LMSC-HEC TR DO65566

(NASA-CR-179046) DEVELOPMENT OF A COMPUTATIONAL AERO/FLUIDS ANALYSIS SYSTEM Final Report (Lockheed Missiles and Space Co.) 24 p CSCL 22B

N87-20343

Unclas G3/16 45307

DEVELOPMENT OF A COMPUTATIONAL AERO/FLUIDS ANALYSIS SYSTEM

FINAL REPORT

Contract NAS8-35774

30 January 1987

Prepared for

NATIONAL AERONAUTICS AND SPACE ADMINISTRATION
MARSHALL SPACE FLIGHT CENTER, AL 35812

by

P.B. Kelley

Lockheed
Missiles & Space Company, Inc.
Huntsville Engineering Center
4800 Bradford Drive, Huntsville, AL 35807

FOREWORD

This final report is submitted by Lockheed Missiles & Space Company, Inc., Huntsville Engineering Center, to the National Aeronautics and Space Administration's George C. Marshall Space Flight Center, Alabama, for Contract NAS8-35774 entitled "Development of a Computational Aero/Fluids Analysis System."

The NASA-MSFC Contracting Officer's Representative for this contract was Mr. Charlie C. Dill, Jr., ED32.

CONTENTS

LIST OF TABLES

LIST OF FIGURES

1. INTRODUCTION

Lockheed Missiles & Space Company, Inc., Huntsville Engineering Center, submits this final report to NASA-Marshall Space Flight Center's for Contract NAS8-35774 entitled "Development of a Computational Aero/Fluids Analysis System."

The Space Shuttle program provides MSFC with two unique and difficult fluid flow problems which requires continued analysis and refinement. These are the external aerodynamic flows over the Shuttle surfaces and the internal gasdynamic flows in the SSME components. The large and expanding MSFC aerodynamic data base associated with the Shuttle flights necessitates the development of analysis tools and techniques that provides MSFC with the capability of rapidly and efficiently accessing, analyzing, and reformulating the data base as new data become available from wind tunnel tests and future flights. Configuration changes or performance enhancements to the Shuttle during the operational phase of the program require rapid assessment and evaluation of the aerodynamic effects on the vehicle. Increased life of the SSME components is a continuing goal with the current engine configuration as well as for planned upratings of the SSME system. Fluid flow analyses of the engine components are essential to gaining an understanding of the current problem areas and to design better components for future engine modifications. Both of these fluid dynamics disciplines associated with the Shuttle required an analysis capability which can rapidly generate numerical data to investigate potential problems. The Computational Aero/Fluids Analysis System provides MSFC with the in-house analytical capability to perform state-of-the-art computational analysis in support of the Shuttle flights.

A discussion of the technical tasks completed during this contract is presented in Section 2. An overview of the procedures required for use of the Aero/Fluids Analysis System (AFAS) is presented in Section 3.

2. TECHNICAL DISCUSSION

2.1 SCOPE OF WORK

Lockheed provided all of the personnel, equipment, and computer software required to develop a computational aero/fluids analysis system for MSFC. This system has the capability of rapidly and efficiently performing aerodynamic analyses of test, flight, and theoretical data. The ability to rapidly generate SSME flow environments is a part of the overall capabilities. Lockheed developed, modified, and enhanced existing software to provide MSFC with a workable in-house capability. The software included in the analysis system provides the ability to perform graphical compilation/comparisons of static stability and airloads data as a function of standard aerodynamic independent parameters, the ability to perform mathematical manipulations of these data, and the ability to generate three-dimensional flowfield and thermal environments in various components of the SSME. The assessment and development of the system included documentation, training courses and on-site instruction in use of the system by MSFC personnel. Lockheed demonstrated the overall system capabilities by analyzing example aerodynamic SSME problems.

The following paragraphs detail the specific equipment and computer software that Lockheed used to develop the Computational Aero/Fluids Analysis system for NASA-MSFC.

2.2 EQUIPMENT REQUIREMENTS

The external aerodynamic flow and internal gasdynamic flow associated with the Space Shuttle required an analysis system that can rapidly and efficiently access, manipulate, and reformulate the large and expanding MSFC Shuttle external aerodynamic data base while providing the capability to numerically analyze complex fluid flow fields associated with the SSME system. This analysis system provides NASA-MSFC with the in-house analytical capability to perform state-of-the-art computational analysis in support of the Shuttle and future programs.

In order to provide this computational capability, Lockheed purchased, delivered and installed at NASA-MSFC a Digital Equipment Corporation (DEC) VAX 11/750 computer system with the appropriate hardware and software as listed in Table 1.

2.3 AERO/FLUID ANALYSIS SYSTEM SOFTWARE

Lockheed provided an interactive graphics analysis program to MSFC for the computational aero/fluid analysis system (AFAS). This program and supporting utility software provides MSFC with the capability to analyze, develop, and manipulate both external aerodynamic pressure data and six-component static stability data in a timely and cost effective manner.

The AFAS program is an interactive computer graphics program which allows an engineer to apply his judgment to the development of pressure distributions and the smoothing of wind tunnel pressure data in a real time environment. The purpose of the program is to produce airloads which are compatible with vehicle stability data and which reflect engineering judgment. AFAS employs interactive computer graphics techniques and enables the engineer to balance pressure distributions to force data. The engineer/analyst can interactively develop a pressure distribution either longitudinally along a vehicle section or circumferentially around a vehicle cross section. Then, using menu selectable commands, the analyst can integrate the distribution to produce force and moment data. The user can then change the pressure distribution and rebalance the data as needed. The original data remains unchanged until the engineer completes his analysis and saves his final pressure distributions. All the commands that are available to the engineer using this program are listed in a menu format from which is selected the appropriate command by entering the letter or number corresponding to the selected command. After selection of a

Table 1 EQUIPMENT LIST

Item No.	Quantity	Description
1	1	DEC VAX-11/750 System Kernel with 2 Mbytes of ECC MOS Memory
2	1	DEC RA60 Cabinet-Mounted, 205 Mbytes Capacity, Removable Media Disk Drive with UDA50 Controller
3	1	DEC RA81 Rack Mounted, 456 Mbytes Capacity, Winchester Technology Disk Drive
4	1	DEC TU80 Magnetic Tape Subsystem with (9-Track, 1600 bpi Recording Density
5	1	DEC LXYZZ Graphics Line Printer with 600 1pm Printing Speed and Dot Matrix Graphics
6	1	DEC LA120 DECwriter II System Console Terminal
7	1	DEC DMF32 Multifunction Communications Controller with 8 Asynchronous, 1 Synchronous, and 1 Parallel Interface
8	1	DEC MS750-CD 4 Mbytes ECC MOS Expansion Memory
9	1	DEC FP750 Floating Point Accelerator with 2 Mbytes ECC MOS Expansion Memory and VAX-11 FORTRAN
10	1	DEC VAX/VMS Level II System Startup Service
11	4	DEC VT220 Alphanumeric Video Terminals
12	2	Tektronix 4107 Color Graphics Terminal
13	2	Tektronix 4695 Color Copier
14	-	Cabling and Accessories as Required

particular command, the program prompts the user through the command selected. Upon completion of the processing of the selected command, the user is then returned to the main program menu to select another command or terminate the interactive session. Files created and/or altered during an interactive session are saved for later use.

