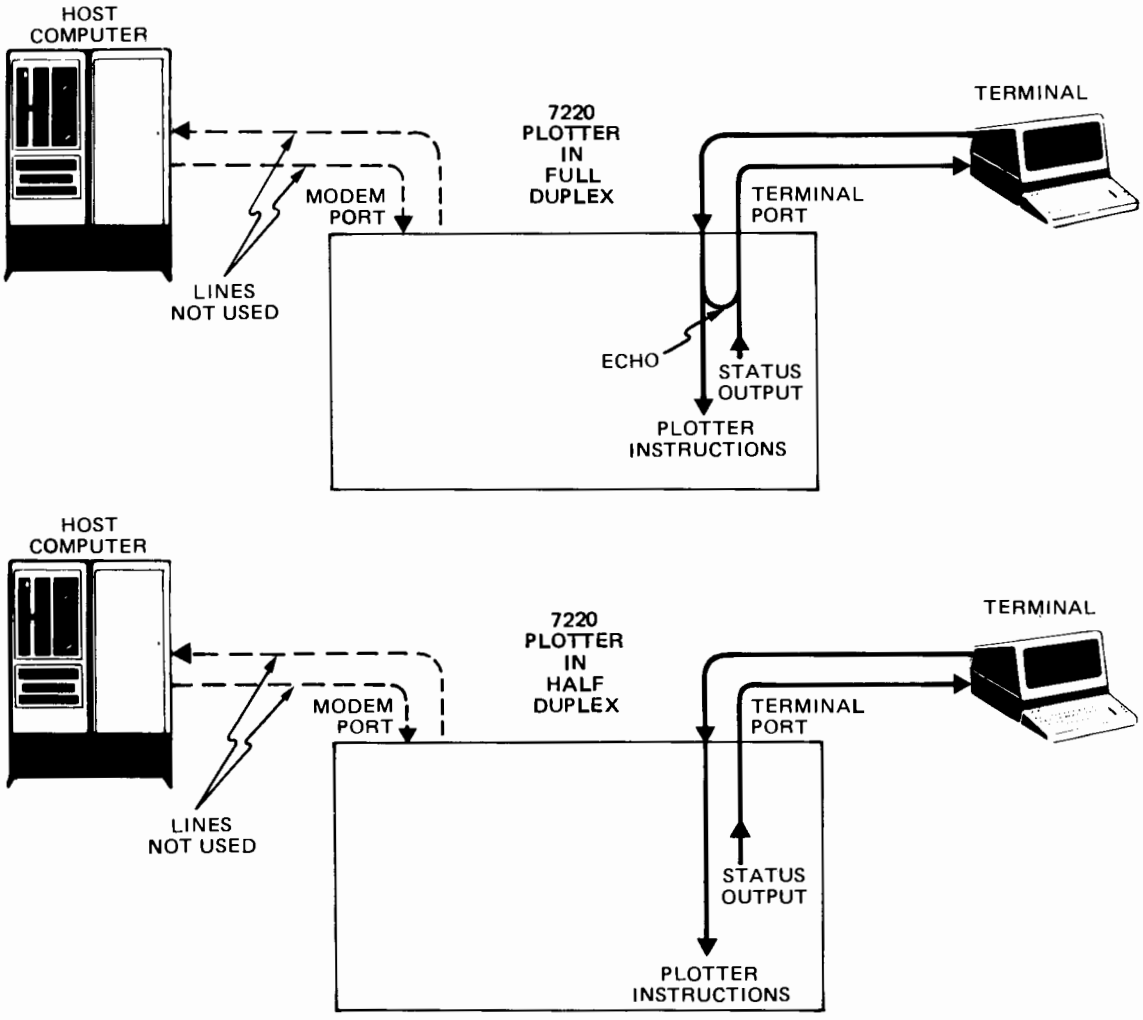
The plotter is placed in the Local Programmed-Off Mode when the LINE switch is turned on and the front panel [LOCAL] pushbutton is pressed. In this mode, the pushbutton lamp is on steady and the processor scans for a Plotter On instruction from the terminal as shown in the figure below. The lines between the host computer and the plotter modem port are not used and any data from the computer is ignored. The rear panel DUPLEX switch is operational in this mode of operation. When the switch is set to FULL, the data received from the terminal is echoed (retransmitted) to the terminal. When the switch is set to HALF, this echo is suppressed and the line from the plotter terminal port to the terminal is not used.



