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DDP-516 COMPUTER GRAPHICS SYSTEM CAPABILITIES

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16. Abstract

This report describes the capabilities of the DDP-516 Computer Graphics System. One objective of this report is to acquaint DOT management and project planners with the system's current capabilities, applications hardware and software. The Appendix is devoted to discussion of representative DOT project applications.

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1.0 INTRODUCTION

This report summarizes the many existing features of the DDP-516 Computer Graphics System. Examples of the current applications are presented on pages A-3 to A-38. A significant increase in the operational capabilities of the DDP-516 Graphics System will soon be achieved with the addition of data phone communications. A user will be able to dial up a remote computer or computer network and utilize this computer for processing and storage which would be too large for the 516. The DDP-516 Graphics System (GOTS) is an operational, fully developed and supported interactive graphics system utilized for selected Transportation System Projects. The system is composed of a spectrum of input/output devices, and the DDP-516 computer. The computer has a 32K core memory plus two disks, magnetic tape, analog-digital input capability, a disk operating system (DOS), a time shared DOS, and a wide variety of FORTRAN, graphics and utility programs on file. There are many varied projects and users on the system at this time. Transportation system projects selected for this system usually require interactive graphics capabilities, advanced techniques, rapid turn around time and support by experienced computer graphics personnel. Special projects have included the processing and three color plotting of analog data from magnetic tape. Schematic overviews of the Interactive Graphics System are shown in Figures 1 and 2.

1.1 MAJOR FEATURES

1.1.1 Computer System Operations

The system is very versatile and reliable and can operate in several modes:

- In dedicated, stand-alone mode either for batch processing or interactive graphics
- In time sharing mode supporting up to five remote terminals through dataphone dial-up.

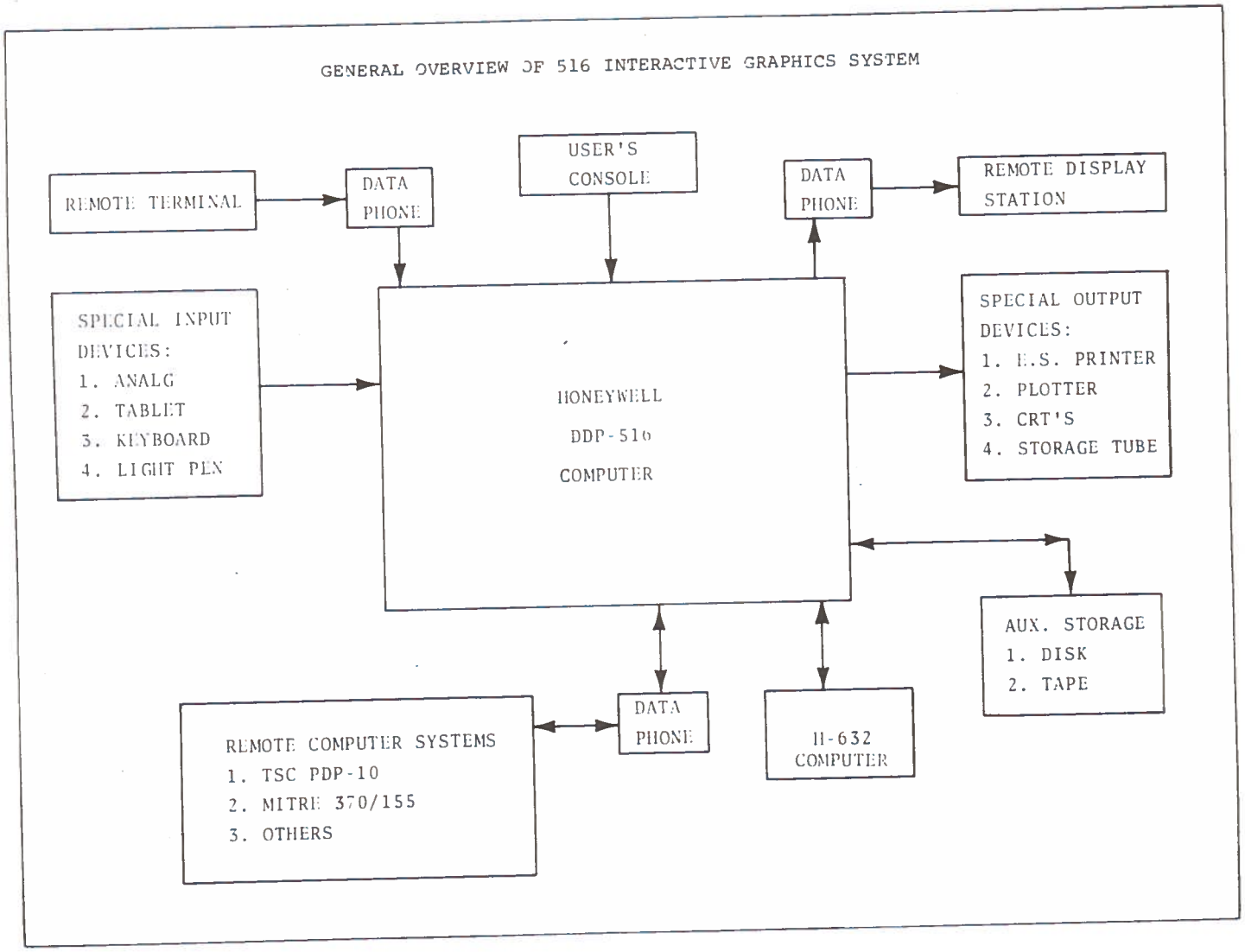


Figure 1. General Overview of 516 Interactive Graphics System

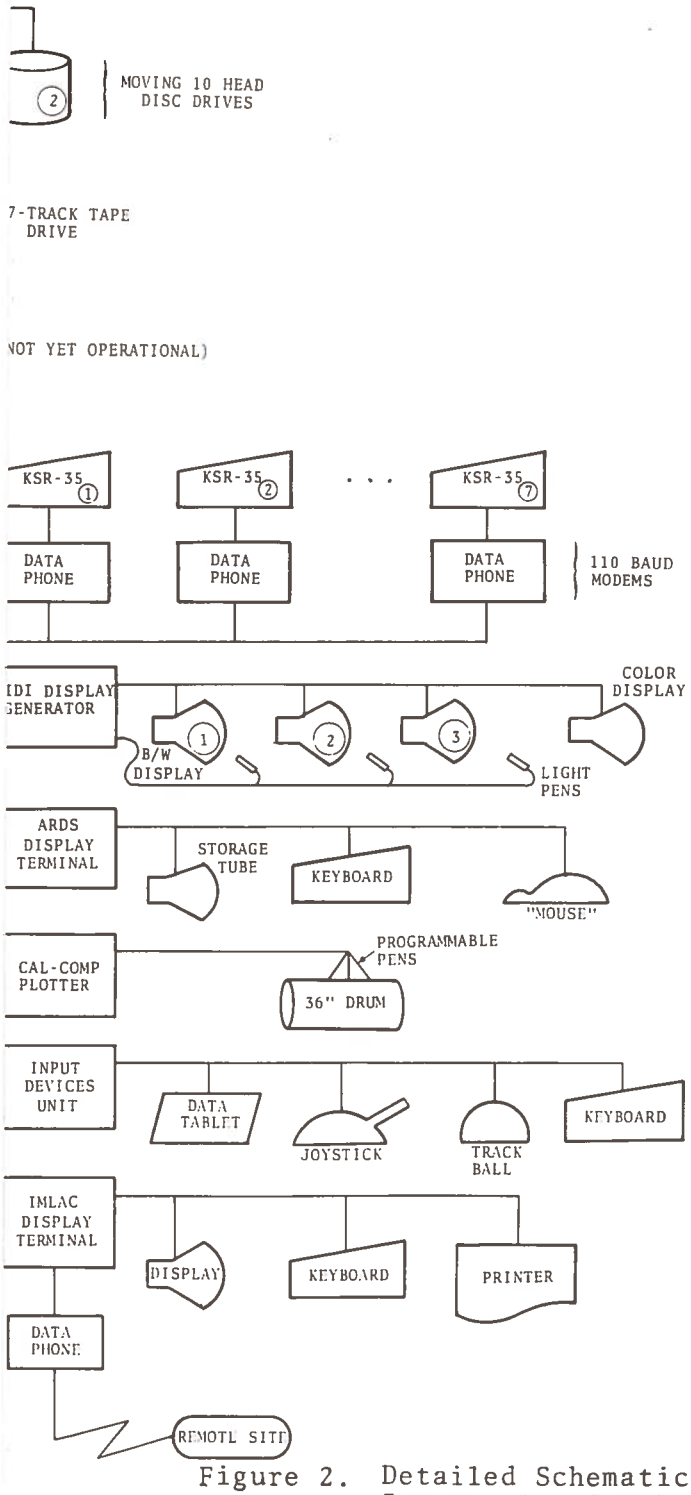


Figure 2. Detailed Schematic of Interactive Graphics System

- In hardwire coupled mode to the H-632 where the 516 performs I/O functions and the H-632 is used for memory and processing and with options for card reader, line printer and magnetic tape read or write.
- In high speed dataphone dial up mode to other TSC and external computers to utilize larger capacity.

Inputs - The system can accept data from a number of input devices including:

- Paper tape
- Analog devices
- Light Pen
- Tablet and stylus
- Keyboard
- In coupled mode with H-632 - punched card and magnetic tape.

Outputs - The following output devices are available individually or in any combination:

- Three monochrome CRT's
- ARDS storage tube terminal
- CALCOMP three pen drum plotter
- IMLAC CRT terminal (which also can operate stand alone or via dataphone to another computer)
- VERSATEC high speed electrostatic plotter and printer (which also can be dialed up from the TSC PDP-10 computer) Teletypewriter

The system is highly flexible and designed for modular growth to meet project requirements. For example, as new devices are added such as an IMLAC CRT display terminal or the electrostatic high speed printer/plotter, a minimum of effort is required for integration of both hardware and full software support.

1.1.2 Operations Via Data Phone

The usage of the 516 system via communication lines includes two types of operation. The first is the use of remote terminals such as teletypewriters and display stations. This capability is currently operational under time sharing which can support up to

five simultaneous users. The second type of operational configuration will be the coupling of the 516 system via data phone links to a remote computer such as the TSC PDP-10 or the MITRE 370/155. Another option available to a user would be connecting to computer networks such as the ARPA network. This type of operation will permit usage of the 516 as an input-output processor with full graphics available to the user. The storage and processing functions will be performed on the remote computer. One currently planned application is the STAR project (OS-212) where large programs will be processed on the MITRE 370/155. Inputs will be from the 516 and outputs may utilize CRT displays, printer, storage tube display and/or the CALCOMP plotter. Another type of operation could be the use of a remote computer data bank where programs and data are maintained and updated and would be available to TSC.

1.1.3 Hardware

The DDP-516 consists of 32k core memory, two random access disks of 14 million character capacity, and one magnetic tape drive. The computer is directly coupled to the H-632 computer which has 32k core plus a 28 million character disk memory. The peripheral equipment consists of the following:

- Three monochrome CRT displays with light pens (See Appendix for details)
- A Sylvania data tablet
- A CALCOMP drum plotter
- A teletypewriter console plus five TTY's for time share operation
- An ARDS storage tube terminal
- An IMLAC CRT display station
- An electrostatic printer/plotter
- Analog input devices - trackball and mouse

1.1.4 Software

A major feature of the system is the modular software support package. Additional peripheral devices required for new project applications can be added with minimal effort. Existing software is modular and is utilized immediately by the new devices with the inclusion of only a small driver-adapter routine. Software support includes:

- A disk operation system (DOS)
- A time shared DOS for five terminals
- FORTRAN and GASP languages
- Utility programs for each peripheral device
- A comprehensive graphics library
- Diagnostic programs and messages
- Editing using CRT for display.

1.1.5 Personnel

A factor in the overall developmental system capability is the large number of experienced personnel who have utilized the graphic system. A list of some of these persons is shown in the Appendix.

1.1.6 Documentation

The system is fully documented at all levels of software and hardware. A summary of the major documents available to system users is shown in the Appendix.

The next section will describe in more detail the hardware and software elements that comprise the computer graphics system.

2.0 MAINFRAME

2.1 HARDWARE

The central processing unit of the Graphics Oriented Transportation Simulation Facility (GOTS) is a Honeywell model DDP-516. The DDP-516 is an integrated circuit 16-bit word general purpose digital computer with 32,768 words of core memory. This computer has become popular for a wide range of applications. The 516 features include:

- A high speed arithmetic unit
- A real time clock
- A priority interrupt system
- A direct multiplexed control channel used for high-speed data transfer

Other available features include:

- An extensive graphics I/O system
- A variety of mass storage peripherals
- A hardware paging system
- An analog to digital (A/D) converter

2.2 SOFTWARE

The DDP-516 supports a number of standard software packages. These standard packages include:

2.2.1 FORTRAN IV Compiler

The compiler has been modified and expanded so it may be used as a systems programming language and allows flexible *bit* manipulation. The compiler modifications produce new efficient code and give the user a powerful high-level language.

2.2.2 Assembler

The assembler allows the user to program the computer in assembly language (DAP) and also includes a macro-preprocessing capability.

2.2.3 Program Loader

The loader allows the user to load his programs into the computer without having to worry about address relocation and proper linking of routines.

