

DIGIGRAPHIC

**MAN ↔ MACHINE**

SYSTEMS

**DIGIGRAPHIC SYSTEM 270  
FUNCTION CONTROL PROGRAM  
SPECIFICATIONS**

**CONTROL DATA**

CORPORATION

270-FCP32-465-7

DIGIGRAPHIC SYSTEM 270  
FUNCTION CONTROL PROGRAM  
SPECIFICATIONS

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CONTROL DATA CORPORATION  
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## 1.0 Introduction

This Specification defines the Function Control Program (FCP) which is the primary programming component of the Digigraphic System.

### 1.1 Scope

The Function Control Program as defined herein implements a single Display Console capability and is applicable to the hardware configuration as delineated in the Digigraphic System Description, a preliminary information manual issued June 15, 1964. FCP as defined by these specifications will be implemented on the first operational model of the Digigraphic System (illustrated in figure 1-1) being installed at the Control Data Digigraphic Laboratories, Burlington, Massachusetts.

### 1.2 Applicable Documents

The following documents form a part of this specification as appropriate. In the event of conflicting provisions, the provisions of this specification shall prevail.

Control Data Corporation  
Digigraphic System Description  
Preliminary Information Manual

Control Data Corporation  
3200 Computer System  
Preliminary Reference Manual

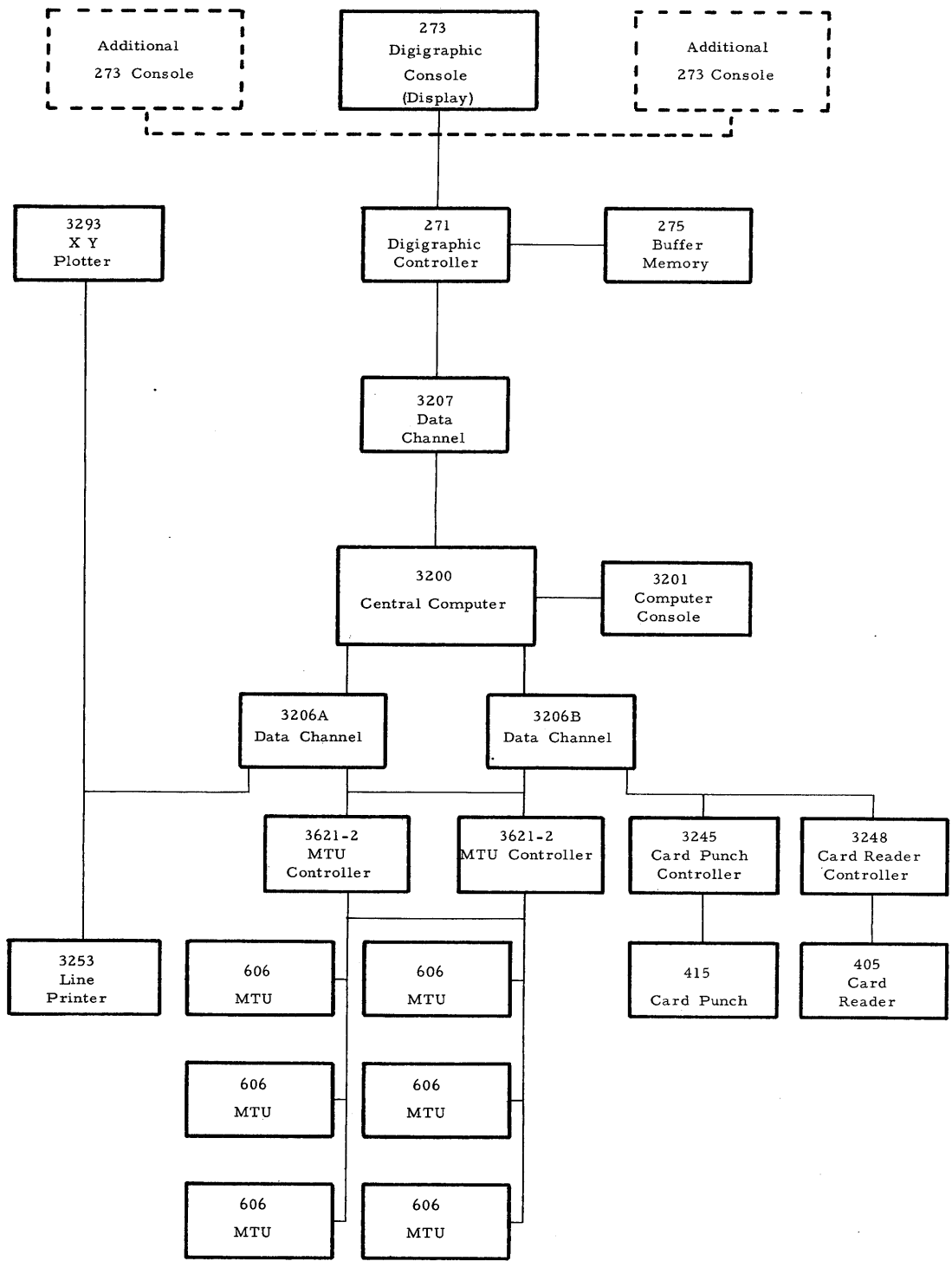
Control Data Corporation  
3200 Computer System  
System Information Manual

Control Data Corporation  
3200 Computer System  
SCOPE/COMPASS Reference Manual

Control Data Corporation  
3200 Computer System  
FORTAN/Reference Manual

### 1.3 System Requirements

The Function Control Program provides the principal framework for Digigraphic System Operation. Direct and efficient communication of



Typical Digigraphic System \*

Figure 1-1

\*Configuration at Digigraphic Laboratories, Burlington, Mass.

graphic data between man and machine is implemented by this program through:

- a. User-oriented, program interpreted controls.
- b. User-created and FCP generated on-line/off-line displays.
- c. Direct manipulation of such displays through Light Pen and Keyboard action.

1.3.1 FCP Functions. The program modules comprising FCP are designed to allow application processing during passive viewing of the console display or during operator response intervals. The specific functions performed by FCP are as follows:

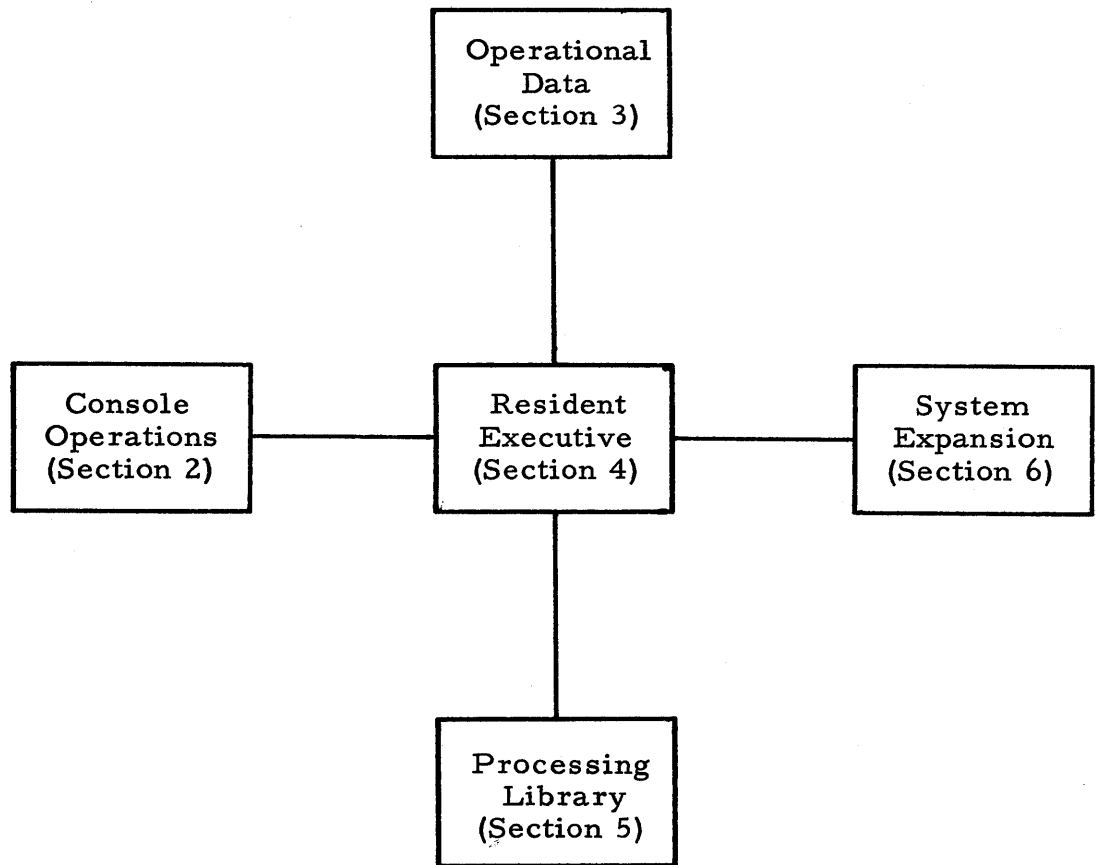
- a. Execution of FCP routines and application programs on a time-shared basis.
- b. Processing of data for generation of off-line steady-state displays.
- c. Processing of Keyboard and Light-Pen operations, including Light Pen actuated Light-Buttons.
- d. Generation of specified graphic forms as a result of console action and/or computer input.
- e. Logical linking of graphic information under operator control.
- f. Simulation of specific operator action through the FCP Application Interface.
- g. User adaptation and redefinition of system controls through the FCP Application Interface.

