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AERODYNAMIC PRELIMINARY ANALYSIS SYSTEM

PART II USER'S MANUAL AND PROGRAM DESCRIPTION

BY

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SUMMARY

A comprehensive aerodynamic analysis program based on linearized potential theory is described. The solution treats thickness and attitude problems at subsonic and supersonic speeds. Three dimensional configurations with or without jet flaps having multiple non-planar surfaces of arbitrary planform and open or closed slender bodies of non-circular contour may be analyzed. Longitudinal and lateral-directional static and rotary derivative solutions may be generated.

The analysis has been implemented on a time sharing system in conjunction with an input tablet digitizer and an interactive graphics input/output display and editing terminal to maximize its responsiveness to the preliminary analysis problem. Nominal case computation time of 45 CPU seconds on the CDC 175 for a 200 panel simulation indicates the program provides an efficient analysis for systematically performing various aerodynamic configuration tradeoff and evaluation studies.

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INTRODUCTION

This manual describes the commands and procedures for operating the Aerodynamic Preliminary Analysis System. It has been compiled in alphabetical order to simplify useage.

Once in the system, the analyst is in a self contained interactive environment wherein he can input vehicle definitions, perform aerodynamic analysis, and display the computed results without exiting the system. It is however not necessary to finish an entire job at one setting. Geometry and analysis can be left partially complete and resumed at a later session. This mode has the further benefit of protecting against large information losses in the event of a machine failure.

Definition of the various program functions have been made brief with user options clearly described. The briefness is by design as it has been found that practice is the best teacher of the system.

As a result of the program flexibility and freedom of choice no attempt has been made to define a recommended order of application. Guides are suggested. The analyst is urged to develop his own preferred useage in the process of learning the system.

The complete program is available from COSMIC (Computer Software Management and Information Center, 112 Barrow Hall, University of Georgia, Athens, Ga 30602) as Aerodynamic Preliminary Analysis System, LAR 12404.

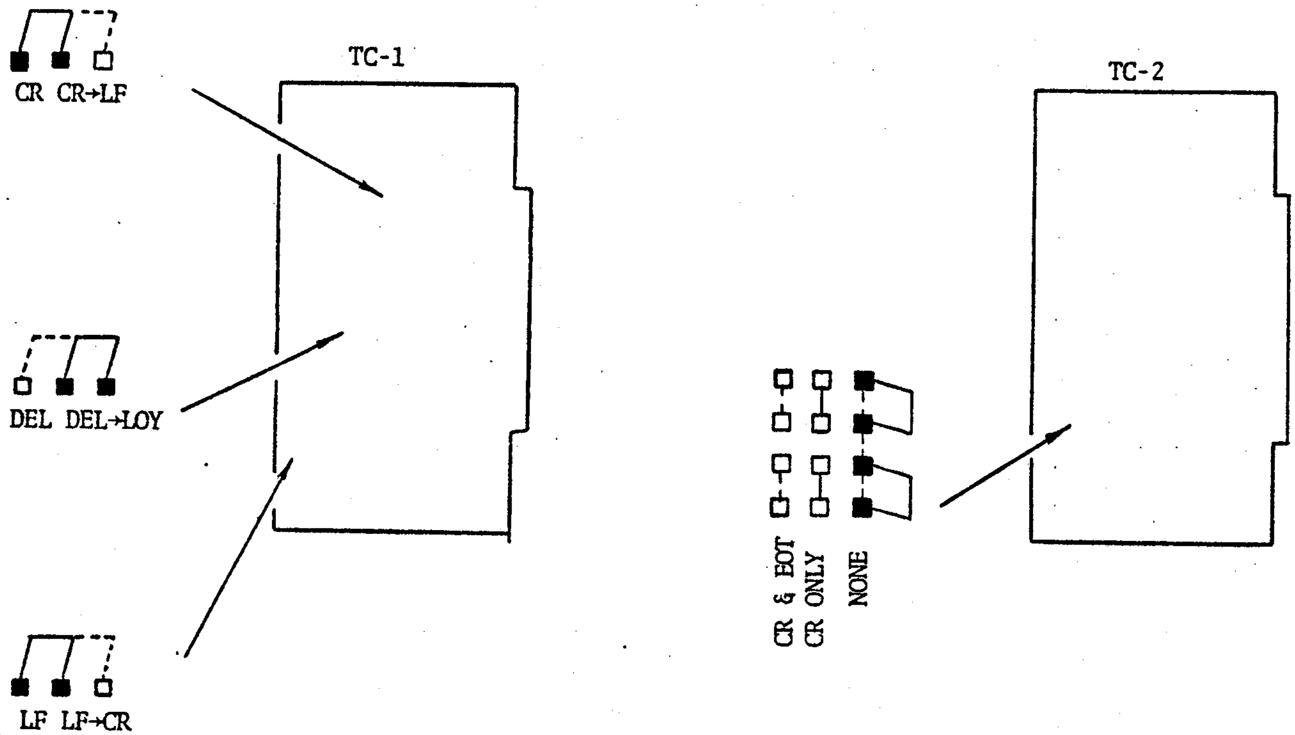
SYSTEM HARDWARE REQUIREMENTS

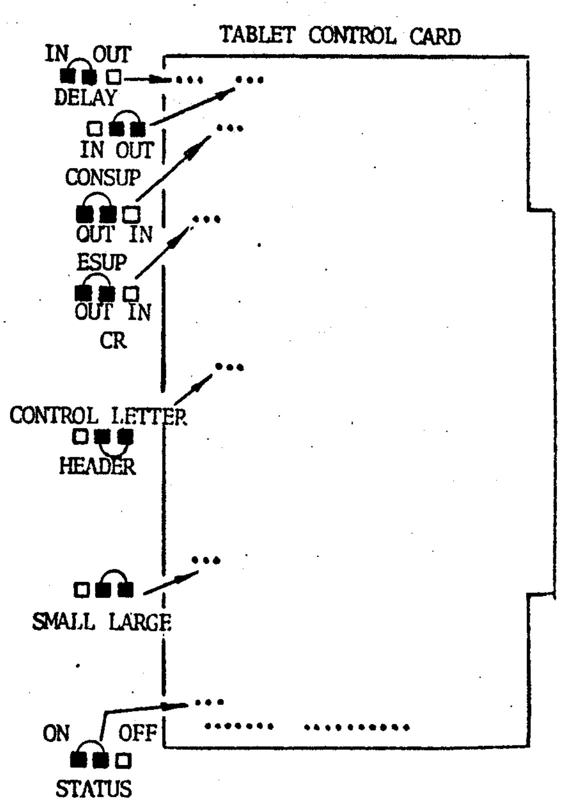
This system, as it is available from COSMIC, was designed for operation on a CDC CYBER 175 and other CDC computing hardware. When compiled and loaded on the CYBER 175 using the included segmentation schemes, the programs will occupy a core space not exceeding 70k octal.

The interactive programming has been set up to operate using Tektronix graphics hardware as the primary interface with the system. The Tektronix 4014 graphics terminal is used for keyboard input and graphics display, and the Tektronix 4954 digitizing tablet is used for inputing geometry components. Transmission speeds of less than 120 characters (1200 BAUD) per second reduce the graphical efficiency of the interactive programming and inhibit the efficiency of the system. Interested parties should verify the existence of such hardware and speeds at their facilities prior to acquisition of the program.

Strapping options on the Tektronix 4014 circuit boards will vary from installation to installation depending on computing equipment interfaces. The options used in the initial installation are shown on Table I for the TC-1, TC-2 and Tablet interface control boards. It is recommended that the strapping options not be altered until after the program has been run once or twice since the hardware is probably correct for that installation. For further information on Tektronix hardware and setup, see Tektronix publications entitled "4014 and 4014-1 Computer Display Terminal Users", and "4953/4954 Graphics Tablet".

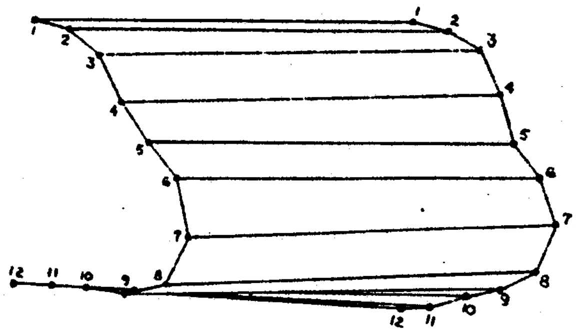
TABLE I TEKTRONIX 4014 STRAPPING



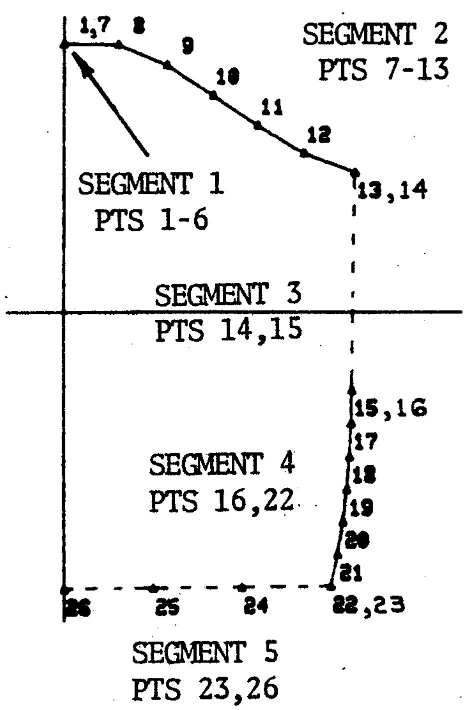


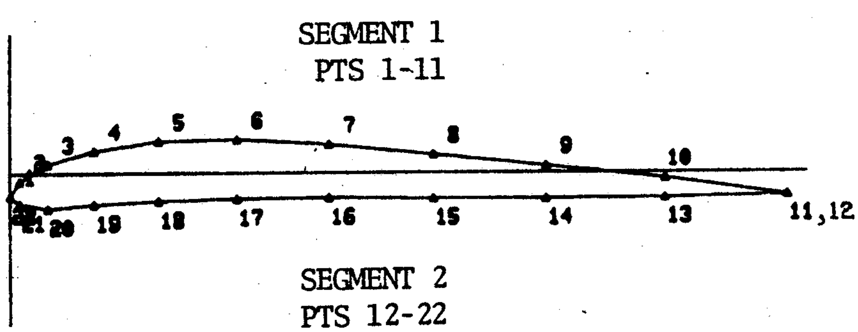
CONFIGURATION GEOMETRIC SIMULATION

The geometry description selected for this system is the method of stacked sections where each section of a component contains the same number of defining points as indicated.



