

 SPERRY RAND

UNIVAC

**ADVANCED
GRAPHIC
DISPLAY SYSTEM**

TYPE 1557/1558

GENERAL
DESCRIPTION

This manual describes a UNIVAC® system. It is as complete and accurate at the time of publication as is feasible by current documentation techniques. The Univac Division will issue complete revisions of this manual when necessary. The Univac Division reserves the right to make such additions, corrections, and/or deletions as, in the judgment of the Univac Division, are required by the development of its systems. To assure that you have the current version of this manual and for the current status of the system, contact your local Univac Representative.

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1. INTRODUCTION

The UNIVAC Advanced Graphic Display System (see Figure 1-1) permits the dynamic entry and display of data to or from its own processor storage or that of a remote computer. Data may be entered, or altered, by keyboard or by a light pen (optional). The data entered or displayed may consist of alphanumeric information of the usual kind or may take more complex forms, such as engineering or architectural drawings. The information displayed may be enlarged or reduced, and the entire contents of the screen may be rotated.



Figure 1-1. Graphic Display Console

The system is designed for dynamic interaction between the operator and a computer on a level not previously available. For example, a circuit diagram can be drawn (actually drawn, with a light pen) on the display console, and entered into the computer together with selected parameters.

The computer can then be used to model the performance of the circuit, recommend changes, and even incorporate alterations directly into the circuit diagram depending on the performance of the model.

This type of interaction requires very close coordination and presents a considerable overhead load on the interface. The computer is required to sustain the mechanics of the display as well as provide the processing services demanded by the program.

The Univac Division has resolved this difficulty by designing a small general purpose computer in the UNIVAC Display Controller Type 1557 to satisfy the requirements of the display and even to satisfy many problem-related processing requirements. The net result is a very powerful system that can be programmed independently to perform many diverse display services and can be connected to a time-sharing computer, either remotely or directly, for unlimited processing of graphical applications programs.

1.1. DYNAMIC APPLICATIONS

The system may be successfully applied to many problems; some are mentioned for basic and specific uses.

1.1.1. Basic Uses

Conceptually, the UNIVAC Advanced Graphic Display System is not a hardware-limited system. It was designed to produce maximum processing capabilities in order to permit an extensive range of software control. From the users' point of view, this system is literally a free-form system limited only by the range of expression permitted by the software.

The system can be adapted, through software, to any input format or control command structure. When combined with a powerful computer system, such as the UNIVAC 1108 Multi-Processing System, the UNIVAC Advanced Graphic Display System has practically unlimited applications capabilities. A summary of some proven and effective uses is:

■ STATISTICAL DATA HANDLING

The system is capable of collection, collation, updating in storage, and presentation of data in tabular and/or graphic forms.

■ DATA REDUCTION

Large masses of data can be assimilated, extrapolated, and then presented in comprehensible and workable graphic or tabular form.

■ SIMULATION

Graphic presentation may be made of an actual or a projected system or situation. User can directly observe dynamic reactions to selected conditions.

■ COMPUTER-AIDED DESIGN

A design model can be evolved empirically on the display screen. This model can then be examined in terms of natural parameters, production, costs, marketability, etc.

■ PATTERN RECOGNITION

Sample information, statistical or graphic, can be compared with many complex patterns and identified.

■ ABSOLUTE AND RELATIVE EVALUATION

Equipment and materials can be compared with various standards and specifications to determine acceptability and value.

■ REAL-TIME PROCESS CONTROL

System model and current performance data are displayed to the user who can regulate and control the actual system by instructing it through the display console.

■ COMPUTER PROGRAM ANALYSIS

Proposed programs can be examined on the display screen and corrected or modified directly.

1.1.2. Specific Uses

Specific applications encompass the entire gamut of computer usage, because the system literally functions as an extension of the normal means of expression. In addition to letters and pictures, the user has full use of the enormous computational capabilities of a computer such as the UNIVAC 1108. Examples of diverse applications within selected areas are:

■ MANAGEMENT AND MARKETING

- Management information briefing center
- Cost control
- Sales analysis and forecasting
- PERT analysis updating
- Flowcharting
- Data reduction and retrieval
- Trend recognition
- Market modeling projections
- Performance evaluations
- Investment analysis
- Fiscal planning
- Distribution optimization
- Wage and salary analysis
- Advertising evaluation

■ ENGINEERING AND RESEARCH

- Process simulation
- Telemetry data reduction
- Computer-aided design
- Stress and strain analysis
- Medical diagnosis and research
- Mathematical modeling
- Integrated circuit mask design

- Route layout
- Molecular structure analysis
- Subsurface contour display
- Schematic drawing storage
- Oil and mining exploration
- Styling
- Three-dimensional projections
- Manufacturing feasibility
- Construction estimating
- Curve fitting

■ PRODUCTION

- Real-time process control
- PERT analysis
- Quality control
- Subjective product testing
- Warehouse automation
- Process simulation
- Inventory control
- Numerical control taping
- Data logging
- Alarm monitoring
- Furnace and rolling mill control
- Production programming
- Power network monitoring
- Construction scheduling
- Product mix
- Procurement
- Time-motion studies

2. EQUIPMENT DESCRIPTION

2.1. CONFIGURATION DESCRIPTION

The UNIVAC Advanced Graphic Display System is composed of two major units: the Display Controller Type 1557 and the Display Console Type 1558. The purpose of the display controller is to provide computing and control capabilities to handle, internally, display functions and programs that are tailor-made by the user to meet his requirements. It also serves as an interactive device to the UNIVAC 1108 processor to provide additional large-scale processing capabilities.

The display console consists of a CRT display, keyboard, display control, and an optional light pen. The unit is designed for display of random points, vectors, alphanumeric characters, and special symbols. It features a high-speed, high-precision CRT to accommodate a wide variety of graphic displays.

The basic configuration of the UNIVAC Advanced Graphic Display System interfaces directly with an I/O channel of the UNIVAC 1108 processor or indirectly through a modem, with the UNIVAC 1108 or any other computer. Each arrangement is shown in Figure 2-1. The maximum configuration of the system is shown in Figure 2-2.