1.3.2 Off-line Console Status. To implement the specified design criteria, FCP removes the Display Console from active (on-line) status upon completion of operator or application initiated graphic operations. As a result, the Display Console is completely off-line during the following states:

- a. Console Inactive - occurs prior to System initialization or following a "sign-off" by the operator. In this state there is no display.
- b. Output Display (Steady State) - occurs after specific graphic data has been processed for display. In this state, the stored data is continually displayed off-line until the console operator initiates a new action.
- c. Pending Light-Pen or Keyboard Interrupt - occurs during intervals between external interrupts. The console remains off-line until an interrupt occurs and upon completion of interrupt processing automatically reverts to off-line status. Procedurally, all required parameters are progressively defined before a function is initiated.

#### 1.4 System Programming Organization

FCP operates as an unstacked job under control of SCOPE-32. Minor modifications are made to SCOPE-32 by FCP at load time. Under SCOPE-32 control, the normal Control Data I/O procedures apply. FCP is read from the SCOPE-32 Library tape by a specialized loading routine. Execution control is then transferred to the Resident Executive. From this point on, FCP is executed as a function-defined sequence of programs extracted from the modular system library. The Function Control Program is organized as shown in figure 1-2. This figure depicts the Resident Executive as the control center of the Digigraphic Programming system. The Console Operations described in section 2 result in programming calls for developing and acting upon the operational data described in section 3. The Resident Executive, section 4, performs both Computer System and Digigraphic System executive functions and provides system time-sharing control. Functional routines are called from the Processing Library, section 5, as a result of specific console operations, or by the FCP Application Interface as defined in section 6.



Function Control Program Organization

Figure 1-2



## 2.0 Console Operations

Console Operations include the steps necessary to activate the system, perform graphic operations, and terminate system activity upon completion of specific assignments. All pertinent system controls are physically located on the Display Console.

### 2.1 Operational Steps.

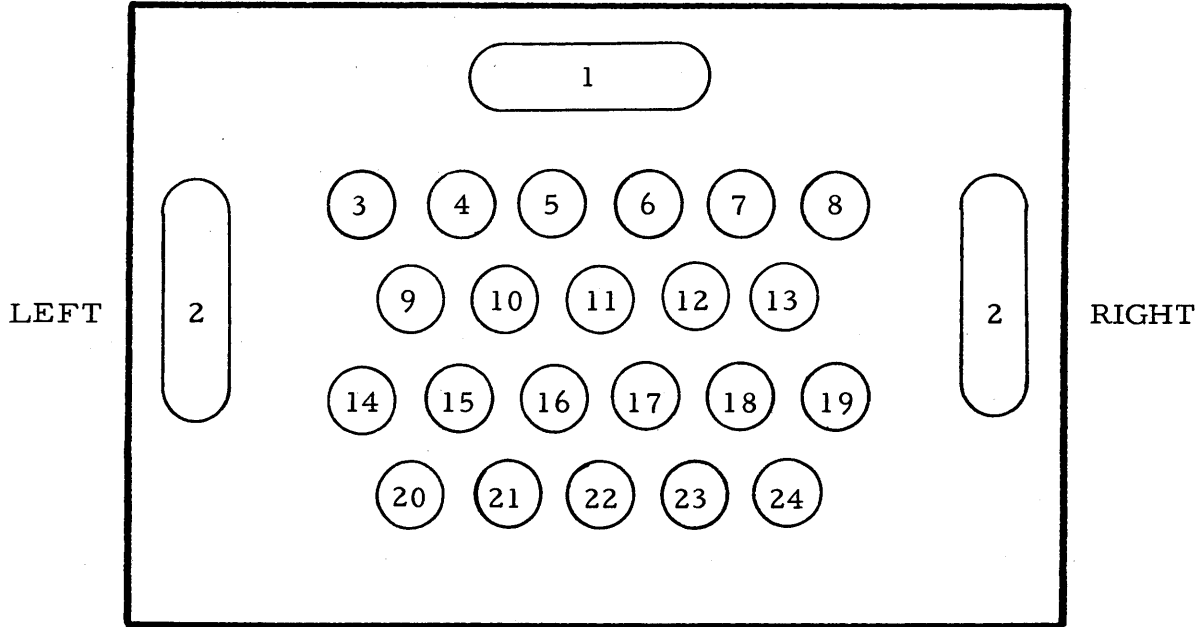
Console operations are summarized by the following procedural steps:

- a. System initialization. Load system including FCP. This step enables only the Sign-On function. There is no display.
- b. Sign-On. This step is initiated by pressing the ACCEPT button. A display track is assigned to the console and all Keyboard and Light Button controls are assigned and enabled. The Frame, Light Buttons and Registers are displayed. At this point installation defined accounting procedures can be executed.
- c. General Digigraphic Operations. For specific details refer to functions described in sections 2.2, 2.3, and 2.4.
- d. Sign-Off. Activate Sign-Off (SO) Light Button to transfer control to a termination routine and revert to the system initialization state with only the Sign-On function enabled and with no display. At this point installation - defined accounting procedures can be executed.

### 2.2 FCP specified Keyboard assignment.

The Keyboard button functions enabled by FCP are defined below. The related numerical assignment and unique identifying character are given following each button name. Numerical assignment and the related physical position of each button is shown in figure 2-1. With the exception of Keyboard button #22, the functions associated with each button are freely reassignable under program control.

TOP



Keyboard Button Number Assignment

Figure 2-1



2.2.1 OVERRIDE (O) (#15) Secondary Constraint button used with one of the following buttons:

ACCEPT  
REJECT  
BASE  
NORMAL  
CENTER  
GRAPHIC ENTITY  
CLEAR PICK

See the description of these buttons for use.

2.2.2 ACCEPT (A) (#2) - Pressing this button causes the last graphic created and its associated display to be stored as operational data. All unlocked picks in the Pick Table are cleared. If the OVERRIDE button is pressed along with the ACCEPT button, the entire Pick Table is also cleared.

2.2.3 REJECT (R) (#1) - Pressing this button erases both the graphic being created and the resultant temporary display. REJECT also clears all unlocked picks from the Pick Table. If the OVERRIDE button is pressed along with the REJECT button, the graphic being created, the resultant temporary display, and the entire Pick Table will be cleared.