2.2.4 Editor

With the editor a non skilled user can search for, manipulate or delete large blocks of data, programs or other files. Using the teletype a programmer can do character string searches, multiple substitutions, printouts of selected portions of text, CRT verification and other convenient operations.

2.2.5 Debugging Package

This program package allows the user to access and modify specific core locations and to monitor his program during execution.

2.2.6 Diagnostic Programs

An extensive set of diagnostic programs are used to test the various functions and hardware elements of the computer.

2.2.7 BASIC Interpreter

This package supports users who wish to program the computer using the BASIC language.

2.2.8 GASP Simulation Language Package

A GASP simulation language package for DOT projects written in GASP language is also supplied.

In addition to the above programming languages and aids there is also an extensive set of library routines available. These routines are used so often by so many users that they are organized into a library. They include the standard FORTRAN functions for

computing sines, cosines, logarithms, exponentials; functions for handling complex and double precision numbers; and many higher-level routines for performing statistical analyses, solving differential equations, doing integration, solving simultaneous linear equations and doing matrix manipulations.

3.0 NON-GRAPHIC PERIPHERALS

The DDP-516 has available and supports a wide range of peripheral devices for functions such as mass data storage, communications and general input/output. These devices include:

1. Two 10 moving-head disc drives
2. A 7-track magnetic tape drive
3. 512 track magnetic drum (currently inoperative)
4. An analog to digital converter
5. An electro-static 500 line/min line printer
6. A console teletype and a time-sharing terminal communications system
7. A high speed paper tape reader/punch
8. A coupler to the H-832 computer

All of these devices are supported by software that give the user program control to exercise their functions. In addition the disc drives are supported by a highly sophisticated and flexible disc operating system (DOS).

4.0 GRAPHIC PERIPHERALS

A continuing design objective for the GOTS system has been to offer the user community a wide range of computer graphic capabilities supported by a comprehensive set of software packages. The software presents these graphic capabilities to the user at a level which allows him complete flexibility in his program design with minimal need for the specific device commands necessary to control the particular device. The use of the graphic software packages for writing interactive programs is analogous to the use of a high-level programming language for writing general-purpose programs; both allow the user to implement his algorithm without having to have detailed knowledge about the timing of the machine, or its addressing scheme, or its specific instruction repetoire.

Specifically, the graphic peripherals include:

1. A dynamic (refreshing) display system supporting three black/white (B/W) displays and one color display. A light pen input is available for each B/W display. This system allows vector generation of variable intensity and of several line structures, generation of a full set of alphanumerics, circle generation and random positioning of the beam on the display. The software that supports this display system allows the user to exercise all the display's functions with FORTRAN-callable routines. In addition, the software provides automatic display updating (refreshing) from the display buffer contained in memory, and services the signals generated by the light pens to present that information to the user in a manner that is relevant to his display. The color display is supported by a set of very similar routines, in addition there are routines to control color, hue, and intensity.

2. A remote storage-tube display terminal. This display, in effect, appears to the computer to be a teletypewriter. Display of lines and random beam positioning is done by interpreting some of the characters sent to it as special commands. The terminal has a keyboard for input of alphanumeric information and a *mouse* for input of graphic information. The display itself is a storage-tube i.e., once something is presented on the display it will remain there until the whole screen is erased.

   There are two software systems that support this device. The first is a set of basic routines that allow the user to generate lines or text from subroutine calls in his program. The second includes the capabilities of the first, but also an extensive set of routines for the semi-automatic generation of graphs using linear and/or logarithmic axes, data scaling and curve labelling.

3. A 36-inch drum plotter with three programmable pens. This is a digital incremental plotter capable of producing line drawings such as charts, graphs and maps with features such as symbols, numbers, and letters. The plotter has three pens which may be used to produce multi-colored drawings under program control.

   The software that is available for the plotter includes the set of routines standardly used on a plotter (data scaling, axis drawing and labelling, character generation, number plotting, line drawing and curve drawing). Additionally, there are routines to produce contour maps, define line structure, generate circles, control over-all plot scaling and to control pen selection.

4. A programmable display terminal. This is a display terminal incorporating both a display processor and a mini-computer, allowing the terminal to be used in a stand-alone configuration or as an intelligent terminal interfaced to another computer directly or over

standard telephone lines. The system is capable of displaying complex and dynamic data which defines the picture. Since a mini-computer is an integral part of the system, some picture processing can be performed at the terminal, freeing some of the host computer's resources. At present the terminal is supplied with the software necessary to define the system in a teletype replacement configuration. Characters may be transmitted between the terminal and the host computer and displayed on the screen. Local editing may be done on the characters stored in the terminal from the terminal keyboard.

5. A high speed electro-static printer. This device is used for output of data in either a line printer mode (at 500 lines/minute) or for producing graphic plots.
6. An (X-Y) data input tablet. This is a device which is used to input graphic information to the user's program. The tablet returns to the user the (X-Y) coordinate pair that is being pointed to by a stylus. The position of the stylus is also input as a value indicating the proximity of the stylus to the tablet surface.

    A set of basic software routines exist which handle the automatic interogation of the tablet and tracking of the stylus by posting a cross on the display at the coordinates pointed to by the stylus. These routines also allow the user to obtain the position of the stylus and its height above the tablet.

5.0 DISK-OPERATING SYSTEM

DOS is a core resident, one user, console-oriented operating system which allows the user to completely control the computer and execute programs with little use of paper tape. This system is described in detail in the DOS Users Guide DOT-TSC-OST-72-14. DOS consists of:

1. an interactive command language, which controls execution of file system commands, utility functions, system programs, I/O routines, and user programs;
2. a file system and disk management system which simplifies the creation, deletion, and updating of source, object, and data files;
3. a collection of system programs including a FORTRAN compiler, a DAP assembler, loaders, source editors, on-line debug packages, and a binary editor, which are fully integrated with the file system and command language;

One of the more salient features of DOS is its file system. The file system gives the user the ability to organize collections of data, source, and object files under user-specified names. He has the ability to save and delete files by merely supplying the correct command and a name. All files are stored in a user file directory (UFD) which is made available to the user when he attaches to that directory. Each user has his own directory and all he has to do is insert and delete his files. All other data management and clerical functions are provided for the user by DOS.

The user interacts with DOS by typing commands at the KSR-35 console. When the command is received, the supervisor either performs the desired action immediately or initiates the appropriate system program. When the action has been performed or if an error is detected, the user is notified and the supervisor waits for a new command.

The Time Shared Disk Operating System (TSDOS) is a time-shared seven user system which is compatible with DOS and uses the same disk. Under TSDOS the user sees a system nearly identical to DOS.

All commands have the same name and format; the file structure is identical and the user invokes the same subroutines to communicate with the teletype, the disk, the display and light pen. Other I/O devices are not available to the user under TSDOS, but he may prepare a program which uses these devices, save it on the disk, then later run the program under DOS. The user actually has more memory available for programming under TSDOS because the user sees an empty 32k of memory whereas under DOS, he must share this memory with the operating system.

APPENDIX A
APPLICATIONS

APPLICATIONS

This Appendix presents a representative selection of DOT project applications produced on the 516. The detailed routines for producing these outputs are currently stored in the graphics library on disk file. They may be readily used for different applications with minimal user input. The following illustrative cases show:

1. The capabilities mentioned in this publication are demonstrated capabilities not just potential capabilities.
2. The range of applications is very broad
3. The 516 has been successfully used as a tool for many TSC projects.

The following examples are included:

	Application	Project
1.	Information Display	HS-204
2.	Information Storage and Retrieval	HS-204
3.	Data Analysis	UM-204
4.	Planning	Management
5.	Benchmark	OS-207
6.	I/O Device	OS-207
7.	Multimedia Display	OS-207
8.	Demonstrations	Management
9.	Simulation	FA-206,FA-13,FA-203

INFORMATION DISPLAY

Information display programs are available to draw:

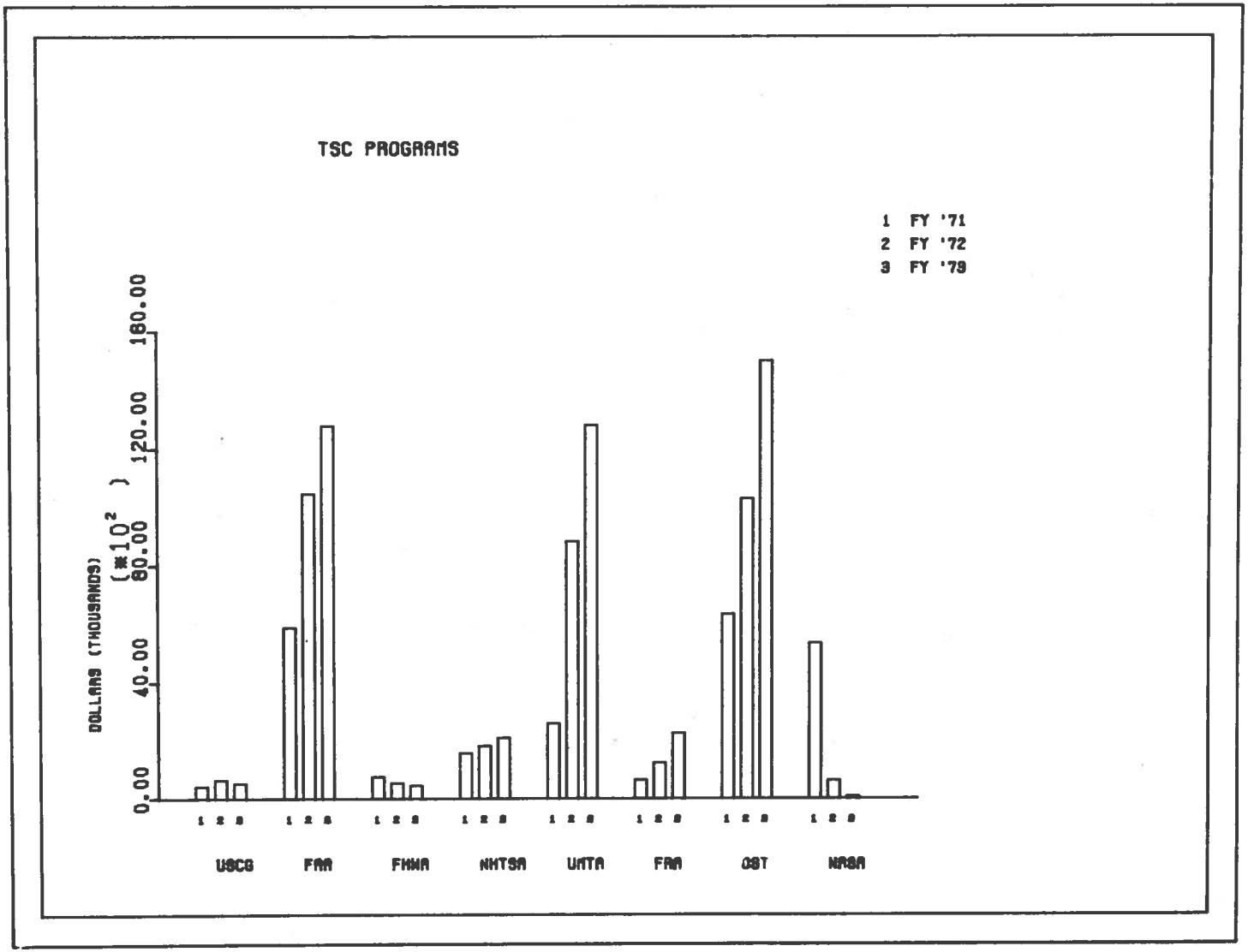
- Bar Charts
- Pie Charts
- Trend Charts
- Multivariable Graphs
- Logarithmic Graphs
- Functional Scales

These programs are user oriented and operate automatically by a few simple commands. The commands are given in response to teletype requests.

The next pages show sample output along with brief explanations.

BAR CHARTS

The accompanying bar chart (Figure A-1) was prepared for management. All data was entered in the interactive mode in response to computer questions. The program is designed to handle up to thirty groups of data and a large number of entries in each group. The output graph will be automatically scaled to filling the allocated space on the X axis. The Y axis will be automatically scaled to include the maximum data value. The entire graph may be sized from five to thirty inches at the user's request. Three different colors are also available to the user.


TSC PROGRAMS
1 FY '71
2 FY '72
3 FY '79
DOLLARS (THOUSANDS)
(*10²)
0.00
40.00
80.00
120.00
160.00
1 2 3
USCG
FAA
FHWA
NHTSA
UMTA
FRA
OST
NASA

PIE CHARTS

Pie charts have wide application in showing how components relate to a whole.

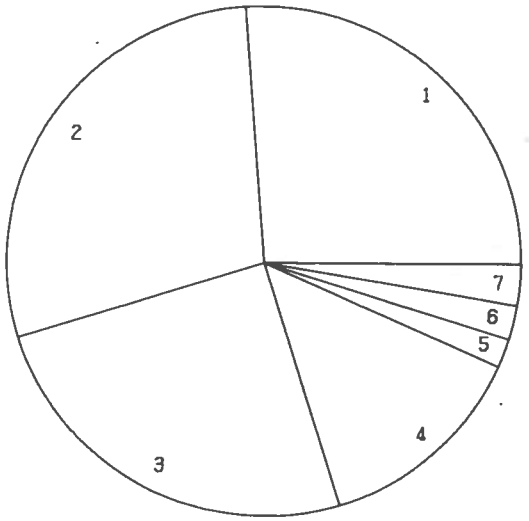
The pie chart in figure A-2 was drawn in response to a single command. As with the bar chart, a user can specify whether he wants to:

1. Draw a pie chart already on file
2. Edit an existing pie chart
3. Create a new pie chart, or
4. Stop the program

The computer automatically computes the percentage each component represents and does the complete graphical layout including the inclusion of the total.

