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COMPUTER AIDED ANALYSIS CONTROL AND DISPLAY SYSTEM FAMILIARIZATION MANUAL

MANNED SPACECRAFT CENTER

HOUSTON, TEXAS

November 8, 1968

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COMPUTER AIDED CONTROL AND DISPLAY SYSTEM

FAMILIARIZATION MANUAL

PREPARED BY

D. Osgood, Project Engineer
Data Systems Development Branch

APPROVED BY

O. Patterson
Head, Data Systems Development Section

J. Overton
Chief, Data Systems Development Branch

P. Vavra
Chief, Information Systems Division

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SECTION 1

SUMMARY

The Computer Aided Analysis Display and Control System rapidly analyzes communications systems for the Apollo Program. It aids the analyst in the determination of optimum equipment configuration and operation. In addition, the system mathematically defines new communication systems or links to meet theoretical conditions.

Through a series of programs, the system uses the speed and accuracy of the IBM 360/44 computer and the digital television display system to solve communications problems. At critical points in the analysis procedure, the communications analyst can intervene. By observing the video monitors and activating the console controls, he can select the program, define the problem, and evaluate the resultant solution.

The system provides three capabilities: system synthesis, performance prediction, and postmission analysis. Programs operate on two types of communication systems: developmental and predefined. The end product of the system is a graphic display of the analysis results. This display can be temporarily held on a video screen or plotted on paper for permanent retention.

SECTION 2

INTRODUCTION

2.1 SCOPE of MANUAL

This manual explains the planned capabilities of the Computer Aided Analysis Display and Control System (CAADS). It presents the overall design of the major programs. A typical program is selected to demonstrate operator-equipment interaction. In addition, the manual briefly describes the system equipment.

At present only a portion of the planned capabilities exist. RF coverage analysis programing for performance prediction is currently under test and modification. It is contemplated that by late 1969 the basic capabilities for developmental analysis will be operational.

For detailed system information, consult the following publications:

a. Program Plan for Development of a Computer Aided Analysis System, Staff Plan, C. T. Dawson EB/2, Oct. 19, 1967.

b. Communications Computer Analysis System Program Requirements, LEC Report no. 602011-1, Oct 27, 1967.

c. Computer Graphics System Requirements, LEC Report no. 703002-1, Jan. 23, 1968.

d. Computer Aided Analysis System Input Program Requirements, LEC Report HASD no. 703008, Aug. 5, 1968.

e. System Description, Communications Analysis Display Subsystem, LEC Preliminary Report no. 703003, April 26, 1968.

f. Post Analysis Program Requirements, LEC Report no. 703009-1, Aug. 12, 1968.

g. Computer Aided Analysis System Output Program Requirements, LEC Report HASD no. 703010, Aug. 30, 1968.

2.2 PURPOSE

The purpose of CAADS is to improve Apollo system communications - and do this on a near real-time basis. The system solves communication problems by processing digitized data under direction of stored programs in the IBM 360/44 computer. A digital display system presents the solutions to the operator. The CAADS also models new communications systems and computes and displays their theoretical efficiencies.

SECTION 3

SYSTEM DESCRIPTION

3.1 FUNCTIONS

The CAADS is a problem-oriented system whose functions are analysis and display. Analysis is conducted by solving study objectives such as signal-to-noise ratio, optimum modulation indices, and radio-frequency coverage. The display function is performed by the digital television display system (DTDS) which converts digital data to video images on standard TV screens.

In the system operation, the communications analyst responds to a series of video displays by operating the DTDS alphanumeric keyboard. The sequence of displays is designed to guide the analyst to the solution computed for his preselected study objective. An example of a study objective is a graph of signal-to-noise ratio versus time.

3.1.1 Analysis

Two types of analysis can be conducted. Predefined analysis uses system configurations that have been established through mathematical modeling. Developmental analysis uses element configurations that are experimentally designed by the analyst.

Five major programs implement the analysis function. These are (1) optimum mode selection, (2) performance prediction, (3) postmission analysis, (4) mathematic modeling, and (5) problem source identification. Operational routines that are common to all major programs provide for operator intervention in the analysis procedure. These are executive programs, input programs, study objective programs, and output programs. Figure 3-1 shows the relationships among these programs. The dotted lines show data flow. The solid lines show control. Arrays are sets of core locations in the computer used for data storage.

As shown, the executive program calls in the input program. This program presents a sequence of displays to the operator allowing him to select