Plotter In Local Programmed-Off Mode

Local Programmed-On Mode

The plotter is placed in Local Programmed-On Mode when the LINE switch is on, the [LOCAL] pushbutton has been operated (the pushbutton lamp is on steady) and a Plotter On instruction is received from the terminal. In this mode, the [LOCAL] pushbutton lamp is flashing and the plotter operates in response to instructions from the terminal as shown in the figure below. The plotter also provides the same outputs, when requested by the terminal, as provided in the On-Line Programmed-On Mode. The communication channels between the host computer and plotter modem port are not used and any data from the computer is ignored. The rear panel DUPLEX switch is also operational in this mode. In FULL DUPLEX the terminal input is echoed to the terminal, and in HALF DUPLEX the echo is suppressed.



Plotter In Local Programmed-On Mode

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13

Appendix

Plotter Default Conditions

Relative character direction	Horizontal (DR1,0)
Line type	Solid line
Line pattern length	4% of the distance from P1 to P2
Input window	Total platen area
Relative character size	(SR.75, 1.5) width = 0.75% of $\lvert P2_X - P1_X \rvert$ height = 1.5% of $\lvert P2_Y - P1_Y \rvert$
Scale	Off
Symbol mode	Off
Tick length	Tp = Tn, 0.5% of $\lvert P2_X - P1_X \rvert$ for X-tick or 0.5% of $\lvert P2_Y - P1_Y \rvert$ for Y-tick.
Standard character set	Set 0
Alternate character set	Set 0
Character slant	0°
Mask value	223
Digitize clear	On
Label terminator	ETX
Automatic pen pickup	On
Pen velocity	36 cm/s
Adaptive pen velocity	Off

P1 and P2 are changed only with the Initialize command (IN). They are not affected by ESC. K and the Default command (DF).

The current pen location is moved to the lower-right corner with the Initialize command (IN), but is unaffected by ESC. K and the Default command (DF).

On the 7220T, the cutter is enabled only with the Initialize command (IN). It is not affected by ESC. K and the Default command (DF).

HP-GL Error Messages

These error messages are displayed by executing a HP-GL Output Error instruction OE.

error 1	Instruction not recognized The plotter has received an illegal character sequence.
error 2	Wrong number of parameters Too many or too few parameters have been sent with an instruction.
error 3	Bad parameter The parameters sent to the plotter with an instruction are out of range for that instruction.
error 4	Reserved
error 5	Unknown character set A character set out of the range 0 through 4 has been designated as either the standard or alternate character set.
error 6	Position overflow An attempt to draw a character (LB or UC) or perform a CP that is located outside of the plotter's numeric limit of ±32767.
error 7	Reserved
error 8	Out of paper (7220T)

Connecting The RS-232-C Interface

The 7220 plotter interfaces to the RS-232-C communications lines through the MODEM or TERMINAL standard 25-pin female connectors mounted on the back of the plotter. The plotter is compatible with EIA RS-232-C and CCITT V.24 protocols but requires only three lines for data communications. These lines are identified and described in the following table.

MODEM Minimum Interface Connector Pin Allocations

Pin No.	RS-232-C	CCITT V.24	Function/Signal Level
2	BA (TDATA)	103	Data line from plotter to modem (ON = "0" = +12 V; OFF = "1" ≈ −12 V)
3	BB (RDATA)	104	Data line to plotter from modem (ON = "0" = +3 V to +25 V; OFF = "1" = −3 V to −25 V)
7	AB (SGND)	102	Signal ground (Return line)

TERMINAL Minimum Interface Connector Pin Allocations

Pin No.	RS-232-C	CCITT V.24	Function/Signal Level
2	BA (TDATA)	103	Data line to plotter from terminal (ON = "0" = +3 V to +25 V; OFF = "1" = −3 V to −25 V)
3	BB (RDATA)	104	Data line from plotter to terminal (ON = "0" = +12 V; OFF = "1" ≈ −12 V)
7	AB (SGND)	102	Signal ground (Return line)

In addition to the minimum requirements for communications, four more lines are connected at the TERMINAL and MODEM connectors. These four lines are identified in the following table.