Each section can be broken into segments to improve point to point dependencies, reflect segments which are wetted (exposed) or un-wetted, and improve curve fitting on individual sections as illustrated below. The total number of points in any one component is limited to 500.





TYPE 3 and 4

TYPE 1 and 2

The system contains eight types of components for geometric construction and analysis.

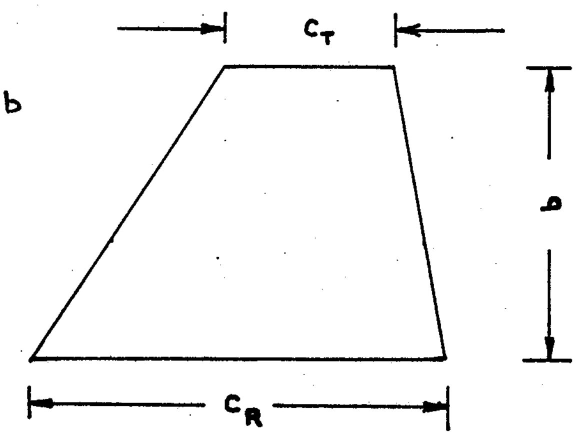
TYPE 1: CENTERLINE BODY. Maximum number of segments per cross section is ten. The alignment of each section is perpendicular to the X-axis at construction although this can be changed after input. Components of this type are fuselages and centerline nacelles.

TYPE 2: OFF-SET BODY. Has the same characteristics as a TYPE 1. This component is used to simulate engine nacelles, fuel pods, etc.

TYPE 3: HALF SURFACE. Geometric quantities are based on a non-reflected trapezoidal representation.

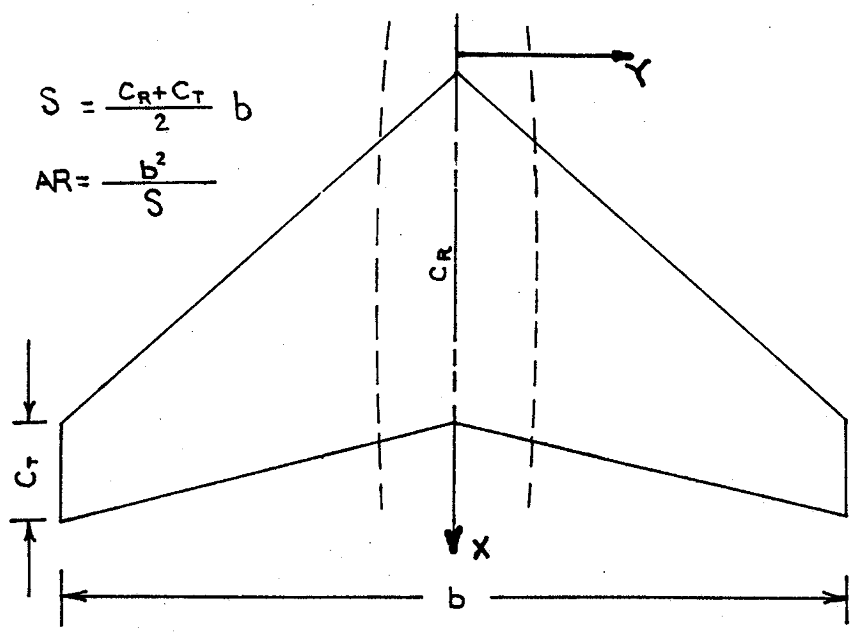
$$S = \frac{C_R + C_T}{2} b$$

$$AR = \frac{b^2}{S}$$



This option is used to simulate vertical tails, end plates, and other components which do not require a reflected image. When a TYPE 3 surface is edited the view displayed is an unwrapped pictorial based on a line described by the points comprising the leading edge of each section. When a component section is listed it is displayed as a full faced cross section cut. TYPE 3 components (and TYPE 4) normally have two segments per cross section, an upper surface and a lower surface, but three are permitted to allow for airfoils with blunt trailing edges.

TYPE 4: SYMMETRIC SURFACE. Geometric quantities are based on a reflected trapezoidal representation.



Wings are typical TYPE 4 components. The symmetric surfaces in the local file are scanned to select the reference first suggested for the total configuration. TYPE 4 surfaces are edited by displaying the component as it appears in the X-Y plane.

TYPE 5: INTERFERENCE SHELLS or flat plate surface constructions. Input using the INTERFERENCE function or card data.

Multiple interference shells associated with a particular slender body are combined into a single component. TYPE 5 constructions will default to TYPE 3 if a slender body (TYPE 7 or 8) is not present.

In the EDIT function, interference shells are unwrapped and displayed so the overall paneling distribution can be viewed. The EDIT function is also used on chordwise paneling of interference shells. The LIST function is used to add segments.

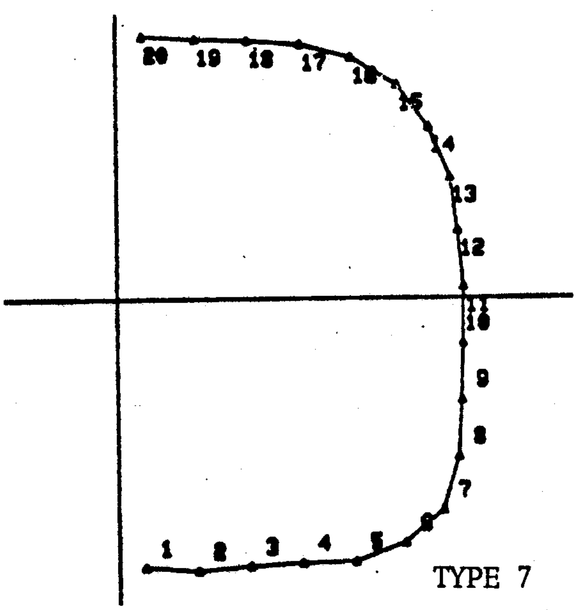
TYPE 6: JET FLAPS. Input using the INTERFERENCE function. A jet flap is constructed in the presence of a surface component to which it is attached. The surface trailing edge panel chord length establishes the first panel of each jet flap section. Axial geometric panel spacing is used in EDIT and INTERFERENCE.

Under EDIT a TYPE 6 is treated identical to a TYPE 5.

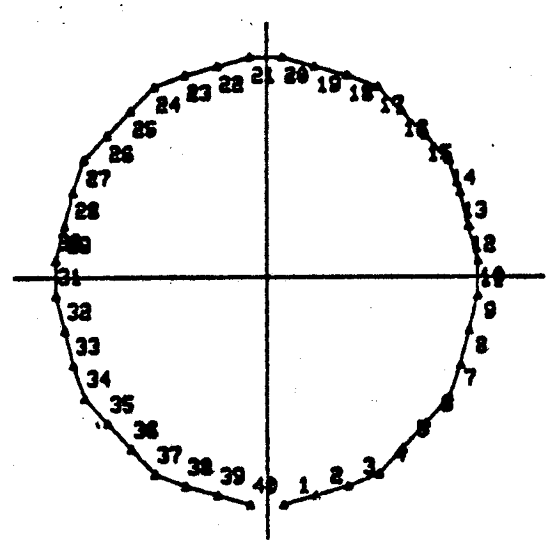
TYPE 7: CENTER-LINE SLENDER BODY. Used in solving the isolated body solution, see TYPE 8 description below.

TYPE 8: OFF-SET SLENDER BODY. Slender bodies are generated by combining TYPE 1 or TYPE 2 components to build up vehicle components. Bodies constructed of 1's and 2's are designated TYPE 7. Bodies made up of all TYPE 2's are designated TYPE 8. The user is limited to two slender bodies when performing the isolated body solution.

Slender bodies are designed to conform to a geometric simulation of the input bodies which can be utilized by the isolated body program. The cross sectional description of TYPE 7 and TYPE 8 are



TYPE 7



TYPE 8

described from bottom to top counter-clockwise with points evenly space about the cross section. TYPE 7 sections have 20 points, TYPE 8 sections have 40 points (maximum).

COMPONENT NUMBERING

The procedure for cataloging components using a numbering system is subject to the following rules.

1. Component numbers must be greater than 50 in order to make the distinction between record location and component numbers when using the system.

2. The viscous drag program will search for consecutive component numbers when a type 1 or 2 component is analyzed in order to treat the combined components as a single body. Up to ten consecutive bodies are allowed. Bodies always start at a decimal value (110, 300, 420, etc) while bodies to be grouped with another body have a unit increment from the previous component. For example components 100, 101,.....108, 109 would all be grouped together and analyzed as one body by the viscous drag program.

3. Interference shells must be numbered within 10.0 of the slender body they belong to. Multiple interference shells (more then one shell for a slender body) must sit in the working (local) file with the most forward shell first and the remaining shells in order behind it, see below.