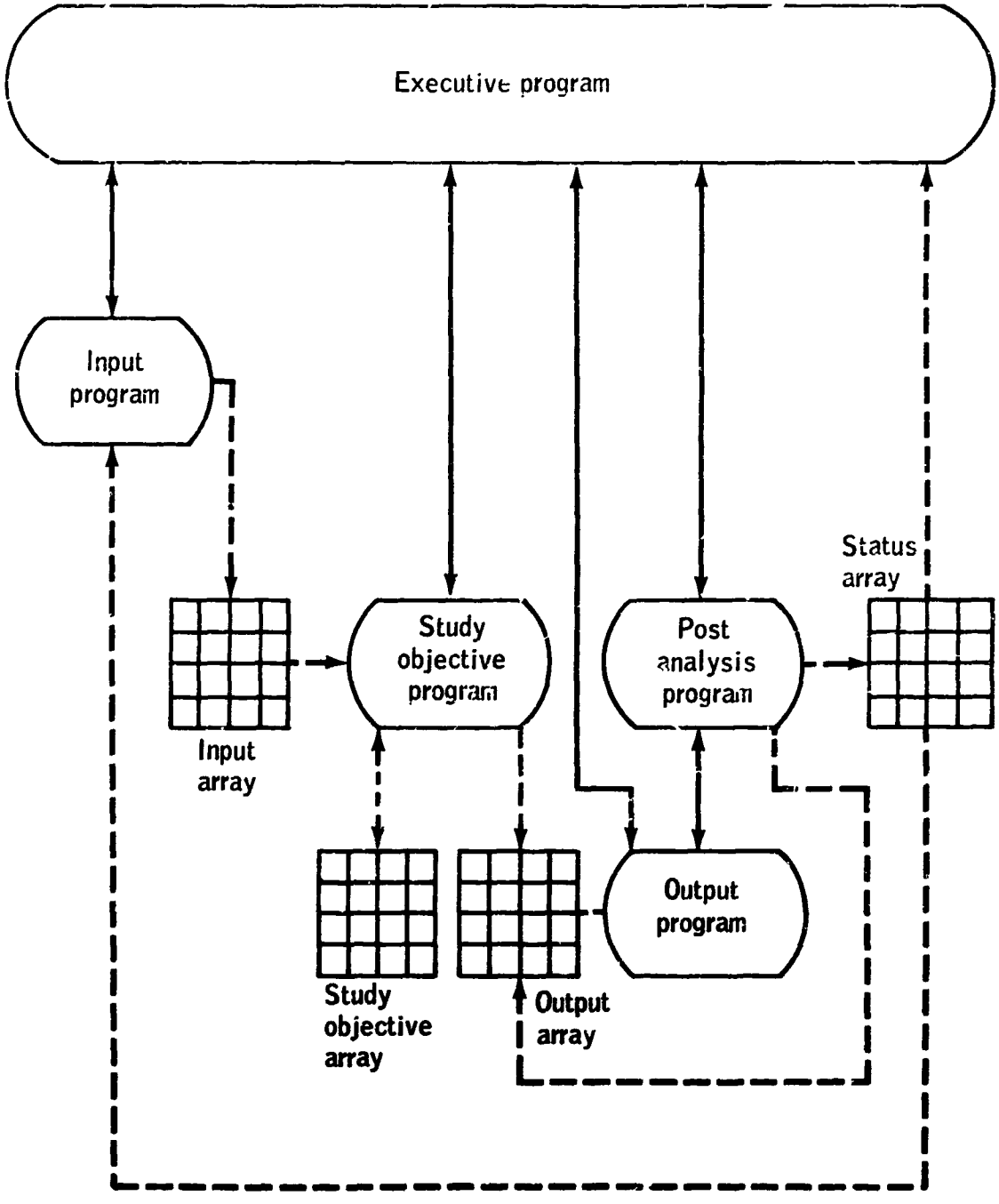


Figure 3-1. Operational programs.

the communication system configuration, type of analysis, and parameter values. These values are stored in the input array. The executive program then calls in the selected study objective program. The study objective program stores its computed results in the output array. The executive program then calls up the output program which displays grids, graphs, and axes on the monitor screen using plot control data from the output array.

If the operator desires, the executive program can call up the postanalysis program which presents him with display options from which he can select a modification to the system parameters, graphic plots, or study objectives.

Program relationships to the study objective program are shown in figure 3-2. Initially, the executive program turns control over to the assembly program which calls up the desired study objective program. This program utilizes the communication system and analysis program to accomplish the required computations. The communication system is made up from link subroutine programs which, in turn, are made up from element subroutines. The element subroutines have access to a library of mathematical functions such as bessel and gamma functions. The output program displays results either on screens, Gerber plots, or both.

3.1.2 Display

Displays function to inform and guide the communications analyst and present him with a visual solution of the analysis problem.

The system uses two types of displays. One type is video monitors which display data temporarily when directed by the various programs or operator actions. The other type of display is the hard-copy display which is generated by operator action.

Video display monitors are mounted on DTDS consoles above the alphanumeric keyboards. The three monitors are fed by recirculator channels selected by the executive program. These displays present the operator with a selection of options, a read-out of selections made, and the analysis results. Manual control of the display process is

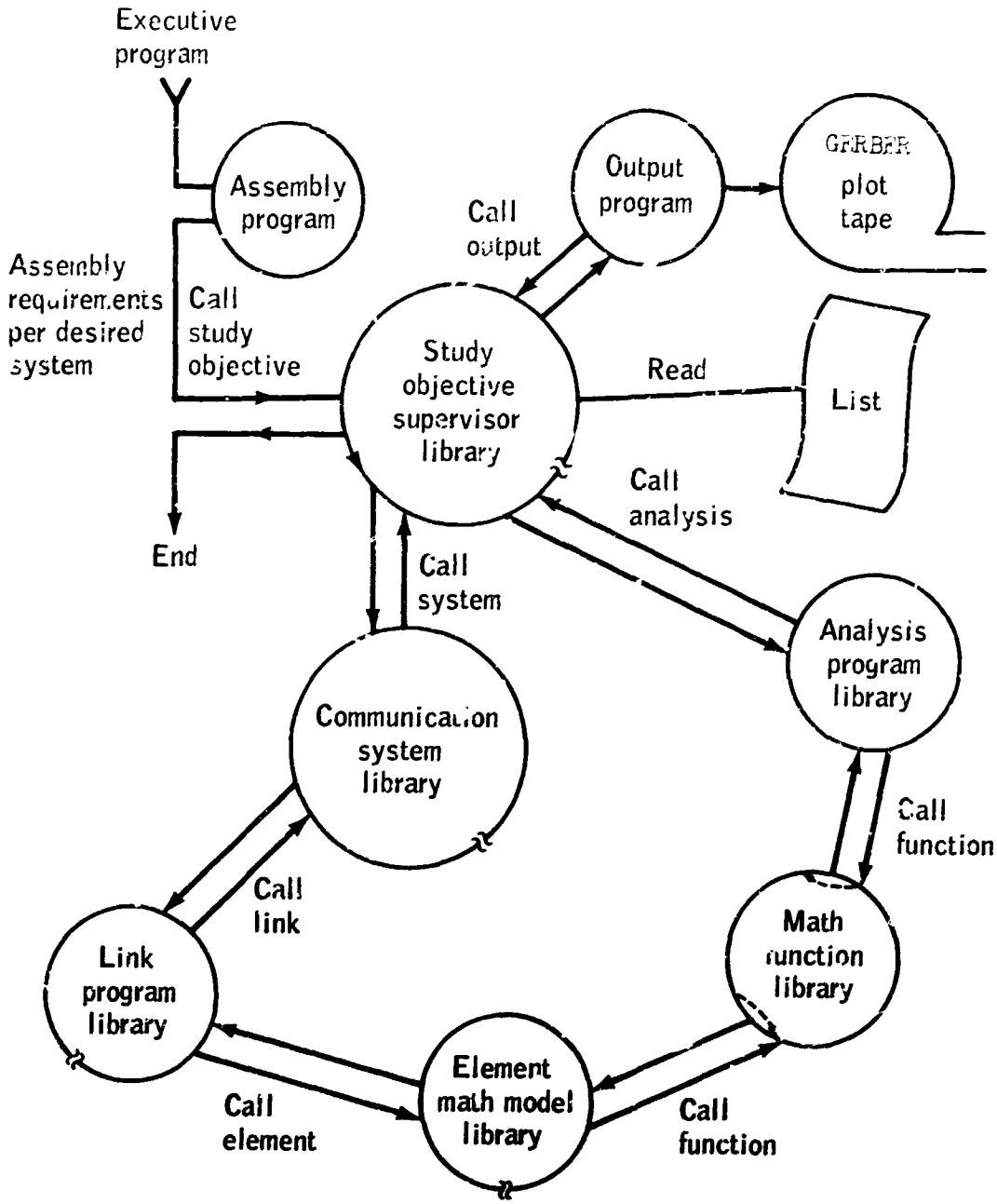


Figure 3-2.- Study objective program control.