In this case the user entered via teletypewriter only two commands: A MESSCHER and R APPLE. Then all subsequent entries were in response to a computer generated question. The user entered the title, seven items and amounts. The computer calculated the percentages and plotted the chart. With one command the user may change size of chart from one- to thirty-inches. This chart required about one minute to enter the data, one second to process, and one minute to plot.

NOISE ABATEMENT PROGRAM/ INFO. SCI. DIV./ R-2520



	ITEM	AMOUNT	PCTG
1	DIRECT M/Y SAL. + BEN.	72.10	26.22
2	OVERHEAD	78.80	28.58
3	TECH. SERV. CONTRACT	69.00	25.09
4	EQUIPMENT	37.30	13.56
5	COMPUTER TIME	5.00	1.82
6	MAINTENANCE	6.00	2.18
7	SUPPLIES	7.00	2.55
		275.00	

Figure A-2

TREND CHARTS

The computer drawn chart seen in Figure A-3 shows the capability to utilize user provided data points, automatically calculate and plot the extrapolation to a specified limit. The basic routine is on file in the graphics library.

The solid lines connect user specified data points. The dashed line is a straight line continuation of data as predicted by the computer.

The 516 performs its predictions by least squares fitting a high order polynomial to the existing data, and using the slope of the polynomial's tangent at the point of departure to predict the direction of the dashed line. The order of the polynomial used may be controlled by the user. Full interactive editing and size selection capability is available.

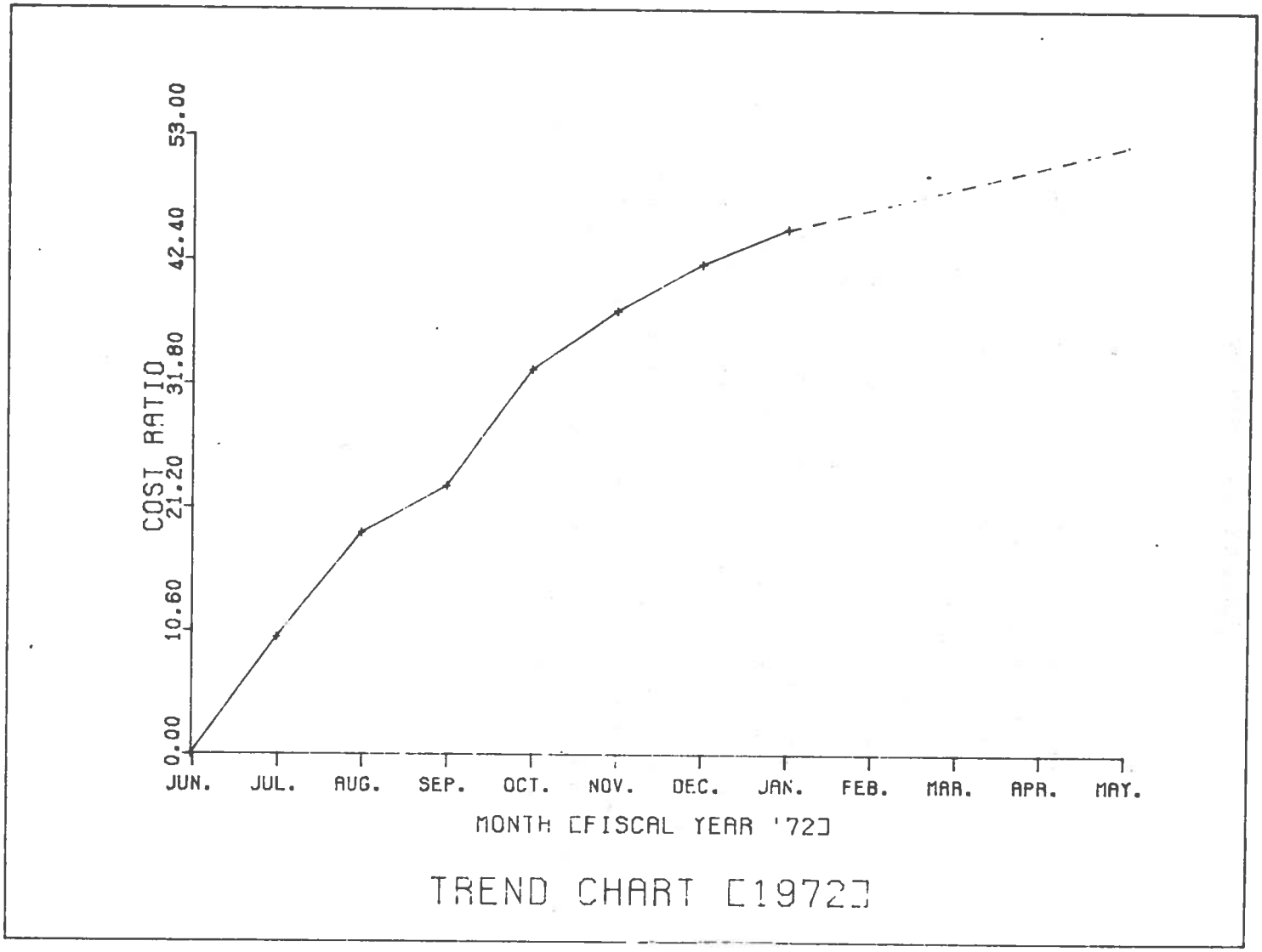

COST RATIO
0.00
10.60
21.20
31.80
42.40
53.00
JUN.
JUL.
AUG.
SEP.
OCT.
NOV.
DEC.
JAN.
FEB.
MAR.
APR.
MAY.
MONTH (FISCAL YEAR '72)
TREND CHART (1972)

Figure A-3

MULTIVARIABLE GRAPHS

By using different line demarkations many curves can be plotted on the same graph.

The salary curves in Figure A-4 use the 516 graphics system *AXIS* and *SCALE* in their production.

This feature of the graphics library is, of course, available for any application. It will automatically scale each axis and set up and print numerical values over the range the user requires. (The axis and chart titles are user provided).

Because the graphics system will draw this graph up to a 30-inch size, it is especially valuable for producing output required for large audience viewing.

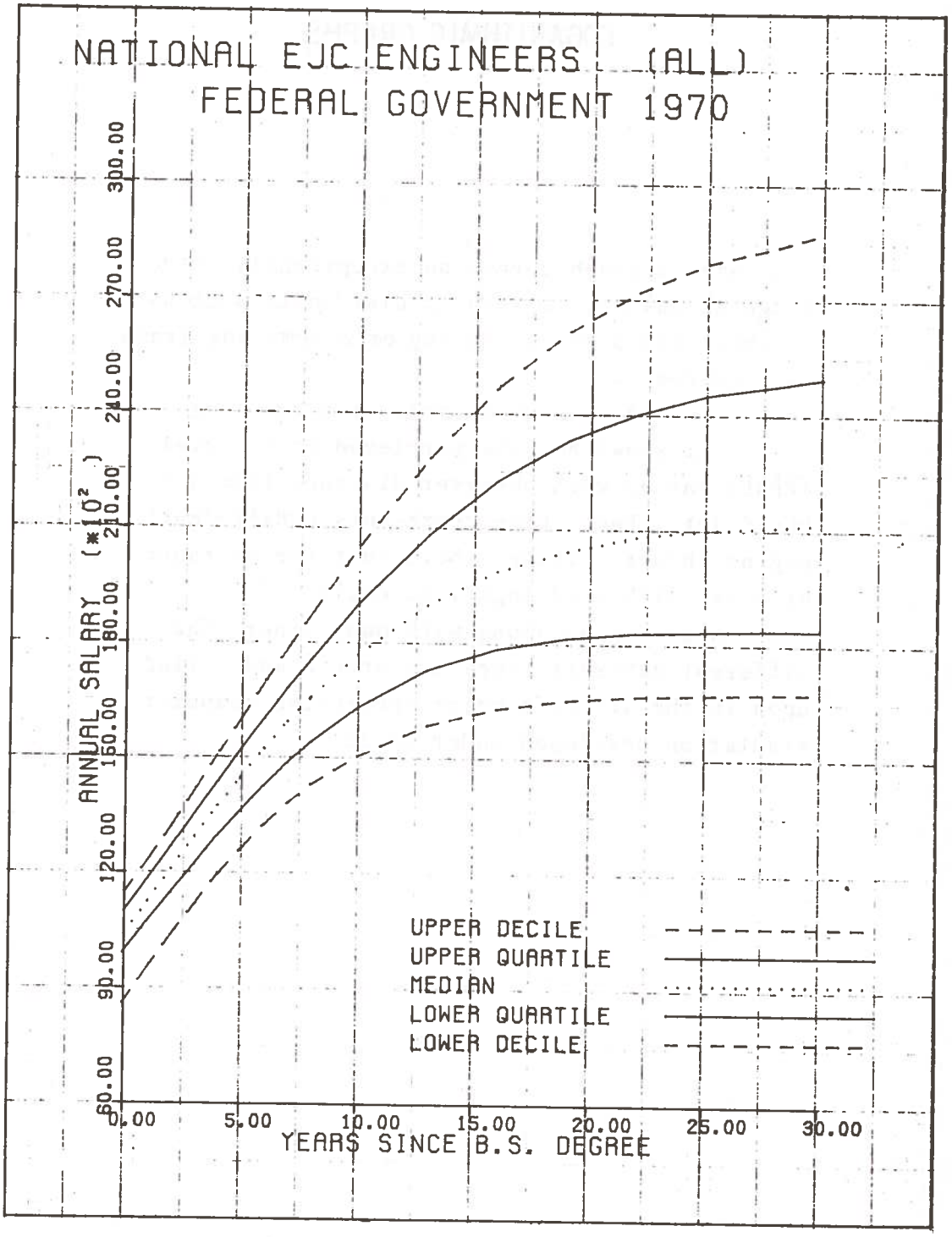

NATIONAL EJC ENGINEERS (ALL)
FEDERAL GOVERNMENT 1970
ANNUAL SALARY (*10²)
60.00
90.00
120.00
150.00
180.00
210.00
240.00
270.00
300.00
0.00
5.00
10.00
15.00
20.00
25.00
30.00
YEARS SINCE B.S. DEGREE
UPPER DECILE
UPPER QUARTILE
MEDIAN
LOWER QUARTILE
LOWER DECILE

Figure A-4

LOGARITHMIC GRAPHS

When a graph covers an exceptionally wide range of values, or when special units such as decibels are used, a log/log or a semi-log graph is required.

Figure A-5 is an example of a semi-log plot. It shows how the percieved noise level (EPNL) varies with observer distance from a DC-10 jet. Each curve represents a different engine thrust setting. Note that the distance axis is calibrated logarithmically.

These curves along with many others for different aircraft types are stored and called upon in the aircraft noise prediction computer simulation developed under OS-207.