AFAS can integrate pressure data on wings, vertical stabilizers, fins, cylinders, and arbitrary cross-section fuselages. Although AFAS was developed specifically to handle the Space Shuttle Launch Vehicle (SSLV), it is capable of handling almost any arbitrary cross-section body.

2.4 HARDWARE PROCUREMENT, INSTALLATION, AND TRAINING

The Digital Equipment Corporation VAX 11/750 system, composed of hardware and software listed in Table 1, was purchased by Lockheed. Considerable effort was expended in ordering and installing this equipment and ensuring that personnel were properly trained to utilize the system.

The first task performed was to ascertain the specifications for the system. The hardware list was checked in detail to ensure that all system requirements were satisfied. All interfaces were checked to make certain there were no incompatibilities. Checks were made to ensure that all software purchased was required and that it would work as specified.

The second task performed was to make certain that the site for the computer was compatible with the selected hardware. DEC required that the site be agreeable to them in order to secure maintenance agreements. The DEC representatives inspected the site and prepared a computer printout that listed all air-conditioning, power plug, and power requirements. NASA-MSFC assumed responsibility for getting the proper air-conditioning and power installed. As part of this task Lockheed prepared a site layout which showed where all the equipment was to be installed. This layout took into consideration the acceptable lengths of power cables and signal cables.

The third task included receipt and installation of the computer at NASA. Hardware installation was performed by DEC and software installation was performed by Lockheed. Following equipment installation, Lockheed quality tested the computer system to make certain all software and hardware was operational.

The fourth task required training of NASA personnel in the use of the computer system. Basically, two levels of training were necessary. A system manager was trained from NASA. Second, all the users were trained. Lockheed performed these activities using the training credits provided with the purchase of the system.

2.5 TRAINING AND ON-SITE INSTRUCTION

Lockheed provided on-site instruction and training to MSFC personnel in two categories: (1) computer system use, and (2) analysis software use.

2.5.1 Computer System Use

Two levels of training and instruction were provided for computer system use. The first level involved training a system manager to handle system-level tasks associated with the VAX system. In order to perform this training, Lockheed utilized the training credits that were provided with the purchase of the computer system.

The second level of instruction included computer-user instruction for MSFC users. Lockheed prepared and presented to users of the computer system a short course covering the use of each of the computer system features. Course material was prepared by Lockheed for participants. This instruction included hands-on demonstration of the capabilities of the computer system.

2.5.2 Analysis Software Use

Lockheed also provided on-site instruction in the use of the analysis software that was be included in the analysis system. Sample cases were run by Lockheed personnel to demonstrate the capabilities of the analysis software.

2.6 SUMMARY

The Computational Aero/Fluids Analysis System provides MSFC personnel with the analytical capability to perform state-of-the-art computational analyses in two unique and difficult fluid dynamics disciplines associated with the Space Shuttle program. This system provides the analysis tools and techniques for rapidly and efficiently accessing, analyzing, and reformulating the large and expanding MSFC external aerodynamic data base while also providing tools for complex fluid flow analyses of SSME engine components. Both of these fluid flow disciplines, external aerodynamics and internal gas-dynamics, required this capability to ensure that MSFC can respond in a timely manner as problems are encountered and operational changes are made in the Space Shuttle program.

3. AFAS USER PROCEDURES

This section presents an overview of the required procedures for using the AFAS system. The menus that are provided in the system are presented and their usage is explained.

3.1 SYSTEM ENTRY

The user enters the AFAS system by executing a command procedure that prompts the user for the storage location of his data files. This location is a directory specification. Upon receiving a storage location, AFAS then prompts the user through several questions pertaining to device type and data type. Once these questions are sufficiently answered, the AFAS Main Menu appears.

3.2 MENU FUNCTIONS

AFAS is driven by four major menus that offer the user a wide variety of functions.

The Main Menu (Fig. 3-1) is the first menu the user will see after loading a data file into AFAS. From this menu the user can perform various functions such as interpolation, integration, and duplication. Also, the user can plot a graph, select a plot mode or access any of the other menus. The user must exit AFAS through the Main Menu to ensure proper closure of all data files.

The Graph Options Menu (Fig. 3-2) allows the user to manipulate data while viewing a plot. The user can add or remove points, magnify data or overlay several rings of data on a selected ring. An example of an overlay