2.2.4 ERASE (E) (#13) - Pressing this button causes the graphic under Light Pen surveillance to be non-displayed. This graphic is removed from the operational data upon pressing the ACCEPT button. Pressing the REJECT button will cause the graphic to be redisplayed.

2.2.5 GRAPHIC ENTITY (G) (#18) - During a "Pick", pressing this button causes FCP to identify a graphic as the picked element. While "Tracking", pressing this button causes FCP to generate a line entity. If the OVERRIDE button is pressed while the GRAPHIC ENTITY button is held down, FCP will monitor Light Pen movement at a program defined sample rate and accumulate a series of points. These points are then used to generate a series

of polystring entities which when displayed correspond to free-hand movement of the Light Pen.

2.2.6 POINT (P) (#19) - Pressing this button causes FCP to create and save a set of point coordinates for use in subsequent graphic construction. These coordinates are obtained from the X, Y registers or derived from the current Light Pen position.

2.2.7 CENTER (C) (#16) - Pressing this button defines a picked point as a center-point. When used with the GRAPHIC ENTITY button the CENTER button defines the picked line as a center-line. When used during tracking, this button defines a circle-drawing mode of operation where the center point is derived from the first Light Pen position, and the radial point from the second. Pressing OVERRIDE while holding the CENTER button causes inversion of these point definitions.

2.2.8 BASE (B) (#17) - Pressing this button constrains line construction through Light Pen tracking to a preset angle. Pressing OVERRIDE and BASE constrains such line construction to horizontal only.

2.2.9 NORMAL (N) (#12) - Pressing this button constrains line construction through tracking, perpendicular to a preset angle. Pressing OVERRIDE and NORMAL constrains such line construction to vertical only.

2.2.10 TRANSFORM (T) (#10) - Pressing this button causes a positional modification of a graphic according to preset conditions.

2.2.11 TRANSFORM A COPY (TC) (#9) - Pressing this button generates a modified copy of a graphic based on preset conditions.

2.2.12 LIGHT PEN (LP) (#22) - This button is wired in parallel with the switch on the Light Pen. Pressing this button causes FCP to initiate a search to identify the graphic which is under Light Pen surveillance.

2.2.13 LOCK (L) (#14) - Pressing this button causes the graphic under the surveillance of the Light Pen to be locked in the Pick Table.

2.2.14 END POINT (EP) (#24) - Pressing this button with the Light Pen enabled and positioned on the light from a straight line or a circular arc, causes the coordinates of the end point of the line or arc closest to the Light Pen to be placed in the Pick Table.

2.2.15 CLEAR PICK (CP) (#8) - Pressing this button clears the Pick Table of all unlocked picks. When this button is pressed in conjunction with the OVERRIDE button, all picks, locked and unlocked are cleared from the Pick Table.

2.2.16 Undefined Buttons - Undefined buttons are subject to definition through the application interface.

### 2.3 FCP-Defined Control Surface

The Control Surface functions displayed by FCP are defined below. Six sets of alphabetic symbol combinations are displayed on the lower Control Surface with each set forming a Primary Light Button. When a Primary Light Button is picked, a specified set of alphanumeric symbols is displayed which identify the Secondary Light Buttons designated by the Primary picked.

2.3.1 Frame and Permanent Tracking Cross. An 11 x 17 inch rectangle forms the initial frame. This frame bounds the Working Surface and forms the Control Surface segments on the CRT. A permanent Tracking Cross is displayed with the frame and functionally is on the Working Surface.

2.3.2 Graphic Form (GF). Picking this Light Button signals FCP to construct a specific graphic form. The designated Secondaries include:

- a. Dot (DE)
- b. Line (LE)
- c. Circle (CE)
- d. Circular Arc (CA)
- e. Polystring (PE)

2.3.3 Point/Line Classification (PL). This Light Button family serves to specify for construction purposes additional information concerning a point or a line. At present one secondary is implemented, namely: Center (CP).

2.3.4 Group Control (GC). The Group Control Light Button implements two distinct sets of Secondaries: the first set allows creation, modification, and elimination of groups; and the second serves to define group level. The first set of Secondaries include:

- a. Collect (CG)
- b. Remove (RG)
- c. Add (AG)
- d. Break (BG)

The levels defined by the second set include:

- a. One level above current level (1G)
- b. Two levels above current level (2G)
- c. Four levels above current level (4G)
- d. Highest group level (TG)

2.3.5 Utility Control (UC). A variety of control functions are implemented by this Primary. These include:

- a. Redisplay (RD)
- b. Non-display (ND)
- c. Call Application Program (AP)
- d. Terminate Application (TA)
- e. Sign-off (SO)

2.3.6 Drawing Control (DC). This Light Button family controls storage and retrieval of complete drawings. The Secondaries implemented by this Primary include:

- a. Identify (ID)
- b. Store (ST)
- c. Select (SE)

2.3.7 Alphanumeric Control (AC). This Primary Light Button implements a set of controls concerned with development of alphanumeric data. These Secondaries include:

- a. Label (LA)
- b. Note (NT)
- c. Text (TX)
- d. Value (VL)

2.3.8 Line Control. Four line-type segments are continuously displayed on the lower Control Surface. The line types displayed include:

- a. Solid —————
- b. Hidden - - - - -
- c. Center — — —
- d. Phantom — — —

2.3.9 Zoom Control. The lower Control Surface contains two Light Buttons for controlling framed area magnification, these include:

- a. Double (DP)
- b. Halve (HP)

2.3.10 Light Registers. FCP implements 11-Light Registers which provide for operator input of data and for output of program initiated responses. These registers are:

- a. The Assembly Register (operator input) having a capacity of 24-BCD characters.
  - b. Message Register (program response) having a capacity of 24-BCD characters.
  - c. X and Y Coordinate Registers
  - d. Length Register
  - e. Angle Register
  - f. Two Save Registers each having a capacity of 12-BCD characters.
  - g. Category Field Register having a maximum capacity of four octal digits.
- } each having a 16-character capacity (sign, decimal point, a 10-digit floating point value field, and a sign and three digit exponent field.)

- h. Reference Field Register having a maximum capacity of eight octal digits.
- i. Zoom Index Register having a maximum capacity of two-digits. Only the values from -22 through +11 are interpreted.

## 2.4 Light Pen Operation

The following operations are performed in conjunction with the Keyboard and Light Button controls.

2.4.1 Picking. Picking is that function performed by FCP which identifies specific graphics or points on these graphics through interpretation of light seen by the Light Pen. All graphic data is accompanied by identifying information when written in Buffer Memory. When a Light Pen strike interrupt occurs, the identifying data associated with the graphic seen by the Light Pen is read into core memory. This data is used by FCP to identify the display seen by the Light Pen.

2.4.2 Light Pen Tracking. Tracking is that FCP function which maintains cognizance of the position of the Light Pen as it moves across the Console CRT screen. The Tracking routine is initiated by identifying either the permanent tracking cross which is part of the frame display or the tracking cross which has just been used. Light Pen tracking is used to establish new points on the Working Surface for either free-hand drawing or subsequent graphic construction.

### 3.0 Operational Data

The Function Control Program processes four major classes of data with each defined uniquely as to tabular format and data content. These four operational tables are referred to as the Digigraphic List, the Pick Table, the Processing Sequence Table, and the Byte List.

#### 3.1 Digigraphic List

The Digigraphic List (DL) is an ordered and centralized tabular output of FCP which defines the full extent of data created and processed by FCP.

3.1.1 Digigraphic Data Structure. The Function Control Program defines graphic data in terms of a program controlled coordinate system referred to as the Construction Grid, and presents this data in terms of a coordinate system referred to as the Display Grid. This grid has complete facility for both magnification in powers of two and freedom of movement over the Construction Grid.

3.1.1.1 Graphic Development. The Construction Grid coordinate system has  $2^{23} - 1$  points on both X and Y axes. All graphics are developed by FCP as planar forms on this grid.