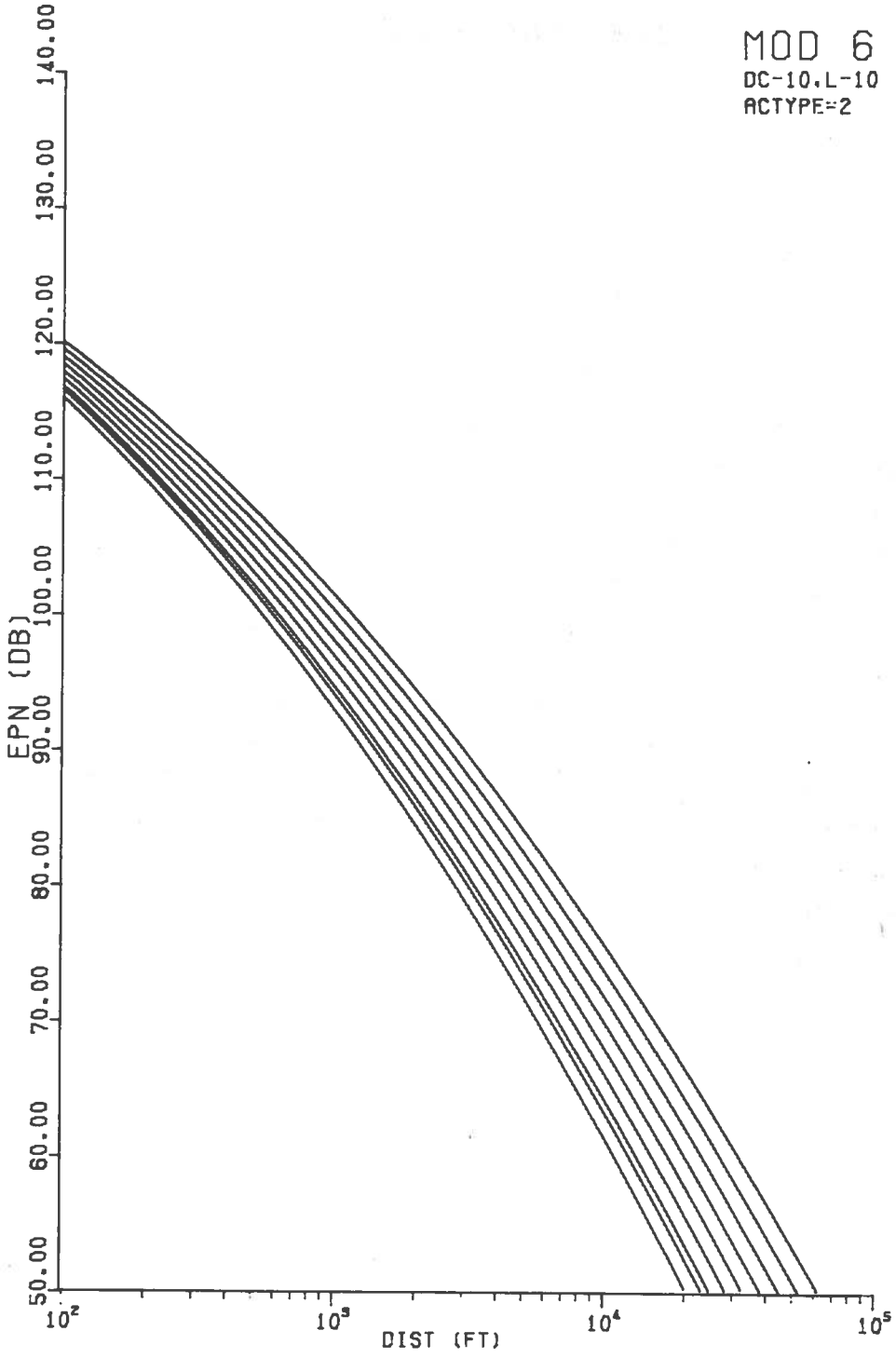

MOD 6
DC-10,L-10
ACTYPE=2
EPN (DB)
140.00
130.00
120.00
110.00
100.00
90.00
80.00
70.00
60.00
50.00
10^2
10^3
10^4
10^5
DIST (FT)

Figure A-5

FUNCTIONAL SCALES

Sophisticated graphs require "functional scales" - a functional scale is a calibrated curve. In the simplest case the curve is a straight line and the calibrations are linear.

Figure A-6 is an example of a non-standard functional scale drawn by a 516 graphics library program. The user has full interactive control over the tic mark spacing, size, and annotation.

Functional scales are used in nomographs and special plots.

In this case the user supplied the equation of a circle to the program and typed in the values at which tic marks should be annotated. This pattern of tic mark size was also typed in by the user. These values could be modified at any time during the running of the program.

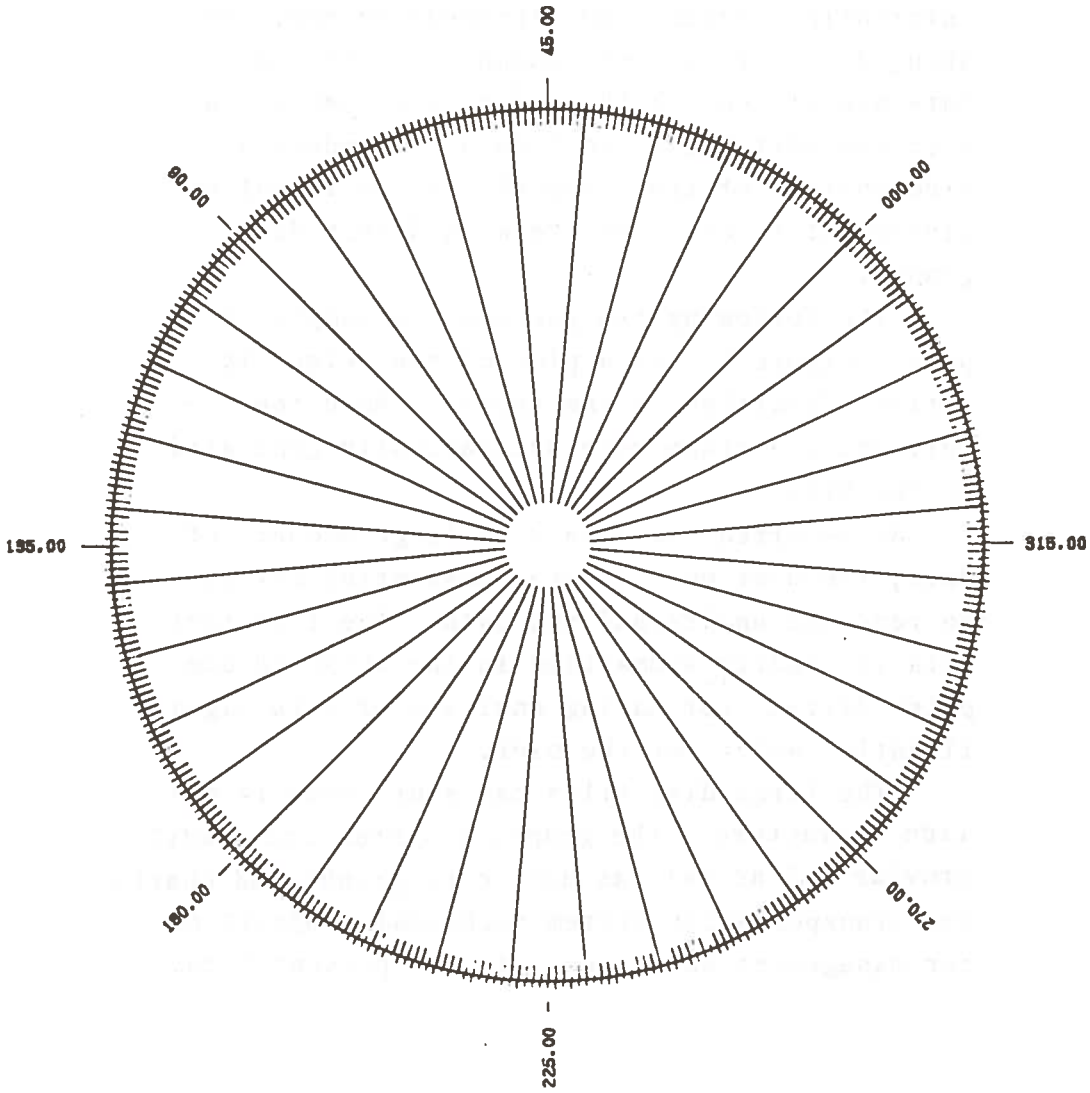


Figure A-6

INFORMATION STORAGE AND RETRIEVAL AND DISPLAY

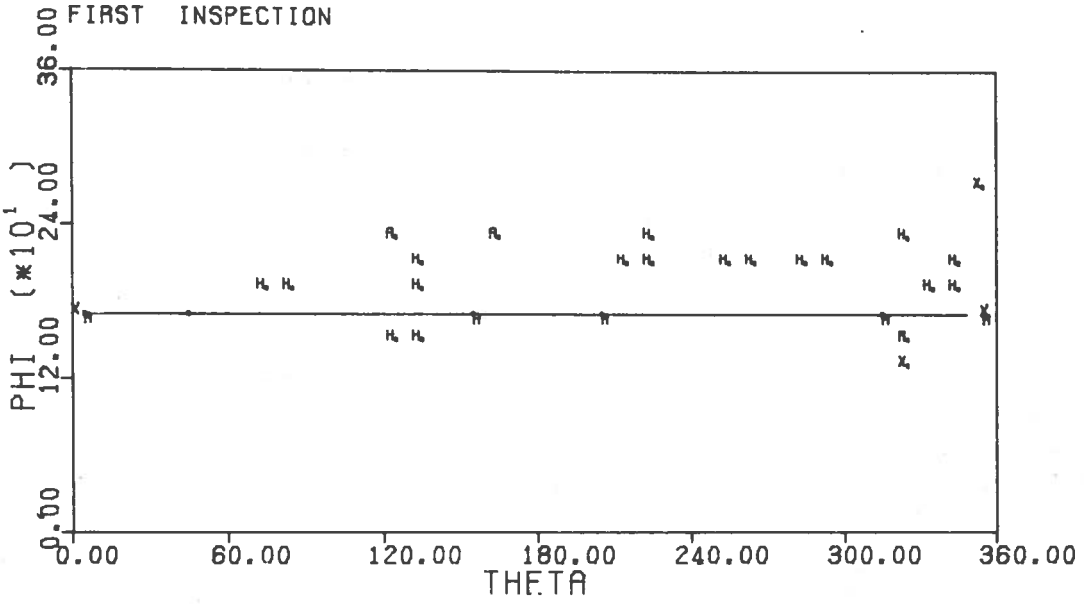
HS-204 (Tire Testing) uses the 516 as an information storage and retrieval system. By using disc files, large amounts of tire test data are stored. With appropriate commands a user can edit files, sort data or produce a wide variety of typed reports on individual or classes of tires, complete with defect data graphs.

The following two pages are a sample report. Figure A-7 is a plot of the defect locations described in the report. Both the report and the graph were automatically generated by the 516.

As is often the case with large amounts of data, the user must devote substantial effort to read and understand the data. The tire test data is readily summarized in the attached computer driven plot making analysis of data significantly easier for the user.

The large disk files can store some 14 million characters. The graphics system can readily provide CRT as well as hard copy graphs and charts for transportation system technical projects or for management data, analysis and presentation.

DEFECT DATA-PLOTTED 01T6178B



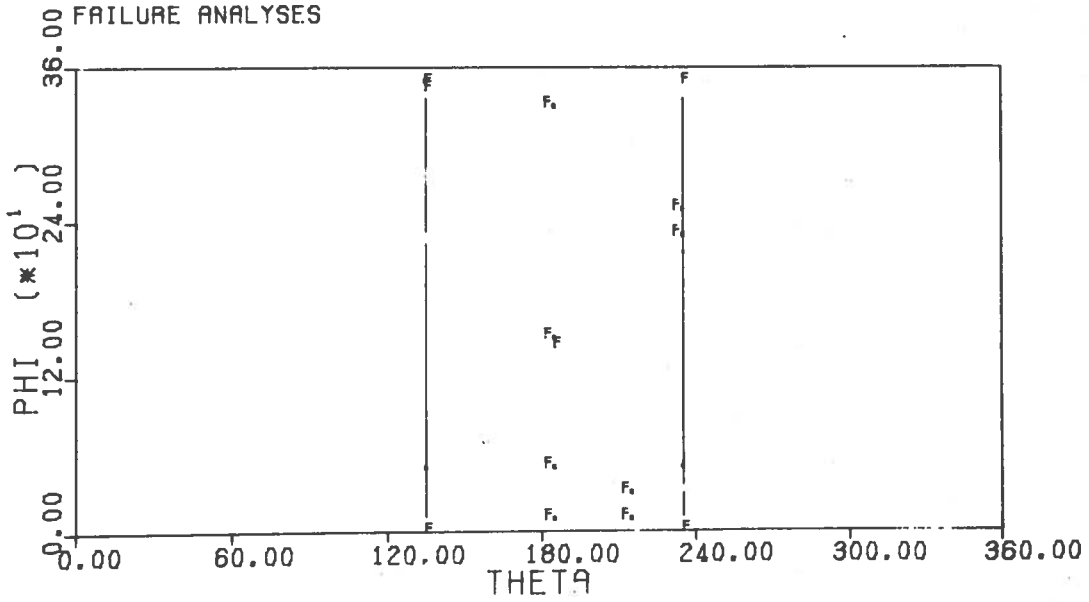


Figure A-7

REPØRT ØN TIRE ØIT6178B

1. DESCRIPTIØN

MANUFACTURER: THE GØØDYEAR TIRE + RUBBER CØ.
TIRE SIZE: G78-15. DATE ØF MFG: NØT RECØRDED
BRAND NAME AND CØMMENTS: CUSTØM PØWER CUSHIØN
RETREAD MANUFACTURER: ØMA
MATRIX SIZE: VV DATE ØF MFG: NØT RECØRDED
CØNSTRUCTIØN: BELTED 2 PLY/2 BELT
MATERIAL: PØLYESTER/GLASS
PHYSICAL CHARACTERISTICS: HIGHWAY, TUBELESS, BLACKWALL

2. TEST HISTØRY

TEST LØCATIØN: ØGDEN TECHNØLØGY LABØRATØRY INC., LØNG ISLAND, N.Y.
TEST TYPE: ENDURANCE TØ MVSS 109
START DATE: 46 WEEK 71
TEST DURATIØN: 2 DAYS
STARTING MILEAGE: 0
ENDING MILEAGE: 1700
CØMMENTS: PASSED