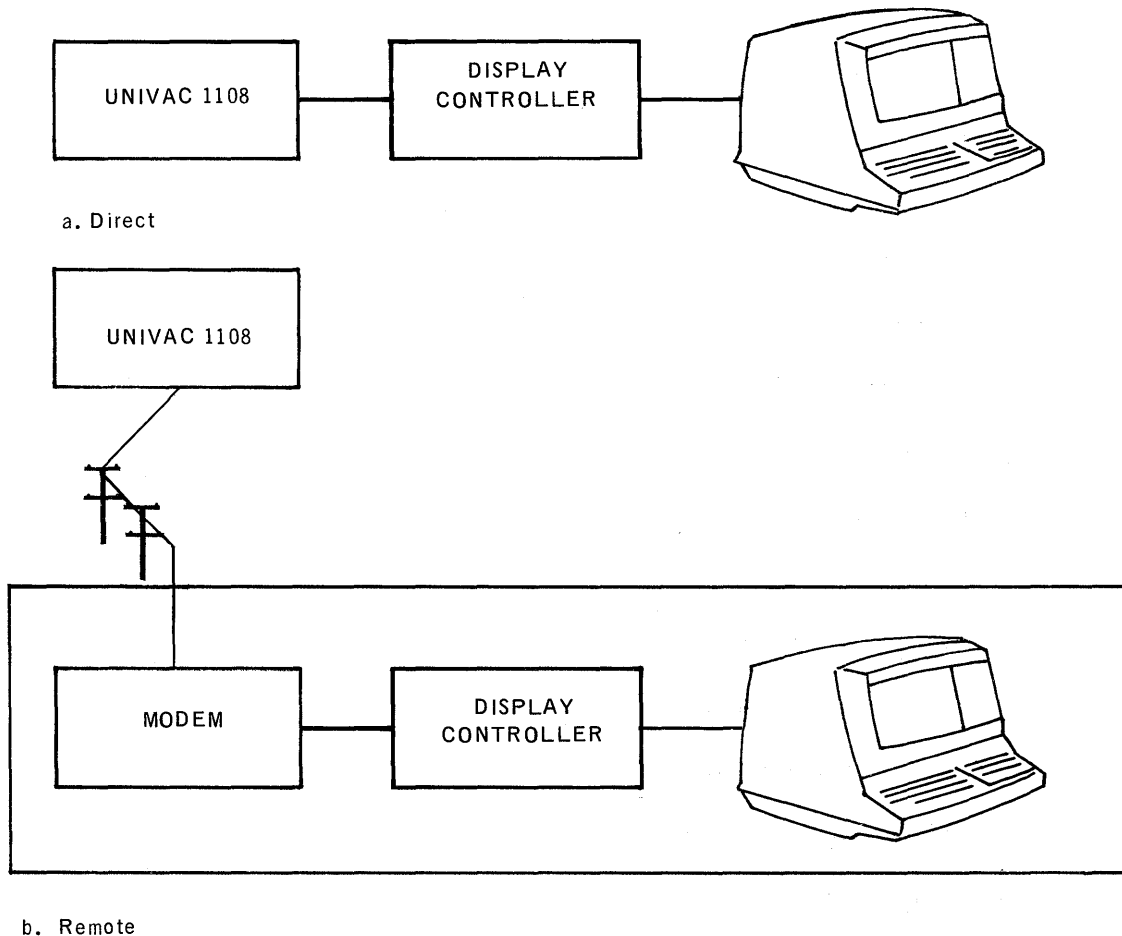


Figure 2-1. Two Arrangements of the Basic Configuration

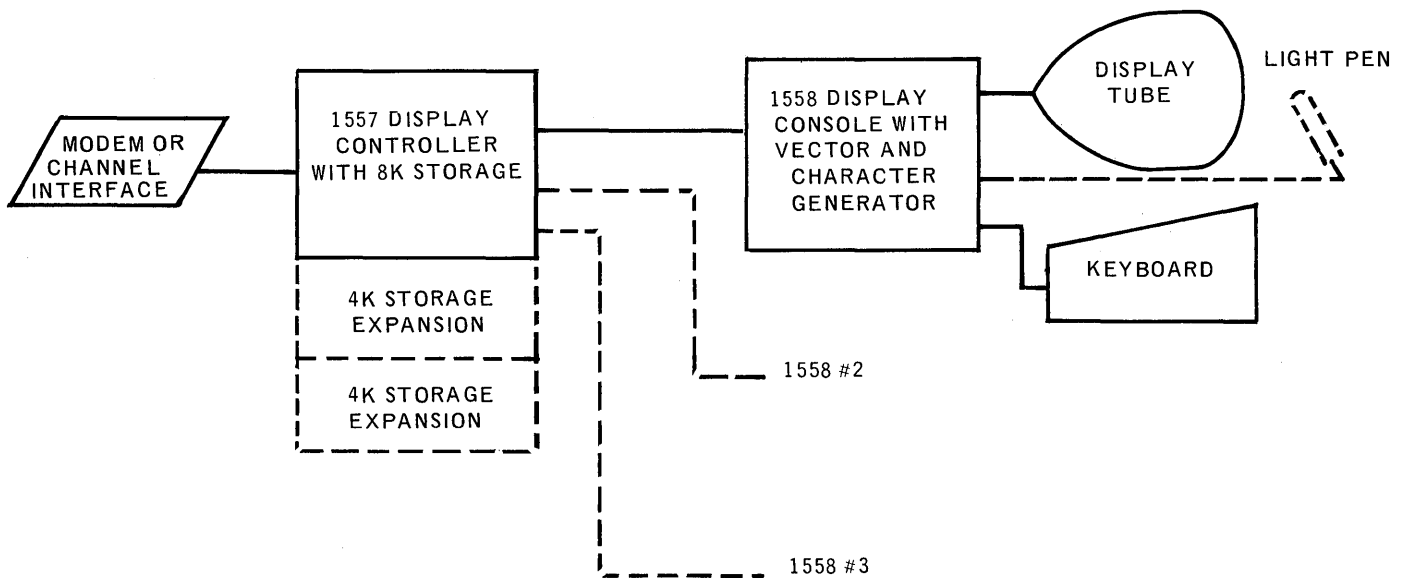


Figure 2-2. Maximum Configuration

2.2. FUNCTIONAL DESCRIPTION

The various functions of the display controller and display console are described separately.

2.2.1. Display Controller

The display controller provides all local control and processing for the system. It can interface either a computer or communications facility on one side and the display console(s) on the other. It consists basically of storage, processor, and input/output control sections.

2.2.1.1. Storage

The basic storage in the display controller contains 8,192 locations. Each storage location contains one data or instruction word (18 bits). Storage size can be increased by up to two increments of 4,096 words for a total of 16,384 words.

Storage design is of the plated wire type with a cycle time of 700 nanoseconds for each one-word access. Most instructions require two cycles for execution for an average execution time of 1.4 microseconds. Consecutive instructions can be executed at a rate of 715,000 instructions per second.