accomplished by typing on the alphanumeric keyboard. The machine language program generating the displays is stored in two memories. Complete displays usually used on the option screen are held in the DTDS random access memory (RAM). These complete displays are called up by inserting the RAM tape address into the program. Displays which can be modified by the operator or computer programs are held in the IBM output buffer. Data from either source are converted to display language suitable for television-type display by the display assembler subsystem of the DTDS.

The Gerber plotter provides hard-copy displays of graphs. This equipment is presently operational only in an off-line mode. The function is initiated by the operator through keyboard action. When the option to print out the analysis results on the Gerber plotter is presented to the operator and acted upon in accordance with program instructions, the display held in the computer buffer is read onto magnetic tape. The computer buffer word format is converted to Gerber tape format by a portion of the Hydra II program. The completed tape must be manually inserted into the incremental tape transport of the Gerber system. A typical Gerber plot is seen in figure 3-3.

3.2 EQUIPMENT

Hardware consists of three systems. The IBM 360/44 computer sequences programs and formats data. The digital television display system converts computer data to displayed information. The Gerber plotter produces display artwork from a magnetic tape input.

3.2.1 IBM 360/44 Computer

This equipment group consists of a central processing unit, an internal disk storage unit, magnetic tape transports, a selectric typewriter to input or output data, and a printer for hard-copy read-outs. The 2701 data adapter interfaces the DTDS with the computer. This unit enables the computer to receive and transmit commands and data in the proper format. It checks parity and assures correct signal levels. The central processing unit computes using a cycle time of one microsecond, 32k word storage, and a standard 32-bit word. The disk storage unit stores

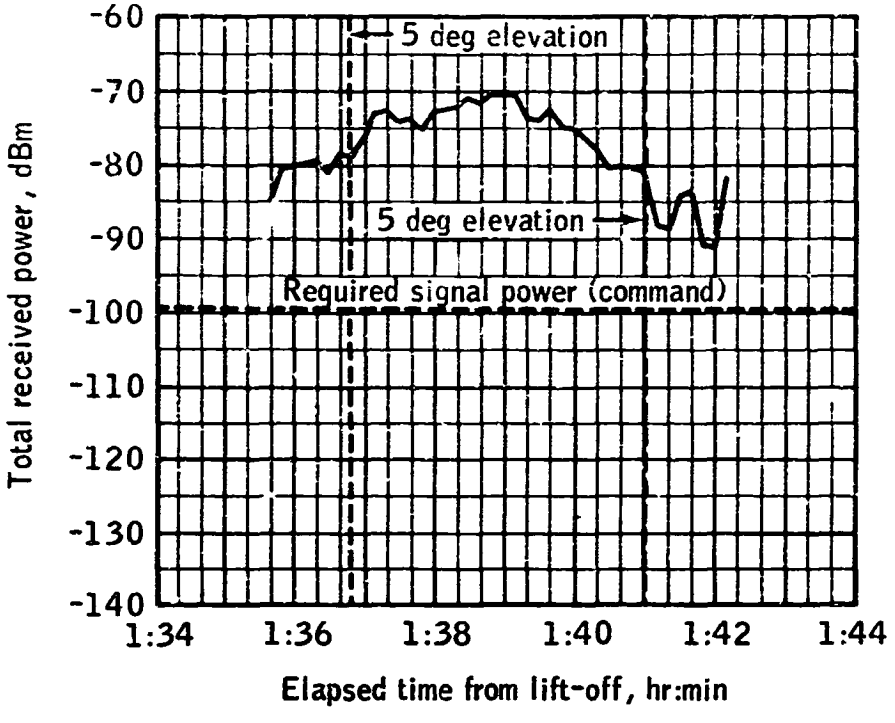


Figure 3-3.- Gerber plot.

up to 250k words with an average access time of approximately 70 milliseconds. Of the three tape transports, two are seven-track and one is nine-track. The printer prints at a 240-line-per-minute rate. This equipment is shown in figure 3-4.

3.2.2 Digital Television Display System

This system converts digital data from computers and operator keyboards into video signals for display by 729-line television monitors. The system consists of a display processor subsystem, display assembler subsystem, recirculating memory subsystem, random access memories, and four operator keypacks. The system is contained in 13 standard relay racks, two special cabinets, and four consoles. See figure 3-5.

The display processor subsystem generates vectors and characters, converts computer system display aspect ratio from square to rectangular for the video screens, and communicates with the computers. The display assembler subsystem assembles individual display elements into a complete background and transmits these backgrounds to recirculators which serve to maintain a constant picture on the video screens.

The special cabinets seen in figure 3-5 (center-rear) are random access memories. These units store complete background displays on endless tape loops. Each tape loop stores up to 3.1 megabits of data. Since each cabinet contains two cartridges of eight tape loops each, the total storage capacity of a RAM is 50.2 megabits. The backgrounds can be retrieved and displayed by keyboard action or by programing the computer. For a more detailed description of the DTDS, see the system FAMILIARIZATION MANUAL or USERS' GUIDE available in the Information Systems Division library.