3.1.1.2 Graphic Presentation. The Display Grid consists of a square with  $2^{12} - 1$  points on a side. (For the initial hardware design, only the ten high order bits will cause discernable beam changes). This square circumscribes the console CRT screen. Graphics are displayed by assigning a specific relationship between a Construction Grid unit and a Display Grid unit. This relationship is referred to as the Zoom Index. This relationship affects only the size and level of detail of displayed graphics and does not in any way affect the mathematical descriptions of graphics. Operationally, a viewing window is formed on the Display Grid by specific frame parameters. The area within the window is defined as the Working Surface. The remainder of the CRT screen forms the Control Surface.

3.1.1.3 Non-Graphic Relationship. The Function Control Program allows three independent modes of graphic linkage. These are grouping, category and reference data. Grouping is defined as a set of hierarchical relationships for purposes of collective reference. Category and reference data serve to define other relationships independent of group structure.

3.1.2 Digigraphic List Addressing. The smallest addressable information unit within the DL is the Entity. An entity is defined as a variable length block containing a range of data specified by the entity type. The DL is stored in Buffer Memory as a series of addressable data blocks called Pages. Entities are contained on pages along with directories which maintain internal page addressing. This technique allows maximum use of page storage. An entity is referred to by its DL address (page directory address) which remains inviolate until the specific entity is removed.

3.1.3 Digigraphic List Structure. The Digigraphic List is made up of two distinct sections: The Preamble and the General List. The Preamble exists with the DL when the list is stored on tape. The purpose of the Preamble is to contain that information necessary for subsequent system set-up and operation. The General List contains the total pages constituting a specific Working DL.

3.1.4 Entity Record. There are five general classes of entities: Control Surface, Alphanumeric, Graphic, Linkage, and Application. Each class of entity is comprised of a discrete number of entity types, each uniquely defined by a key field type code. This code consists of two octal digits. A second code consisting of two octal digits is used to modify the type code, when applicable.

3.1.4.1 Control Surface Entity Class. There are four defined Control Surface entity types, namely the Tracking Cross entity, the Frame entity, the Register entity, and Light Button Control entity.



3.1.4.2 Alphanumeric Entity Class. There is one Alphanumeric entity type in this class.

3.1.4.3 Graphic Entity Class. There are five defined entity types within this class, namely: Dot, Line, Circle, Circular Arc, and Polystring.

3.1.4.4 Linkage Entity Class. The one defined entity type in this class is Group.

3.1.4.5 Application Entity Class. There are 448 unique entity key fields available in this class. Specific application programs may assign these codes as required.

3.1.5 General Entity Format. All entities contain a common prolog, referred to as the Descriptor. The remaining data is unique to the specific entity type.

3.1.5.1 Descriptor. The descriptor contains four basic fields: the Key field, the Category Field, the Reference Field, and the Parental Pointer Field.

3.1.5.1.1 Key Field. This twelve bit field, occupying the high order bits of the first entity word, heads all entity types. The first six bits, the type code, define the entity type headed and the second six bits, contain related modifying data.

3.1.5.1.2 Category Field. The Category Field occupies the last six-bits of the first word of all entity types. The remaining six bits of this first word can be used for Category Field expansion. However, FCP reserves the right to preempt these bits starting at the high order bit.

3.1.5.1.3 Reference Field. The Reference Field is a 24-bit field which occupies the second word of all entities. At present, this field is available only for application program use.

3.1.5.1.4 Parental Pointer Field. This 24-bit field is the third word of all entities. Zeros in this field indicate that the pertinent entity is not currently grouped. When the pertinent entity is grouped, this field contains the DL address of its parent.

3.1.5.2 Data Field. This field is "n" computer words long where "n" is defined by the specific entity type.

3.1.6 Specific Entity Types. Figure 3-1 summarizes all entity Key Field and Category Field formats and defines all related type codes. The format of each specific entity type follows.

3.1.6.1 Frame Entity Format.

- Word 1. Key Field and Category Field
2. Reference Field
  3. Parental Pointer
  4. Display Grid  $X_c$
  5. Display Grid  $Y_c$
  6. Display Grid  $\Delta X$
  7. Display Grid  $\Delta Y$
  8. Construction Grid  $X_c$
  9. Construction Grid  $Y_c$

NOTE: This entity is not used directly to generate the primary frame or to scissor the graphic elements of the Digigraphic List.

3.1.6.2 Primary Light Button Entity Format

- Word 1. Key Field and Category Field
2. Reference Field
  3. Parental Pointer
  4. BCD Mnemonics (Right Justify)
  5. Display Grid X and Y Coordinates
  6. Construction Grid X Coordinate
  7. Construction Grid Y Coordinate
  8. Number of Secondary Light Buttons and Vertical Display Order

DL Control Word

Key Field													Category Field										
Type Code						Modifier						Category Field											
23	22	21	20	19	18	17	16	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
00 Reserved																	C O N T R O L						
01 Frame						Frame Definition						Category											
03 Register						Construction Control Grid Control Display Grid Control 0=Null 1=Integer 2=Flt. Pt. 3=BCD						Category											
04 Primary Light Button												Category											
05 Secondary Light Button												Category											
06 Unassigned																							
07 Unassigned																							
10 Alphanumeric						Usage Code 00 Text Bits 01 LBL 13-12 10 VLU 11 Note						Category					G R A P H I C						
11 Dot						Line Pattern						Category											
12 } Unassigned						Style Wt.																	
13 Line						15-14 13-12																	
14 Circle						00 Solid 00																	
15 Circular Arc						01 Hdn.																	
16 Thru' Unassigned						10 Cent																	
17 Unassigned						11 Phan																	
22 Polystring																							
23 Unassigned																							
24 Thru' Unassigned 67																							
70 Group						No. of Entities						Category					NON- GRAPHIC (nondisplay- able)						
71 thru' 77 Application Entities												Category											

DL Control Word Summary

Figure 3-1

9. DL Address of First Secondary Light Button or Transfer Code and Transfer Address if No Secondary

.  
. .  
.

n. DL Address of Last Secondary

### 3.1.6.3 Secondary Light Button Format

- Word 1. Key Field and Category Field
2. Reference Field
  3. Parental Pointer
  4. BCD Mnemonics (Left Justify)
  5. Display Grid X and Y Coordinates
  6. Construction Grid X Coordinate
  7. Construction Grid Y Coordinate
  8. Transfer Code and Address

### 3.1.6.4 Register Entity Format

- Word 1. Key Field and Category Field
2. Reference Field
  3. Parental Pointer
  4. Construction Grid X
  5. Construction Grid Y
  6. Register Mnemonic
  7. Display Grid Coordinates X and Y
  8. Zoom Index

	Floating Point Register	Integer Register	BCD Register
9.	Units	Units	BCD Data
10.	FP value	Integer value	BCD Data
11.	FP value		BCD
.			.
.			.
.			.
n.			n ( $n \leq 21$ )

### 3.1.6.5 Alphanumeric Entity Format.

Word 1. Key Field and Category Field

2. Reference Field

3. Parental Pointer

4.  $X_o$  } starting coordinates for first character  
 5.  $Y_o$  }

6. Zoom Index at time of entry (in character 0 position)

7. BCD list (1) 4-BCD characters per word

.