Each display console has direct access to storage and obtains data on a cycle-stealing basis. Accesses by the display console are interleaved with the normal demand of the display controller. Therefore, operations within the display controller and the display console(s) function simultaneously and asynchronously.

2.2.1.2. Processor

The processor of the display controller performs instructions using a single-addressing scheme. Through the use of its one-word accumulator, basic arithmetic and logical instructions are accomplished. Multiplication and division are also possible, if programmed.

2.2.1.2.1. Instruction Repertoire

The display controller executes two types of instructions:

- Type 1. There are 15 type 1 instructions (see Figure 2-3) which access memory and perform arithmetic, logical, and sequence control functions.
- Type 2. There are 11 type 2 instructions (see Figure 2-3) which control input/output, designator testing, and program sequence changes.

1557 TYPE-1 INSTRUCTIONS



F-FIELD IN OCTAL	MNEMONIC	INSTRUCTION
01	J	Jump
02	RJ	Return Jump
03	SAD	Store Address
04	LAD	Load Address
05	INC	Increment
06	DTN	Decrement and Test Negative
07	WS	Word Shift
10	A	Add
11	AN	Add Negative
12	AND	Logical And
13	XOR	Exclusive Or
14	L	Load
15	LH	Load Half
16	S	Store
17	SH	Store Half

Figure 2-3. Instruction Repertoire (Part 1 of 2)

TYPE-2 INSTRUCTIONS



\hat{F} -FIELD IN OCTAL	MNEMONIC	INSTRUCTION
00	STP	Stop
04	T	Test
05	SET	Set Designator
06	RSA	Right Shift Algebraic
07	LSL	Left Shift Logical
12	OVD	Override Data
	OVF	Override Function
13	SCA	Store Channel and Acknowledge
	ACK	Acknowledge
14	OUT	Activate Output Buffer
15	IN	Activate Input Buffer
16	RSC	Right Shift Circular
17	LSC	Left Shift Circular

Figure 2-3. Instruction Repertoire (Part 2 of 2)

In addition, a manually controlled bootstrap operation executes an initial load routine to resume normal operation when a program rerun is necessary, because of an error condition or loss of power. Through the use of a printed-circuit card, 32 instructions are hardwired for subsequent transfer to a selected block of storage, but can be changed manually to accommodate other bootstrap operations for different interfaces.

2.2.1.2.2. Indexing

The indexing capabilities of the display controller are:

- Advance Mode – when the advance mode designator is set, the address field of the type-1 Computational (but not control flow) instructions is incremented by one, after execution.
- I/O Data Transfers – one-count increment or decrement of the memory address is controlled by the buffer address word during I/O data transfers.
- Subroutines – at the discretion of the programmer, a subroutine can be written using type-1 instructions to increment the address field.

2.2.1.3. Input/Output Control

The display controller transfers input or output data in any one of three control modes:

- Externally Specified Address (ESA) Mode Transfer – this mode allows, on a demand basis, the exchange of a series of commands and requests between the display controller and the display console(s) to sustain continuous operation at each console.
- Internally Specified Index (ISI) Mode – the ISI mode controls the transfer between the display controller and the central processor. Through the use of a buffer control word, the contents of previously established input or output buffers are loaded or emptied depending upon the type of instruction executed. Also, the generation of an interrupt can be specified in the buffer control word to occur when the data transfer is completed.
- Forced Output to Console Mode – this mode causes the display controller to execute an output command for display purposes. The display is usually limited to a few words. Its primary use is to initiate the ESA mode in a display program.

2.2.1.3.1. Interrupts

The display controller provides a method of interrupting, under program control, the normal flow of any operational program. It recognizes eight interrupts. Each interrupt has a priority assignment and causes an instruction to be executed which enters an interrupt processing subroutine. A description of the interrupts, together with their priority assignments and entrance addresses, is given in Figure 2-4.

INTERRUPT	PRIORITY (Highest to lowest)	ENTRANCE ADDRESS (Octal)	DESCRIPTION
Sixteen-Millisecond Clock Interrupt	8	0017	Occurs every 16.6 milliseconds to accommodate the refresh of any display.
One-Millisecond Clock Interrupt	7	0016	Occurs every 1.1 milliseconds when the CLOCK CONTROL designator is set.
External Interrupt 3	6	0015	Originates from display console 3.
External Interrupt 2	5	0014	Originates from display console 2.
External Interrupt 1	4	0013	Originates from display console 1.
External Interrupt 0	3	0012	Channel 0 external interrupt
Output Monitor Interrupt	2	0011	Programmable interrupt that occurs when the output buffer is emptied.
Input Monitor Interrupt	1	0010	Programmable interrupt that occurs when the input buffer is emptied.

Figure 2-4. List of Interrupts

2.2.1.3.2. Direct Channel Interface

The display controller is equipped to connect, by way of the direct channel interface, to an on-site UNIVAC 1108 System. A series of control lines is used to exchange data, in an 18-bit word format, between the two systems. Programs residing in either the UNIVAC 1108 or the display control determine when exchanges of input or output data are to take place. The interface also makes provisions for interrupting the operation of each system.

2.2.1.3.3. Modem Interface

The display controller is equipped to connect, by way of a modem interface, to the telephone facility to satisfy a wide variety of interface requirements. The modem interface is suitable for use with either the 201B or the 205B2 Modem. Data transmission is bit serial at a rate of 2000 or 2400 bits per second, depending on the type of modem.

2.2.2. Display Console

The display console is freestanding and contains all the components required for its operation. It interfaces with the operator on one side and the display controller on the other. This unit can operate independently or in concert with any other display console in the system. Functionally, it includes the display screen, display control, vector and character display generation, keyboard, and the light pen.