FILE: WORK

REC	COMP NO.	NAME	TYPE
1	700.00	SLENDER BODY	7
2	701.00	FOR. INTE SHELL	5
3	702.00	MID INTE SHELL	5
4	703.00	AFT INTE SHELL	5

4. Type 4 components when numbered within 10.0 and stored in consecutive records in the work file will be combined together as one component. The inboard component should be followed by successive outboard components, see below.

FILE: WORK

REC	COMP NO.	NAME	TYPE
10			
11	400.0	INBD WING	4
12	401.0	CNTR WING	4
13	402.0	OTBD WING	4

FILE ORGANIZATION

The geometry is stored in the permanent file using the CDC MS system to have direct access to any component in the file. The first record contains the number of components, title and the component directory. Records 2 through 51 are for component storage, one component per record, a fixed 1973 words in each record. The storage locations of each record and a description of each variable are given in table II.

The variables are placed in order of importance so quantities needed more regularly can be accessed without reading an entire record. Each component is sufficiently complete that a minimum of calculation is necessary to display, change or analyze the geometry.

TABLE II COMPONENT FILE COMPOSITION

RECORD 1 is the contents file		
LOCATION	VARIABLE	DESCRIPTION
1	NR	NUMBER OF COMPONENTS IN FILE
2-19	TITLE(1)-TITLE(18)	TITLE OF FILE
20	MP	FILE UNITS FLAG
21-70	COMP(1)-COMP(50)	SEQUENTIAL LISTING OF COMPONENTS IN FILE

RECORDS 2-51 are for component storage		
LOCATION	VARIABLE	DESCRIPTION
1	COMPN	COMPONENT NUMBER
2	ITYPE	COMPONENT TYPE
3-6	ANAM(1)-ANAM(4)	COMPONENT NAME
7	NH	NUMBER OF CROSS SECTION
8	NPH	NUMBER OF POINTS PER CROSS SECTION
9	NX	NUMBER OF SEGMENTS PER CROSS SECTION
10	NT	NUMBER OF LONGITUDINAL DISPLAY LINES
11	IEDD	WING DATA STORAGE FLAG
12-21	NMAX(1)-NMAX(10)	NUMBER OF POINTS PER SEGMENT
23-31	NOUT(1)-NOUT(10)	WETTED SURFACE FLAG FOR EACH SEGMENT
32	XMN	MINIMUM X OF COMPONENT
33	XMX	MAXIMUM X
34	YMN	MINIMUM Y
35	YMX	MAXIMUM Y
36	ZMN	MINIMUM Z
37	ZMX	MAXIMUM Z
LOCATION 38-51 are used for type 3 and 4 only		
38	SW	TRAPEZOIDAL AREA
39	AR	ASPECT RATIO
40	TAPER	TAPER RATIO
41	SWE	SWEEP (LEADING EDGE)
42	DIH	DIHEDRAL
43	SPA	SPAN
44	CR	ROOT CHORD
45	CT	TIP CHORD

LOCATION	VARIABLE	DESCRIPTION
46	CB	MEAN AERODYNAMIC CHORD $\bar{c}$
47	XFCB	SPAN DISTANCE FROM η = 0 to $\bar{c}$
48	AN	INCIDENCE
49	XBAR	X-LOCATION OF 1/4$\bar{c}$ RELATIVE TO CONFIGURATION
50	ME	UNIT SYSTEM FLAG
51	INFF	WING DATA STORAGE FLAG
52-551	X(1)-X(500)	X-VALUES OF POINTS IN COMPONENT
552-1051	X(1)-Y(500)	Y-VALUES
1052-1551	Z(1)-Z(500)	Z-VALUES
1552-1571	IXX(1)-IXX(20)	POINTS OF LONGITUDINAL DISPLAY LINES
LOCATIONS 1552-1973 are for type 3 to type 6 only		
1572	IFLP	NUMBER OF PANELS IN COMPONENT
1573-1972	IFLA(1)-IFLA(400)	PANEL BOUNDARY CONDITION ARRAY
1973	INFLAP	NUMBER OF CONTROL SURFACES IN COMPONENT

SYSTEM CURVE FITTING ROUTINES

In order to interpolate,smooth and curve fit digitized sections and accomplish the other curve fitting and smoothing computations located throughout the system,a set of specifically designed routines have been set up. They are (1) linear interpolation, (2) a single cubic spline fit, and (3) least squares smoothing.

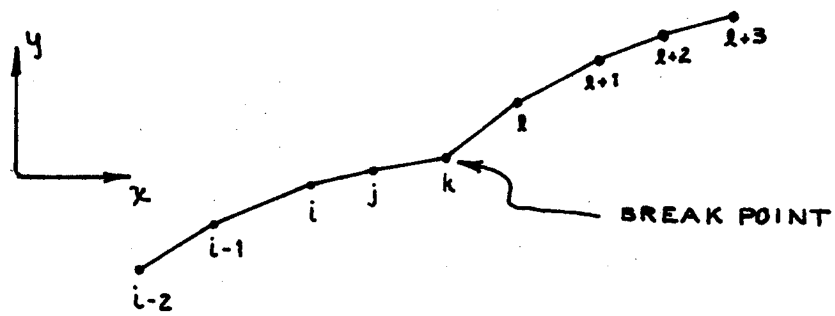
The linear interpolation routine interpolates straight line segments evenly spaced along the set of input points. Its principal uses in the system include finding span references for locating sections at specified eta,s (2y/b), making cross section cuts in the three-view display and interpolating points around the outline section cuts in the SLENDER function.

The cubic spline routine is an adaptation of a simple cubic spline which is point dependent at the endpoints, not slope dependent, giving the user spline control by the nature of his input points. This routine will also calculate derivatives, and do step-wise Simpson integration up to specified point locations. This is the principal routine used for cross section insertion and interpolation and segment interpolation. The interpolation is basically done as a function of X for TYPES 1, 2, 7 and 8 components and as a function of η for TYPES 3 through 6. The cross section cutting is done in conjunction with a break routine which is discussed below.

The least-squares smoothing routine is a fixed endpoint routine allowing smoothing orders up to 9 but never exceeding the number of free points on a line segment. This routine has a built in leading edge radius specification for interpolating airfoil sections. The routine will accept a leading edge radius from zero or above or calculate its own radius if less than zero. Fuselage longitudinal lines can be smoothed with this routine in EDIT where they are passed through the break routine prior to smoothing.

The break routine is designed to interpolate along specific lines on components breaking interpolation and starting again if a break in the line is detected. The break is searched for by checking the states of the curve behind a point relative to the changes which are about to occur at the next point. The routine actually begins performing between the third and fourth component cross sections, if there are less then four sections, the routine is bypassed.

Breaks are found in a defined line using the following algorithm:



Curve Illustrating Typical Break Point
Solved for using Break Algorithm

$j = i + 1$

$k = i + 2$

$l = i + 3$

$dx_i = X_j - X_i$

$dy_i = Y_j - Y_i$

$r_i = \sqrt{dx_i^2 + dy_i^2}$

$S_j = dy_i / r_i$ (sine of angle relative to i and j)

$S_k = dy_j / r_j$ (sine of angle relative to j and k)

$dS_k = (S_k - S_j) / dx_j$

$dS'_k = (dS_k - dS_l) / dS_k$

where dS'_k is a check on the rate of change of the sine before point k relative to the rate of change in the sine about the point k. The empirical bias which has proved most successful to locating break points in a line is

$$dS'_k > 2.45$$

FUNCTION DESCRIPTIONS

The basic format of the system operation is to request a function available in the system, do what ever work is necessary in the function, then return to the **OK** mode of the system. For users familiar with time sharing system, the **OK** mode is similar to the READY or COMMAND modes in the two most widely used systems (TSO on IBM and INTERCOM on CDC respectively). For CDC users some of the functions (CATALOG and ATTACH) have similar definitions to their counterparts on INTERCOM and thinking in terms of components in storage being the equivalent to permanent files on INTERCOM may ease you into the system faster. IBM users will have no such conflicts since similar functions yield similar results.

The function descriptions which follow and the function dictionary are listed in alphabetical order. Sub-commands in the dictionary for any functions are listed in alphabetical order following the function to which they belong. Since an alphabetical description does not give the user any feel for overall program operation, figure 1 is provided to catagorize functions in terms of system usage. Also included in Appendix III are sample sessions illustrating cases of geometry input, component manipulation, analysis set-ups and results display . Using this information as a guide, the user may begin to operate the system.