Additional Connector Pin Allocations

Connector	Pin No.	RS-232-C	CCITT V.24	Function/Signal Level
Terminal	4	CA	105	Request to Send to Plotter
Modem	4	CA	105	Request to Send from Plotter
Terminal	5	CB	106	Clear to Send from Plotter
Modem	5	CB	106	Clear to Send to Plotter
Terminal	6	CC	107	Data Set Ready from Plotter
Modem	6	CC	107	Data Set Ready to Plotter
Both	20	CD	108.2	Data Terminal Ready ON = "1" = +11.5 V (±5%) OFF = "0" = −11.5 V (±5%)

These four lines are wired to TERMINAL and MODEM connectors on the rear panel of the plotter. Their functions are as follows:

1. The Request to Send line (pin 4 TERMINAL or pin 5 MODEM) does not have to be used. However, if it is used, it must be controlled as defined by RS-232-C specifications.

2. The Clear to Send line (pin 5 TERMINAL or pin 4 MODEM) is always held high indicating the plotter is ready.

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3. Data Set Ready line (pin 6) is activated by the modem to tell the plotter that the modem is operational and is activated by the plotter to tell the terminal that the plotter is operational.

4. The Data Terminal Ready line (pin 20) is used in hardwire handshake mode to monitor the available block space in the buffer. The use of this line is explained in Chapter 2 under the paragraph entitled "Hardwire Handshake Mode."

RS-232-C Error Messages

These error messages are displayed by executing a (ESC) (.) (E) instruction.

error 10 Output instruction received while another output instruction is executing. The original output instruction will continue normally while the one in error will be ignored.

error 11 Invalid byte received following the (ESC) (.) in a device control instruction.

error 12 Invalid byte received while parsing a device control instruction. The device control parameters will be defaulted from the parameter where the invalid byte was received to the end of the instruction. The invalid byte will then be parsed.

error 13 Parameter out-of-range (too big, too small, or an illegal value).

error 14 Too many parameters received for a device control instruction. Additional parameters beyond the proper number are ignored and the parsing of the device control instruction ends when a colon (normal exit) or the first byte of another instruction is received (abnormal exit).

NOTE

The receipt of something other than another parameter, a semicolon, or a colon will result in an error type 12 overwriting error type 14.

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error 15 A transmission error has been detected. These are errors generated by the Universal Asynchronous Receiver/Transmitter (UART) (framing error, parity error, or overrun error).

error 16 The input buffer memory has overflowed. This indicates improper handshaking. As a result of the overflow, one byte of data has been lost and therefore eventually a HP-GL error will probably occur.

Scaling Without Using The SC Instruction

The 7220 plotter movements are in terms of plotter units where plotter unit = 0.025 mm. It may be convenient for you to write programs where plotter movements are in some units other than plotter units. These "user units" can be converted into plotter units by the computer using the following equations:

$$\text{X scaled} = \left[\frac{P2_X - P1_X}{U2_X - U1_X}\right] A_X + P1_X - U1_X\left[\frac{P2_X - P1_X}{U2_X - U1_X}\right]$$

$$\text{Y scaled} = \left[\frac{P2_Y - P1_Y}{U2_Y - U1_Y}\right] A_Y + P1_Y - U1_Y\left[\frac{P2_Y - P1_Y}{U2_Y - U1_Y}\right]$$

where:

A_X is the X-coordinate of the desired point in user units

A_Y is the Y-coordinate of the desired point in user units

$P1_X$ is the X-coordinate of P1 in plotter units

$P1_Y$ is the Y-coordinate of P1 in plotter units

$P2_X$ is the X-coordinate of P2 in plotter units

$P2_Y$ is the Y-coordinate of P2 in plotter units

$U1_X$ is the X-coordinate of P1 in user units

$U1_Y$ is the Y-coordinate of P1 in user units

$U2_X$ is the X-coordinate of P2 in user units

$U2_Y$ is the Y-coordinate of P2 in user units

HP-GL Instructions Summary

This section lists the formal syntax for each plotter instruction. Instructions are listed in alphabetical order.