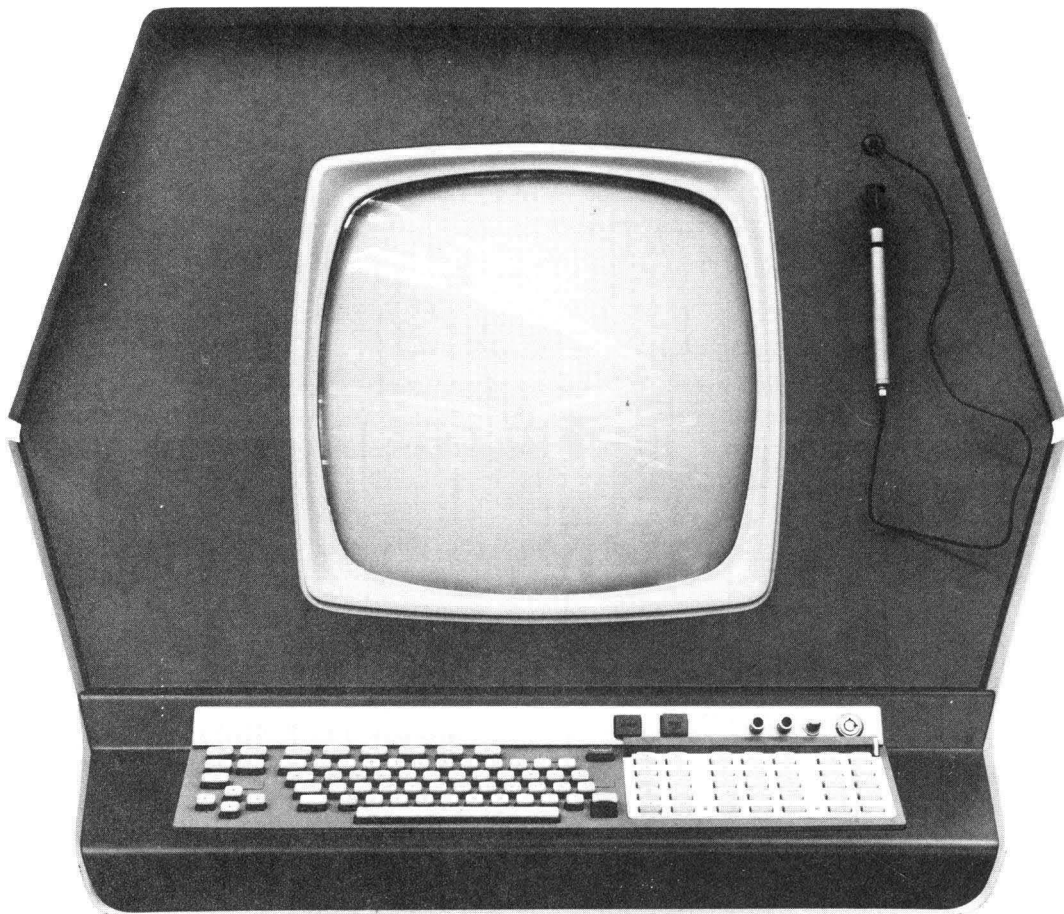


Figure 2-5. Display Screen

2.2.2.1. Display Screen

The display screen (Figure 2-5) is a cathode ray tube (CRT) with a 12-inch square viewing surface. The screen is divided horizontally and vertically into 1024 raster units. One raster unit corresponds to 0.012 inch. The display console uses a special digital deflection technique which provides accurate positioning and excellent linearity. The display brightness may be varied by the operator to maintain a minimum contrast ratio of 10:1.

The presentation is such that no flicker or jitter is perceptible to the operator. In order to accomplish this, the refresh rate of the display surface must be maintained at 60 times each second.

2.2.2.2. Display Control

Because each display console can access memory independently, common display subroutines may be accessed to control the display of each device. These instructions are decoded and executed to control display generation and to interpret light pen activities.

2.2.2.3. Display Generation

A vector generator and character generator provide the many presentations available for display.

2.2.2.3.1. Vectors

The display console uses a constant-velocity vector generator to draw four types of lines to represent vectors: solid, dashed, center line, and end point. These vectors can be displayed at any combination of intensity levels: off, low, and high. The origin of the vector is always the current beam position and can be drawn in absolute or incremental coordinates. It is possible to display a vector of up to 63 raster units in length in two microseconds. Vectors of greater length are displayed by segments of up to 63 raster units each.

2.2.2.3.2. Characters

The binary coded characters in storage must be converted into one-to-eight character-element words that cause the character to be displayed on the screen. This translation is accomplished through a character generator which is essentially a diode matrix array. The character generator can generate 96 unique symbols (see Figure 2-6).

Depending on the symbol complexity, the character element words drive the high-speed stroke generator to paint strokes on the CRT screen. Each stroke is accomplished in one microsecond, with up to eight strokes available for producing one character. Also, the dimensions of each symbol in the character set can be varied in either small (0.09 by 0.12 inch) or large (0.16 by 0.22 inch) size. Up to 56 small characters or up to 28 large characters can be displayed on one line.

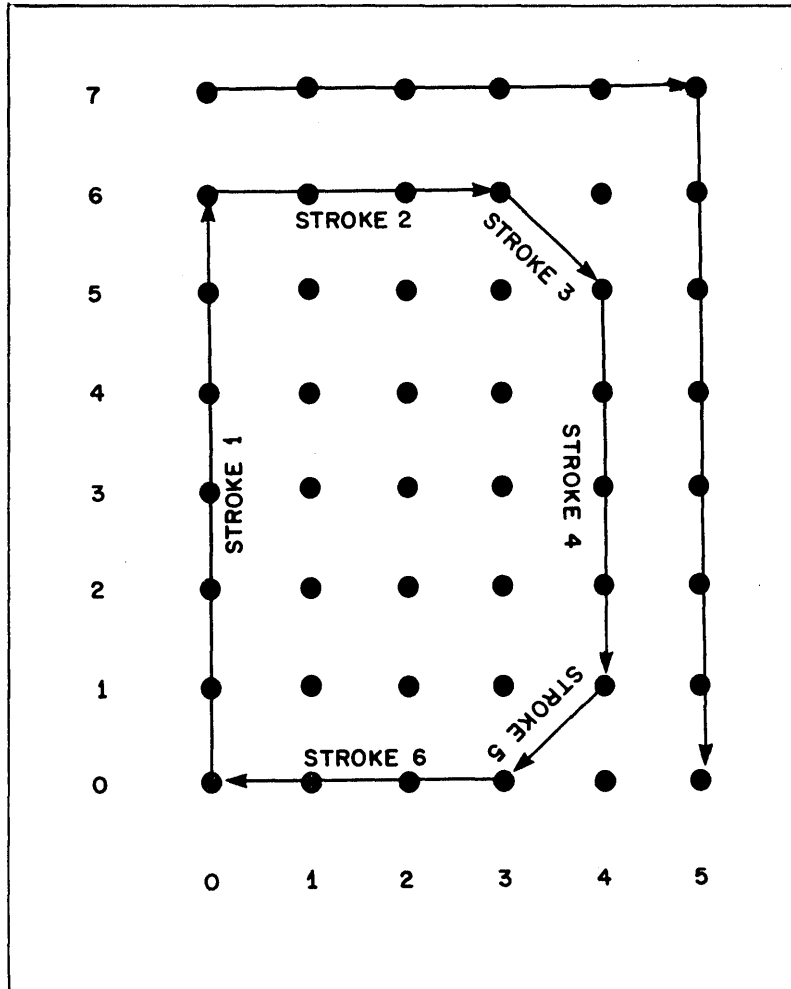


Figure 2-6. Character Generation.