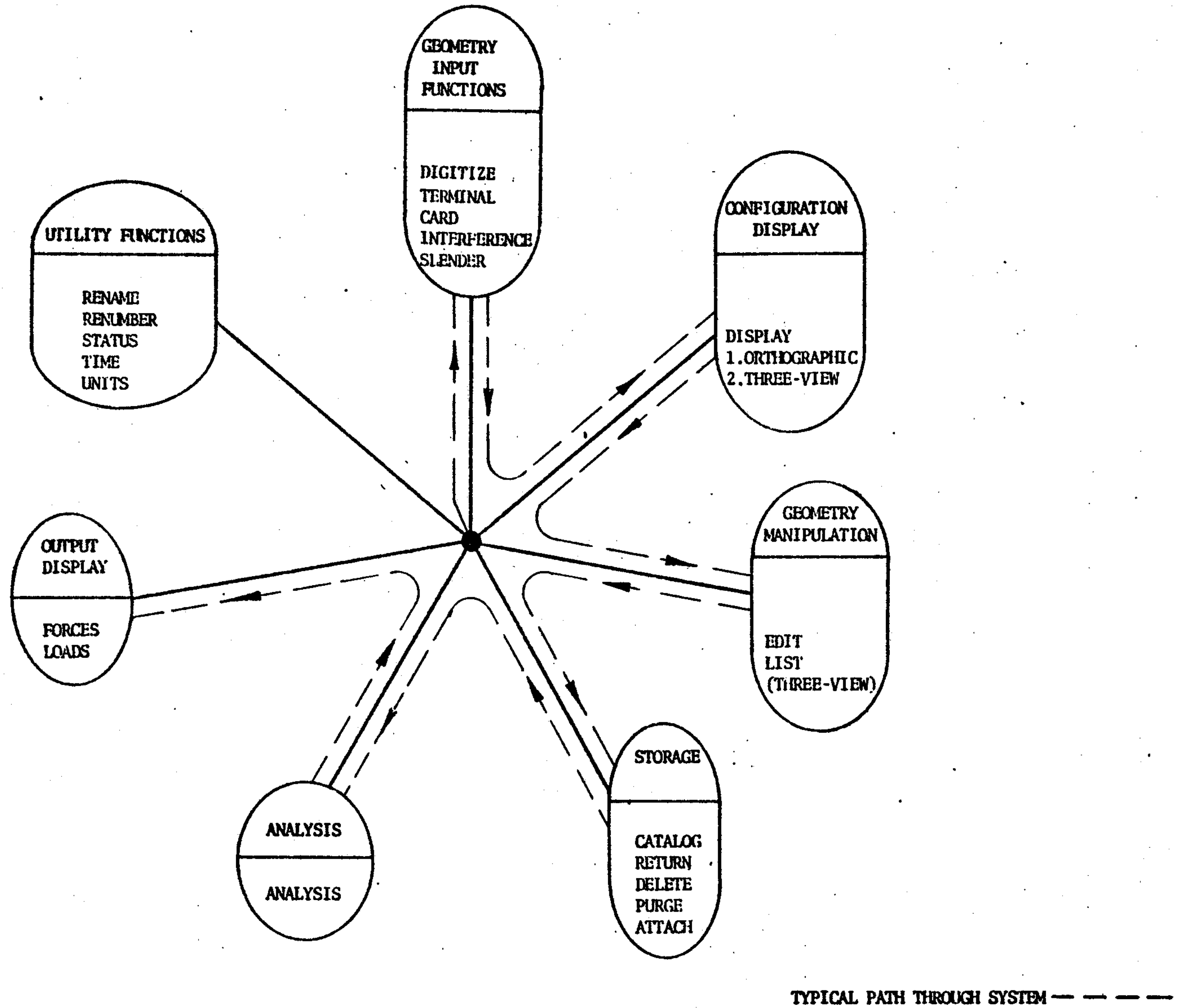


Figure 1. Generic Organization of System Functions and a Typical Path Through the System.

ANALYSIS: Analysis provides local execution of viscous and wave drag solutions and set-up for flagging and processing the panel and isolated body solutions which are run non-interactively outside the control of the program operating system. The system is designed to run, and functions correctly, when the same Mach numbers are used for each requested solution. Obtaining solutions for a given configuration therefore requires some forethought as to the overall Mach number range to be used and then requesting solutions for Mach numbers covering the entire range.

Certain solutions must be determined before others can be carried out. There are, consequently, some guide lines which the user should follow when using the ANALYSIS function.

1) ANALYSIS is performed on all components in the local file and only on components in this file. All components necessary to produce the required solutions must therefore be attached to the local file before execution is initiated.

2) The user will be informed when entering the analysis mode whether or not any previous solutions have been stored in the output file and what Mach numbers were used. If the user selects new Mach numbers all previous solutions are voided. Previously stored solutions are not affected if old Mach numbers are used.

3) The solutions and/or Mach numbers desired on this pass are input by the user. Once he has set up all the solutions he enters CALCULATE and the computations requested are setup or executed in the proper sequence.

4) If the user has requested 100% suction drag he must have previously calculated a vortex panel solution or the wave drag due to angle of attack will default to zero and only wave drag due to volume will be analyzed.

ATTACH: Copies components from the permanent file into the local file.

CARD: Accesses routines designed to input data in card image format. APPENDIX I defines the data which must be supplied to input components using this method.

CATALOG: CATALOG takes the component presently in core and places it in the next available record in the file specified. PERMANENT, LOCAL, or BOTH, are allowable parameters; PERMANENT being the default.

COPY - The copy function is designed for copying the geometric data of a component into another record in the same file. This function is particularly useful for planar components which have been digitized with a large number of points for accurate definition but which must also be used for lifting surface solutions. The maximum number of chordwise panels allowed by the lifting program setup is twenty and by copying a component and repaneling it with the EDIT function a well defined component can be brought into bounds without sacrificing the original definition. The COPY function can also be used to duplicate a component for use in a different location. This can be clumsy and the translate and duplicate sub-commands found in the THREE-VIEW DISPLAY function are recommended for this procedure.

DELETE: The DELETE function is used to eliminate components from the permanent or local file. The file name must be provided which avoids the possibility that components in the wrong file will be deleted by mistake. If the entire local file is to be released, the PURGE function is recommended as the more efficient method.

DIGITIZE: The digitize function takes components layed out as cross-sections on paper and input from a graphics tablet using an interactive pen or digitizing puck. Surface and body components are digitized and curve fitted or smoothed using techniques which have several important differences discussed below. There are also two types of components which are constructed using functions designed specifically for their generation, isolated or slender bodies and jet flaps. The digitize function also allows the user to add sections to previsouly digitized or otherwise input components which allows for replacement of simple sections with more complex ones or insertion of sections to improve definition.

When digitization is completed the user is interrogated as to whether or not he wishes to use the spline fit or smoothing options. If the spline option is chosen the work is done on the component and the system returns to the OK mode. If the smooth option is chosen (by choosing the order of fit used) both the spline and smooth fits for each segment or each section is displayed for comparison. The order of smoothing can be changed and displayed anew. The user chooses at each segment which solution he wants. Segments containing two points are bypassed by the system. The number of points used in a segment is determined initially by the maximum number of points needed to define that segment out of all sections input. This is fixed by first digitization and re-digitizing at a later time will not change this. This rule varies for surface components and is discussed below.

Surface components allow (1) specific sections to be digitized or (2) selection of a cataloged airfoil which will be varied in thickness only. The section default is a 64 series airfoil.

When the component is curve fit or smoothed after digitization a series of events takes place:

1) If the smooth option is selected the user must select whether or not he wishes to use the leading edge radius calculated for each section or use a sharp leading edge.

2) The dihedral of each section is determined based on the partial location of the sections in relation to one another such that the sections are perpendicular to a line found by the points at the leading edge of each section. The exception is a section of a TYPE 4 component on the center line which automatically receives zero dihedral.

3) If the smoothing option is chosen the first and last (upper and lower surface) segment points are summed and an equivalent number of points defined as:

$$NP = \frac{3}{4}(NFIRST + NLAST)$$

is assigned to the first and last segment. If the spline fit is chosen the number of points assigned is defined as

$$NP = \frac{6}{5}(NFIRST + NLAST)$$

4) The scheme for curve fitting is passed on a half-cosine spread of the x-values spaced on the curve S along the points defining the segment under study. The z-values are then interplated directly against these x-values which are then rotated into y and z coordinates by the dihedral assigned to the section. This interpolation scheme provides for maximum definition at the leading edge of the sections where the largest slope variations usually take place.

Non-planar components take the segments of each section as they are input and does its fitting on points evenly spaced along the curve defined by all the input points in that segment. No additional points are added to the maximum input for the segment under study.

DISPLAY : The DISPLAY function allows the user to either display orthographic projections of component combinations or three-views. Each option has its own set of sub-commands.

1) Orthographic Projection

When a single component is being displayed the user can enhance or retract the display lines which connect sections and produce the solidity in the views displayed.

Component(s) can be displayed at different viewing angles to facilitate in the verification of input configurations.

2) Three-Views

When using the three-view option the analyst can (1) display the three-view, (2) cut cross-sections by selecting that function and locating the cross-hairs for the x-location and vertical position of the cross section, (3) translate components to a new location and save or duplicate them at the new location. When cutting cross-sections it is best to work from left to right to allow placement routines to work properly.

EDIT: EDIT is a visual editing (LIST is a numerical edit function) function using specifically designed views of each component to insert sections by interpolation, delete sections, move sections up or down (body components) in the viewing plane, or scale sections up or down based on the selected chord length (surface components). The various options are executed using the cross-hairs with keys on the console controlling the function selection.

In addition,the surface components have a special option for chordwise paneling and control surface set-up. Automatic chordwise paneling for even spacing, half-cosine spacing, or full cosine spacing is provided Geometric spacing is provided for jet flaps using the panel directly in front of the jet flap sections to develop the spacing. The user can also produce his own spacing by using the cross-hairs to construct paneling. He can also specify control surfaces with selected keys from the console.

EXIT: EXIT closes the perm file and plot file and ends the program.

FORCES: The function FORCES is used to display total forces and drag solutions solved for in ANALYSIS. Force data, wave drag, viscous drag, and drag-due-to-lift factor C_{Di}/C_L^2 is displayed versus Mach number. Induced drag is displayed as a function of lift coefficient along with any chosen suction variation. The characteristics of the individual displays are described below. The function symbol for FORCES is FORC**.

Force data displays are requested by asking for the force and the parametric variable (α, β, p, q, r, etc.) desired. Three displays can be shown on a single page. The coefficient combinations suggested under the FORCE sub-commands are the coefficients which are most often requested. However any combination of variables in a solution can be displayed.

Drag due to lift is displayed versus lift coefficient and as C_{Di}/C_L^2 when displayed against Mach number. Drag due to lift is presented for either 0% suction, 100% suction or a semi-empirical drag calculation between the two limits. Suction variations are displayed along with limit polars when this latter option is requested.