AA Arc Absolute Instruction

Page 104

AA X-coordinate, Y-coordinate, arc angle (,chord angle) (;)

AF Advance Full Page Instruction

Page 161

AF (;) or PG (;) or PG1 (;)

These instructions are not usable on the 7220C plotter.

AH Advance Half Page Instruction

Page 162

AH (;)

AH is not usable on the 7220C plotter.

AP Automatic Pen Pickup Instruction

Page 110

AP (interger) (;)

AR Arc Relative Instruction

Page 108

AR X-increment, Y-increment, arc angle (,chord angle) (;)

CA Designate Alternate Character Set Instruction

Page 123

CA character set number (;)

The character set number must be an integer in the range 0 through 4.
If the parameter is omitted, default value 0 is assumed.

CI Circle Instruction

Page 99

CI radius (,chord angle) (;)

CP Character Plot Instruction

Page 139

CP # of character-space widths, # of character-space heights ;

Both parameters must be within the range ±127.999. Decimal portion is optional.

CS Designate Standard Character Set Instruction

Page 123

CS character set number ;

The character set number must be an interger in the range 0 through 4. If the parameter is omitted, default value (0) is assumed.

DC Digitize Clear Instruction

Page 158

DC ;

Parameters are not used.

DF Default Instruction

Page 76

DF ;

Parameters are not used.

DI Absolute Direction Instruction

Page 131

DI run, rise ;

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Both parameters must be in the range of ±127.999. If the parameters are omitted, default values are assumed.

DP Digitize Point Instruction

Page 157

DP ;

Parameters are not used.

DR Relative Direction Instruction

Page 133

DR run, rise (;)

Run is the desired percentage of $|P2_X - P1_X|$. Rise is the desired percentage of $|P2_Y - P1_Y|$. Both parameters must be in the range of ±127.999. If the parameters are omitted, default values are assumed.

DT Define Terminator Instruction

Page 128

DT (t) (;)

(t) is the label terminator that must be used to exit from LB instruction character strings.

EC Enable Cutter Instruction

Page 162

EC (int) (;)

EC with no parameter enables the cutter. Zero is the only recommended parameter to disable the cutter. EC is not usable on the 7220C plotter.

IM Input Mask Instruction

Page 152

IM E-mask value (;)

The parameter must be in the range of 0 through 255. If the parameter is omitted, the default value is assumed.

IN Initialize Instruction

Page 77

IN (;)

Parameters are not used.

IP Input P1 and P2 Instruction

Page 82

IP $P1_X$, $P1_Y$, $P2_X$, $P2_Y$ (;)

Parameters must be in the range of $0 \leqslant X \leqslant 16000$, $0 \leqslant Y \leqslant 11400$. If the parameters are omitted, default values are assumed.

IW Input Window Instruction

Page 153

IW $X_{\text{lower left}}$, $Y_{\text{lower left}}$, $X_{\text{upper right}}$, $Y_{\text{upper right}}$ (;)

X-parameters must be in the range of 0 to +16000 and Y-parameters must be in the range of 0 to +11400.

LB Label Instruction

Page 126

LB character string <ASC>

The ASCII character (parameter <ASC>) is the label terminator defined by the DT instruction. If not set, the terminator will default to ETX.

LT Line Type Instruction

Page 118

LT pattern number (,pattern length) (;)

The range of pattern number is 0 through 6 and the range of pattern length is 0.004 to 127.999. If the parameters are omitted, default values are assumed.

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OA Output Actual Position Instruction

Page 145

OA (;)

Parameters are not used.

OC Output Commanded Position and Pen Status Instruction

Page 146

OC ;

Parameters are not used.

OD Output Digitized Point and Pen Status Instruction

Page 159

OD ;

Parameters are not used.

OE Output Error Instruction

Page 147

OE ;

Parameters are not used.

OF Output Factor Instruction

Page 148

OF ;

Parameters are not used.

OI Output Identifier Instruction

Page 149

OI ;

Parameters are not used.