NOTE: The Letter "D" is Formed by Six Strokes on the Screen. Two Additional Strokes are used to Form the Cursor

2.2.2.4. Console Keyboard

The keyboard is the operator's interface with the operational program of the display controller (see Figure 2-7). From the keyboard, the operator may interrupt the program and perform tasks specified by the program. Each time a key is pressed, an interrupt word is sent to the display controller, and control is transferred to a subroutine which services the interrupt. The course of action taken by the program and the tasks required of the operator are strictly dependent upon the application program.



Figure 2-7. Overall View of Keyboard

2.2.2.5. Light Pen

The light pen (Figure 2-8) is an optional feature available with the display console. It may be used by the operator to draw, detect, and alter or erase lines and points on the screen. Here again, the operational program is interrupted, and subsequent tasks required of the program and the operator are contingent upon the application.

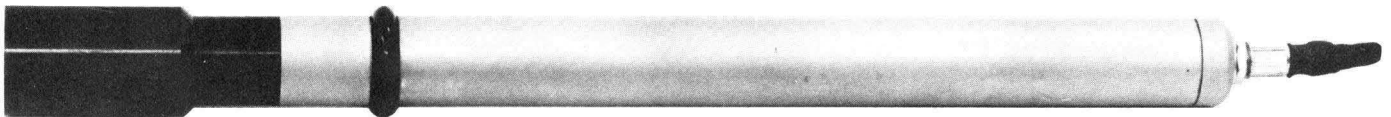


Figure 2-8. The Light Pen

2.2.3. Operator's Controls

The controls and indicators required for basic operation are distributed between the display console and the display controller. The display console contains the alphanumeric keys, function keys, the TRANSMIT key, and the optional light pen. The display controller contains several operator and program switches.

2.2.3.1. Display Console

Most operating functions are performed from the display console. The various input areas are briefly described.

2.2.3.1.1. Typewriter Keyboard

The display console keyboard (Figure 2-9) closely resembles the standard typewriter keyboard. It approximates as closely as possible the typewriter key shape, key travel, and touch pressure. The slope of the keys has been designed to permit easy and comfortable operation. Because of the similarity to a typewriter, very little operator training is required. In addition to the 26 uppercase alphabets, it contains ten numerics, 20 standard punctuation marks, and special symbols.

The primary purpose of the keyboard is to interrupt the program of the display controller. Data presented by the interrupt permits the identification of the depressed key. Display of this character and the course of action required of the operator is dependent upon the application program in the display controller.



Figure 2-9. Typewriter, Cursor, and Control Keyboard

2.2.3.1.2. Function Keys

The function keys (Figure 2-10) are the 35 keys on the right-hand side of the console and the six keys at the top on the left-hand side of the console. These keys function exactly as do the typewriter keys, in that they cause an interrupt when depressed which must be analyzed by the program in the display controller.

The display console is provided with a number of plastic overlays that fit around the 35 function keys on the right-hand side of the keyboard. These overlays are inserted and locked into position by turning the knurled knob down to engage the pressure bar. The overlays contain eight tabs, seven of which may be removed in any of 128 different combinations. When the overlay is locked in place, these tabs activate switches including one that indicates that the overlay is in place. An overlay must be in place for any of the function keys to be operable.

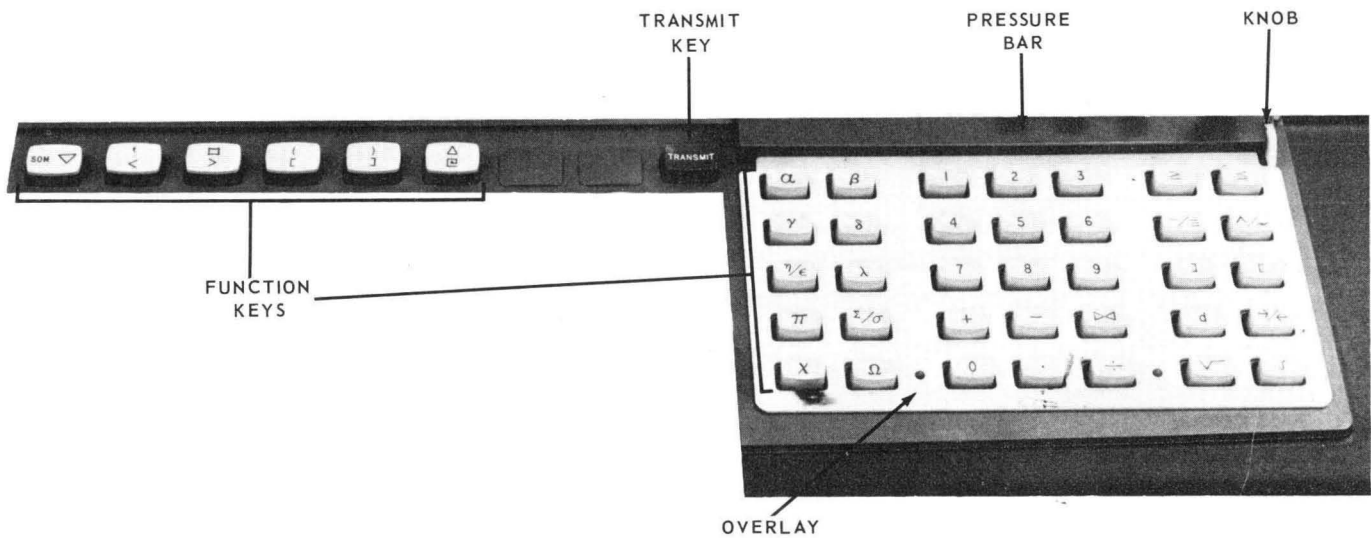


Figure 2-10. Function Keys

2.2.3.1.3. TRANSMIT Key

The TRANSMIT key (Figure 2-10) is located in center of the display console between the keyboard and the group of 35 function keys. Pressing the TRANSMIT key sets up an interrupt word that contains the status of the overlay switches, and then interrupts the display controller. The controller can then read this interrupt and use the overlay information to determine how to process interrupt words from the overlay-controlled function keys (see Figure 2-11).