3.2.3 Gerber Plotter

The Gerber plotter consists of a control cabinet, containing an incremental tape transport and logic circuitry, and a plotting table with an electromechanical stylus mechanism. Magnetic tape coded with BCD alphanumeric seven-channel code

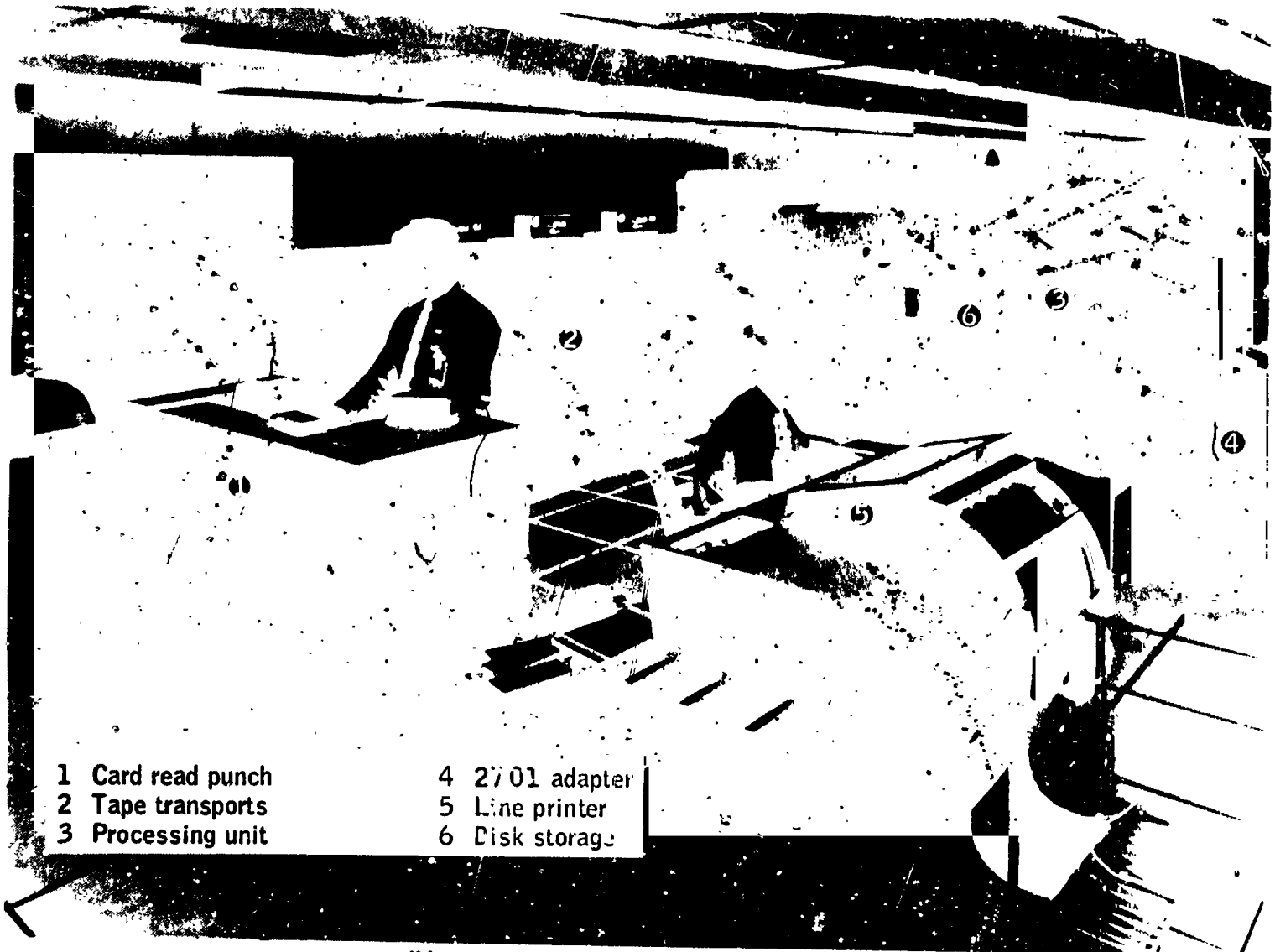


Figure 3-4.- IBM 360/44 Computer.