3. DEFECT DATA - LISTED

```
3401HH01T6178B 75182TCI    0.25SEPGA1.00BT
3401HH01T6178B 85180TCI    0.25SEPGA1.00BT
3401HH01T6178B125145TEL0900.25SEPGA3.00BT
3401HH01T6178B135150TEL0900.50SEPGA2.00BT
3401HH01T6178B135210TDI0902.00SEP5P2.00BT
3401HH01T6178B135195TCI    0.25SEPGA2.00BT
3401HH01T6178B215200TCI    0.25SEPGA1.00BT
3401HH01T6178B220200TCI    0.25SEPGA1.00BT
3401HH01T6178B250200TCI    0.25SEPGA2.00BT
3401HH01T6178B260200TEL0901.00SEPGA9.00BT
3401HH01T6178B285215SCI    0.25SEPGA2.00BT
3401HH01T6178B290205TEL0451.00SEPGA8.00BT
3401HH01T6178B320220SCI    0.25SEPGA3.00BT
3401HH01T6178B225225SCI    0.25SEPGA2.00BT
3401HH01T6178B335190TCI    0.75SEPGA5.00BT
3401HH01T6178B340200TCI    0.50SEPGA5.00BT
3401HH01T6178B345185TCI    0.25SEPGA3.00BT
3411XA01T6178B400170TDI090     CB1       MI
3411XA01T6178B320130TDI0000.25BDL        MI
3411XA01T6178B354260STR0000.30RV0
3411AR01T6178B120230S          6    GA- 20
3411AR01T6178B160230SEL 90    12    GA- 20
3411AR01T6178B150170T          9    TZ- 40
3411AR01T6178B200170TEL 90    27    3P- 40
3411AR01T6178B310170TEL 90    15    2P- 40
3411AR01T6178B  6160TEL 90    12    GA- 60
3411AR01T6178B350160           9    GA- 50
```

```
3501IBØIT6178B200135SEL1808.0 PCSSQ100.
3 12XSØIT6178B180120SDI090     SCL       MA
3 12XSØIT6178B180240SDI090     SCL       MA
3 22AWØIT6178B210130SSI      30       -70BT
3 22AWØIT6178B150150TSI      20       -90
3 22AWØIT6178B250170TSI      15       -70
3 22AWØIT6178B  0185TSI      10       -90
3 22AWØIT6178B357250SSI      10      +100
3 32HHØIT6178B 10185TEL0903.00SEPGA25.0BT
3 32HHØIT6178B 25185TCI    0.50SEPGA5.00BT
3 32HHØIT6178B 35185TCI    0.75SEPGA10.0BT
3 32HHØIT6178B 50185TCI    0.50SEPGA5.00BT
3 32HHØIT6178B 50200TCI    0.75SEPGA10.0BT
3 32HHØIT6178B 55200TCI    0.50SEPGA4.00BT
3 32HHØIT6178B 85200TCI    0.50SEPGA6.00BT
3 32HHØIT6178B105200TCI    2.00SEPGA25.0BT
3 32HHØIT6178B110220TCI    0.50SEPGA4.00BT
3 32HHØIT6178B140190TLI0906.00SEPGA5.00BT
3 32HHØIT6178B175230TEL0904.00SEPGA4.00BT
3 32HHØIT6178B200210TEL0903.00SEPGA25.0BT
3 32HHØIT6178B195180TCI    0.75SEPGA9.00BT
3 32HHØIT6178B200185TCI    0.50SEPGA7.10BT
3 32HHØIT6178B235230WCI    0.50SEPGA5.00BT
3 32HHØIT6178B285180TEL0902.00SEPGA5.00BT
3 32HHØIT6178B305185TEL0902.00SEPGA3.00BT
3 32HHØIT6178B315185 CI    0.50SEPGA4.00BT
3 32HHØIT6178B320200TCI    0.50SEPGA10.0BT
3 32HHØIT6178B325195TCI    0.25SEPGA3.00BT
3 32HHØIT6178B335210TCI    0.25SEPGA2.00BT
3 32HHØIT6178B350205TEL1353.00SEPGA15.0BT

3 32FLØIT6178B180  0TEL0902.50SEP       MA
3 32FLØIT6178B185140TEL0902.00SEP       MA
3 32FLØIT6178B185150TEL0902.00SEP       MA
3 32FLØIT6178B230230TEL0900.75SEP       MA
3 32FLØIT6178B230240TEL0901.00SEP       MA
3 32FLØIT6178B180320TEL0906.00SEP       MA
3 32FLØIT6178B210 10TEL0901.25SEP       MA
3 32FLØIT6178B210 30TEL0901.25SEP       MA
3 32FLØIT6178B180 45TLI0906.00BNP       SA
3 32FLØIT6178B130400SLI0000.50SCS       MI
3 32FLØIT6178B230400SLI0000.50SCS       MI
3 32FLØIT6178B130355SLI0001.50SCL       MA


NUMBER ØF LINES ØF TYPE 3 DATA IS    70
```

DATA ANALYSIS

UM-204 (Rail Profile and Alignment Studies) uses the 516 to convert analog (Capacitor Probe) test data to digital records which are analyzed by numerical methods (Fast Fourier Transforms).

Figure A-8 is a sample of the test data reconstructed from digital records stored on 516 disk and plotted by the 516.

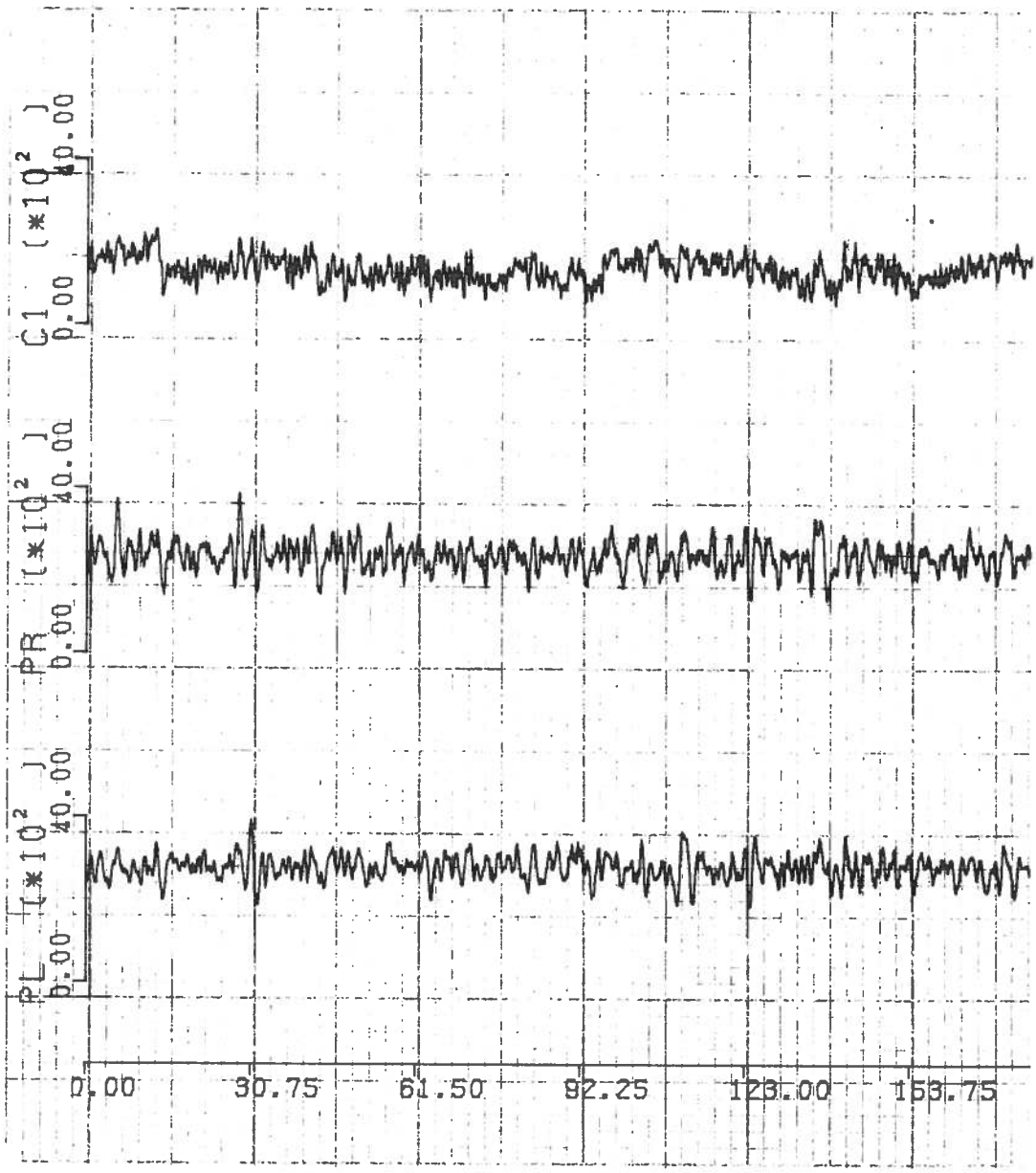

C1 (*10² J)
40.00
0.00
PR (*10² J)
40.00
0.00
PL (*10² J)
40.00
0.00
0.00
30.75
61.50
92.25
123.00
153.75

Figure A-8

MANAGEMENT PLANNING

A management planning model designed by TSC Systems Planning was quickly implemented on the 516 system. The many matrices containing planning data were stored in the computer. The system editing capability permits ready viewing on the CRT of selected data and editing desired. The processing is performed from interactive commands as seen on the attached printout. Outputs can be displayed and/or hard copied at the user's option. The very rapid turnaround time, easy editing and choice of output devices make this project useful to the system planners. This project readily lends itself to the "what if" type of analysis or sensitivity analysis.

The next page contains teletype output from the planning model program. It contains two matrices that give the breakout of work requirements in dollars for skill mix elements (rows) versus project phase (columns) for years 1971 and 1972 respectively. Skill mix elements are:
1) Management, 2) Analysis, 3) System Engineering
4) Engineering Support, 5) Administration
6) Fabrication
Project phases are:
1) Concept, 2) Design, 3) Implementation, 4) Test and Evaluation

The output data can be readily displayed on the CRT, storage tube, or CALCOMP plotter in bar chart or pie chart or trend charts.

```
    C ALL
ØK; A MESSCH
ØK; C ALL
ØK; R *MATX
GØ


MATRIX:W (WØRK-SKILLS)
       Ø (ØRG DISTRIB ØF WØRK)
       P (PRØJECT MIX)
       R (REQUIREMENTS)
       S (SKILL-MIX)
       Q (QUIT)
       B (BACKUP)

ØPERATIØN:Q (QUIT)
          B (BACKUP)
          T (TTY ØUTPUT)
          C (CRT ØUTPUT)
          E (EDIT)
          R (RESTØRE TØ ØRIGINAL)
          N (NØRMALIZATIØN)

TØTAL(K$)=:32444.,
MATRIX:S
ØPERATIØN:B
MATRIX:R
ØPERATIØN:T

  R(L,S,J)=

    L= 1

        1648.155   1313.981    217.375     61.644

        8699.855   1802.263     17.844     64.888

        1056.052   1570.289    316.329      3.244

        3429.330   4399.404    248.197    300.107

        1648.155   1484.312    111.932     63.266

           0.000   2569.563   1262.071    123.287

    L= 2

        1631.932    590.481    957.098     64.888

        8461.389    627.791    108.687     77.866

        1236.116    611.569   1270.182     12.978

        3357.953   2261.346   1231.249    291.996

        1631.932    632.658    533.704     71.377

           0.000   1180.961   5470.055    129.776
```

BENCHMARK

The 516 is a typical medium size, general purpose, computer. Its core size (32k), speed (∿1 microsecond access time) and standard peripherals make it an ideal benchmark for evaluating programs that will be used as standards across the country.

OS-207 required that the Highway Noise Prediction computer program developed by BBN be implemented on the 516.

Reference: Reports: DOT-TSC-FHWA-72-1
DOT-TSC-FHWA-72-2

The next page contains sample output from that program.

TRAFFIC NOISE PREDICTION

TEST CASE 30

PROGRAM INITIALIZATION PARAMETERS

0.00000E+00	1	RECEIVER HEIGHT ADJUSTMELT
0.10000E+01	2	NUMBER OF FREQUENCY BANDS
0.25000E+01	3	STANDARD DEVIATION FOR TRUCKS
0.35000E+01	4	STANDARD DEVIATION FOR CARS
0.00000E+00	5	HEIGHT ADJUSTMENT FOR CARS
0.80000E+01	6	HEIGHT ADJUTSMENT FOR TRUCKS

ROADWAY # 1

NUMBER OF TYPE 1 VEH	VEH/H	MPH
1	0.4500E+02	0.6000E+02

NUMBER OF TYPE 2 VEH	VEH/H	MPH
1	0.5000E+01	0.6000E+02

SOURCE COORD IN FT

NUMBER	X	Y	Z
1	0.1000E+05	0.0000E+00	0.0000E+00
2	-0.1000E+05	0.0000E+00	0.0000E+00

RECEIVER NUMBER	X	RECEIVER COORD IN FT Y	Z
1	0.0000E+00	0.3000E+02	0.0000E+00
2	0.0000E+00	0.3000E+03	0.0000E+00

TEST CASE 30

RECEIVER #	XRC	YRC	ZRC
1	0.0	30.0	0.0

A(500)
65.6

LE(A)	LNP	L90	L50	L10
65.6	92.9	38.9	52.6	66.2

RECEIVER #	XRC	YRC	ZRC
2	0.0	300.0	0.0

A(500)
55.5

LE(A)	LNP	L90	L50	L10
55.5	77.0	36.7	47.4	58.2

I/O DEVICE

The 516 can be used to convert input data from one form to another without extensive use of its computational facilities.