.

n. BCD list (n) where  $n \leq 49$

### 3.1.6.6 Dot Entity Format.

Word 1. Key Field and Category Field

2. Reference Field

3. Parental Pointer

4.  $X_o$  } Construction Grid coordinates of Dot position  
 5.  $Y_o$  }

3.1.6.7 Line Entity.

Word 1. Key Field and Category Field

2. Reference Field

3. Parental Pointer

4. Xo

5. Yo

6. X1

7. Y1

} Construction Grid coordinates of end points

3.1.6.8 Circle Entity Format.

Word 1. Key Field and Category Field

2. Reference Field

3. Parental Pointer

4. Xo

5. Yo

6. Radius (magnitude)

} Construction Grid coordinates of center point

3.1.6.9 Circular Arc Entity Format.

Word 1. Key Field

2. Reference Field

3. Parental Pointer

4. Xo

5. Yo

6. Radius (magnitude)

7. X1

8. Y1

9. X2

10. Y2

} Construction Grid Coordinates of center point

} Construction Grid Coordinates of end points

3.1.6.10 Group Entity Format.

Word 1. Key Field and Category Field

2. Reference Field

4.  
 .  
 .  
 n. } DL addresses of Group members  
 (n ≤ 49)

### 3.1.6.11 Application Entity Format.

- Word 1. Key Field and Category Field  
 2. Reference Field  
 3. Parental Pointer

The remaining words in this entity are subject to definition by the specific application program and are in no way interpreted by FCP.

## 3.2 Pick Table

The function of the Pick Table is to store references to specific parameters selected for subsequent graphic construction or processing by either FCP or application programs. Ninety-words of resident memory are allocated for Pick Table use in this system.

3.2.1 Pick Table Format. Each Pick Table entry (see figure 3-2) consists of up to three information fields: the Descriptor Field, the Address Field, and the Data Field.

3.2.1.1 Descriptor Field. The Descriptor Field is 24-bits in length and contains Entity Type Code, Point-Line Control Code, Register Identification Code, Picked-Type Code, and a lock/unlock bit. The specific bit assignment presently implemented for each code is shown in figure 3-2.

3.2.1.2 Address Field. The Address Field is 24-bits in length and contains the DL address of the pertinent picked entity. All zeros in this field indicates a tracking cross entry.

3.2.1.3 Data Field. The Data Field is 48-bits in length and is included only in point entries. When included, this field contains the X and Y Construction Grid coordinates of the point picked.

3.2.2 Specific Entry Formats. The Function Control Program produces four types of Pick Table entries, namely the Point entry, the Graphic entry, the Group entry, and the Register entry. All Pick Table entries with the exception of the Point entry are two computer words in length and made up of a Descriptor Field and a DL address. As previously indicated, each Point entry contains the additional two-word Data Field which defines Construction Grid Point Coordinates. Pick Table entry formats along with Descriptor Field code definitions are specified in detail in figure 3-2.

### 3.3 Processing Sequence Table

The function of the Processing Sequence Table (PST) is to store for processing reference those pertinent control parameters necessary for execution of FCP and application programs. Primary input to PST is provided by the Demand Monitor Routines and is processed on a priority basis. Working FCP library routines provide secondary inputs in the form of control sequences for subsequent library processing.

3.3.1 Parameters. Parameters stored in PST are in three forms: light control parameters, Keyboard control parameters, and application control parameters. These parameters can be primary or secondary.

3.3.1.1 Light Control Parameters. Light control parameters govern two operations: Light Pen tracking, and use of Light Buttons. Processing order of light control parameters is tracking first and Light Buttons second.

3.3.1.2 Keyboard Control Parameters. Keyboard control parameters serve to indicate both change in Keyboard status and specify that a call is to be made for a selected Keyboard routine. In the latter case, specific buttons are locked out until execution of the current call is completed.

3.3.1.3 Application Control Parameters. These parameters serve to specify that the current call is from an application program.



3.3.2 Structure. Each PST parameter entry contains, in addition to the required parameters, the Buffer Memory address of the routine, the entry address after loading, and related activity control information.

#### 3.4 Byte List

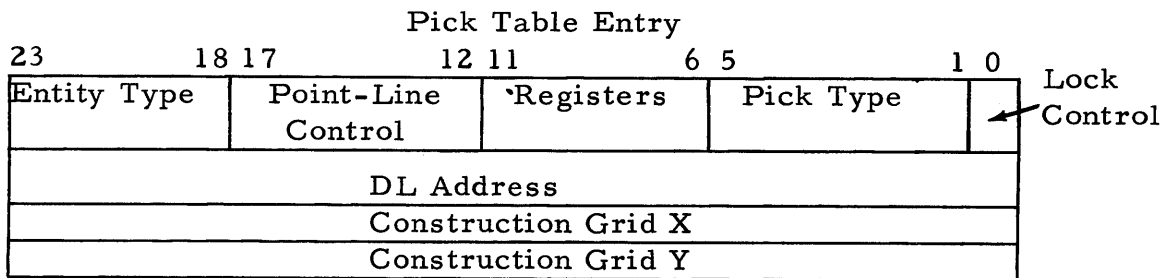
A normal off-line display is generated by a stream of 12-bit bytes previously written on a selected portion of Buffer Memory. As a prior step to generation of an off-line display this byte stream is temporarily core-displayed directly from the Byte List. Upon operator acceptance of the display, this byte stream is merged with the related full display in Buffer Memory. Digigraphic Byte functions and formats are specified in the Digigraphic System Description, a preliminary information manual (see Applicable Documents, section 1.2).

### Pick Descriptor Codes Presently Defined

<p>Entity Type (Same as Type Code in DL Control Word)</p> <p>Point-Line Controls</p> <p style="padding-left: 20px;">00 Null</p> <p style="padding-left: 20px;">01 Center</p>	<p>Pick Type</p> <p>00 Null</p> <p>01 Point</p> <p>02 Point on entity</p> <p>03 Entity</p> <p>04 Group</p> <p>05 Register</p> <p>Lock Control</p> <p style="padding-left: 20px;">0 Unlocked</p> <p style="padding-left: 20px;">1 Locked</p>
--	---

Registers

- 2 Input
- 3 Save 1
- 4 Save 2
- 5 Angle
- 6 Length
- 7 Y-Value
- 8 X-Value
- 9 Category Field
- 10 Reference Field



Pick Descriptor

Figure 3-2

## 4.0 FCP Resident Executive

The FCP Resident Executive provides primary control of all system program functions. The Resident Executive occupies approximately 1850 words of high addressed main memory in conjunction with approximately 1700 words of lower memory reserved for the System Monitor. Approximately 1800 words adjacent to the System Monitor are reserved for COMMON information. These three areas control execution of the Digigraphic programming system.

### 4.1 System Monitor

The System Monitor is basically the standard SCOPE-32 Monitor with minor modifications to permit operation with FCP. With the System Monitor, complete compatibility is maintained with standard 3200 programming systems.

4.1.1 SCOPE-32. Through SCOPE-32, FCP has available the complete range of hardware manipulative routines.

4.1.2 SCOPE Modifications. Presently two minor modifications are known. These are as follows: core limits for loading programs are decreased to provide a larger resident area, and the SCOPE Abnormal Program Termination Control is modified to permit continuous FCP operation.

4.1.3 I/O Drivers. Specialized I/O drivers operating under SCOPE CIO will be made available for those devices unique to the Digigraphic System and which are not otherwise obtainable from Control Data Corporation.

### 4.2 I/O Control

The I/O Control section of the Resident Executive is an ordered collection of I/O routines which because of timing requirements, cannot operate under normal SCOPE CIO control. Operationally these routines perform two overall functions: configuration control, and control of unique I/O equipment.

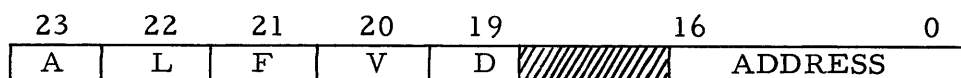
4.2.1 Configuration Control. Configuration control involves two specific areas: overall system configuration and specific display console configuration.

4.2.1.1 System Configuration. System configuration control data provides FCP with the specified logical hardware assignments for unique I/O equipment.

4.2.1.2 Console Configuration. Console configuration control data provides FCP with the specified logical-hardware assignment parameters and data for definition of the console operating environment.