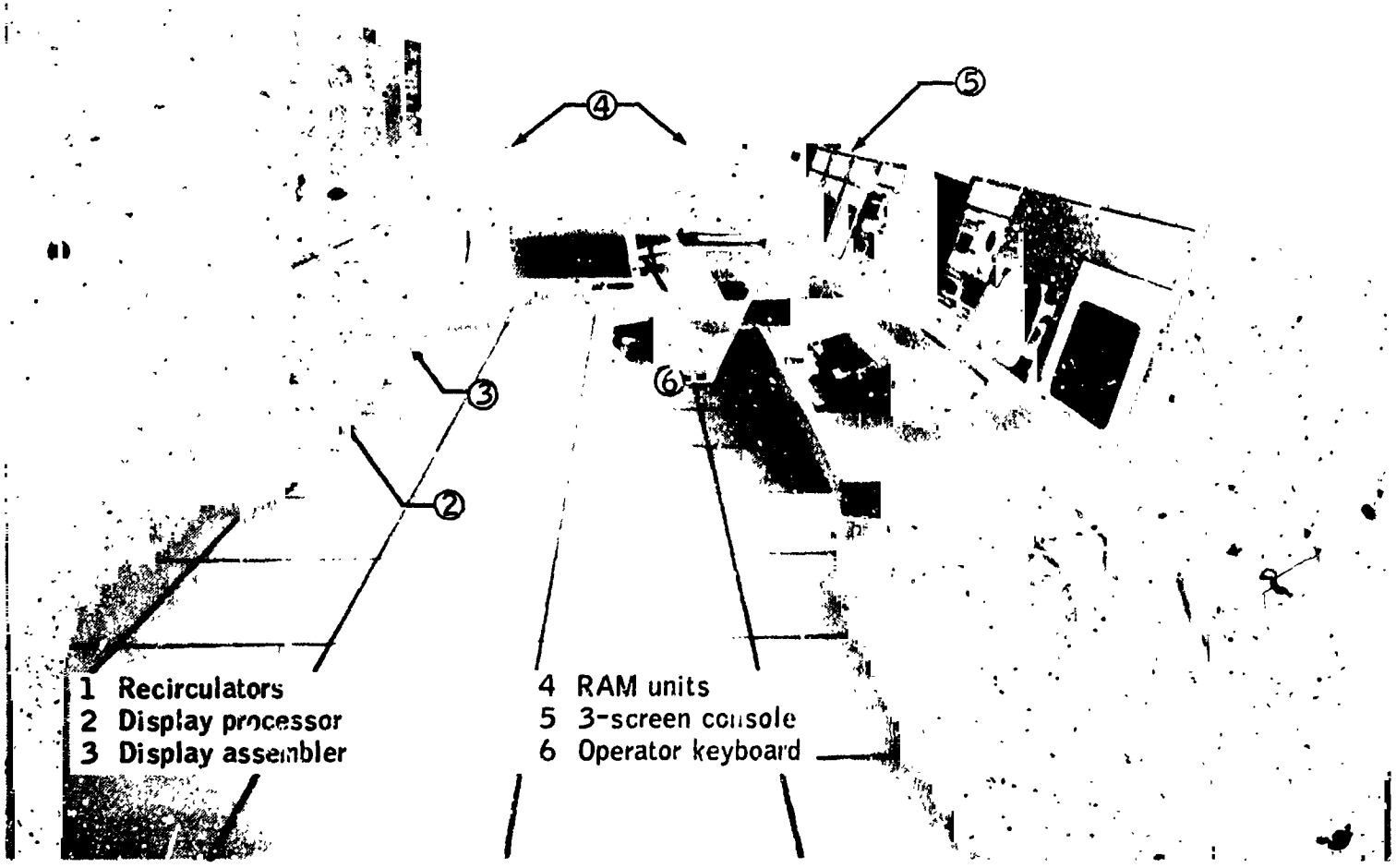


Figure 3-5.- Digital television display system.

generates positioning commands to the plotting table (60 by 50 inches in area). The transport accepts IBM tapes. Commands can be accepted for vectors up to 9.999 inches. This length can be scaled up to 16 times by control panel switch settings. Control electronics, located in the right-hand rack of the cabinet, consist of logic plug-in modules. Plotter traverse speed is a function of command rate, varying from 60 inches to 600 inches per minute. Figure 3-6 shows the plotting table with the tape transport and control logic cabinet to the rear.

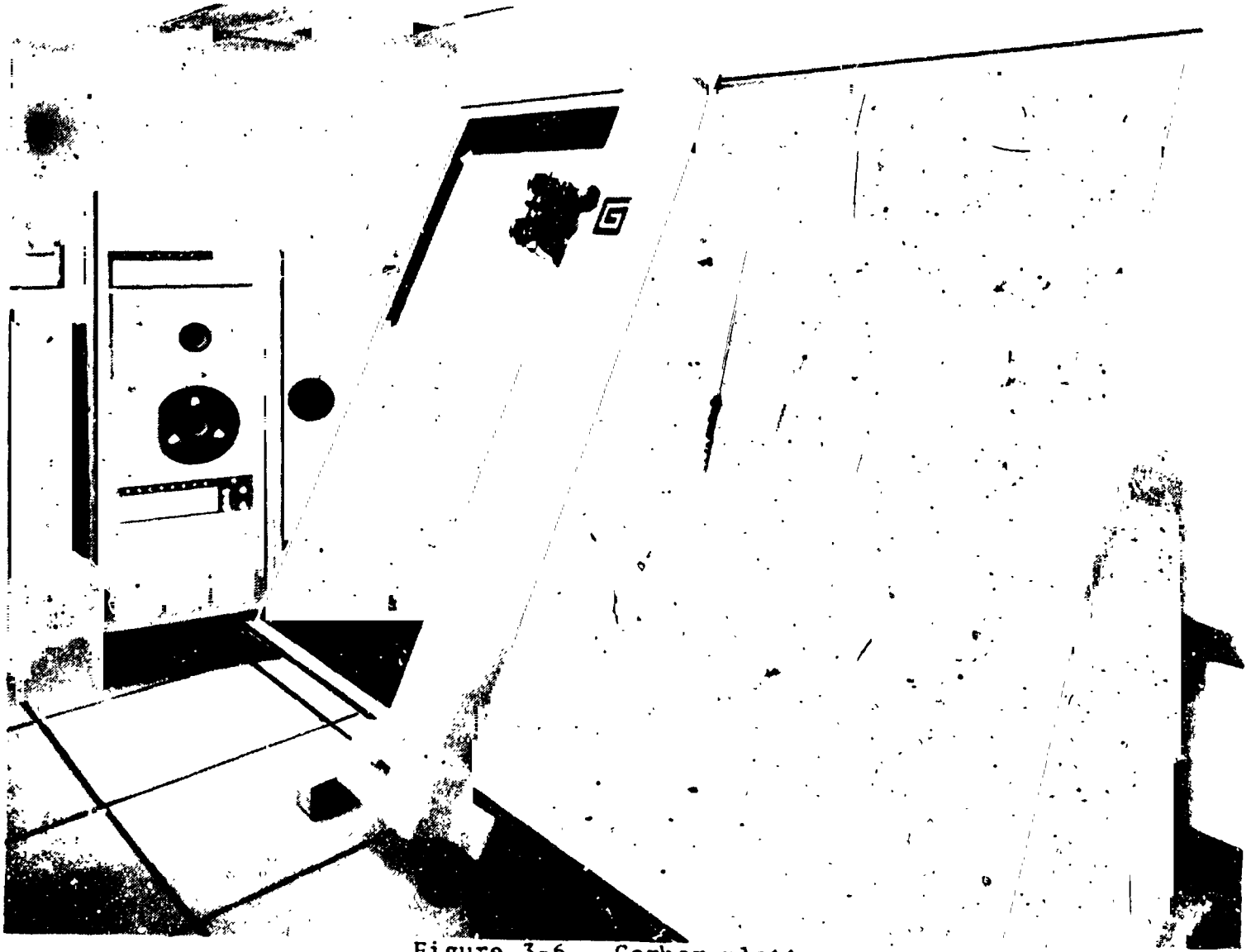


Figure 3-6.- Gerber plotter.

SECTION 4

SYSTEM OPERATION

4.1 INTRODUCTION

The postanalysis program is selected to acquaint the reader with system operation. This program returns to the input program, extracting data stored in the input array to assist in making system changes. The program also uses the output program to reflect system changes on the video screens or magnetic tapes. Thus, the postanalysis program permits an iterative analysis of the communication system under investigation.

4.1.1 Theory of Operation

Assume the operator desires to scale a portion of a graph presented as a study objective analysis result. He also wants this expanded graph in hard-copy form. He then initiates the postanalysis program and interacts with the program in a series of steps or units. (A unit is defined as a display and possible operator response.)

The option screen displays options currently available. The operator selects an option by typing its number on the alphanumeric keyboard. This selection is displayed on the selection screen. When he completely defines his requirements to the system, the output display screen displays the solution. If he is satisfied with the solution (in this case, an expanded portion of the graph), he then directs the system to provide him with a hard copy of it.