For OS-207 a mobile noise measurement lab detected and recorded aircraft noise at Logan Airport. The noise tapes were entered into the 516 via an analog to digital converter, processed and plotted as PNLT (tone corrected) and dBA each as time curves. A single EPNL value was also calculated and plotted. A sample curve is shown in Figure A-9.

In this case a DC-9 aircraft had taken off from Logan Airport and the recorder microphone was located in Everett. This actual data was, in turn, used to successfully validate the Noise Abatement Model.

The 516 will be used to accept output from larger machines (e.g. STAR program on the Mitre 370/155 computer) and produce meaningful, post processed information displays such as contour maps.

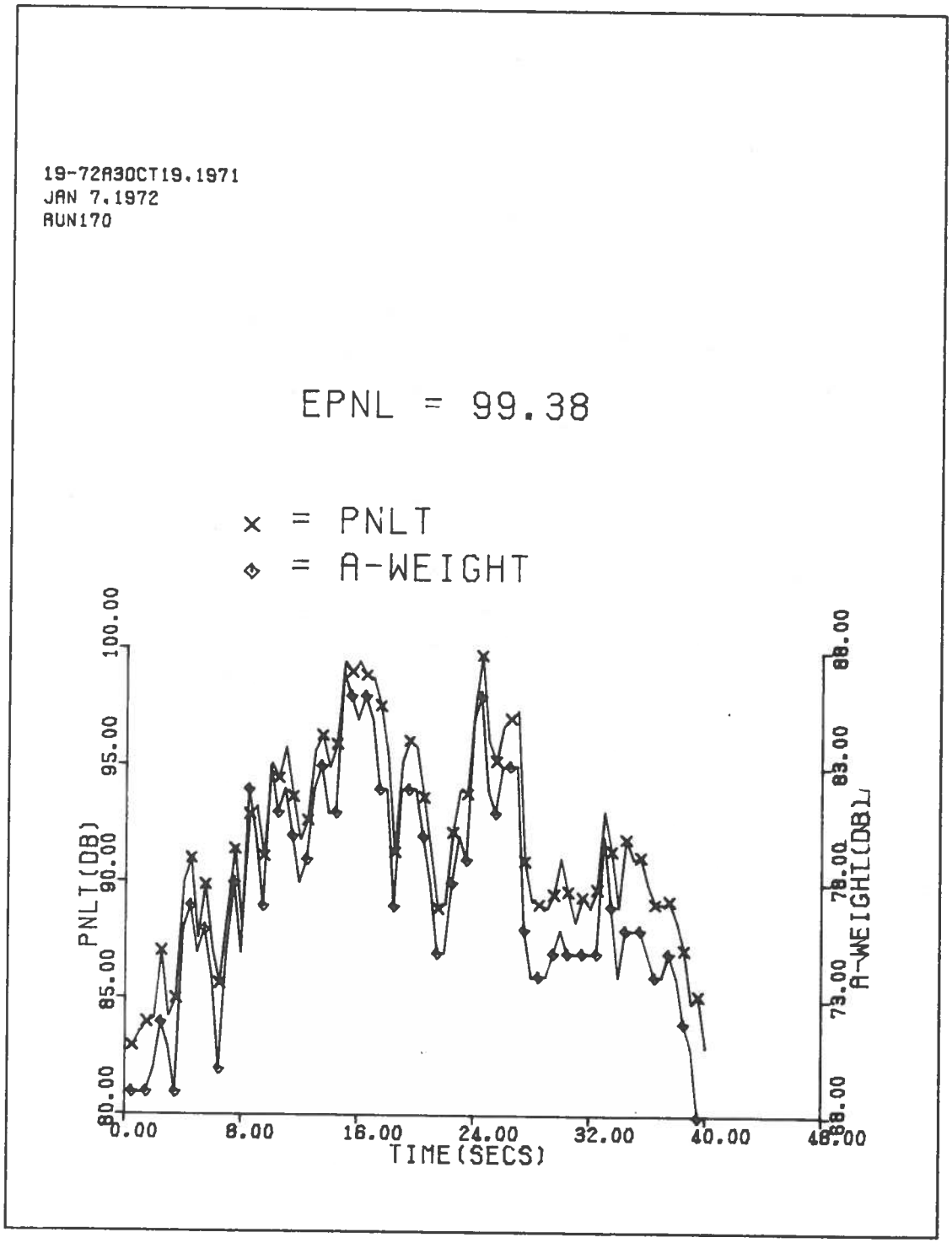

19-72A30CT19.1971
JAN 7.1972
RUN170
EPNL = 99.38
× = PNLT
◇ = A-WEIGHT
PNLT(DB)
100.00
95.00
90.00
85.00
80.00
A-WEIGHT(DB)
88.00
83.00
78.00
73.00
68.00
0.00
8.00
16.00
24.00
32.00
40.00
48.00
TIME(SECS)

Figure A-9

MULTI MEDIA DISPLAY

Often a project requires the use of more than one type of output device in simultaneous operation. The 516 simultaneously supports two black and white CRT's, a storage tube display, a color CRT, a digital plotter and a teletype. In the immediate future an IMLAC terminal and an electrostatic printer/plotter will be incorporated in the system.

OS207's aircraft noise abatement project utilizes 516's multimedia capability to interactively display aircraft noise contours around a runway on a CRT. All noise contours from a series of interactive inputs are accumulated on a storage tube contour map. The final contour map is then drawn by the CALCOMP plotter for permanent record. A hard copy of a series of contours as seen on the storage tube was drawn by the 516 in Figure A-10.

A sensitivity analysis for other projects might follow a similar methodology.

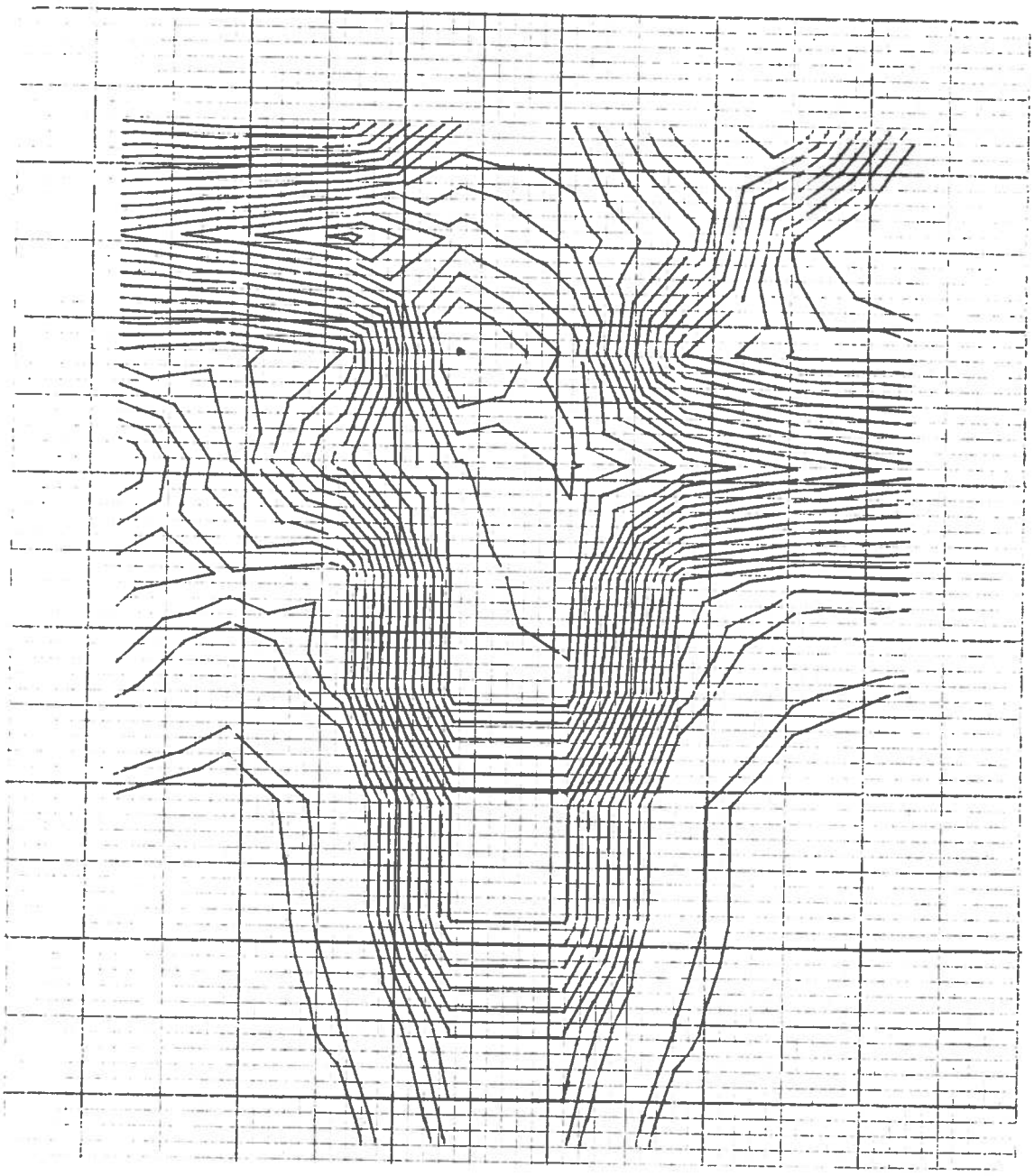


Figure A-10

DEMONSTRATIONS

The 516 is frequently used to demonstrate ongoing projects. Several features are often utilized:

- Graphical outputs on all devices
- Interactive capability, and
- Rapid turnaround time

Abridged versions of the applications mentioned in this report are on a disk library accessible to the 516 and are available for demonstration on request.

Figure A-11 is a plotted copy of a CRT image taken from one of the 516's demonstrations. It shows an airport's runway and flight paths together with a noise contour of 84 NEF. The words at the bottom of the picture are interactive graphics selectable options. The options are chosen by touching the CRT screen in the vicinity of the displayed word with a stylus.

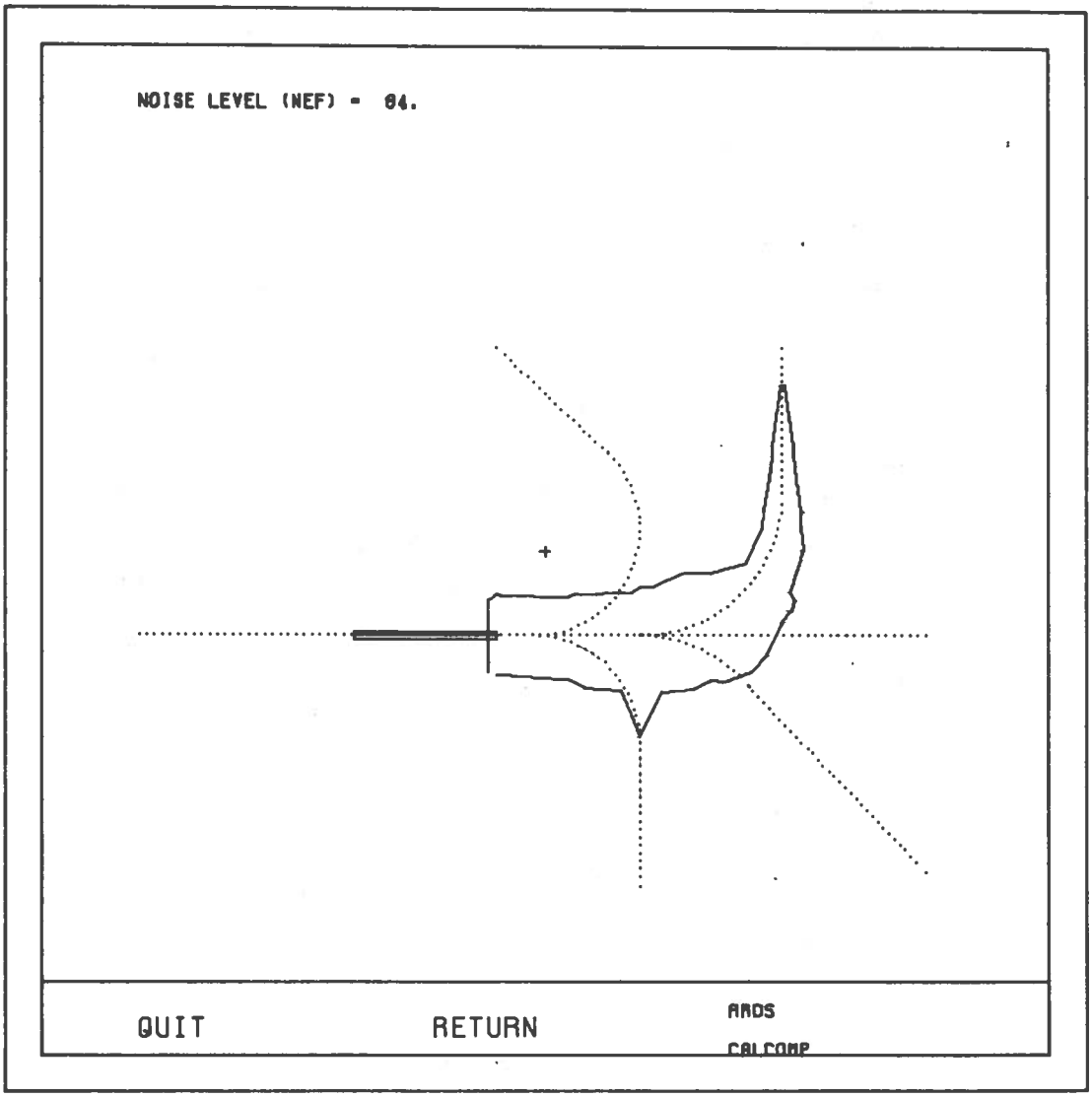


Figure A-11

SIMULATION

The 516 has been used very successfully in the area of simulation.

a. FA-13 (Human Factors/Air Traffic Control)

Two real time air traffic control simulations were developed and run. The first, a stochastic model, allowed the controller a 3-D view of his air space with zoom capabilities. (Figures A-12 and A-13) The second simulation is deterministic. It shows a plan view of a terminal area complete with runways and approach flight paths. Planes entering the displayed air space have flight ID tags with updated altitude and speed information. Planes can be controlled interactively. (Figures A-14 and A-15)

b. FA-206

The Air Traffic Flow Control project involves the simulation of air traffic under a wide variety of conditions and the study of the effects of Flow Control procedures.