4.2.1.3 Digigraphic Keyboard Configuration. The use of the Digigraphic Keyboard and its associated functions are controlled by three Keyboard control tables: the Keyboard Assignment Table (KAT), the FCP Function Table (FCPFUNCT), and the Verb Table (KYVERB).

4.2.1.3.1 The Keyboard Assignment Table (KAT). This table is a 24 word array in resident COMMON corresponding to the numbered Keyboard buttons (see figure 2-1), in which one word is assigned for each button. Each word of the array has the following format:



- A = 0 entry unassigned
- = 1 entry assigned and must be defined
  
- L = 0 entry active if assigned
- = 1 entry locked out
  
- F = 1 FCP defined
- = 0 application defined
  
- V = 0 verb control
- = 1 modifier control
  
- D = 0 button released
- = 1 button pressed

The address field of each entry relates to the functional table currently associated with that button.

4.2.1.3.2 FCP Function Table (FCPFUNCT). When a button has been defined as an FCP modifier, the address field is a 17-bit address of a character in resident COMMON memory. The low order bit of the character will be set to "1" whenever the button is pressed, and reset to "0" when the button is released. (Note: The other 5 bits of the character will not be disturbed). The Function Table is a 24-character table where only the first nine words are used by FCP. These assignments are defined below:

FCPFUNCT (1, 1)	=	LIGHT PEN SWITCH
FCPFUNCT (1, 2)	=	POINT
FCPFUNCT (1, 3)	=	GRAPHIC FORM
FCPFUNCT (1, 4)	=	LOCK
FCPFUNCT (1, 5)	=	END POINT
FCPFUNCT (1, 6)	=	CENTER
FCPFUNCT (1, 7)	=	BASE
FCPFUNCT (1, 8)	=	NORMAL
FCPFUNCT (1, 9)	=	OVER-RIDE

(Note: The remainder of this table is for application use. FCP may preempt these characters positions, however, FCP will use these positions only in ascending order.)

4.2.1.3.3 Verb Table (KYVERB). When a button has been defined as an FCP verb, the address field is the 15-bit address of a two word table entry which contains the overlay information for the verb. This overlay information will be fed directly to the Sequence Processor. For FCP, the verb parameters are stored in this table and functionally organized as follows:

KYVERB1	=	REJECT
" 2	=	Initiate, then accept
" 3	=	COPY
" 4	=	TRANSFORM
" 5	=	CLEAR PICK
" 6	=	ERASE

4.2.2 FCP I/O Drivers. There are two specialized I/O drivers which, due to timing restrictions, must operate under direct FCP control rather than under SCOPE-32 CIO control. These are the Auxiliary Memory Driver and the Core Display Driver.

4.2.2.1 Buffer Memory Driver. This specialized I/O-routine controls reading and writing of Buffer Memory. Since Buffer Memory is used for storage of off-line display data as well as for auxiliary FCP storage, this routine maintains complete cognizance of memory formats.

4.2.2.2 Core Display Driver. This routine controls display of a byte stream directly from core memory through the Digigraphic Controller without changing off-line display data.

### 4.3 Demand Monitor

The FCP Demand Monitor processes all Digigraphic System interrupts. The structure of the Monitor is such that interrupt lockout is rarely imposed on the system for more than 4-milliseconds at a given time. The Monitor also makes use of Buffer Memory I/O lag time by performing at such times, those short tasks which can be accomplished without aborting or inhibiting the current task.

4.3.1 Control Procedure. All system interrupts are processed by the Demand Monitor in the following manner: the interrupt hardware is disabled, the pertinent interrupt is processed, and after processing of the specific interrupt is complete, the interrupt hardware is again enabled.

4.3.2 Computer System Priority Processor. In addition to processing specialized Digigraphic interrupts, FCP processes interrupts due to power failure, I/O processing terminations, and central processor malfunction.

4.3.3 Digigraphic System Priority Processor. Two categories of interrupts are processed by the Demand Monitor, namely: Actual time interrupts and Real Time interrupts. Actual Time interrupts include Maintenance and Sector Pulse interrupts, and are fully processed on a first

priority basis by the Demand Monitor at the instance of occurrence. Real Time interrupts include Keyboard change and Light-Pen strike interrupts whose processing is initiated by the Demand Monitor on a second-priority basis.

4.3.3.1 Maintenance Interrupts. The Demand Monitor is entered when the Digigraphic Controller or the Display Console loses power. At this time a diagnostic is supplied to the computer operator and, in the case of the console, all references are deleted from processing tables. If a power failure occurs on the Controller, FCP operations terminate and a diagnostic is supplied to the computer operator. Parity errors are generally processed immediately after Buffer Memory or Console data transfers.

4.3.3.2 Sector Pulse Interrupt. The Demand Monitor is entered when the Digigraphic Controller generates a sector pulse interrupt. As a result of this interrupt the Sector Interrupt Table is checked by the Demand Monitor to determine the cause of the interrupt. Presently, there exist five causes of sector interrupt.

4.3.3.2.1 Light Pen Strike Enable - Disable. All console Light-Pen strike interrupt enables are initiated on a Sector "0" interrupt. Releasing the Light Pen switch disables this interrupt.

4.3.3.2.2 Tracking. All entrances to the Tracking routine are initiated on a Sector Pulse Interrupt. When the Light Identification Processor identifies the light under Light Pen surveillance as the Tracking Cross, the Tracking routine is immediately synchronized with the Buffer Memory tracking cycle. A tracking cycle, once synchronized, is reinitiated on every third Buffer Memory sector pulse interrupt until the pertinent tracking operation is completed by releasing the Light Pen switch. This provides an effective tracking rate of 150-points per second or 18-inches of pen movement per second.

4.3.3.2.3 Pick Control (ID-Read). The first result of a Pick operation is the sector number containing the byte stream of the entity under surveillance. In order to identify this entity, an ID-Read is enabled during the next Buffer Memory revolution, one sector time prior to the sector containing the pertinent entity. When the second Light Pen strike occurs the console X and Y Accumulators are transferred to core memory as specified by the ID-Read instruction. The ID bytes after the reset byte are transferred to the core memory locations following the X, Y Accumulator values.

4.3.3.2.4 Buffer Memory Transmission. All requests for Buffer Memory read or write are enabled one sector prior to the sector in which the read or write is to be executed. On a read or write sector pulse interrupt, the Buffer Memory I/O Driver issues a Controller Connect and an Input or Output Word instruction. After the pertinent I/O operation terminates, a parity check is made. Detection of a parity error causes FCP to read or write the sector a second time. Two successive read or write parity errors on the same operation causes FCP to notify the computer operator of a solid parity error through the on-line typewriter.

4.3.3.2.5 Core Display Transmission. All core displays are synchronized to a sector pulse interrupt. When the sector pulse interrupt occurs, the core display is initiated and a Function instruction is issued to select a sector pulse interrupt fifteen sectors later. Display of the core bytes is synchronized by the Buffer Memory clock. The core display continues until all bytes have been outputted. The core display remains synchronized to sector pulses until the programmed termination condition is satisfied.

4.3.3.3 Keyboard Change Processor. The Demand Monitor is entered on any Keyboard change. Upon entry, the new Keyboard status is compared with the previous status and the change is recorded. The specific button definition is obtained from the Keyboard Assignment Table and used as a



modifier. A character flag is then set in COMMON indexed by the function number. If the button is defined as a verb, an entry point parameter is set in the Processing Sequence Table for the next pass of the Sequence Monitor (see section 4.4). If simultaneous Keyboard change requests are present, processing within the Demand Monitor will continue until all changes have been processed.

4.3.3.4 Light Pen Strike Processor. The Demand Monitor is entered if light is detected while the Light Pen is enabled. An immediate programmed check is made to determine if the Light Pen is sensing stray light or valid display light. When an invalid Light Pen strike occurs, the Light Pen is re-enabled and the routine is exited. When a valid strike occurs, parameters are established to enable an ID-Read in actual time.