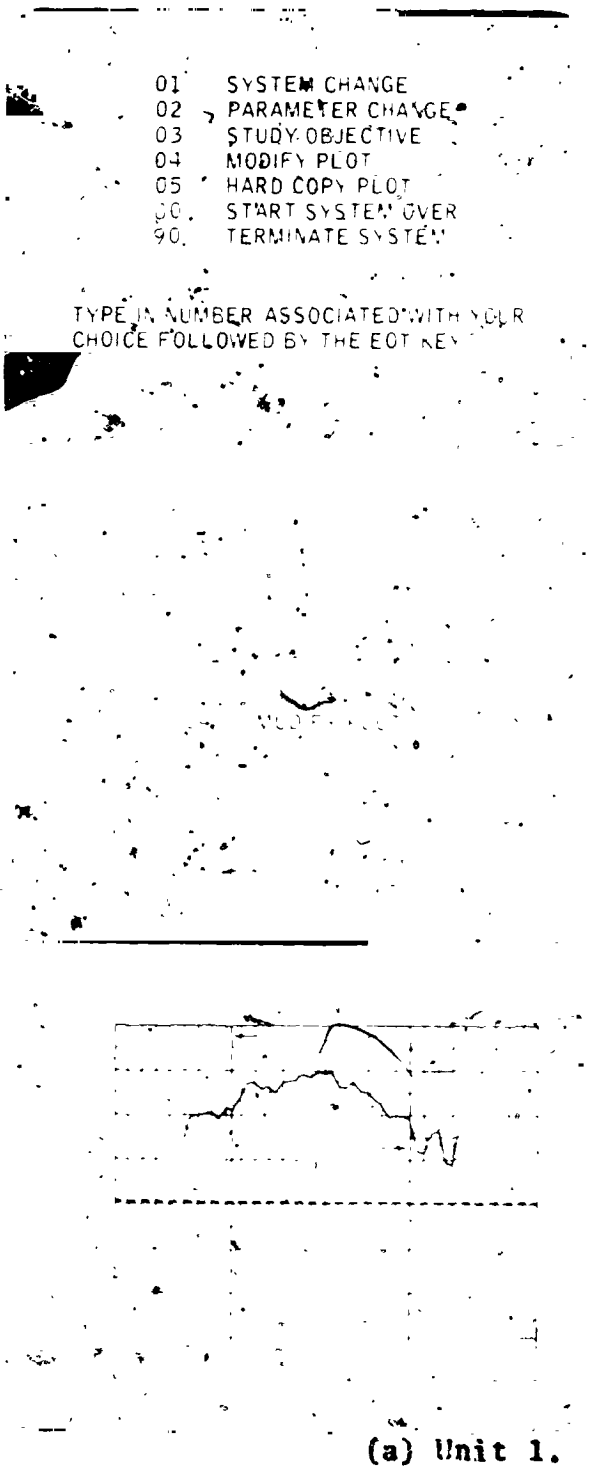
Figure 4-1 shows video screen displays. Table I lists operator actions. The reader can follow the program sequence by associating units noted in the table and on the figures.

4.1.2 Postanalysis Program

TABLE I.- OPERATOR ACTIONS

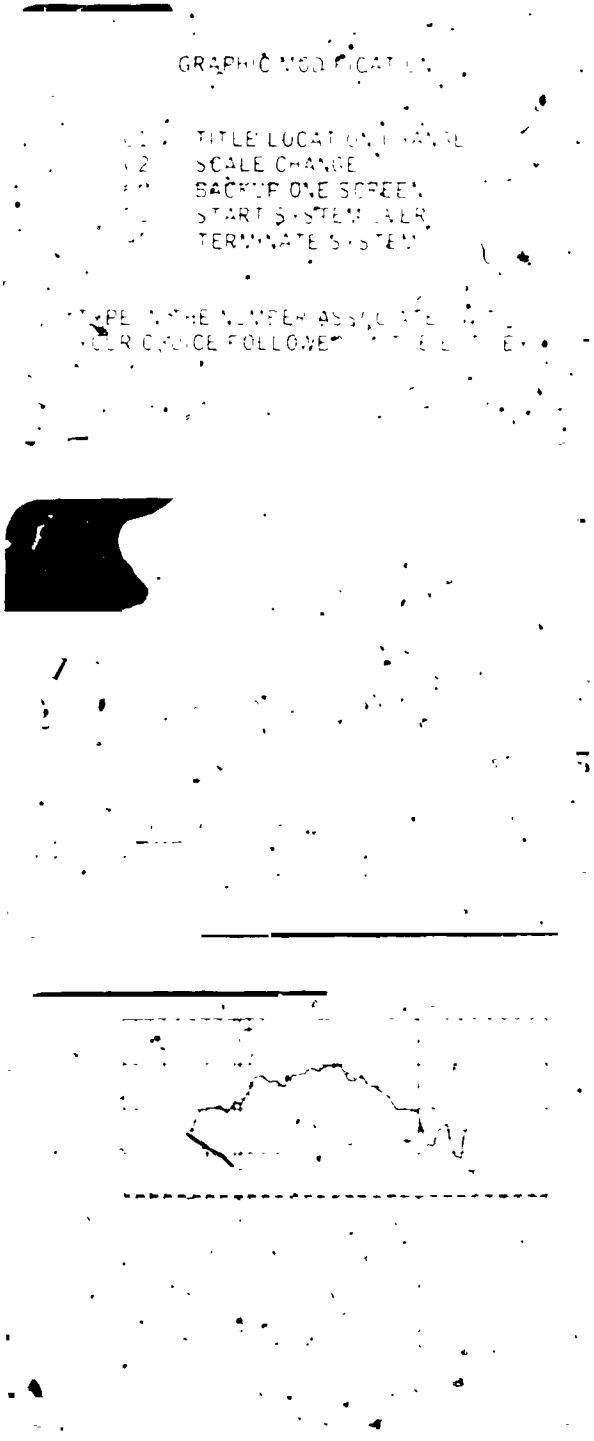
Unit	Option selection	Key selection	Remarks
1	04 MODIFY GRAPHIC PLOT	(1) 04 (2) EOT	
2	02 SCALE CHANGE	(1) 02 (2) EOT	
3	01 MIN. VALUE XXXX.XXX	(1) 01 (2) EOT (3) 1.368 (4) EOT	Horiz. scale change. Type in numerical value.
	02 MAXIMUM VALUE YYYY.YYY	(5) 02 (6) EOT (7) 1.410 (8) EOT	Type in numerical value.
	70 DISPLAY NEXT PROPER SCREEN	(9) 70 (10) EOT	
4	01 MIN. VALUE XXXX.XXX	(1) 01 (2) EOT (3) -100.000 (4) EOT	Vertical scale change. Type in numerical value.
	02 MAX. VALUE YYYY.YYY	(5) 02 (6) EOT (7) -60.000 (8) EOT	Type in numerical value.
	70 DISPLAY NEXT PROPER SCREEN	(9) 70 (10) EOT	Graph expands at this time.
5	05 HARD-COPY PLOT	(1) 05 (2) EOT	
6	01 GERBER PLOT	(1) 01 (2) EOT	Generate tape.