The DDP-516 graphics system is used as follows:

- graphical inputs are drawn onto the tablet
- one CRT displays user options
- another CRT (Fig. A-16) displays the aircraft movements, maps weather
- the storage tube (Fig. A-17) displays performance type data

b. FA-206 (continued)

The simulation of a large combination of enroute flight operations combined with the impact of flow control procedures produces detailed graphical tabular results.

Some of the many system features include the capability to:

- use either simulated or actual flight traffic data
- to input airports, weather maps
- to zoom in on any selected area in the map
- to reconfigure traffic control boundaries and airport locations
- to simulate a period, backup in time and resimulate with different conditions
- to enter air routes, VOR's, fixes, STARS and CIDS

The two illustrations are CRT photographs of 1) air traffic control areas, major airports and selected traffic and 2) shows for Kennedy and LaGuardia airports the number of aircraft enroute to and number delayed in the air.

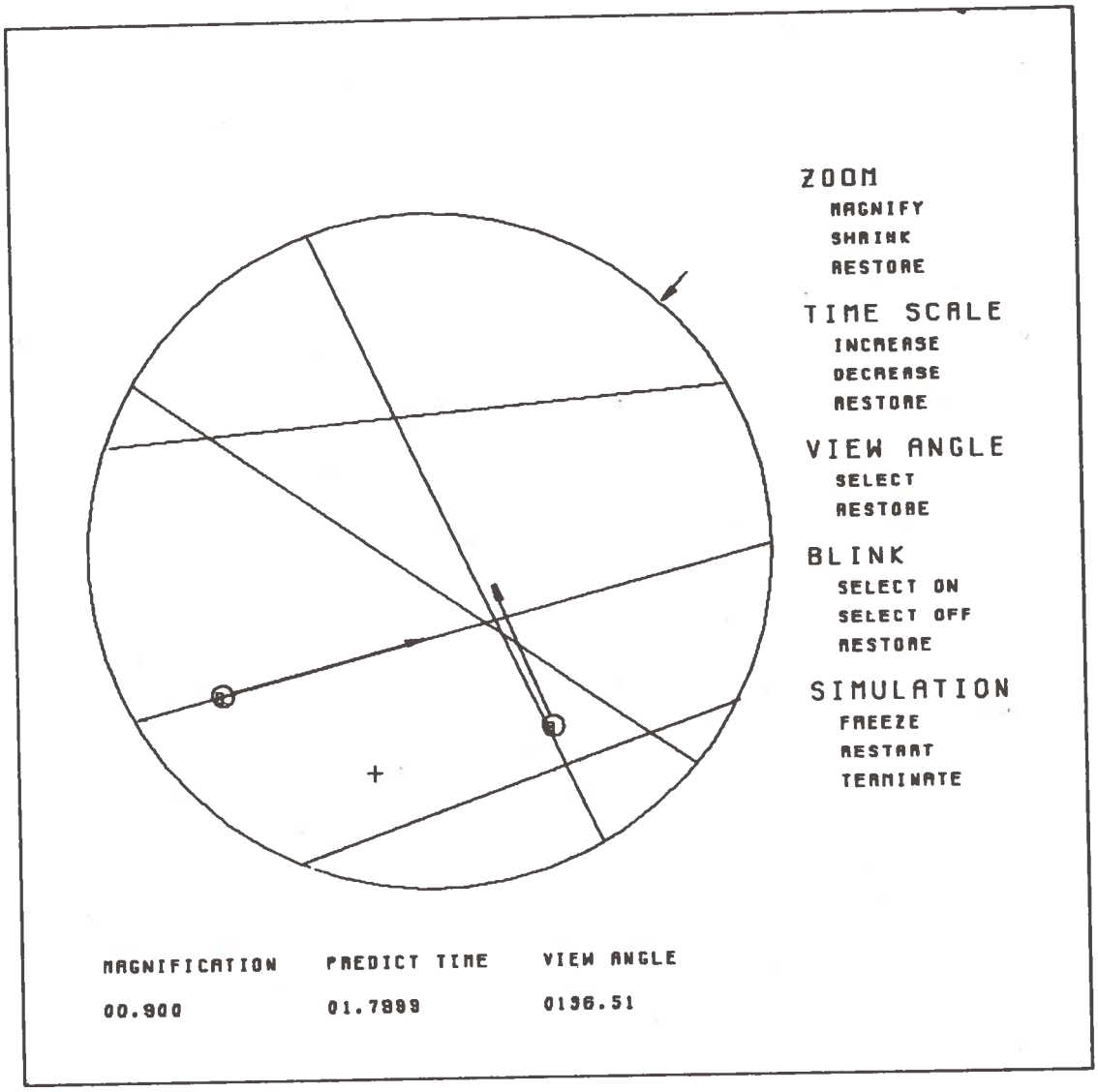

ZOOM
MAGNIFY
SHRINK
RESTORE
TIME SCALE
INCREASE
DECREASE
RESTORE
VIEW ANGLE
SELECT
RESTORE
BLINK
SELECT ON
SELECT OFF
RESTORE
SIMULATION
FREEZE
RESTART
TERMINATE
MAGNIFICATION
00.900
PREDICT TIME
01.7899
VIEW ANGLE
0136.51