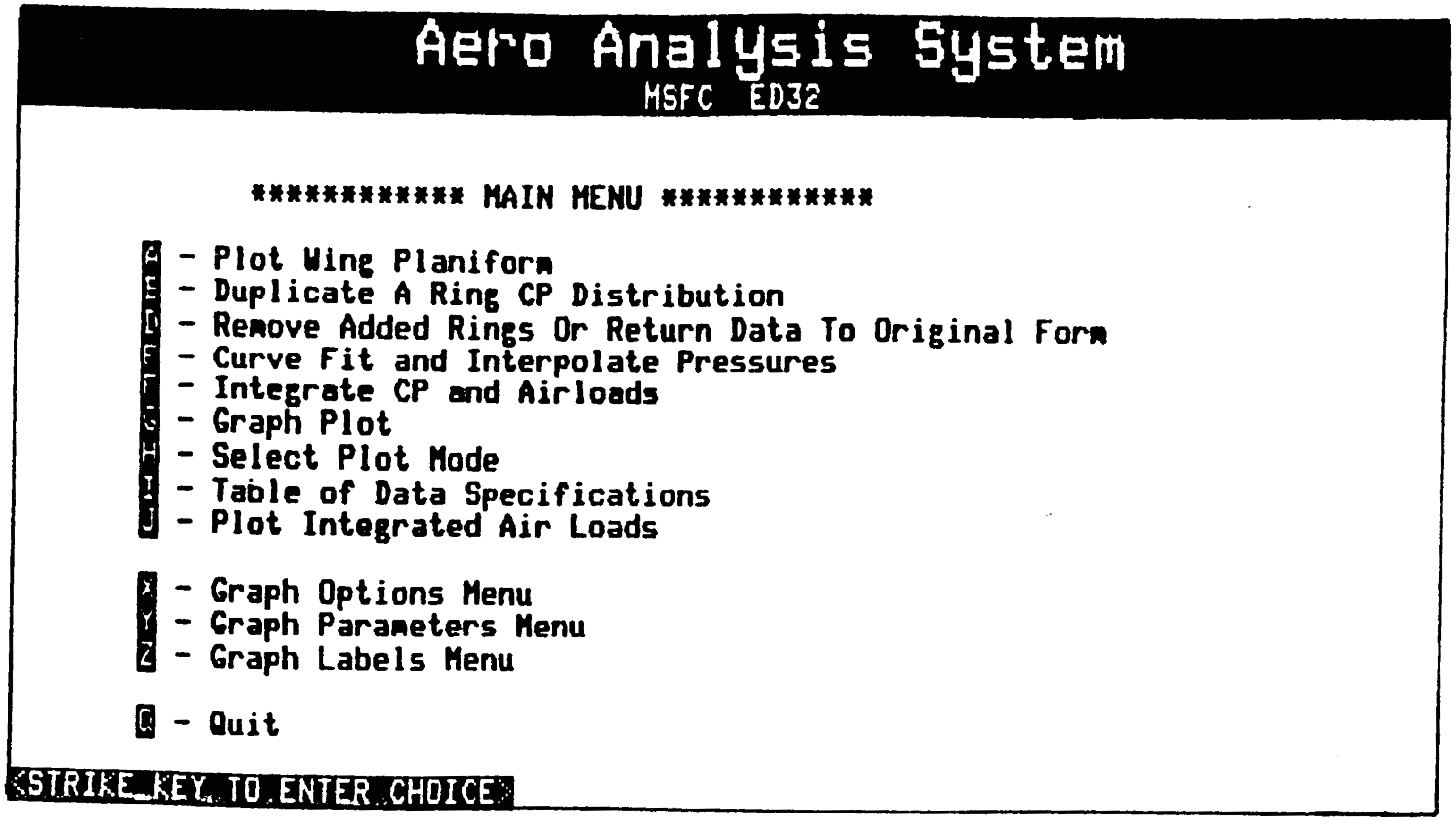

Fig. 3-1 Main Menu

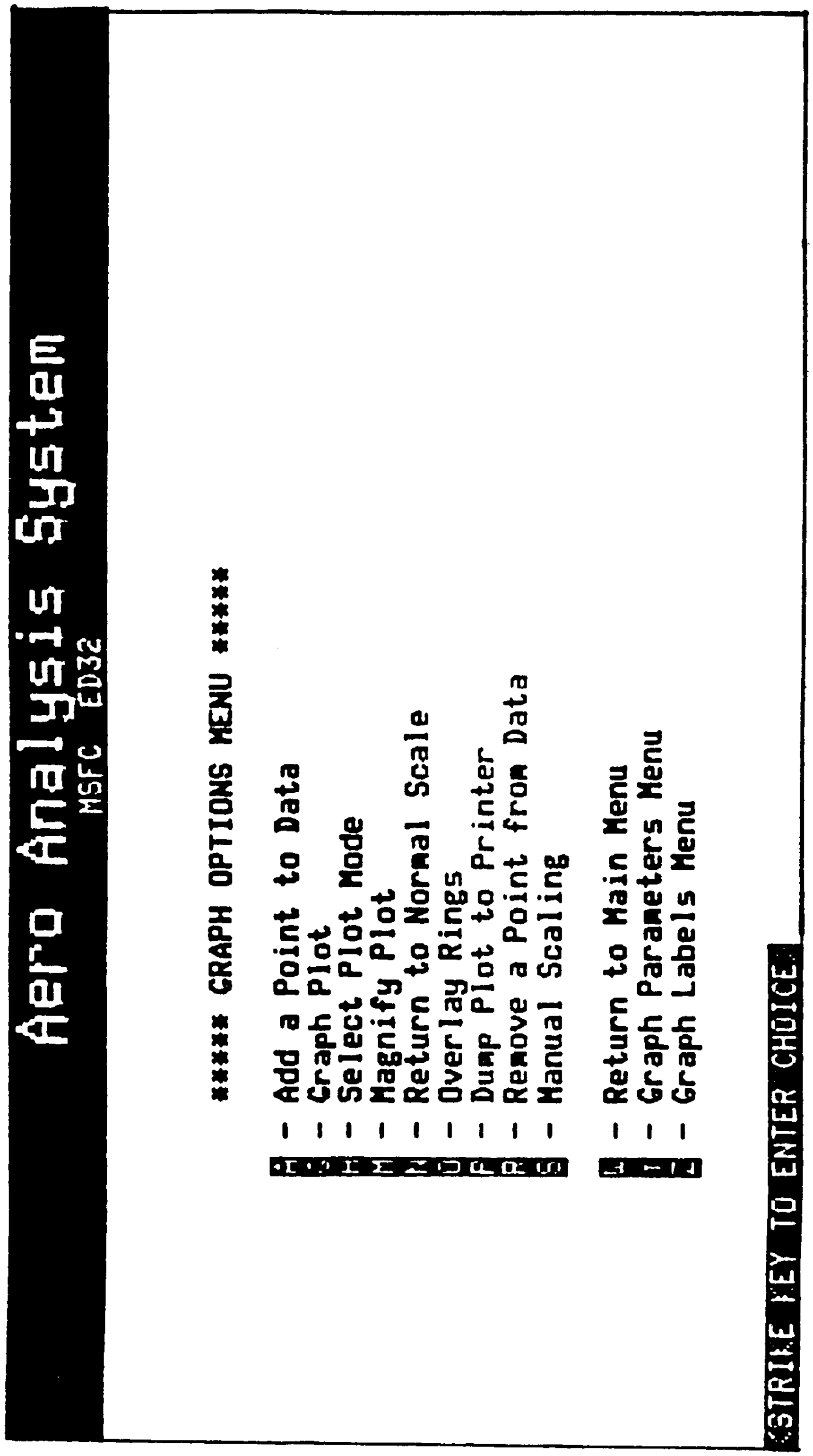

Fig. 3-2 Graph Options Menu

plot is shown in Fig. 3-3. The Graph Options Menu also contains a manual scaling option. This option allows the user to change X and Y scaling parameters, numbers of divisions on a graph and also change the format of the axis division labels. Figure 3-4 shows the Manual Scaling Menu.

The Graph Parameters Menu (Fig. 3-5) gives the user the option of changing the physical characteristics of a graph. Grid lines can be added on major divisions only or on both major and minor divisions. Figures 3-6 and 3-7, respectively, illustrate these options. Also, symbols and lines can be added or suppressed through options in the Graph Parameters Menu.

The Graph Labels Menu (Fig. 3-8) provides the user with the opportunity to manipulate the labels on a graph. Figure 3-9 shows a display of the label positions available and the number of characters allowable for each label. Through this menu, the user can change any or all labels, suppress any or all labels, read labels from a file, or store new labels to a file. Figure 3-10 shows the Change Label Menu, and Fig. 3-11 shows the Suppress Labels Menu.