1558 CHARACTER SET																
2 ⁶ 2 ⁵ 2 ⁴	2 ³ 2 ² 2 ¹ 2 ⁰															
	0000	0001	0010	0011	0100	0101	0110	0111	1000	1001	1010	1011	1100	1101	1110	1111
000							Tab	Insert Disp.		Delete Disp.	Erase Disp.	C.R.	Scan Up	Scan Down	Scan Left	Scan Right
001								Insert Line		Delete Line	Erase Line	Cursor Home				
010	Space	!	" Quote	#	\$	%	&	Rt. Apos.	()	*	+	comma	- hyphen	period	/
011	0	1	2	3	4	5	6	7	8	9	:	;	÷	=	▷	?
100	π	A	B	C	D	E	F	G	H	I	J	K	L	M	N	φ
101	P	Q	R	S	T	U	V	W	X	Y	Z	√	∇ ^{sum}	λ	Ω	∫
110	☒	C	≤	≥	d	Σ	η	\	^	→	Δ	⊠	Lft. Apos.	}	-	{
111	χ	α	β	γ	δ	ρ	ε	≠	~	←	@	>	<]	≡	[

Non-Positioning
 Non-Printing

Note: 2⁸ - Function Key
 2⁷ - Transmit Key

Figure 2-11. Keyboard and Character Function Codes

2.2.3.1.4. Optional Light Pen

The display console light pen (Figure 2-12) is a photoelectric device that senses images on the cathode-ray tube screen by means of a photocell located in its body. It may be used to draw, detect, alter, and erase lines and points on the screen in conjunction with an appropriate controller program. The light pen is held by the back of the barrel with the index finger held above, not touching, the front part of the barrel. The pen is held over the desired image and the finger is then placed on the front of the barrel to enable detection of the spot. If the pen is aimed properly, detection should occur rapidly (within 16 milliseconds), an interrupt word is generated and then sent to the controller. The controller program is presented with sufficient data to determine which image was sensed by the pen. The action to be taken (e.g. to add or delete a line) is determined by the controller program.

There are two lenses available for the light pen. One lens has a viewing angle of 33 degrees and is used when the points on the screen are widespread. The other lens has a viewing angle of four degrees and is used where more careful discrimination of images is required.

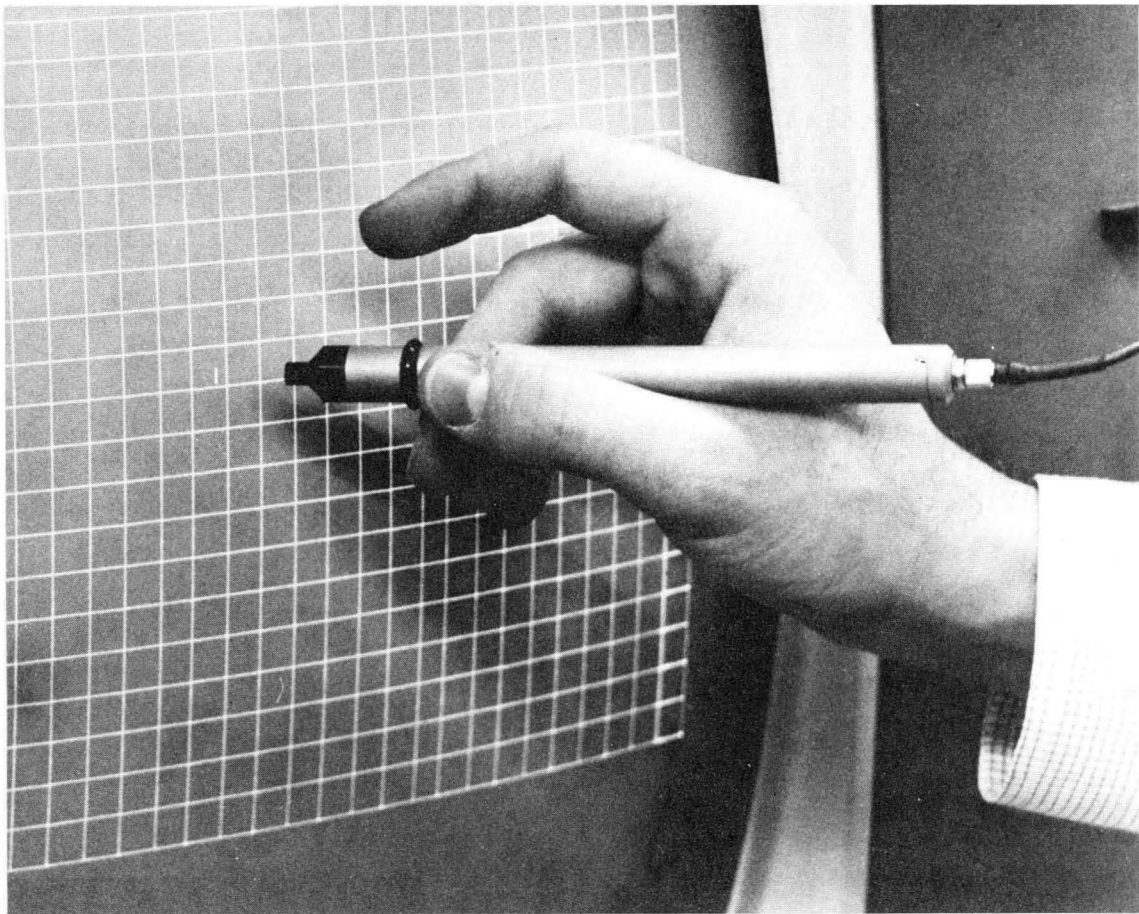


Figure 2-12. Light Pen in Use

2.2.3.2. Display Controller

The operator uses the nine switches on the maintenance panel during normal operation. These switches, located on the top portion of the maintenance panel (Figure 2-13) are:

■ BOOTSTRAP

This toggle switch enables the loading of the bootstrap program when in the up position.

■ OP STEP

This toggle switch enables the display controller to execute a single instruction when in the up position. If the switch is down, instructions are executed sequentially.

■ 16 MSEC-OFF

When this toggle switch is placed in the up position, the 16-millisecond clock is enabled. The down position disables the clock.

■ READ-WRITE-OFF

The functions of this three-position switch are:

- READ position enables display controller to perform single-address reading.
- WRITE position enables display controller to perform single-address writing.
- OFF position has no influence on the operation of the display controller.

■ MC-START

The functions of this three-position switch are:

- MC position master clears the display controller by clearing all registers.
- START position initiates normal execution of the stored program.
- Center position has no influence on the operation of the display controller.

■ Program Switches

When any of the four program switches, labelled k field 6, 7, 8, and 9, is set to its up position and the corresponding bits of the k field in the instruction are set, the TEST (04) instruction skips the next instruction.