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OO Output Option Instruction

Page 150

OO ;

Parameters are not used.

OP Output P1 and P2 Instruction

Page 83

OP ;

Parameters are not used.

OS Output Status Instruction

Page 151

OS ;

Parameters are not used.

PA Plot Absolute Instruction

Page 93

PA X_1 coordinate, Y_1 coordinate (, X_2 coordinate, Y_2 coordinate, . . ., . . .,X_n coordinate, Y_n coordinate) ;

X- and Y-coordinates must be integers and are limited to the range of ±32767 in nonscaled mode and ±16383 in scaled mode.

PD Pen Down Instruction

Page 92

PD ;

Parameters are not used.

PG Advance Full Page Instruction

Page 96

See AF.

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PR Plot Relative Instruction

Page 96

PR X_1 increment, Y_1 increment (, X_2 increment, Y_2 increment, . . ., . . .,X_n increment, Y_n increment) ;

X- and Y-increments must be integers and are limited to values between ±32767 referenced from the platen point 0,0 in nonscaled mode, and ±16383 in scaled mode.

PU Pen Up Instruction

Page 92

PU (;)

Parameters are not used.

SA Select Alternate Character Set Instruction

Page 125

SA (;)

Parameters are not used.

SC Scale Instruction

Page 84

SC Xmin, Xmax, Ymin, Ymax (;)

All four parameters must be entered. Xmin must be less than Xmax and Ymin less than Ymax.

SI Absolute Character Size Instruction

Page 135

SI width, height (;)

Both parameters must be in the range of ±127.999. If the parameters are omitted, default values are assumed.

SL Character Slant Instruction

Page 138

SL tan θ (;)

The degree of slant is a decimal number in the range of ±127.999 and is equivalent to the tangent of the angle θ from the vertical. If the parameter is omitted, default value is assumed.

SM Symbol Mode

Page 116

SM character (;)

Characters between ASCII 33 and 126, excluding ASCII 59 (;) and ASCII 44 (,), can be used. If the parameter is omitted, symbol mode is turned off (default).

SP Select Pen Instruction

Page 91

SP pen stall number (;)

Pen stall number equals 0 to 8.

SR Relative Character Size Instruction

Page 137

SR width, height (;)

Width is the desired percentage of $|P2_X - P1_X|$. Height is the desired percentage of $|P2_Y - P1_Y|$. Both parameters must be in the range of ±127.999. If the parameters are omitted, default values are assumed.

SS Select Standard Character Set Instruction

Page 124

SS (;)

Parameters are not used.

TL Tick Length Instruction

Page 114

TL tp, tn (;)

Both parameters must be in the range of ±127.999. If both the parameters are omitted, default values are assumed. If a second parameter is omitted, negative tick length is 0 and no negative tick is drawn.

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UC User Defined Character Instruction

Page 141

UC (pen control parameter,) X-increment, Y-increment,
(pen control parameter,) (X-increment, Y-increment,).... (;)

Pen control parameter must be an integer (+99 for pen down and −99 for pen up are commonly used). X- and Y-increments can range from ±98 character grid units.

VA Adaptive Pen Velocity Instruction

Page 111

VA (;)

Parameters are not used.

VN Normal Pen Velocity Instruction

Page 112

VN (;)

Parameters are not used.

VS Velocity Select Instruction

Page 110

VS pen velocity (, pen number) (;)

The pen velocity parameter should be an integer between 1 and 36. If the optional pen number is specified, the speed will apply only to that pen.

XT X-Tick Instruction

Page 113

XT (;)

Parameters are not used.

YT Y-Tick Instruction

Page 113

YT (;)

Parameters are not used.

RS-232-C Instructions Summary

This section lists the formal syntax for each RS-232-C device control instruction.

ESC . (or ESC . Y Page 44

Plotter On

Places the plotter in the programmed-on state.

ESC .) or ESC . Z Page 44

Plotter Off

Places the plotter in the programmed-off state.

ESC . @ [(<DEC>) ; (<ASC>)] : Page 58

Set Plotter Configuration

Enables or disables hardwired handshake mode where:

<DEC>	Set maximum buffer size (0 to 9999 characters).
<ASC>	Set configuration options character. ASCII decimal equivalent of 4-bit word (0 to 15).