Figure A-12

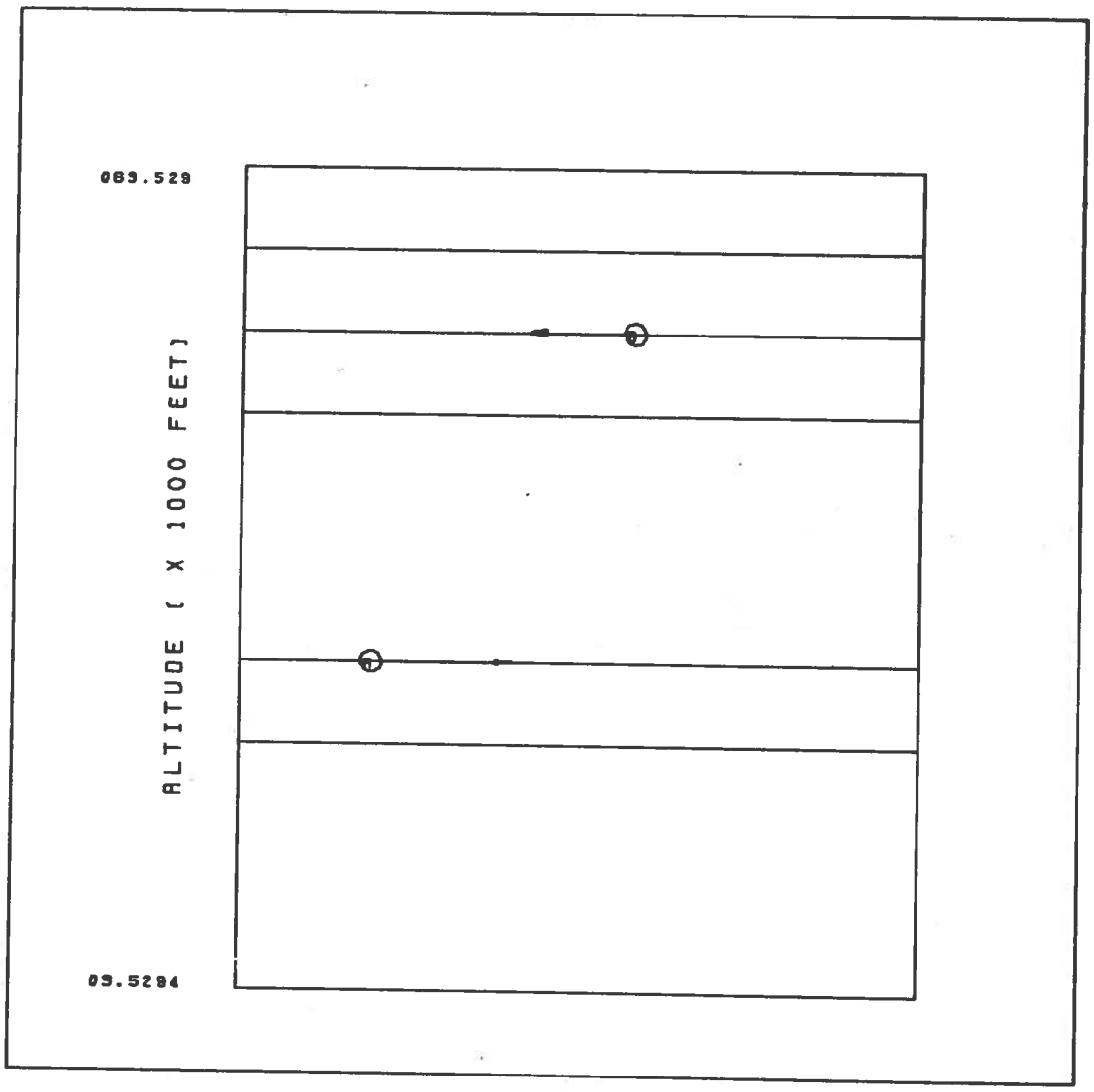


Figure A-13

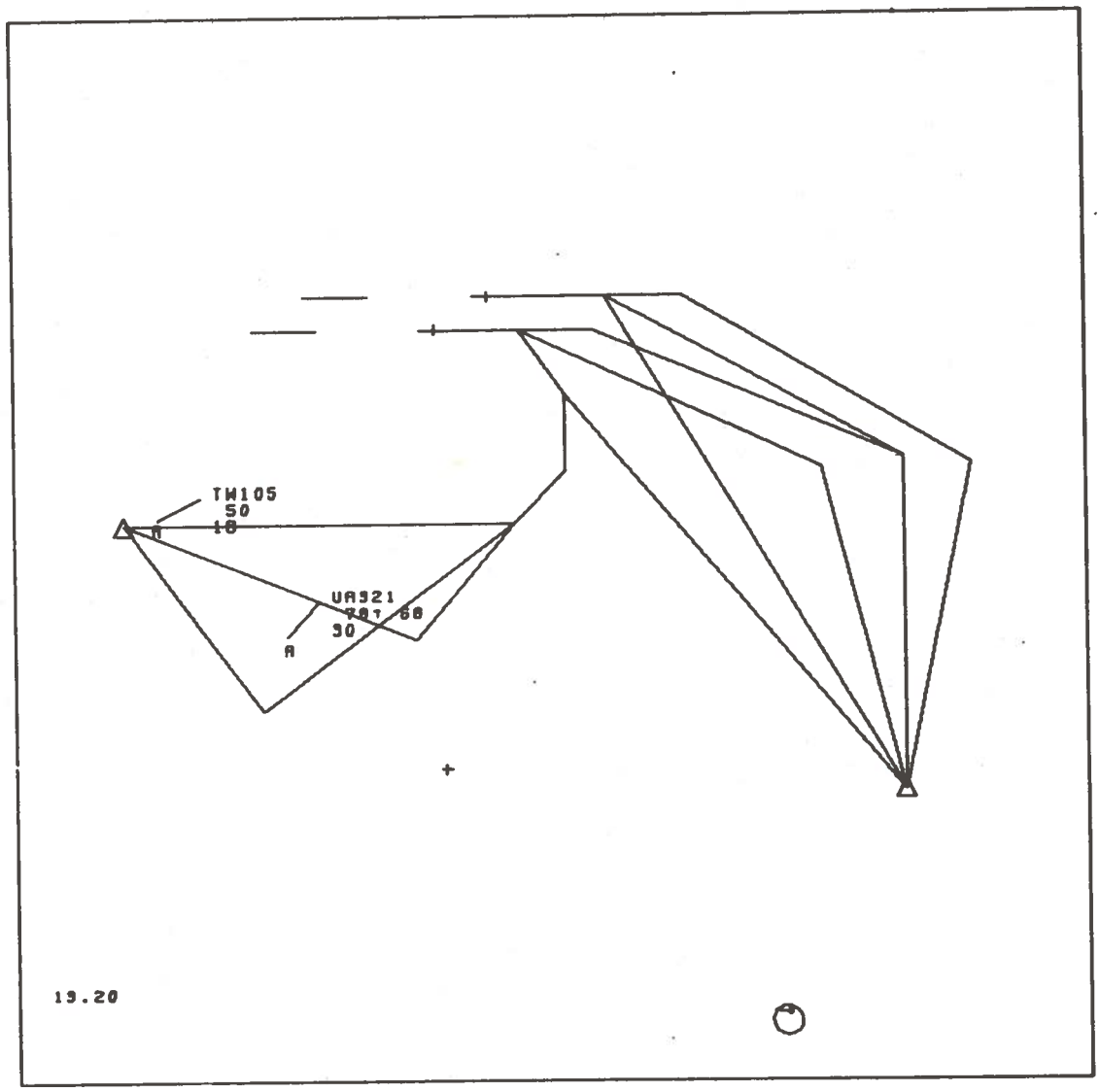


Figure A-14

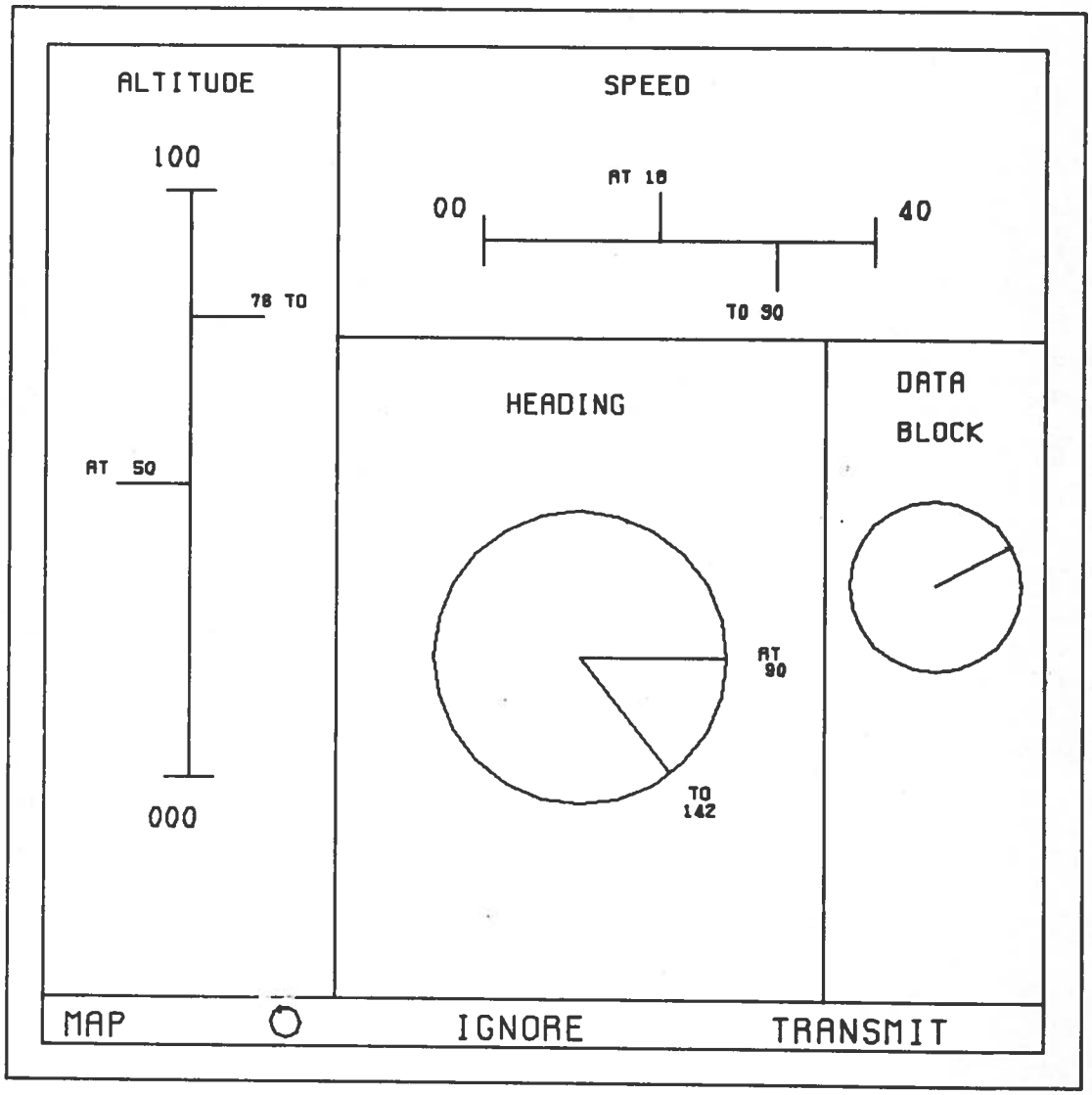

ALTITUDE
100
78 TO
AT 50
000
SPEED
00
AT 18
40
TO 90
HEADING
AT
90
TO
142
DATA
BLOCK
MAP
IGNORE
TRANSMIT

Figure A-15

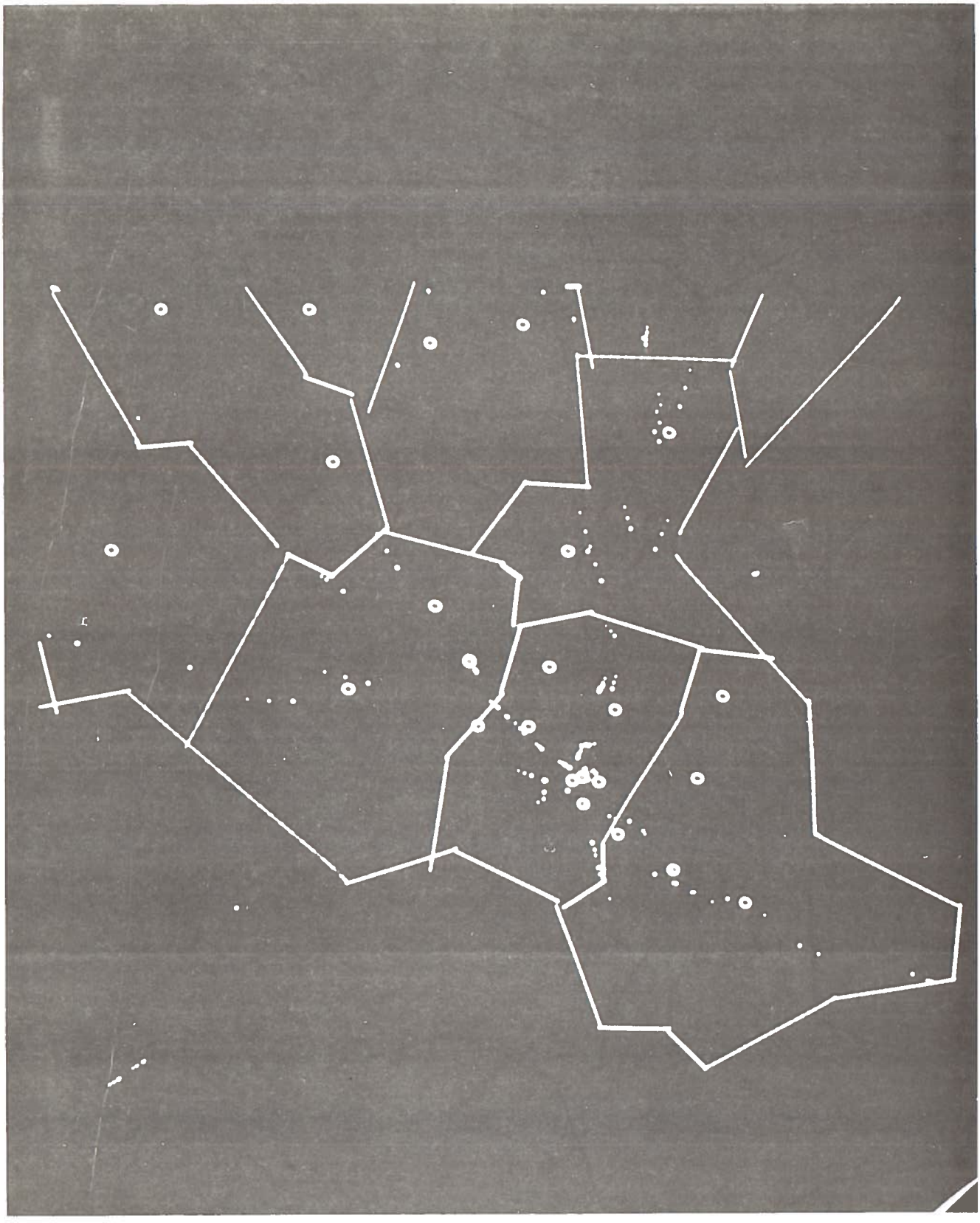


Figure A-16. ATC Area Map

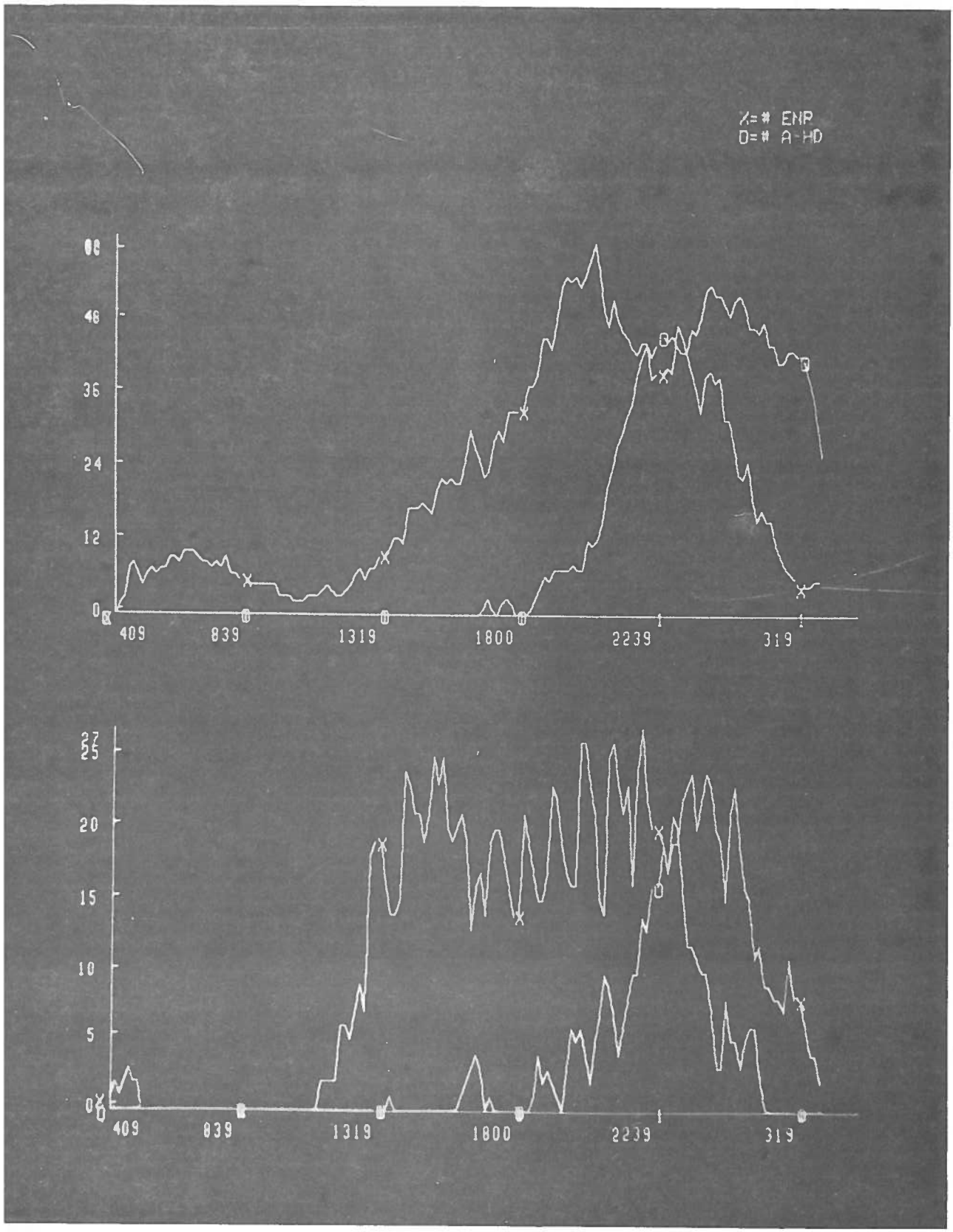


Figure A-17. Number of Aircraft Enroute and Number Delayed for LaGuardia and Kennedy Airports

DDP-516 GRAPHICS SYSTEM DOCUMENTATION

Disk Operating System User's Guide DOT-TSC-OST-72-14
May 1972 Jan P. Carlson
DDP-516 TSDOS Reference Manual RPT-579
October 1970 Jan P. Carlson
DDP-516 Programmers Reference Manual M-973
August 1968 Honeywell Inc.
Series 16 Summary Description
1971 Honeywell Inc.
Graphics Reference Manual
DOS System Library Memos #1 through #39
Individual Manuals for Each Input/Output Device

DDP-516 GRAPHICS SYSTEM - USERS

Jan Carlson
Ella Evdorkimoff
Mike Form
Judith Gertler
Robert Hinckley
Joe McGann
Bud Medeiros
Peter Mengert
Walter Messcher
Bob Montanari
Jim Steinberg
Julie Sussman
Tom Talbot
Jack Taub
Henry Theberge
Gary Wang
Dick Wright
Andres Zellweger