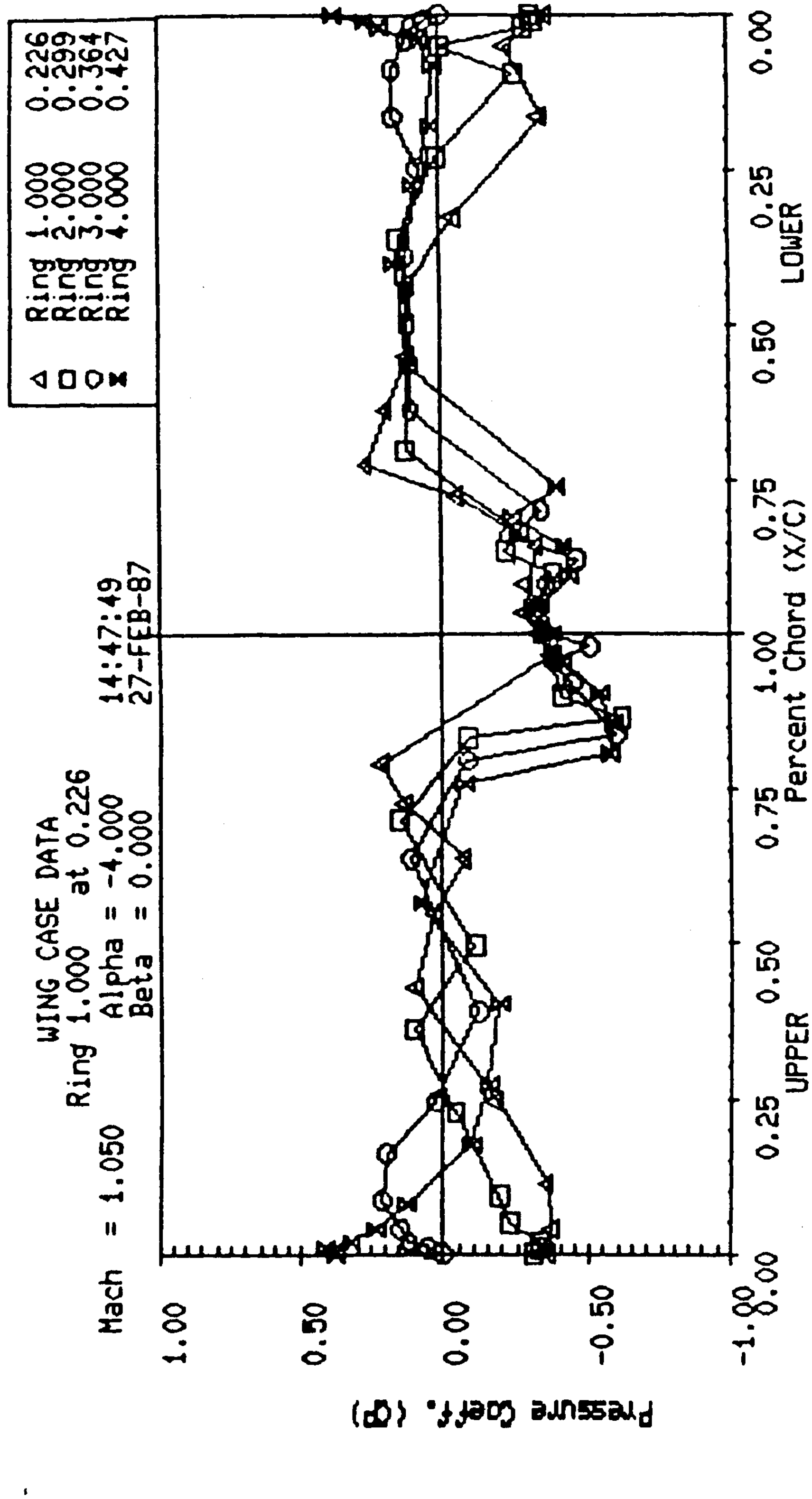

Fig. 3-3 Example of Overlay Plot

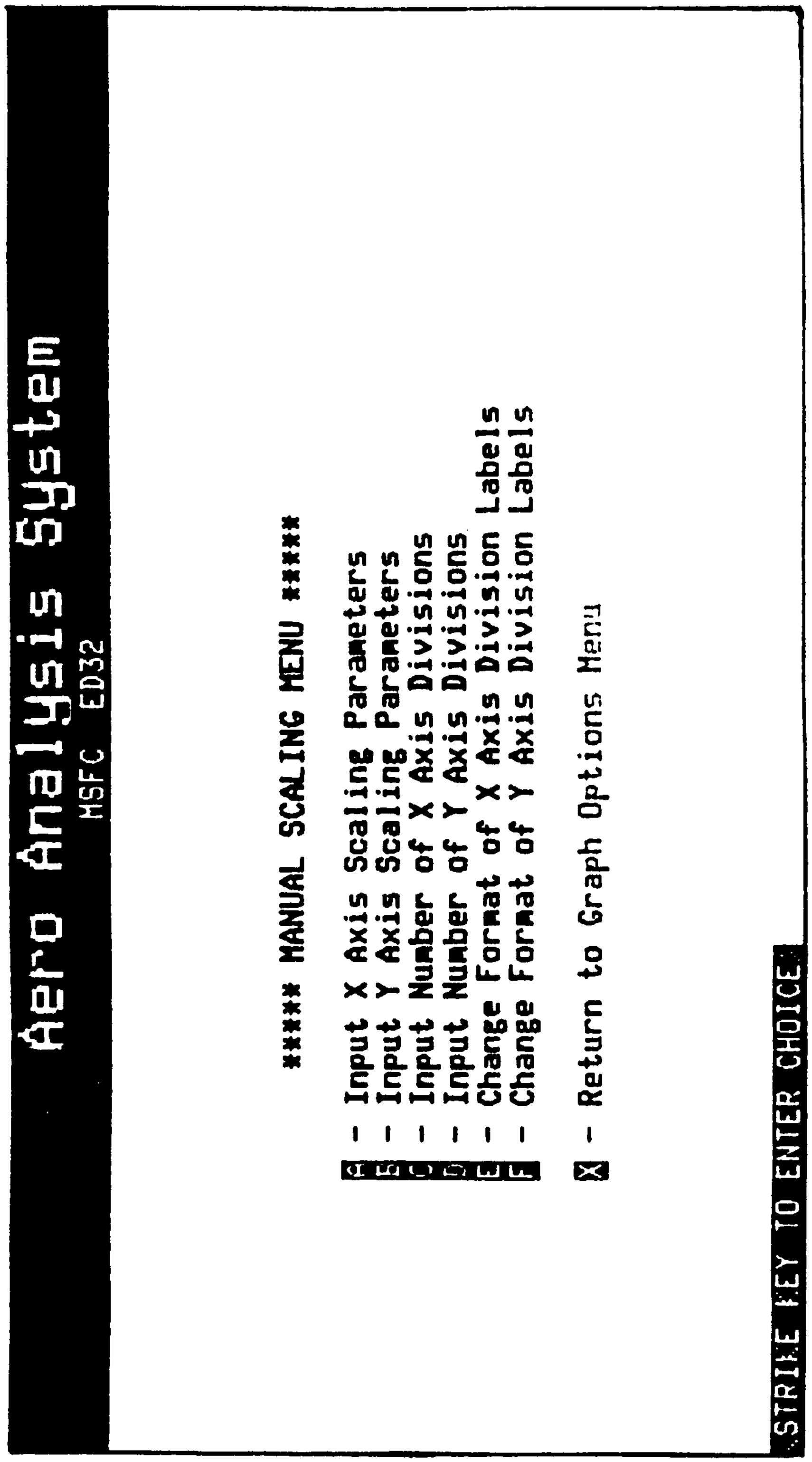

Fig. 3-4 Manual Scaling Menu