#### 4.4 Sequence Monitor

The Sequence Monitor controls execution of application programs during intervals between interrupt processing. Data specifying application program sequence is obtained by the Sequence Monitor from the Processing Sequence Table.

4.4.1 FCP Execution Control. FCP execution control function performed by the Sequence Monitor includes reallocation of memory to permit execution of FCP Library Processing routines.

## 5.0 FCP Processing Library

All FCP routines with the exception of FCP resident are contained in the Processing Library. This Library is stored in Buffer Memory as fixed binary data ready for loading by the Sequence Monitor.

### 5.1 Digigraphic List Processor

The DL Processor performs all processing functions directly related to the Digigraphic List. Routines within the DL Processor are available to both FCP and application programs.

5.1.1 List Processing. The list processing functions performed include entry, retrieval, modification, and deletion of entities. In addition to these manipulative functions, the DL Processor maintains sole control of storage and retrieval of DL entities and as such is the only FCP routine requiring cognizance of page-directory addressing.

5.1.1.1 Page-Directory Maintenance. The function of the Page-Directory routine is to maintain the DL page and update the DL page-directory. The page-directory scheme is described in section 3.1.2. Digigraphic List Addressing.

5.1.1.2 Enter Entity. The Enter Entity routine, in addition to performing normal entity storage, changes the parental pointers of related entities when the stored entity is a Group.

5.1.1.3 Entity Retrieval. The normal output of the Entity Retrieval routine is the DL address of the desired entity. The pertinent entity can also be obtained by request.

5.1.1.4 Entity Deletion. The functions performed by this routine are the exact inverse of the Enter Entity routine.

5.1.1.5 Change Entity. The function of this routine is to perform partial changes to entity parameters. Where such changes effect the length of an entity, specific DL Processor routines perform the page maintenance required.

5.1.2 Linkage. FCP linkage capabilities permit multi-entity referencing in two independent manners: through Key Category, and Reference Field assignment and through hierarchy grouping. Single entity searches are made on the basis of Key/Category, and Reference Fields.

## 5.2 Geometric Processor

The Geometric Processor accepts input parameters and references from the Pick Table in the form of entity DL address, points on such entities, and free space points on the Construction Grid. Using analytic geometry techniques, these parameters are processed to form appropriate graphic entities.

5.2.1 Entity Format Generator. The function of the Entity Format Generator is to set up the entity descriptor in a designated temporary area. The specific geometry processing routine then appends the related mathematical description.

5.2.2 Frame and Permanent Tracking Cross. The entity forming the frame and permanent tracking cross is created by the Frame Generator and is entered in the DL only when the DL is written on magnetic tape. During normal operation this entity is maintained in resident storage.

5.2.3 General Tracking Cross. The entity forming the general tracking cross (the Light Pen position sensor) is maintained by the Tracking Routine of the Light Identification Processor. The general tracking cross entity is entered in the DL only when the DL is permanently stored. During normal operations this entity is contained in COMMON storage.

5.2.4 Control Surface. The entities necessary to display the FCP-specified Control Surface configuration (see figure 2.3) are automatically entered in the DL at Sign-On. Permanent modifications to this Control Surface configuration can be made by a specific installation for use as a standard. Job-oriented changes are implemented only by application programming.

5.2.5 Alphanumerics. Appropriate entities to develop alphanumeric data on the Construction Grid are created through interpretation of operator action by the Alphanumeric Generator. The starting position on the Construction Grid is obtained from the Pick Table for inclusion in the alphanumeric entity being generated. The specific characters are obtained through operator selection using the Control-Surface alphanumeric keyboard.

5.2.6 Dot. A Dot entity is created by the Dot Generator using data obtained from the Pick Table. Four methods of defining a dot entity are currently permitted. These are:

- a. Picking a point.
- b. Picking the X, Y registers.
- c. Picking a point and the X, Y registers (the X, Y registers are interpreted as  $\Delta X$ ,  $\Delta Y$ .)
- d. Picking a point, the Length Register, and the Angle Register.

5.2.7 Line. A line entity is created by the Line Generator using data obtained from the Pick Table. Four methods of defining a line are currently available. These are:

- a. Picking two Points.
- b. Picking a point and the X, Y registers (X, Y registers are interpreted as  $\Delta X$ ,  $\Delta Y$ ).
- c. Picking a point and the Length and Angle registers.
- d. Picking a point, a line, and the Length Register.

5.2.8 Circle. A Circle entity is created by the Circle Entity Generator using data obtained from the Pick Table. A circle is currently defined in four ways:

- a. By picking a center point and the Length register (the Length Register defines the radius).
- b. By picking a center point and a point defining the circumference.
- c. By picking three points all assumed to be on the circumference.
- d. By picking three lines (the intersection of these lines are assumed to be circumference points).

5.2.9 Circular Arc. A circular arc entity is created by a subordinate routine of the Circle Generator when two circumference points are picked on an existing circle.

### 5.3 Display Processor.

Through the Search and Fetch routines of the DL Processor, the Display Processor obtains graphic entities, subjects these entities to a current frame limit test and if within these limits produces an appropriate byte stream.

The Display Processor is made up to two major routine types: Delta Generators and the Display Byte Generator. The Delta Generators compute linear approximation increments for the pertinent graphic. The Display Byte Generator accepts these increments and produces a corresponding byte stream. This byte stream is then displayed. It should be noted that for each graphic entity type there is a corresponding delta generator which produces the required input to the Display Byte Generator.

5.3.1 Delta Generators. For each graphic entity type included in section 5.2 there is a corresponding delta generator for producing the required display.

5.3.2 Display Byte Generator. The Display Byte Generator is made up of two separate parts: namely, the Byte Initiation Routine and the Byte Manipulation Program. The Byte Initiation Routine produces the appropriate reset and incremental bytes to reposition the beam. Display bytes specifying required beam motion and displayed line characteristics are produced by the Byte Manipulation Program.

### 5.4 Pick Processor

The Pick Processor is entered as a result of an interrupt generated by the real-time clock during normal sequence processing. The ID bytes transmitted to core memory serve to specify the DL address of the pertinent graphic and whether the graphic is on the Working Surface, on the Control Surface, is the tracking cross, or the frame.

5.4.1 Working Surface. One of three specific Pick Table entries will result from picking a graphic on the Working Surface. These are: an entry for a point on the pertinent graphic, an entry for the pertinent graphic, or a group entry referencing the pertinent graphic entity's parent. It should be noted that additional hierarchal levels can be reached by subsequent Light Button action (see section 2.3.4).

5.4.2 Control Surface. There are two possible results from picking a Control Surface Graphic, these are: A Pick Table entry identifying a picked register, and execution of a Light Button-controlled routine.

5.4.3 Tracking Processor. The Tracking Processor, which is part of FCP Resident, provides a primary man-machine communication link between a Digigraphic Console display and the Light Pen. There are two primary display elements associated with the Tracking Processor. These are the Tracking Cross and the Writing Point.

The Tracking Cross is a displayed cross approximately 3/4" by 3/4" which is generated by the Tracking Processor and serves as a link between the Light Pen and the Writing Point. The Tracking Processor senses the position of the Light Pen and moves the Tracking Cross to correspond with pen movement. As the Tracking Cross is moved, the Writing Point moves either in conjunction with the Tracking Cross or according to a specific constraint (e.g. horizontal, vertical, and angular constraints). In all cases a displayed dot remains fixed with respect to the Tracking Cross.

The Writing Point is a dot generated by the Tracking Processor and is displayed in the upper left quadrant of the Tracking Cross. The purpose of the Writing Point is to enable Light Pen definition of specific points on the Construction Grid such as the center point of a circle or the starting and ending points of a line.

5.4.4 Frame Processor. Controls are provided to allow the Working Surface to frame variable portions of the Construction Grid in both position

and magnification. The Frame Processor provides magnification based on integral powers of two. The Frame can view the total Construction Grid or any portion of it.