Note- For a list of standard option codes, refer to table II.



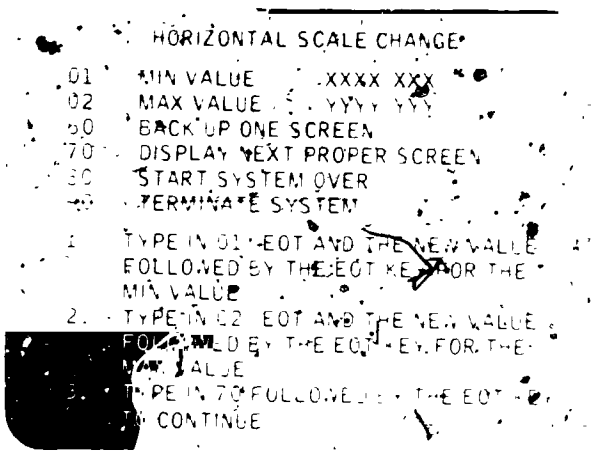
(a) Unit 1.

Figure 4-1.- Sequence of unit displays.

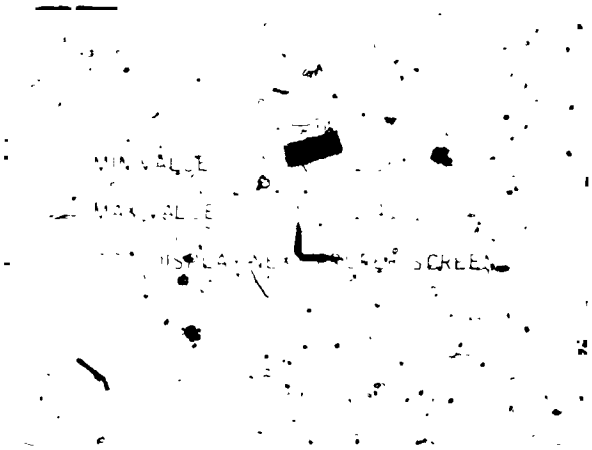


(b) Unit 2.

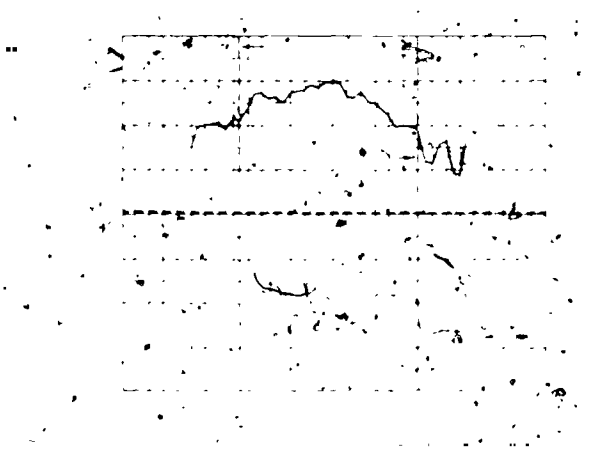
Figure 4-1.- Continued.



Option screen



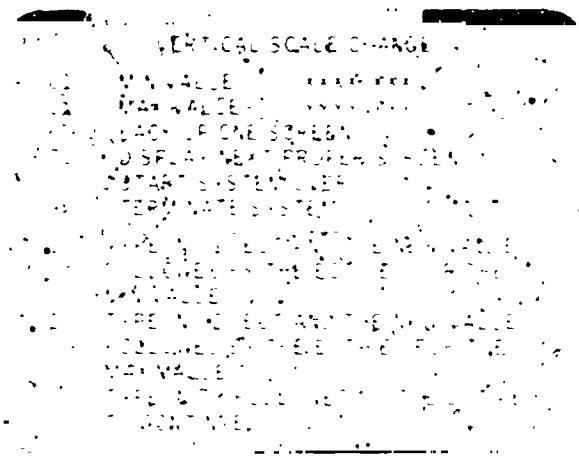
Selection screen



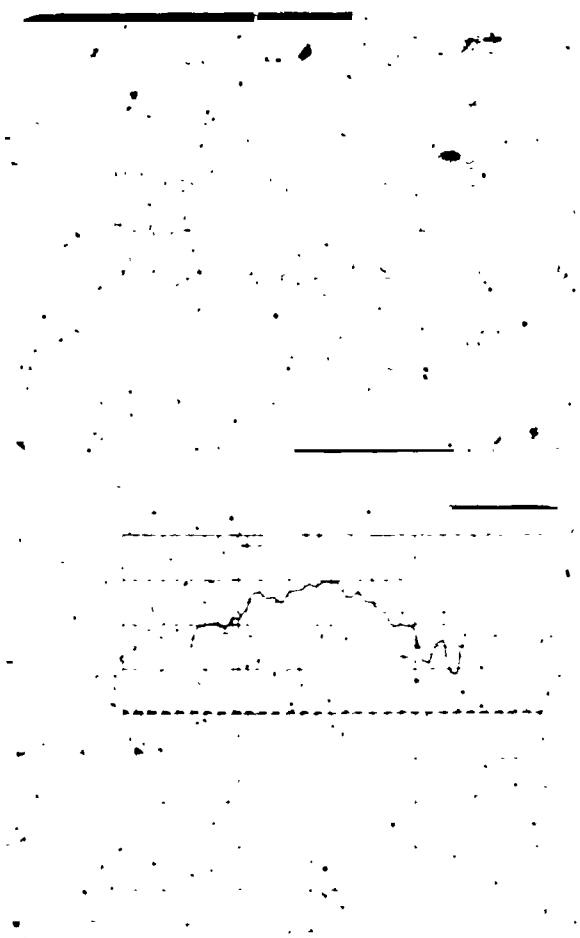
Output display screen

(c) Unit 3.