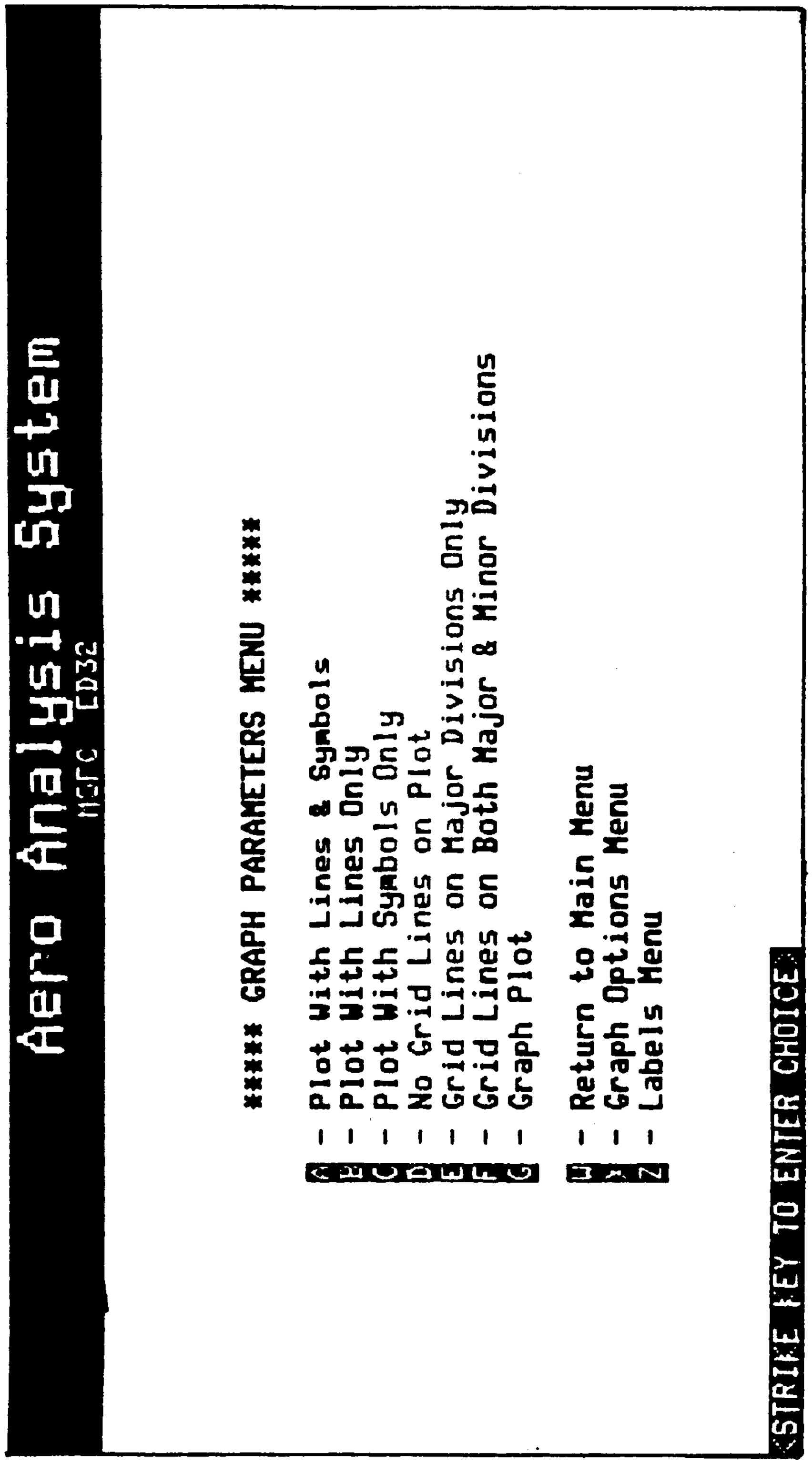

Fig. 3-5 Graph Parameters Menu

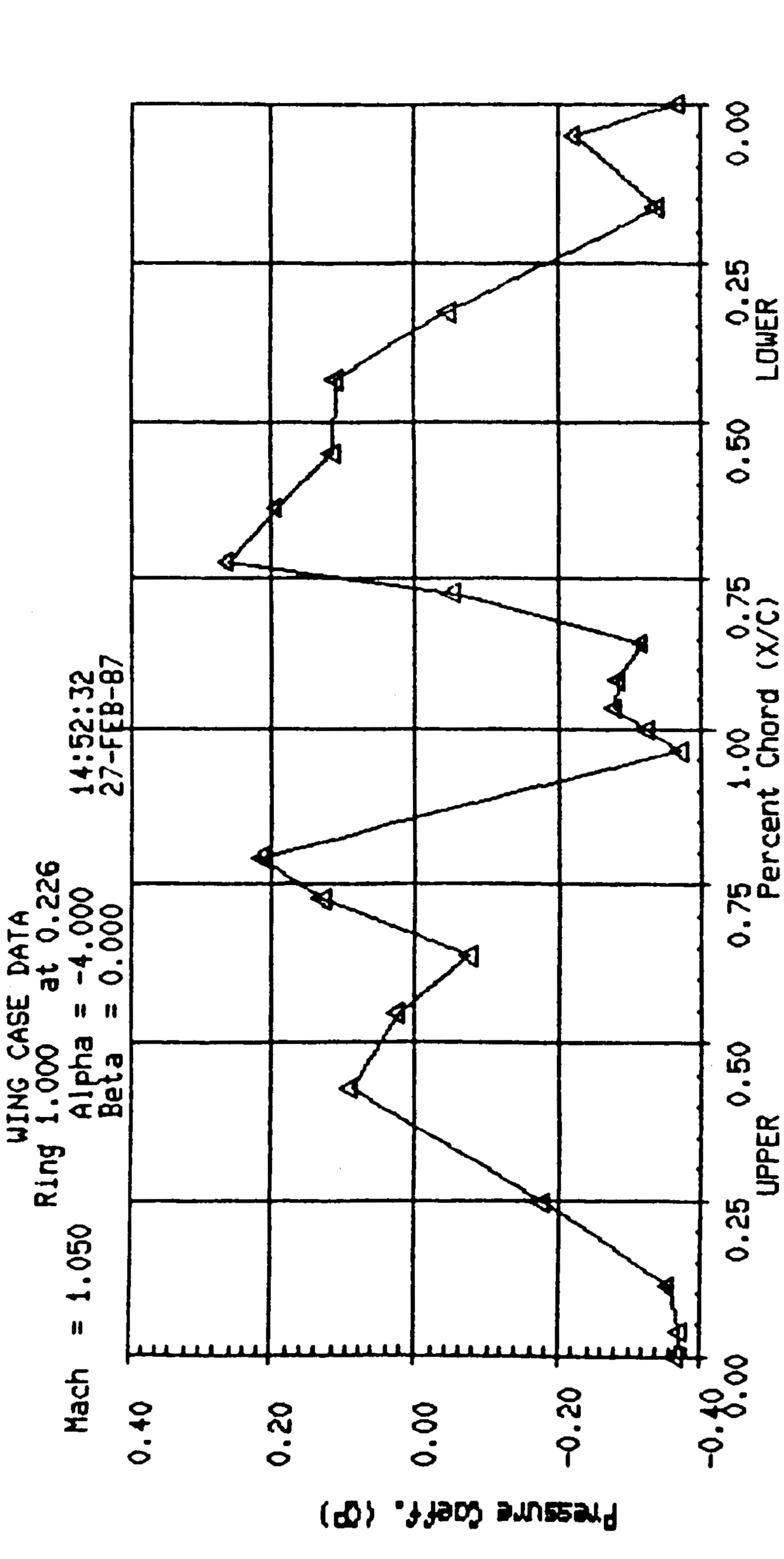