## 6.0 System Expansion Library

The most important single design aspect of the Digigraphic Programming System is the facility for modular system expansion. Present system expansion includes the Application Interface. As utility programs and application packages are developed, the specifications for these will be included in this section.

### 6.1 Application Interface Library

In order to accomplish the application interface functions provided by FCP, a series of Application Interface routines are defined. These routines operate in conjunction with the FCP to perform those functions for the application which duplicate operator action. In addition, several routines are provided to enable the application program to reinterpret and supplement system controls. Call statements of BCD words and numerical parameters establish the conditions for the proper execution of the interface routines. In all cases application interface routines are callable as FORTRAN subroutines.

In the FORTRAN CALL statements associated with the interface routines, several variations can appear:

- a. Those parameters specified as BCD constants can also be integer variables provided those variables have been preset with the specified BCD constants.
- b. Those parameters which can be ignored must be present in the call statement as dummy parameters.

NOTE: The following is an example of a typical Application Interface -

FORTRAN CALL Statement configuration:

```
CALL MENTI (0, IERR, 3HCNN, ICAT, 0, 0)
```

The options on the first parameter ("0") are: DI = Display, ND = Non Display, ER = ERASE. The value zero indicates that none of the options are requested, thus no change. The second parameter (IERR) is the location of an error flag. The third parameter (3HCNN) indicates that a change is to be made on the



Category Field (character C) and that the last two parameters (characters NN) will be ignored. ICAT contains the value for the Category Field. The two remaining zeros are dummy parameters.

### 6.1.1 Parameters

#### 6.1.1.1 Entity Type Codes (ET)

DOT	dot	PLS	polystring
LIN	line	GRP	group
CIR	circle	ANU	alphanumeric
CAR	circular arc		

#### 6.1.1.2 Entity Type Modifiers (ETM)

ETM = C<sub>1</sub>C<sub>2</sub>C<sub>3</sub> where:

for graphics: C <sub>1</sub> - C <sub>2</sub>		C <sub>3</sub>
SO	solid line	S
HI	hidden line	
CE	center line	
BO	boundary line	

6.1.1.3 Light Button Mnemonics. The following list contains the FCP Light Button BCD mnemonics for display purposes and for use by application interface routines.

NOTE: Primary Light Buttons have leading blanks and  
Secondaries have trailing blanks.

<u>Light Button Name</u>	<u>Type</u>	<u>Codes for FCP Light Buttons</u>
Graphic Form	Primary	GF
Dot	Secondary	DE
Line	Secondary	LE
Circle	Secondary	CE
Circular Arc	Secondary	CA

<u>Light Button Name</u>	<u>Type</u>	<u>Codes for FCP Light Buttons</u>
Polystring	Secondary	PE
Point Line Classification	Primary	PL
Center	Secondary	CP
Group Control	Primary	GC
Collect	Secondary	CG
Remove	Secondary	RG
Add	Secondary	AG
Break	Secondary	BG
Level 1	Secondary	1G
Level 2	Secondary	2G
Level 4	Secondary	4G
Top	Secondary	TG
Utility Control	Primary	UC
Redisplay	Secondary	RD
Non-display	Secondary	ND
Call Application Program	Secondary	AP
Terminate Application	Secondary	TA
Sign-Off	Secondary	SO
Drawing Control	Primary	DC
Identify	Secondary	ID
Store	Secondary	ST
Select	Secondary	SE
Alphanumeric Control	Primary	AC
Label	Secondary	LA
Note	Secondary	NT
Text	Secondary	TX
Value	Secondary	VL

<u>Light Button Name</u>	<u>Type</u>	<u>Codes for FCP Light Buttons</u>
Double	Primary	DP
Halve	Primary	HP

6.1.1.4 Keyboard Assignment Table Mnemonics. The following table shows the relationship between a physical Keyboard button and its logical assignment. Modifier buttons have a character flag address (FCPFUNCT) in COMMON. Verb buttons have a transfer address in table KVERB. Use of the intermediate table allows reassignment of physical buttons without affecting the logical function of the buttons.

<u>Keyboard Button</u>	<u>KAT No.</u>	<u>FCP Function No.</u>	<u>KVERB No.</u>	<u>Mnemonic</u>
Reject	1		1	R
Accept	2		2	A
Unassigned	3			
↑ ↓	4			
	5			
	6			
	7			
Unassigned	7			
Clear Pick Table	8		7	CP
Transform Copy	9		3	TC
Transform	10		4	T
Unassigned	11		5	SP
Normal	12	8		N
Erase	13		6	E
Lock	14	4		L
Override	15	9		O
Center	16	6		C
Graphic Entity	17	7		B
Point	18	3		G
Unassigned	19	2		P
↑ ↓	20			
	21			
Unassigned	21			
Light Pen	22	1		LP
Unassigned	23			
End Point	24	5		EP

6.1.1.5 Flag Word. Presently, all error flags or error signals returned to the application program are minus values, for example minus one (77777776). Minus zero will not be used as an error flag.

6.1.1.6 FCP Defined Register Call Mnemonics

<u>Name</u>	<u>Mnemonic</u>	<u>Length in BCD Characters</u>	<u>Mode</u>	<u>3200 Words Needed for Mode Value</u>
X <sub>1</sub> Coordinate	X1	0	Flt Pt	2
Y <sub>1</sub> Coordinate	Y1	0	Flt Pt	2
Length	LE	0	Flt Pt	2
Message Register	MR	24	BCD	6
Assembly Register	AR	24	BCD	6
Category	CA	2	BCD	1
Save Register 1	S1	12	BCD	3
Save Register 2	S2	12	BCD	3
Reference Field	RF	4	BCD	1

6.1.2 General Subroutine Structure. Application interface subroutines in general are structured to perform three sequential functions; namely, collection of data from pertinent calling sequences, implementation of FCP processing sequence, and dispersion of resultant data to the application program as required.

6.1.3 Control Routines. The application interface control routines allow the user to redefine a specified range of Digigraphic System controls according to his requirements. These control functions include:

- a. The ability to restrict specific Console controls to application program use only.

- b. Definition or redefinition of Keyboard functions.
- c. Creation of both primary and secondary Light Pen control elements.
- d. Restoration of Console control to the operator.
- e. Termination of application-defined Keyboard functions and Light Pen control elements.
- f. Transfer of control by the application program to FCP and the Console operator.

6.1.4 Fetching Routines. The purpose of the fetching routines is to allow an application program to scan the DL for specific data and retrieve that data when found. Functionally these routines provide for a search of the DL for an entity through use of a Key Field, Category Field, and Reference Field mask. When a comparison is found between masked values and a given parameter, the desired entity is returned to the application program. If a match is not found, an indication of this condition is returned.

6.1.5 Pick Routines. The application interface pick routines permit an application program to perform the following functions:

- a. Request an operator to use the Light Pen to pick a specified parameter.
- b. Define a particular entity or a point on an entity as a Pick Table entry.
- c. Transfer the content of the Pick Table to memory locations controlled by the application program.

6.1.6 Entity Manipulation Routines. Through use of the entity manipulation routines, an application program can create, enter, modify, and transform a DL entity according to a set of specified rules. The specific entity manipulations permitted through the application interface are as follows:

- a. Create an entity using application defined parameters and store the created entity in the DL. This function essentially duplicates creation of entities by the operator at the console.
- b. Enter an existing application entity into the DL.
- c. Modify any or all fields in an entity to the extent allowed by the specific field or fields.

6.1.7 Control Surface Routines. Through the control surface routines, specific data and control manipulations can be performed by an application program on the Digigraphic Control Surface and Working Surface. These include:

- a. Entrance and display of application defined parameters in specific Control Surface registers.
- b. Retrieval by the application program of data from specified Control Surface registers.
- c. Repositioning of the Tracking Cross on any part of the Working Surface according to coordinates provided by the application program.
- d. Redefinition of Working Surface Frame and/or position.
- e. Change of Zoom Index value.

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