Figure 4-1. Continued.



Option screen

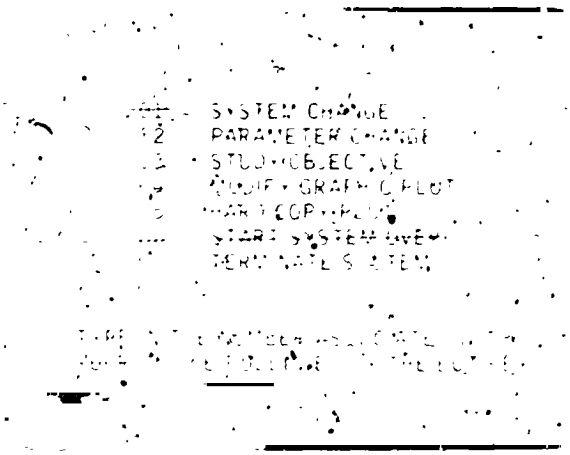


Selection screen

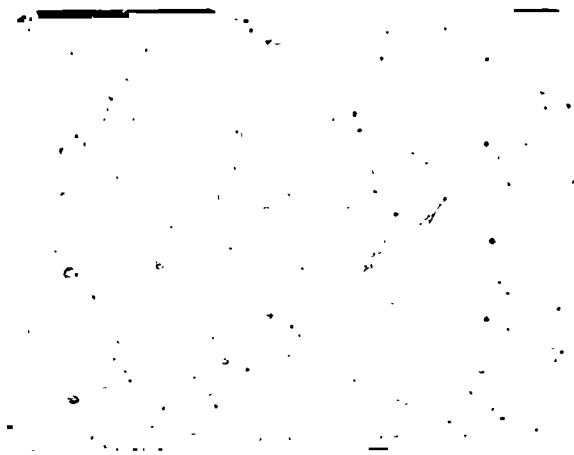
Output display screen

(d) Unit 4.

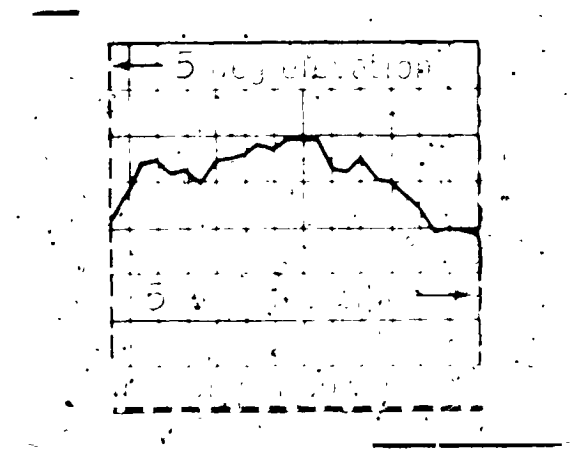
Fig 4-1.- Continued.



Option screen



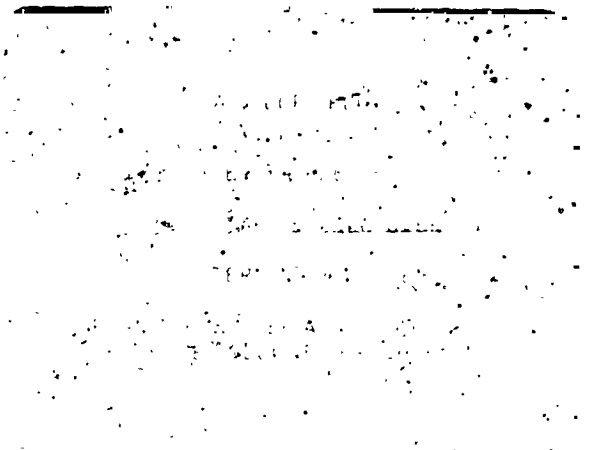
Selection screen



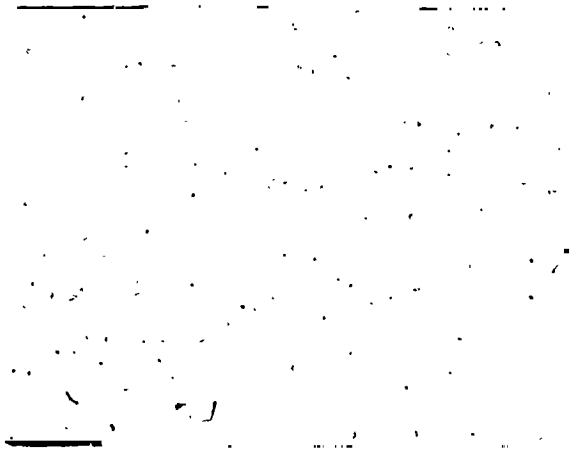
Output display screen

(e) Unit 5.

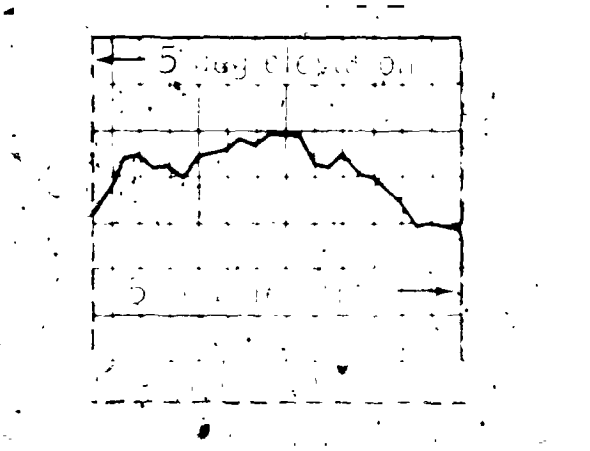
Figure 4-1.- Continued.



Option screen



Selection screen



Output display screen

(f) Unit 6.

Figure 4-1.- Concluded.

TABLE II.- STANDARD OPTION CODES

Code	Use
EOT	Terminate inputs from keyboard.
60	Back up one unit.
70	Display next proper unit in sequence.
80	Start over. Return to executive program and initialize all arrays. Call in input programs.
90	Terminate system. Return control to executive program.

Note- If a selection is made other than those displayed, an error message will be displayed at the bottom of the screen.