Fig. 3-6 Grid Lines on Major Divisions

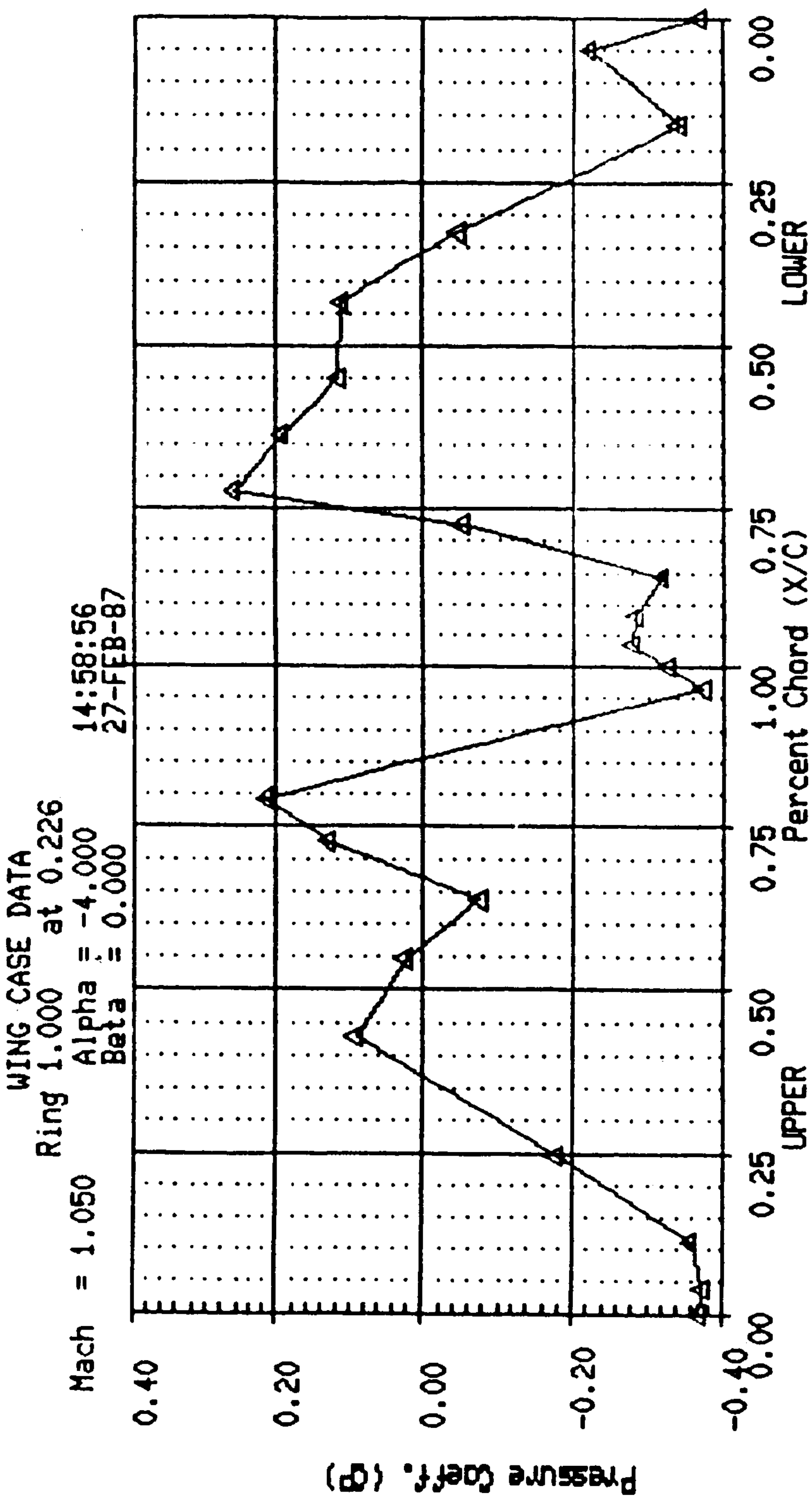

Fig. 3-7 Grid Lines on Both Major and Minor Divisions