ESC . B Page 65

Output Buffer Space

Displays number of byte spaces currently available for data in the buffer.

ESC . E Page 66

Output Extended Error

Displays a decimal code to identify the type of RS-232-C related error that occurred. Does not indicate what type of HP-GL instruction error may have occurred.

ESC . H [<DEC> ; <ASC> ; <ASC> ... <ASC>] : Page 48

Set Handshake Mode 1

Establishes parameters for Set Handshake Mode 1 where:

<DEC>	Block size.
<ASC>	Handshake enable character.
<ASC>...<ASC>	Handshake string of 1 to 10 characters.

Dependent upon parameters of Set Output Mode.

ESC . I [<DEC>] ; <ASC> ; {<ASC>} : Page 48

Set Handshake Mode 2

Establishes parameters for Set Handshake Mode 2 where:

<DEC>	Block size.
<ASC>	Handshake enable character.
{<ASC>}	Handshake string of 1 to 10 characters separated by semicolons.

Independent of Set Output Mode.

ESC . J Page 63

Abort Device Control

Aborts any partially decoded or executed device control instructions.

ESC . K Page 63

Abort Graphic

Aborts any partially decoded HP-GL instructions but permits instructions being executed to finish.

ESC . L Page 64

Output Buffer Size

Displays the size of the data buffer. Always displays 928 with standard buffer or 2976 with expanded buffer, unless size changed by ESC . @ command.

ESC . M [<DEC> ; <ASC> ; <ASC> ; <ASC> ; <ASC>] : Page 46

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Set Output Mode

Sets output mode according to the following parameters

<DEC>	Turnaround delay.
<ASC>	Output trigger character.
<ASC>	Echo terminator character.
<ASC> <ASC>	1 to 2 output terminators.

ESC . N [(<DEC>) ; (<ASC>) . . . (<ASC>)] :

Page 52

Set Extended Output and Handshake Mode

Establishes extended parameters for any output command where:

<DEC>	Delay between output characters.
<ASC> . . . <ASC>	Immediate response string of 1 to 10 characters.

ESC . O

Page 68

Output Extended Status

Displays the status of the 7220T paper advance option by returning a 4-bit status byte. If executed on a 7220C, the status indicates that the paper advance option is off (not present).

ESC . N [<DEC> ; <ASC> . . . <ASC>] :

Page 52

Set Extended Output and Handshake Mode

Establishes extended parameters for any output command where:

<DEC>	Delay between output characters.
<ASC> . . . <ASC>	Immediate response string of 1 to 10 characters.

ESC . O

Page 68

Output Extended Status

Displays the status of the 7220T paper advance option by returning a 4-bit status byte. If executed on a 7220C, the status indicates that the paper advance option is off (not present).

ASCII Character Codes

Binary is often used as a code to represent not only numbers, but also alphanumeric characters such as "A" or "," or "?" or "x" or "2." One of the most common binary codes used is ASCII[1]. ASCII is an eight-bit code, containing seven data bits and one parity bit. The plotter uses ASCII for most I/O operations. The parity bit is ignored by the plotter. For example:

Character	ASCII Binary Code	ASCII Decimal Code
A	01000001	65
B	01000010	66
?	00111111	63

A complete list of ASCII characters and their decimal representation is given next.

APPX

[1] American Standard Code for Information Interchange.