Figure 2-13. Maintenance Panel

3. APPLICATIONS

The specific applications of a general-purpose interactive graphic display system such as the UNIVAC 1557/1558 Advanced Graphic Display System are extremely varied. The CRT display is literally the same as a blank piece of paper. The writing and drawing implements are the keyboard and the light pen, which can achieve the same results as a typewriter and pencil with all the added power of a computer to support, augment, and amplify the capabilities of the user.

The primary purpose of the 1557/1558 System is to concentrate the mechanics of graphic and display development and maintenance in a totally self-contained hardware/software package. The system can be structured through the software to respond to almost any user requests and requirements. Display-related subroutines are stored in the 1557/1558 System, and can interface easily and conveniently with a larger computer for extended processing support.

3.1. MAN-MACHINE COMMUNICATIONS THROUGH GRAPHIC DISPLAYS

The main advantage of using a graphic display to establish communications between man and machine is that the mode of problem expression is as close as possible to the manner in which the user would normally set up the problem. For example, if an engineer is developing a design of a logic circuit, he would first block out the problem in a basic sketch and list the main problem elements. The next step would then be to work out a compatible mathematical model and convert the discrete results of the model into increasingly more detailed pictorial refinements of the problem solution. The result would be a detailed functional logic diagram which either embodied the hardware restraints imposed by the available circuitry or which would now be ready for further refinement to include these restraints. The point is that the entire process revolves around visual representation that serves to gather the engineer's thoughts and allows him to partition a larger problem into more easily controllable problem segments, which can then be attacked directly by mathematical or other analytical methods.

A design/analysis procedure of the type just described cannot be supported easily by a computer through the ordinary techniques available with FORTRAN, ALGOL, and similar problem expression methods because the relative rigidity of these methods simply does not allow for the necessary range of expression. Nor do these methods permit useful but difficult-to-express intuitive insights to be incorporated easily into the solution development. These problems are resolved by a graphic display such as the 1557/1558 System provides, because the entire system mirrors the human process and reduces the communications problem to hardware and software modules that, in effect, take over the central task of translation between man and machine. The user can now express a problem, go through an analysis, and develop a solution in graphic terms that are most convenient to him. He does not have to go through a nongraphic artificial language buffer that limits his range of expression.

Given a graphic-based interface with a computer system, the user can literally duplicate any pencil and paper operation but with the added capabilities of simulation, modeling, instantaneous perspective, 'zoom' effects, and many other dynamic techniques. Among the many possible applications of the 1557/1558 System, some techniques of online programming and computer-aided design are explained further to illustrate just how the system can be used (see Figure 3-1).

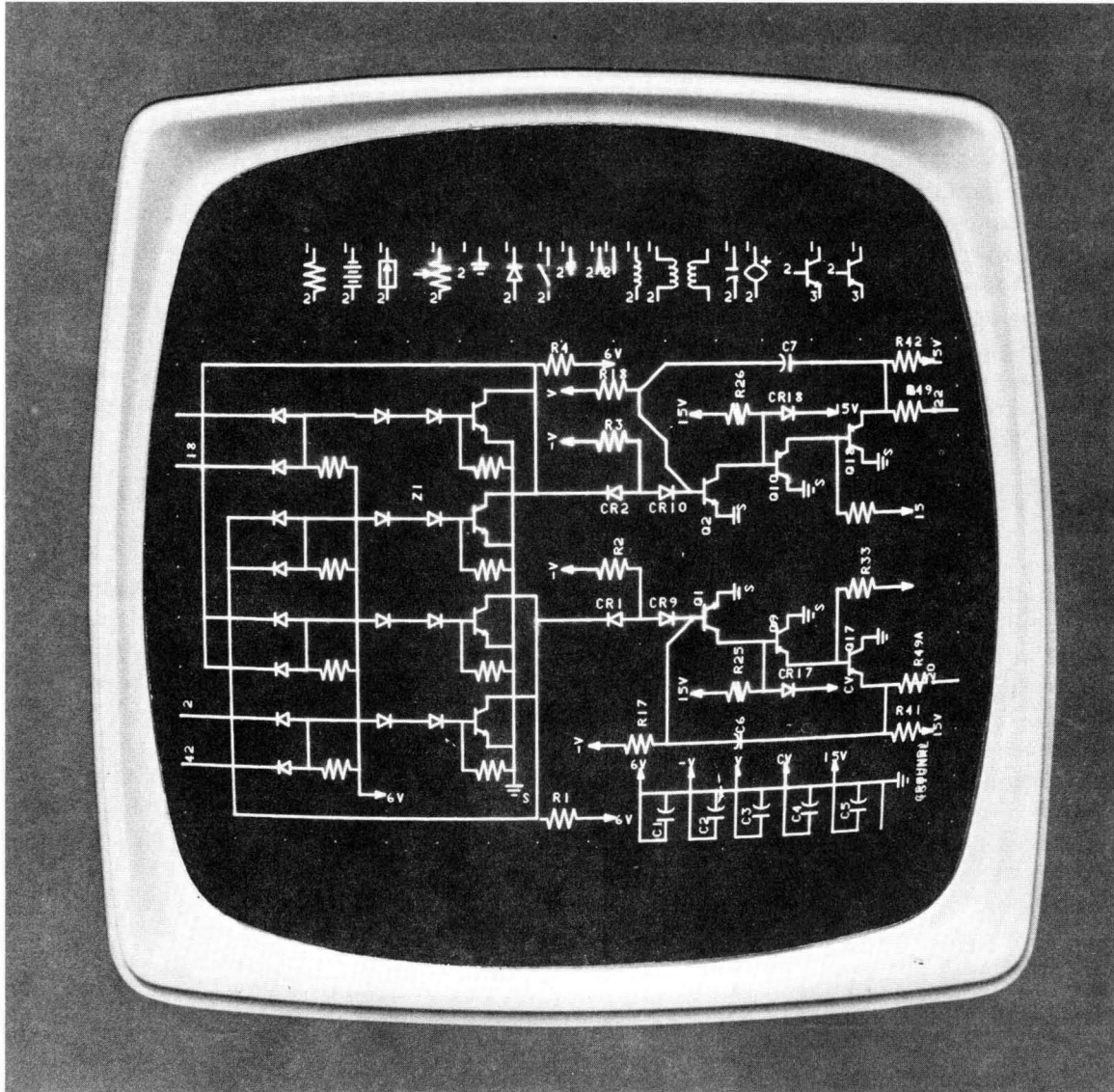


Figure 3-1. Circuit Design Presented on Display Screen

3.2. ONLINE PROGRAMMING

Online programming through a graphic display system may be accomplished at any level desired by the user. At the machine language level, a complete instruction repertoire can be displayed on the display console. The user may then point with the light pen to successive instructions that are automatically chained into a meaningful command ready for compilation or execution. Similarly, the display can consist of subroutine calls for more problem-oriented programming, and a sequence of procedures may be organized for execution when desired. The display can tell the user how many operands are needed and what transformations are allowable, and the whole system may be set up to provide a running program edit. An extensive system of checks, balances, and diagnostics can be coordinated through the display to guide the user to a more effective and efficient program.