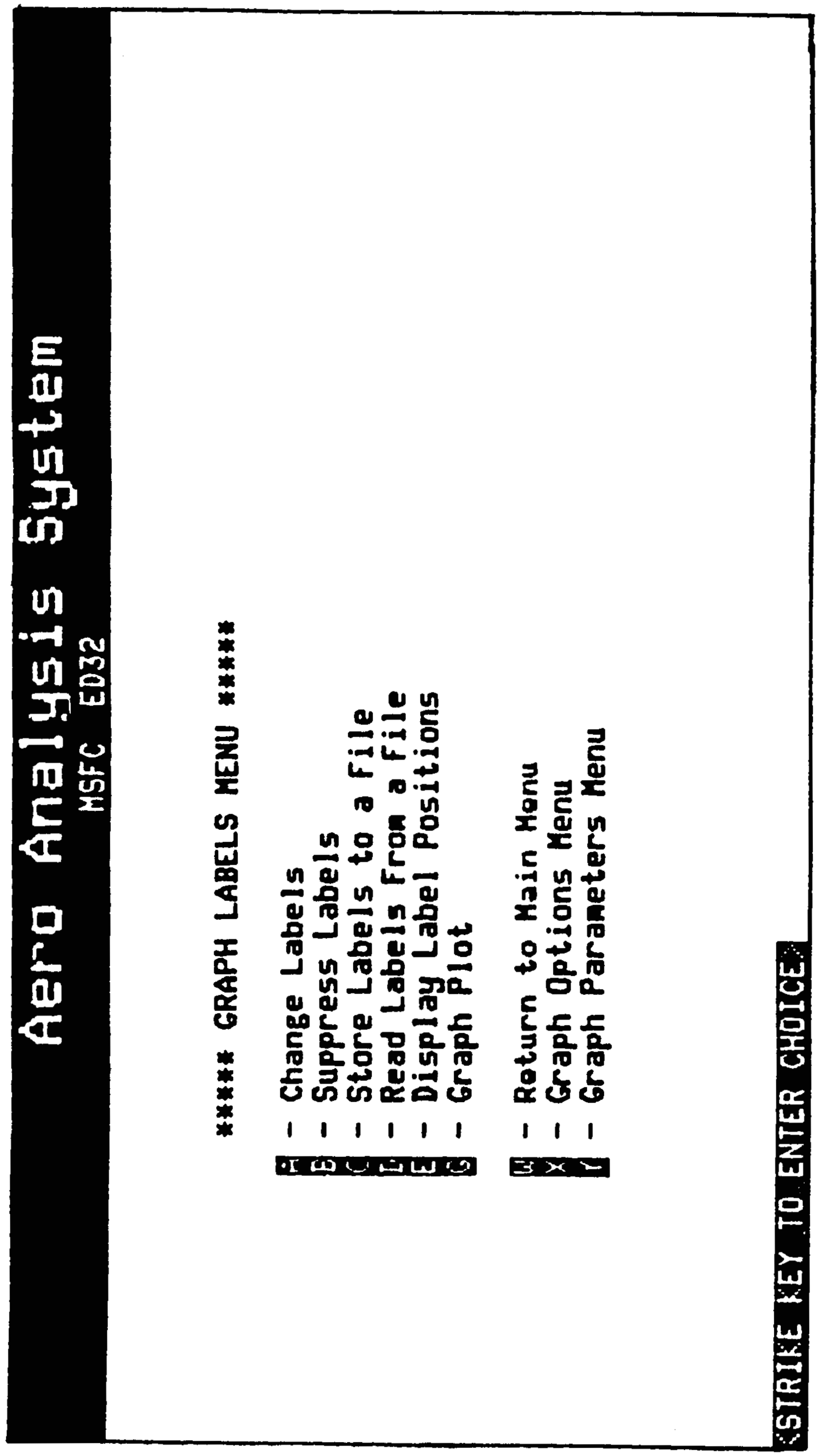

Fig. 3-8 Graph Labels Menu

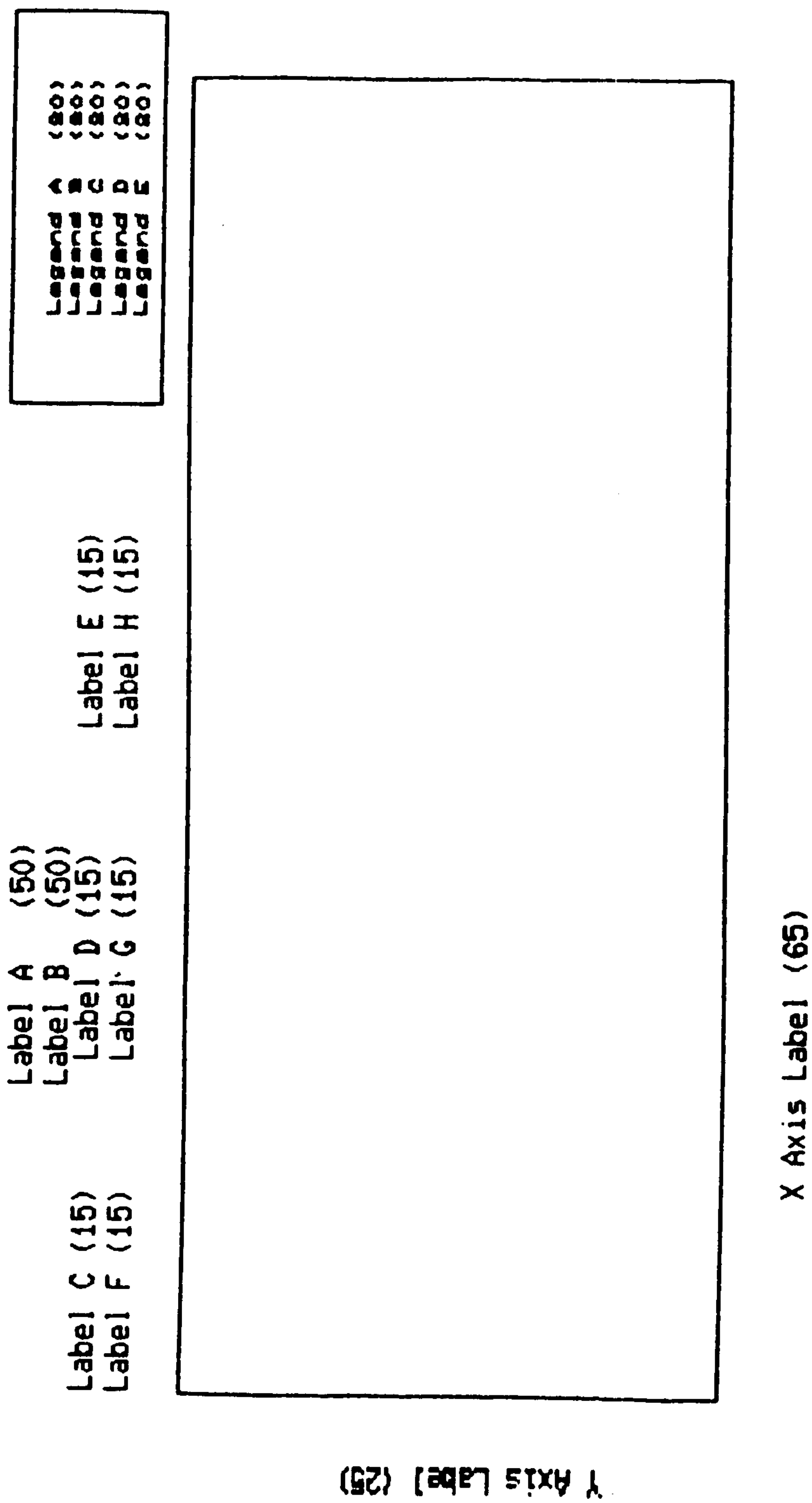

Fig. 3-9 Display of Label Positions