Drag polars are calculated with suction variations based on the equation

$$C_{Di} = C_{D_{100\%}} + S\,(C_{D_{0\%}} - C_{D_{100\%}}) \;;\quad S = f(C_L)$$

where S is the fractional variation of suction. The equation is applied at a constant lift coefficient.

As explained in volume I, the zero percent suction drag is found from the integration of the surface pressures. The 100% suction drag includes the vortex drag from the panel solution plus the incremental far field wave drag due to angle of attack. In addition, an estimation of transonic divergence drag is added to both 0% and 100% drag polars based on the following equations, where M_{DD} is the input drag divergence Mach number:

$$M'_{DD} = M_{DD} - 0.05\,C_L$$

$$\Delta M = M - M'_{DD}$$

$$\Delta C_D = \begin{cases} 0.30\,(\Delta M + 0.02)^2, & \Delta M < 0 \\ 2.50\,\Delta M^2 + 0.0012, & \Delta M \geq 0 \end{cases}$$

Also included in the 0% and 100% drag polars is any drag due to the basic load, i.e. wing camber, body camber, initial surface deflection.

Wave drag (C_{DM}) (far-field supersonic drag due to volume) is displayed versus Mach number and includes an empirical estimation for zero lift divergence drag in the transonic regime. The equations used to estimate divergence drag were discussed above in the drag due to lift section The user is requested to read the FORCES section for a full explanation of the data reduction process.

Viscous drag (C_{Dp}) is displayed versus Mach number at constant pressure and temperature. When viscous drag is displayed,all the solutions that were solved are presented.

INTERFERENCE: The INTERFERENCE function is used to build components which will be paneled for use in the UDP solution. These components include interference shells, jet flaps, and surface constructions used for connecting components together, simulated surface fuselages for yaw or pitch results, etc.

The isolated body interference shell, when declared, has it's leading and trailing edge fixed by the first chord length input. Additional chords need only the y and z location and/or connecting components defined. The jet flap needs only the leading edge and connecting component declared. The length of each jet flap chord will be requested as a function of the connecting chord length. Standard panel build-up requires the leading and trailing edge to define the chord. Also note that when a slender body is not detected in the local file at UDP set-up, any interference shells will default to type 3 bodies. If the component used to build a jet flap is not present at UDP set-up a level error will result informing the user that the jet flap does not connect to anything and execution will continue.

Isolated bodies and planar bodies are constructed with only one panel and must be edited to increase the panels. Jet flaps have two panels when constructed, the first set up specifically for geometric panel spacing.

LIST: LIST is a special edit function designed for single section manipulation, displaying, and coordinate listing. Sections can be deleted, duplicated and inserted (spline-fit) however they must stay within the bounds of the body being listed. Increments can be added, values changed, and sections of non-planar components can be rotated to simulate inlets and other shapes. The use of this routine requires practice, its importance in the system will then begin to become apparent.

The function symbol for LIST is

LIST**

and is displayed after each completed command.

LOADS: The LOADS function is used to display chordwise and spanwise loads calculated with the UDP solution. It will also display the Z/c due to camber or thickness of components set up for UDP; see figures 2 through 4 for examples of LOADS displays.

The function symbol for LOADS is

PSPAN**

PURGE: PURGE is used to clear the local file for executing a new case in ANALYSIS. PURGE sets the record value to zero and is more efficient then deleting all components.

RENAME: RENAME is used to change the name of a component

RENUMBER: RENUMBER is used to change the number of a component

SAVE: SAVE is used on a component which has been edited and updated to replace the old copy with new edited copy.

SLENDER: SLENDER is used to construct slender bodies from previously input TYPE 1 and 2 components. The components can be stacked one behind the other or next to each other. When components are set side by side, an inlet under a fuselage for example, the two parameters input under SLENDER (FACTOR,NPASS) have significance since they determine the bias for section changes; see figure 5.