The 1557/1558 System also provides function keys to extend the online programming capability. Specific functions are, again, determined by the application. To illustrate the possible use of function keys to program the solution of complex mathematical problems, certain keys may be used to introduce modalities that are then interrelated with the functions of other keys for numerical analysis, complex variables, calculus, etc.

The entire concept of online programming through a graphic display system introduces an element of easily sustained man-machine conversation that is very difficult to realize with other input/output equipment. The immediate effect is easier, more error-free programs. The long-range effects are an increasing capability, through continued use, to compress the programming through a shorthand style, and the ability to establish more intricate and useful correlations among data, processes, and solutions.

3.3. COMPUTER-AIDED DESIGN

Computer-aided design provides one of the most fruitful applications of man-machine interaction through displays, because of the nature of the typical design task. For example, the design of a circuit, a truss bridge, a freeform for a fuselage, or car door is not a cut-and-dried procedure except in the most trivial cases. The designer must go through a series of iterations that may require a large number of routine calculations. The designer begins general problem expression and potential solutions which may result in a crude preliminary design. This preliminary design is analyzed, structures or parameters are changed, and a more refined design is tested. The process continues until a satisfactory design results.

The computer-driven display is very useful because it can show the designer, in graphic two-or three-dimensional language, the exact appearance of each intermediate design. The design can be analyzed partially by the computer under direct supervision of the designer. The computer can compute parameters and iterations, drawing the results immediately, and allow the designer to change values and recompute in real time. A great variety of different techniques may be tested in this immediate feedback mode, because the computational and data processing capability of the computer can be coupled with the user's ability to make educated guesses and to initiate possible solutions.

In most computer-aided design programs, the CRT is used under cursor/light-pen/keyboard control in roughly the following manner, but not necessarily in the same sequence:

- (1) The screen is cleared.
- (2) Points, lines, and arcs are drawn either by light pen or keys.
- (3) Geometric constraints (parallelism, perpendicularity, equal angles, or lengths) are imposed.
- (4) Smoothing and linearizing take place.
- (5) Previously defined macros or drawn subpictures may be retrieved from memory and connected into the assembly.

- (6) The configuration may be altered by selective editing.
- (7) Entire subpictures or portions of the screen can be translated, rotated about any arbitrary axis, or nonuniformly scaled about an arbitrary axis.
- (8) The contents of the entire screen can be rotated through any three-dimensional axis.
- (9) The display can zoom in or out on an arbitrary region or component.
- (10) On the basis of function keys, overlays, or selections from a command list, standard computations can be performed on the displayed picture.
- (11) A detailed drawing suitable for output to a drafting machine may be developed. Instructions may be generated for a numerically controlled tool or wire-wrap machine, or a complete parts order list may be produced.
- (12) A finished screen drawing may be appropriately labeled and stored for future use.

The ability to make a change in a single component and then reflect the change in all higher level components is an extremely powerful tool. This uniform substitution capability radically simplifies updating and graphic file maintenance.

The design process quite literally becomes a one-man operation. The original designer participates in the complete design process and most of his laboratory work through display-monitored simulation. He also carries out the drafting and documentation chores. This total involvement is impossible to achieve through ordinary EDP methods and equipment, and is very difficult to sustain over long periods through manual methods, but becomes possible and practical through a device such as the UNIVAC 1557/1558 Advanced Graphic Display System.

4. OPERATION

To specify detailed operational procedures for the UNIVAC Advanced Graphic Display System is difficult because it depends exclusively on the application. However, the following generalizations may aid in establishing an operational pattern to clarify the operator's responsibilities.

- The operator must be familiar with the turn-on procedure for the controller which includes the bootstrapping of the operating program from the central processor. He must also know the procedure for the console turnon and reset. He must know the fault indications and the correction and recovery procedures.
- The operator has the responsibility, if required, of composing messages, using the console keyboard and light pen, and interpreting and responding to messages, and other output from the controller. In order to compose and respond to messages, the operator must be familiar with the operational features of the display console and controller. Also, the operator must know the functions of the operational program.
- Maintenance by the operator is restricted to replacement of air filters. He should also keep all cabinet doors closed to maintain proper circulation of air and should ensure that temperature and humidity are suitable.

APPENDIX A. GENERAL SPECIFICATIONS

DISPLAY

Screen Viewing Area	12 by 12 inches
Raster Count	1024 by 1024
Raster Interval	0.012 inch
Spot Diameter	0.020 inch
Characters	Closed
Generation	Stroke; up to 8/character
Size	Small: 0.09 by 0.12 inch Large: 0.16 by 0.22 inch
Timing	One microsecond/stroke plus two microseconds for space to next character position
Per line	Small: 80 Large: 40
Lines/Display	Small: 56 Large: 28
Max. Screen Capacity	Small: 4480 Large: 1120
Short Vector	Up to 63 raster units (0.768 inch)
Long Vector	Up to 1024 raster units (12 inches)
Refresh Rate	Program Controlled - recommended at 60 times/second
Character Set	96 symbols, including 64-character ANSCII set, Greek, and special symbols

KEYBOARD

Basic Alphanumeric Typewriter
8 Cursor-Control Keys
5 Editing Keys
35 Function Keys
128 Function-Key Overlays
8 Overlay Function Keys

STORAGE

Size	8K, 12K, or 16K
Word Size	18 bits
Cycle Time	700-Nanoseconds
Type	Plated Wire

INSTRUCTION SET

26 instructions (average execution time, 1.4 microseconds)

SUBSYSTEM SIZE

Up to three UNIVAC 1558 Display Consoles for each UNIVAC 1557 Display Controller.

INTERFACE

Direct: Any channel on UNIVAC 1108.

Communication Line: AT&T 205B2 or 201B Modem.

POWER

120 vac, +5%, -10%

Single Phase

60 Hz \pm 0.5 Hz

Controller: 1.7 Kw

Console: 1.5 Kw

SIZE/WEIGHT

Controller: 48 x 24 x 64 inches/1000 lbs.

Console: 35 x 60 x 50 inches/750 lbs.

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 SPERRY RAND