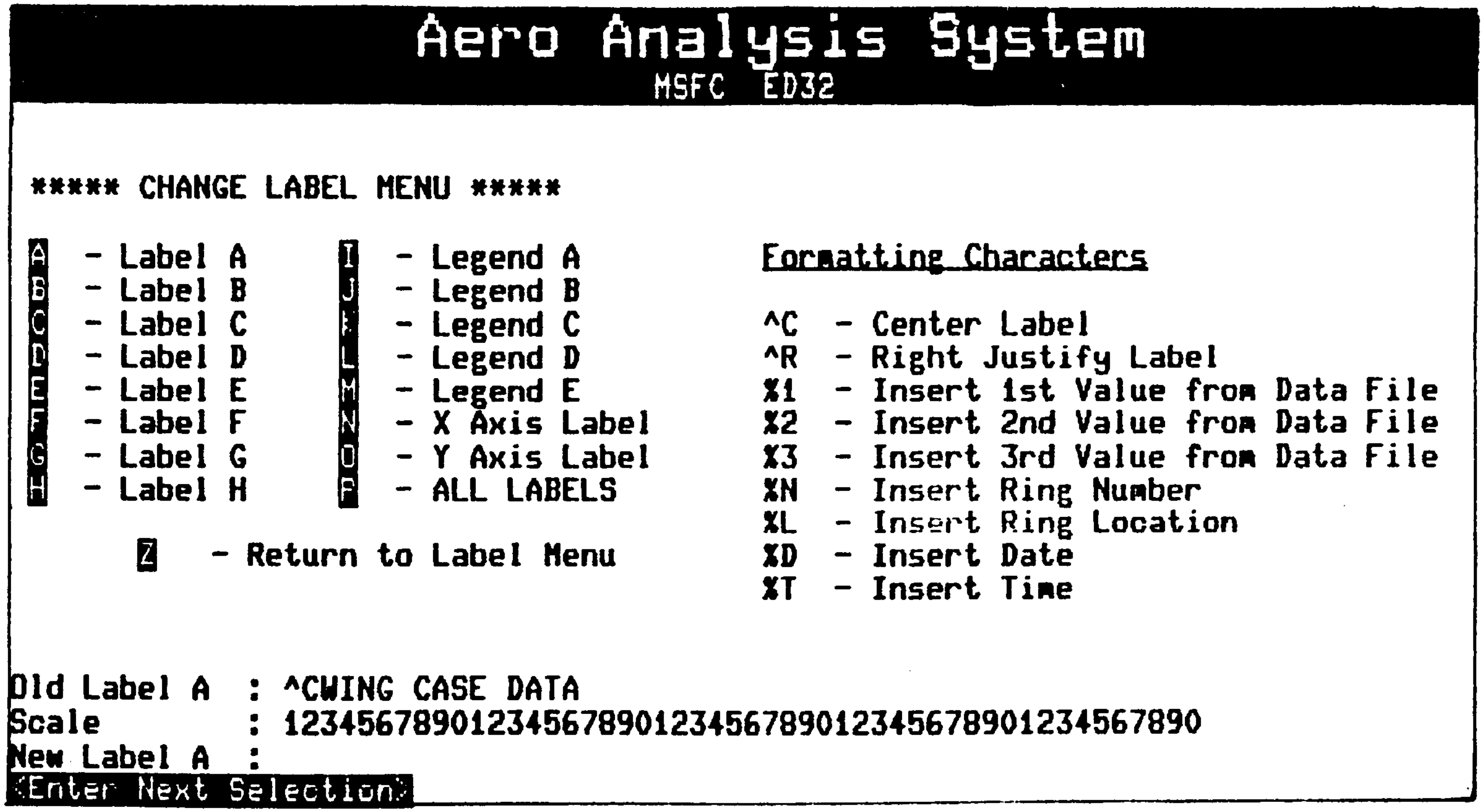

Fig. 3-10 Change Label Menu

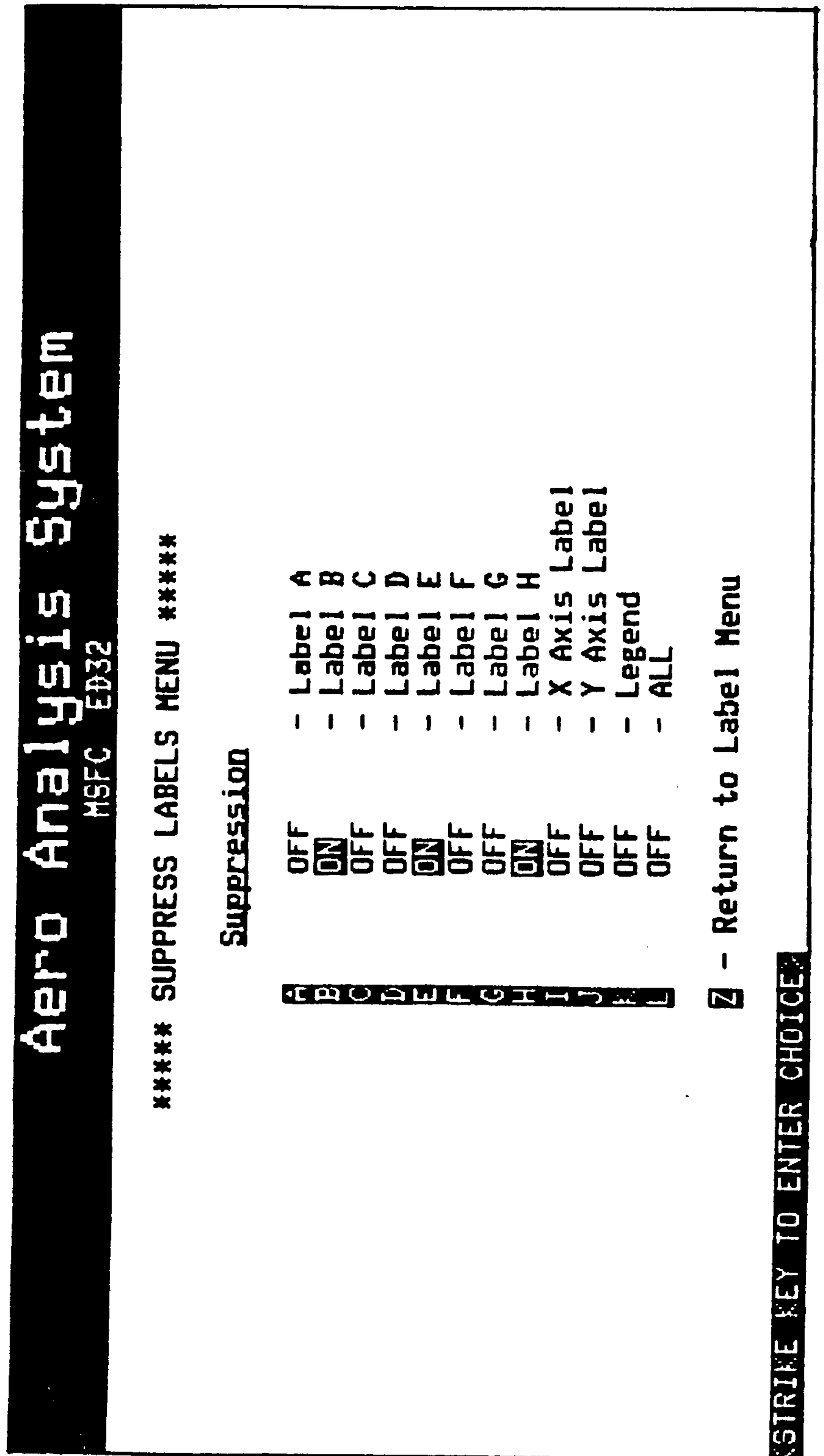

Fig. 3-11 Suppress Labels Menu