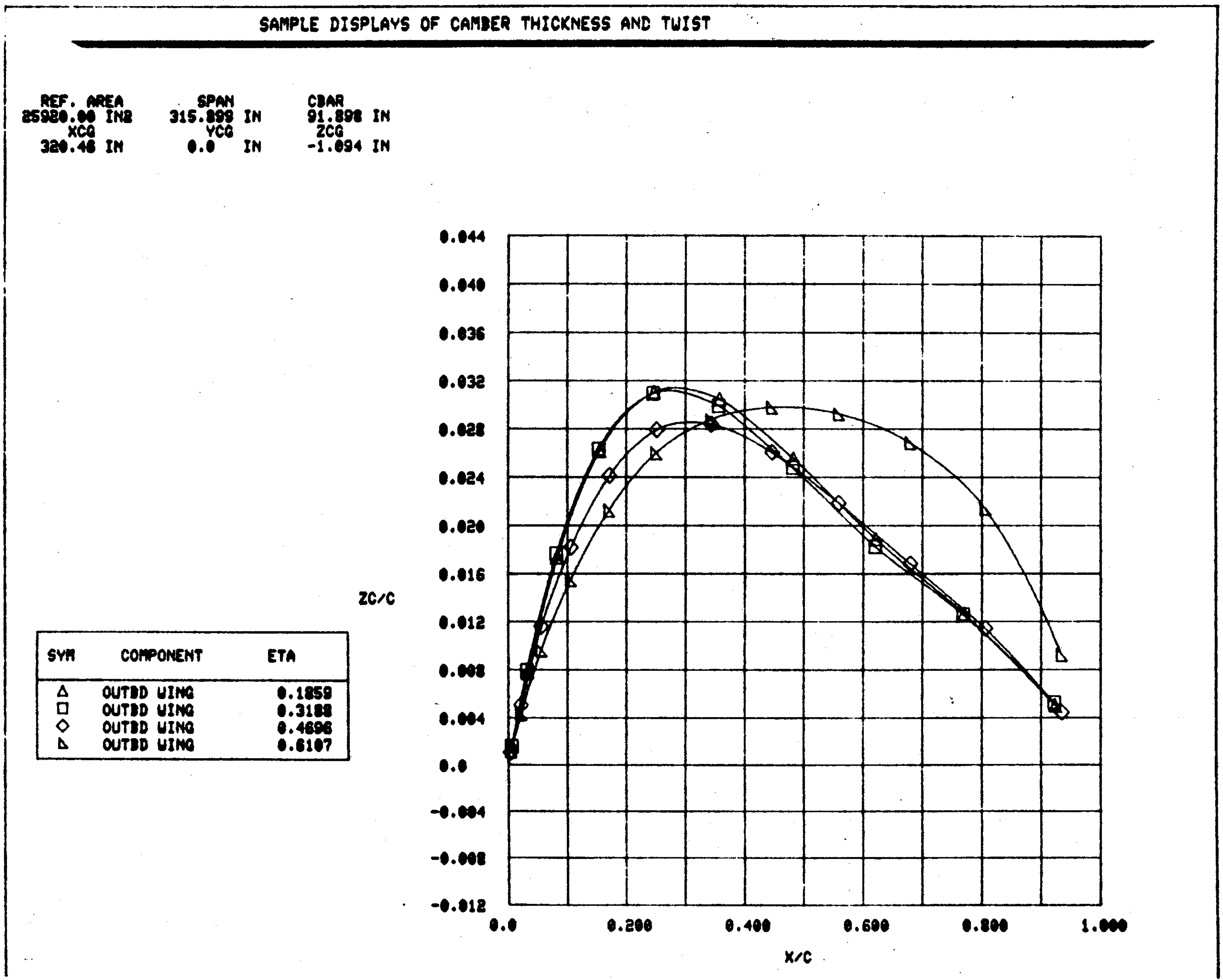


Figure 2. Chordwise Distributions of Camber

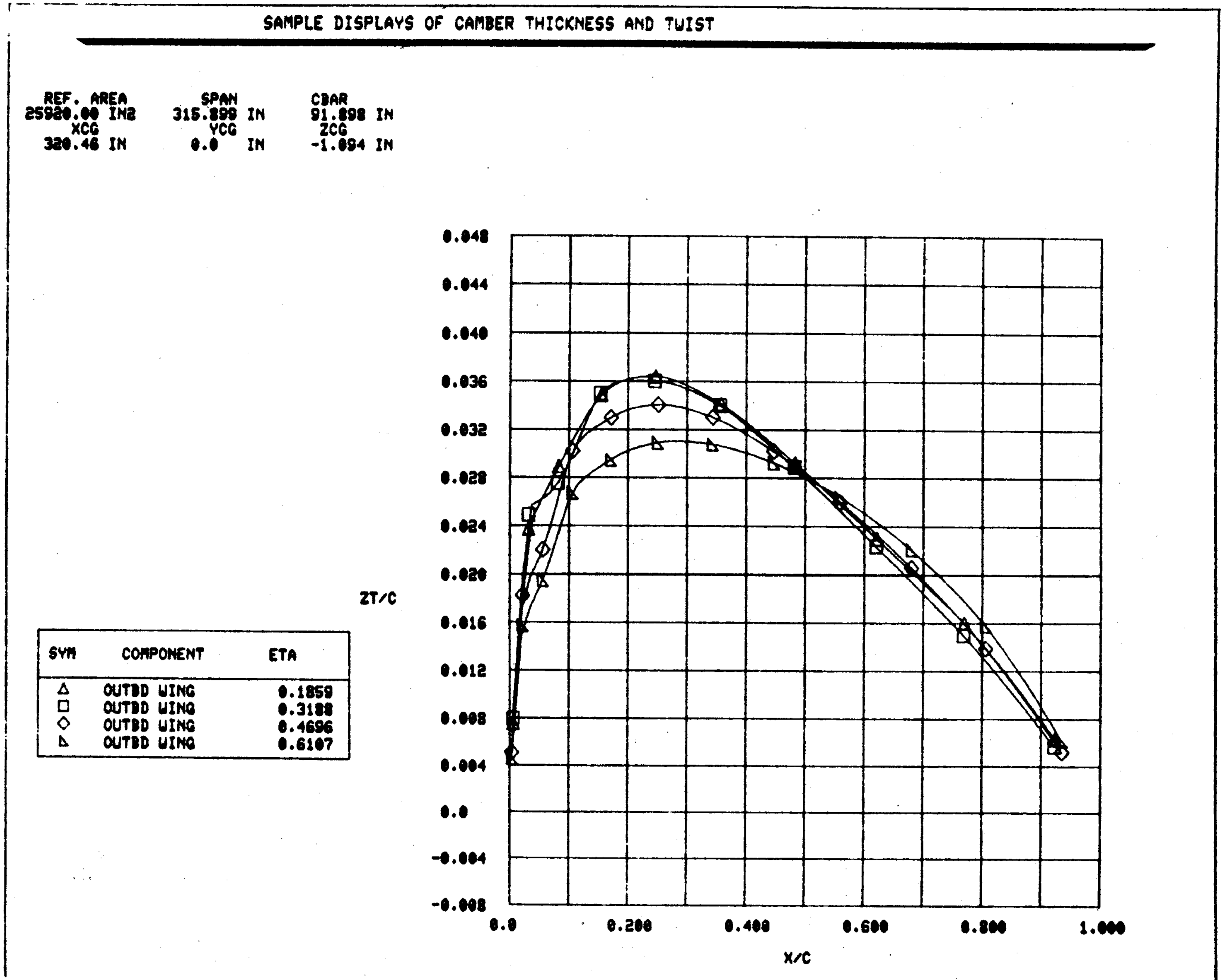


Figure 3. Chordwise Distributions of t/2c

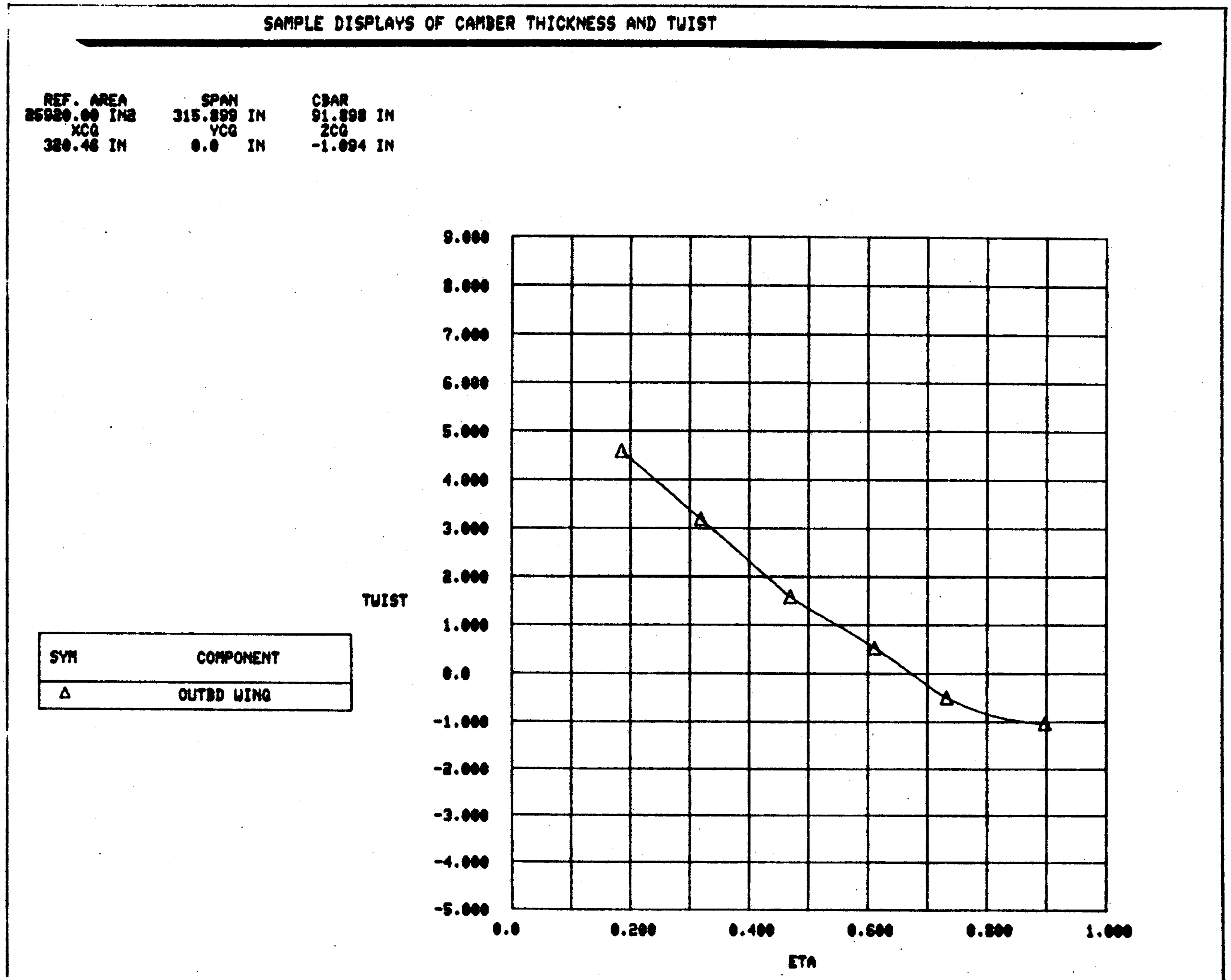


Figure 4. Spanwise Twist Distribution

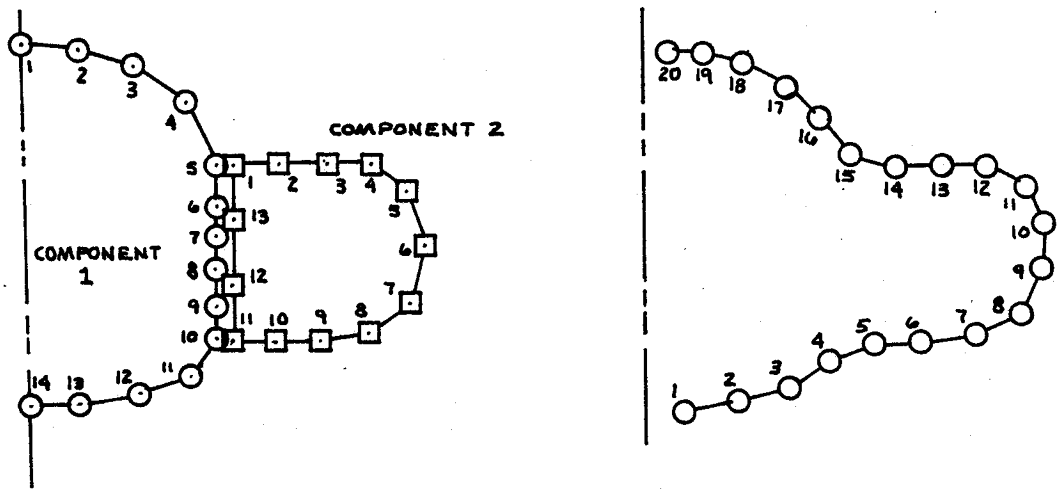


Figure 5 Cross Section Cut Before and After
Outline Generation

The outline routine starts at the top most point of a cross section [(point 1 component 1, (or 1,1)]. When the outline routine gets to point 5 of component 1 (1,5) it checks the distance from point (1,5) to (1,6) and (1,5) to (2,1) and forms the relationship:

$$\mathrm{FACTOR}\,(R[(1,5)\rightarrow(1,6)]) > R[(1,5)\rightarrow(2,7)]$$

where R [(1,5)→(1,6)] is the distance from (1,5) to (1,6). If the relationship is true the outline skips to the second component and follows it as the outline until the next skip takes place (in this case from (2,11) to (1,10) and so on until the outline returns to the centerline or the first point. NPASS is the number of points passed up in the outline check on the section skipped to avoid back-lash problems and speed up a lengthy calculation procedure. In figure 5,NPASS = 2, FACTOR = 0.7 would be sufficient for the program to follow the section outline.

The SLENDER function checks for inlets and exhaust nozzles prior to body termination and combines up to six components into a single construction for isolated body solutions. The user should keep in mind that each component input for later slender body conversion should be input in the same sense, i.e. either all chockwise or all counter clockwise.

<u>TERMINAL</u>: The TERMINAL function allows the user to input simple geometries by typing in basic descriptive parameters into the system.

For surface components (TYPES 3 and 4) the inputs are aspect ratio, area, taper ratio, sweep and dihedral. The analyst then selects the type of wing section to use (five different types, see figure 6) and the root thickness and tip thickness.

Body components (TYPES 1 and 2) are input by selecting strategic points on the body (pilot station, engine face and exhaust for example) and specifying the x-station, cross sectional area (in units of x) and the ratio of the width to height of the sections. The routine performs an Emlord isolated body optimization on the cross sections input and interpolates one Emlord section in between each input section. Components constructed in this way have one segment per cross section and the sections input are all geometrically similar for the whole component. Cross sections include ellipses, half ellipses, rectangles and triangles.

TIME: The TIME function keeps track of the CPU and the approximate cost accumulation during system execution since TIME was last called. The cost algorithm should be updated periodically to reflect most recent costs per CPU second.

TITLE: The TITLE function perscribes a title to the permament or local file which is displayed when editing and displaying components. The local file title is transmitted into analysis and into output files and displays.