Plotter ASCII Code Definitions

Decimal Code	ASCII Character	7220 Function/Character Set				
		Set 0	Set 1	Set 2	Set 3	Set 4
0	NULL	No Operation (NOP)				
1	SOH	NOP				
2	STX	NOP				
3	ETX	Default End Label Instruction				
4	ETO	NOP				
5	ENQ	NOP				
6	ACK	NOP				
7	BEL	NOP				
8	BS	Backspace				
9	HT	NOP				
10	LF	Line Feed				
11	VT	Inverse Line Feed				
12	FF	NOP				
13	CR	Carriage Return				
14	SO	Select Alternate Character Set				
15	SI	Select Standard Character Set				
16	DLE	NOP				
17	DC1	NOP				
18	DC2	NOP				
19	DC3	NOP				
20	DC4	NOP				
21	NAK	NOP				
22	SYN	NOP				
23	ETB	NOP				
24	CAN	NOP				
25	EM	NOP				
26	SUB	NOP				
27	ESC	NOP				
28	FS	NOP				
29	GS	NOP				
30	RS	NOP				
31	US	NOP				
32	SP	Space				
33	!	!	!	!	!	¡
34	"	"	"	"	"	"
35	#	#	#	£	£	¿
36	$	$	$	$	$	$
37	%	%	%	%	%	%
38	&	&	&	&	&	&
39	'	'	'	'	'	'
40	(	(	(	(	(	(
41	)	)	)	)	)	)
42	*	*	*	*	*	*
43	+	+	+	+	+	+
44	,	,	,	,	,	,

NOTE: Plotter will perform an automatic backspace before drawing any of the shaded symbols.

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Plotter ASCII Code Definitions (Continued)

Decimal Code	ASCII Character	7220 Function/Character Set				
		Set 0	Set 1	Set 2	Set 3	Set 4
45	—	–	–	–	–	–
46	.	.	.	.	.	.
47	/	/	/	/	/	/
48	0	0	0	0	0	0
49	1	1	1	1	1	1
50	2	2	2	2	2	2
51	3	3	3	3	3	3
52	4	4	4	4	4	4
53	5	5	5	5	5	5
54	6	6	6	6	6	6
55	7	7	7	7	7	7
56	8	8	8	8	8	8
57	9	9	9	9	9	9
58	:	:	:	:	:	:
59	;	;	;	;	;	;
60	<	<	<	<	<	<
61	=	=	=	=	=	=
62	>	>	>	>	>	>
63	?	?	?	?	?	?
64	@	@	@	@	@	@
65	A	A	A	A	A	A
66	B	B	B	B	B	B
67	C	C	C	C	C	C
68	D	D	D	D	D	D
69	E	E	E	E	E	E
70	F	F	F	F	F	F
71	G	G	G	G	G	G
72	H	H	H	H	H	H
73	I	I	I	I	I	I
74	J	J	J	J	J	J
75	K	K	K	K	K	K
76	L	L	L	L	L	L
77	M	M	M	M	M	M
78	N	N	N	N	N	N
79	O	O	O	O	O	O
80	P	P	P	P	P	P
81	Q	Q	Q	Q	Q	Q
82	R	R	R	R	R	R
83	S	S	S	S	S	S
84	T	T	T	T	T	T
85	U	U	U	U	U	U
86	V	V	V	V	V	V
87	W	W	W	W	W	W
88	X	X	X	X	X	X
89	Y	Y	Y	Y	Y	Y

Plotter ASCII Code Definitions (Continued)

Decimal Code	ASCII Character	7220 Function/Character Set				
		Set 0	Set 1	Set 2	Set 3	Set 4
90	Z	Z	Z	Z	Z	Z
91	[	[	[	[	Ø	[
92	\	\	√	Ç	Æ	¡
93	]	]	]	]	ø	]
94		^	↑		æ	^
95	_	_				
96		`			`	`
97	a	a	a	a	a	a
98	b	b	b	b	b	b
99	c	c	c	c	c	c
100	d	d	d	d	d	d
101	e	e	e	e	e	e
102	f	f	f	f	f	f
103	g	g	g	g	g	g
104	h	h	h	h	h	h
105	i	i	i	i	i	i
106	j	j	j	j	j	j
107	k	k	k	k	k	k
108	l	l	l	l	l	l
109	m	m	m	m	m	m
110	n	n	n	n	n	n
111	o	o	o	o	o	o
112	p	p	p	p	p	p
113	q	q	q	q	q	q
114	r	r	r	r	r	r
115	s	s	s	s	s	s
116	t	t	t	t	t	t
117	u	u	u	u	u	u
118	v	v	v	v	v	v
119	w	w	w	w	w	w
120	x	x	x	x	x	x
121	y	y	y	y	y	y
122	z	z	z	z	z	z
123		{	╥			
124		|	⊢			
125		}	→			
126	~	~		'		
127	DEL	NOP				

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