UNITS: The UNITS function is used to set the units of the geometry file and analysis. The options available are English, Meters and Centimeters, the default being English. English units store reference areas in square feet, meters and centimeters have reference areas stored in their own units.

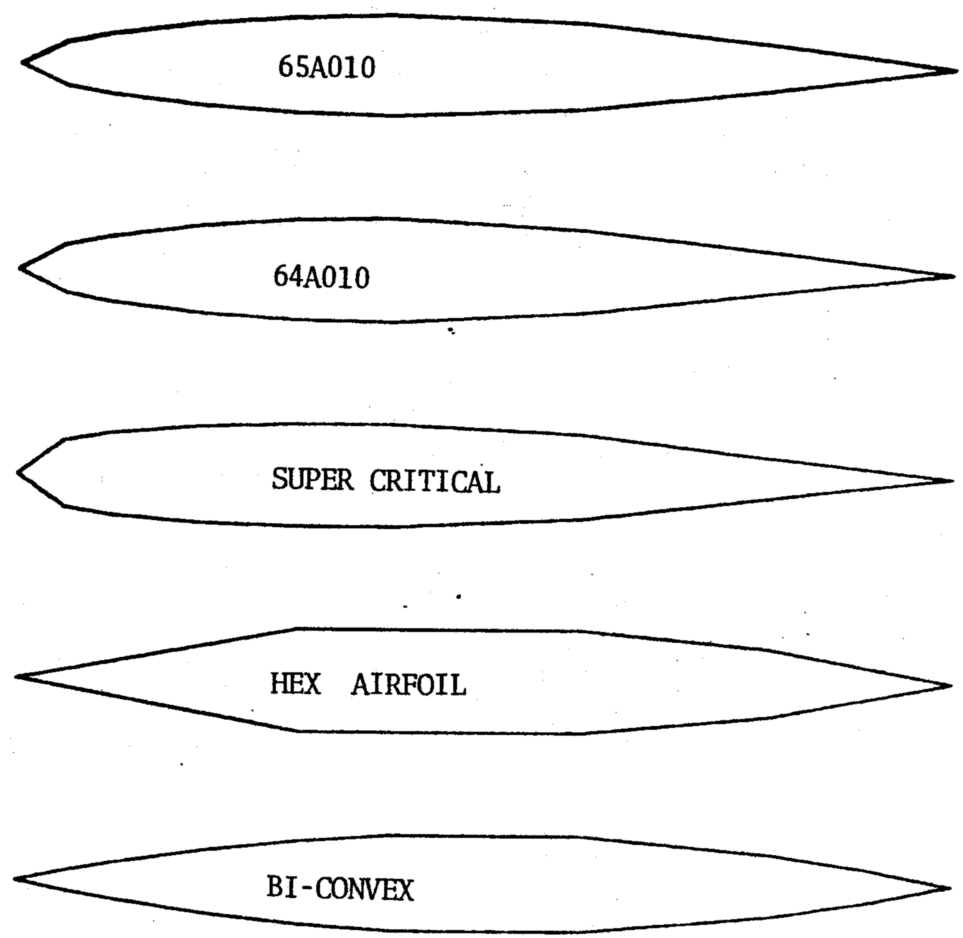


Figure 6. Examples of Wing Sections used in Terminal Function Component Generation

COMMAND EXECUTION DICTIONARY

The Preliminary Aerodynamic Analysis System operates in an interactive time sharing mode. The system will respond quickly and correctly if the proper input is provided. If incorrect instructions are given, the system will make every effort to redirect the user without falling out of execution.

The following comments were made by experienced users and should act as guidelines to the help section of the manual which follows.

1. Use of the system is the best teacher

2. CATALOG new components after construction to avoid destroying the copy in core.

3. EDIT new surface components to insure paneling does not exceed chordwise panel limits of 20. Since the user is limited to 200 panels in the UDP solution dense geometric description should be "thinned".

FUNCTION ANALYSIS

ANALYSIS

OPERANDS: NONE

ABBREVIATION: ANALY

FUNCTION: BRINGS IN ANALYSIS FUNCTIONS.

-VISCOUS-LIFTING-WAVEDRAG-CALCULATE-MACH-END-

SUB-COMMANDS: VISCOUS, LIFTING, WAVEDRAG, CALCULATE, MACH, MDD, END

COMMAND [,MACH NO.1,.....,MACH NO. (UNDER MACH ONLY)] [,P(WAVEDRAG ONLY)]

OPERANDS:	VISCOUS:	VISCOUS DRAG SOLUTION FLAG
	LIFTING:	CONSTANT PRESSURE PANEL FLAG SOLUTION (SET-UP ONLY)
	WAVEDRAG:	WAVEDRAG SOLUTION FLAG
	CALCULATE:	RUN THROUGH SOLUTIONS AND/OR SETUP OF FLAGGED PROGRAM
	MACH:	MACH NUMBERS TO PERFORM SOLUTION AT
	P:	PRESSURE DRAG TO BE INCLUDED IN WAVEDRAG SOLUTION
	MDD:	DRAG DIVERGENCE [DEFAULT = 0.90]
	END	END

ABBREVIATIONS:

VISCOUS:	V
LIFTING:	L
WAVEDRAG:	W
CALCULATE:	C
MACH:	M
P:	P
END:	E

FUNCTION: TO SET UP AND EXECUTE PROGRAMS FOR CONFIGURATION ANALYSIS. THE CONFIGURATION IN THE LOCAL FILE WILL BE USED FOR ALL CALCULATIONS. THE LIFTING SURFACE AND ISOLATED BODY SOLUTIONS ARE DONE OUTSIDE THE MAIN FRAME OF THE PROGRAM DUE TO SIZE LIMITATIONS.

VISCOUS DRAG PROGRAM OPTIONS

SCALE (TO FULL SIZE) : "20.0" (scale from drawing data was input from)

1 * PLOT * NX, X(1),...,X(NX)

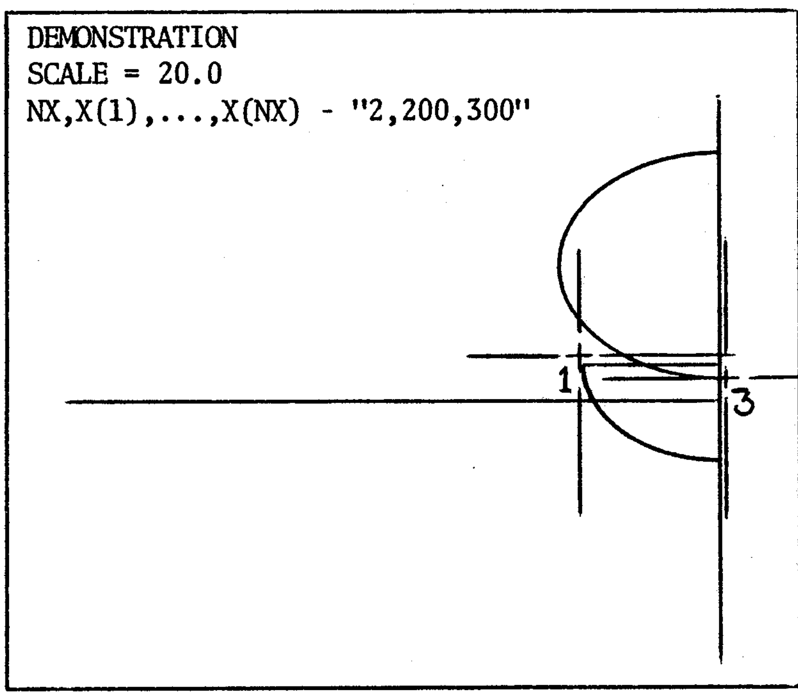
2 * PLOT * NX, XB, XE

3 * NO PLOT * NX = 51 (ALL SURFACES FLAGGED) : "3"

NOTE: " " signifies user response. Typical numbers are indicated.

TO EXIT OPTIONS 1 and 2 enter Ø,Ø,Ø   for answer to NX, etc.

OPTION 1 * PLOT NX,X(1),...,X(NX), (Used to remove non-wetted segments from cross sections)



The cursor (—+—) appears on screen after cross section is plotted. Position cursor at one end of non-wetted surface line; then key in one of the record numbers of the components involved in the intersection. When cursor reappears, locate other end of non-wetted segment and enter record number of second component in the intersection. If second component already has non-wetted segment (indicated by dashed line) enter Ø. When finished or if no segments need to be flagged enter zero. Each pair of entrances of the cursor to remove segments constitutes the removal of one segment from the wetted area calculation of the indicated components. Record numbers are those corresponding to the listing in the local file. Recommended NX ≤ 5 since the screen becomes too cluttered with cross sections to work efficiently.

OPTION 2 * PLOT NX, XB,XE (Also used to remove non-wetted segments)
XB = Beginning X value
XE = Ending X value
Procede as shown in option 1

Option 3 * NO PLOT * NX = 51 (ALL SURFACES FLAGGED)

If all the wetted and non-wetted surfaces have been flagged by the digitizer as a crude approximation of the wetted area Option 3 will produce wetted area and volume plots directly without the arduous task of removing segments.

After the above options are exited the program will plot the surface and volume plots of the configuration (see example problems in Appendix III).

The following options are then displayed:

* Ø EXIT * 1 SF DRAG * 2 EDIT *

Ø returns to or continues in ANALYSIS;2 displays a list of x-mins, x max's for each component and a list of total perimeter and cross section area at each calculated x station, 2 then returns to Option 1 automatically.

1 clears the page for the skin friction drag input.

SKIN FRICTION DRAG INPUT
ENTER SAND GRAIN HEIGHT (KS(FT)): "0.00022"

ENTER PRESS (PSF), TEMP (R), AND DISPLAY MACH NUMBER (0.0 FOR ALL, 999. FOR NONE)

ENTER 0.0, 0.0,0.0 AFTER LAST CASE (8 OR LESS)

ENTER PRESS, TEMP, MACH (DISP) FOR CASE 1: "2116., 518., 0.6"

ENTER PRESS, TEMP, MACH (DISP) FOR CASE 2: "0., 0., 0."

FUSELAGE ENTER: TRANS/LENG, FLAT PLATE 1 * AXIS-BODY 2: "0.01, 2"

WING ENTER: TRANS/LENG, CK, FLAT PLATE 1 * AIRFOIL 2: "0.01, 1.2,2"

NOTES:

1) Display Mach number is one for which the printed results are to be shown. Each Mach number from ANALYSIS input will be calculated for each case.

2) KS, CK are defined in Volume I. Recommended values are given in Table AN-1 and AN-2

3) Regardless of units used for input configuration inputs to the skin friction drag are English units. Proper conversion of configuration dimensions will be made by program.

After selected cases have been displayed (see Appendix III
The options: Ø EXIT, 1 SF DRAG, 2 EDIT, will again be given

TABLE AN-1

TYPE OF SURFACE	EQUIVALENT SAND GRAIN HEIGHT KS (FEET)
Aerodynamically Smooth	0.0
Polished Wood or Metal	.00167 - .00000667
Natural Sheet Metal	.000013
Smooth Matle Paint, Carefully Applied	.0000208
Standard Camouflage Paint, Average Application	.0000333
Camouflage Paint, Mass Production Spray	.0001
Dip-Galvanized Metal Surface	.0005
Natural Surface of Cost Iron	.000833

TABLE AN-2

AIRFOIL	THICKNESS CORRECTION (CK)
AIRFOIL t/c_{max} at 30% Chord	2.0
NACA 64 and 65 Series Airfoils	1.2

-ATTACH-

FUNCTION ATTACH

```
ATTACH,COMP(1),COMP(2),...COMP(N)
```

OPERANDS: RECORD NUMBER IN PLACE OF COMP(N)

ALL

ABBREVIATION: ATTA

FUNCTION: COPIES COMPONENTS FROM PERMANENT FILE AND PUTS THEM IN THE LOCAL FILE.

-CARD-

FUNCTION CARD

```
CARD,COMP(1),COMP(2),....COMP(N)
```

OPERANDS: RECORD NUMBER IN PLACE OF COMP(N)

ALL

ABBREVIATION: NONE

FUNCTION: BRINGS IN COMPONENT PLACED IN THE CARD IMAGE FILE AND PLACES THEM IN THE LOCAL FILE.

FUNCTION CATALOG

$$\boxed{\text{CATALOG, } [\text{,FILE}]}$$

OPERANDS: FILE - PERM [P] [DEFAULT FILE], LOCAL [L], BOTH [B]

ABBREVIATION: CATA

FUNCTION: CATALOG COMPONENT IN CORE INTO REQUESTED FILE

FUNCTION COPY

```
COPY,COMP,COMPN [,FILE]
```

OPERANDS:

COMP - COMPONENT TO BE COPIED

COMPN - COMPONENT NUMBER TO BE COPIED TO

FILE - PERM [P] [DEFAULT FILE], LOCAL [L]

ABBREVIATION: NONE

FUNCTION: COPY A COMPONENT IN REQUESTED FILE TO A NEW RECORD IN THE SAME FILE.

FUNCTION DELETE

```
DELETE,FILE,COMP1[,COMP2,...[,ALL]]
```

OPERANDS: FILE- PERM [P] , LOCAL [L] (MUST BE SPECIFIED)

COMP1 COMPONENT(S) TO BE DELETED

ALL - DELETE ALL COMPONENTS

ABBREVIATION: DELE

FUNCTION: REMOVE UNWANTED COMPONENTS FROM FILES

FUNCTION DIGITIZE

```
DIGITIZE [,COMPN] [,AXIS]
```

OPERANDS:	COMPN:	RE-DIGITIZE COMPONENT COMPN.DEFAULT IS NEW COMPONENT
	AXIS:	NEW AXIS SYSTEM WILL BE REQUESTED.DEFAULTS TO AXIS ON FIRST CALL TO DIGITIZE. DEFAULTS TO PREVIOUS AXIS ON SUBSEQUENT CALLS

ABBREVIATION: DIGI

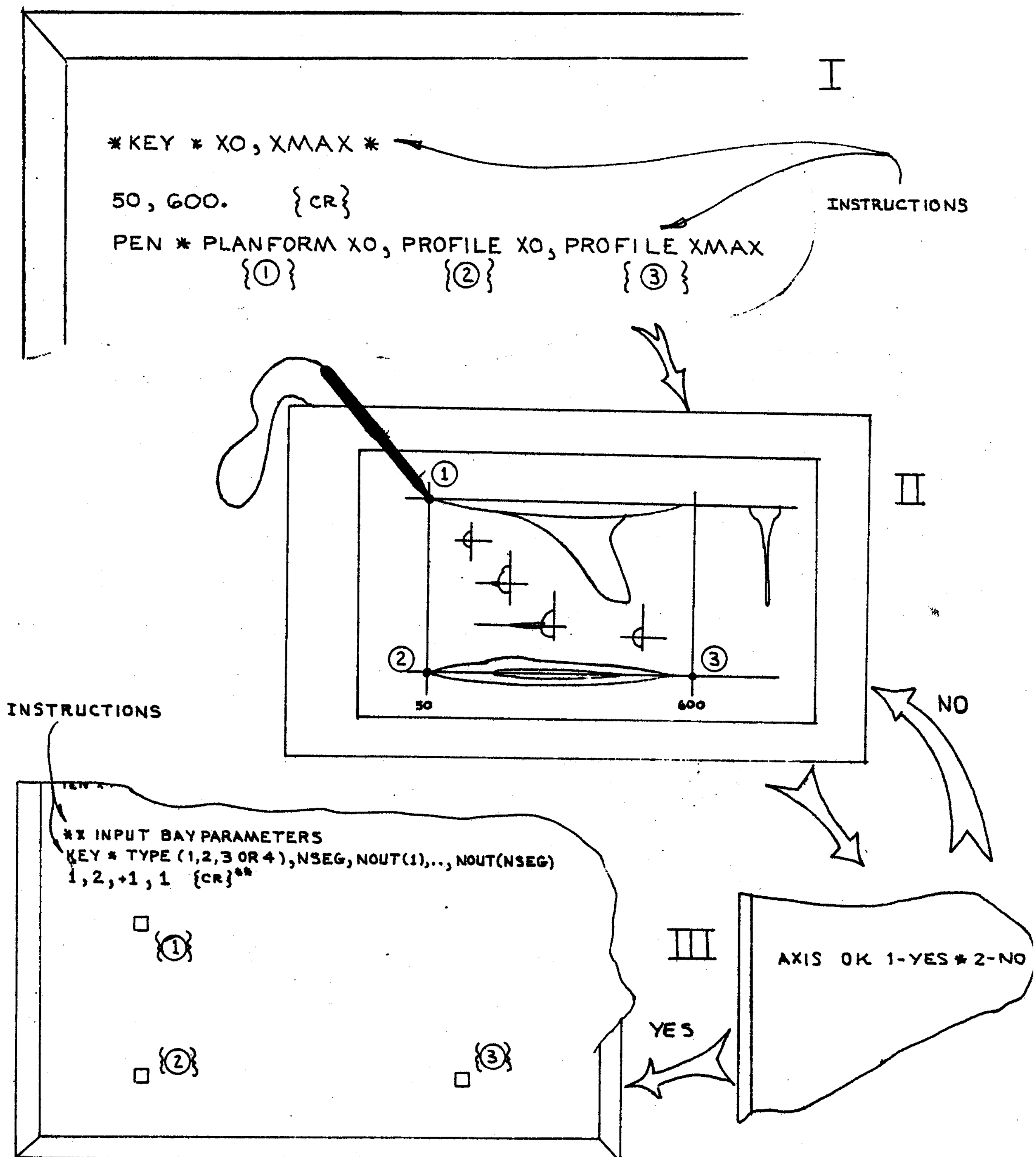
FRUNCTION: DIGITIZE COMPONENT FROM DRAWING OF THE DIGITIZING TABLET

-DIGITIZE-

SYMBOL		DESCRIPTION
①	:	Point input from tablet
{ }	:	Info in bracket would not appear on screen
	:	Indicated information is on graphics screen
	:	Tablet input using digitizing pen or puck
CR	:	Carriage return
•	:	Position of point to be input from tablet
"QUANT"	:	QUANT is a user input

-DIGITIZE-

VARIABLE	DESCRIPTION
XO	:MINIMUM X VALUE FROM DRAWING
XMAX	:MAXIMUM X VALUE FROM DRAWING
TYPE	:1 - NON-PLANAR CENTERLINE (EG. FUSELAGE) 2 - NON-PLANAR OFF-SET (EG. ENGINE POD) 3 - HALF PLANAR (EG. VERTICAL TAIL) 4 - FULL PLANAR (EG. WING)
NSEG	:NUMBER OF SEGMENTS/SECTION
NOUT(I)	:WETTED-UNWETTED SEGMENT FLAG 1 - WETTED -1 - UNWETTED
TOC	t/C MAX OF AIRFOIL TOC < 0 PROGRAM ASSUMES USER IS INPUTTING AIRFOIL SECTION TOC > 0 PROGRAM USES LAST INPUT AIRFOIL SECTION SCALED TO NEW CHORD AND TOC



** IF POINTS ① ② ③ ARE INPUT INCORRECTLY ENTER 0,0,0
AND REPEAT II

SET UP AXIS SYSTEM AND SCALING

* AXIS OK YES 1, NO-2

* INPUT COMPONENT NUMBER: "700.0"

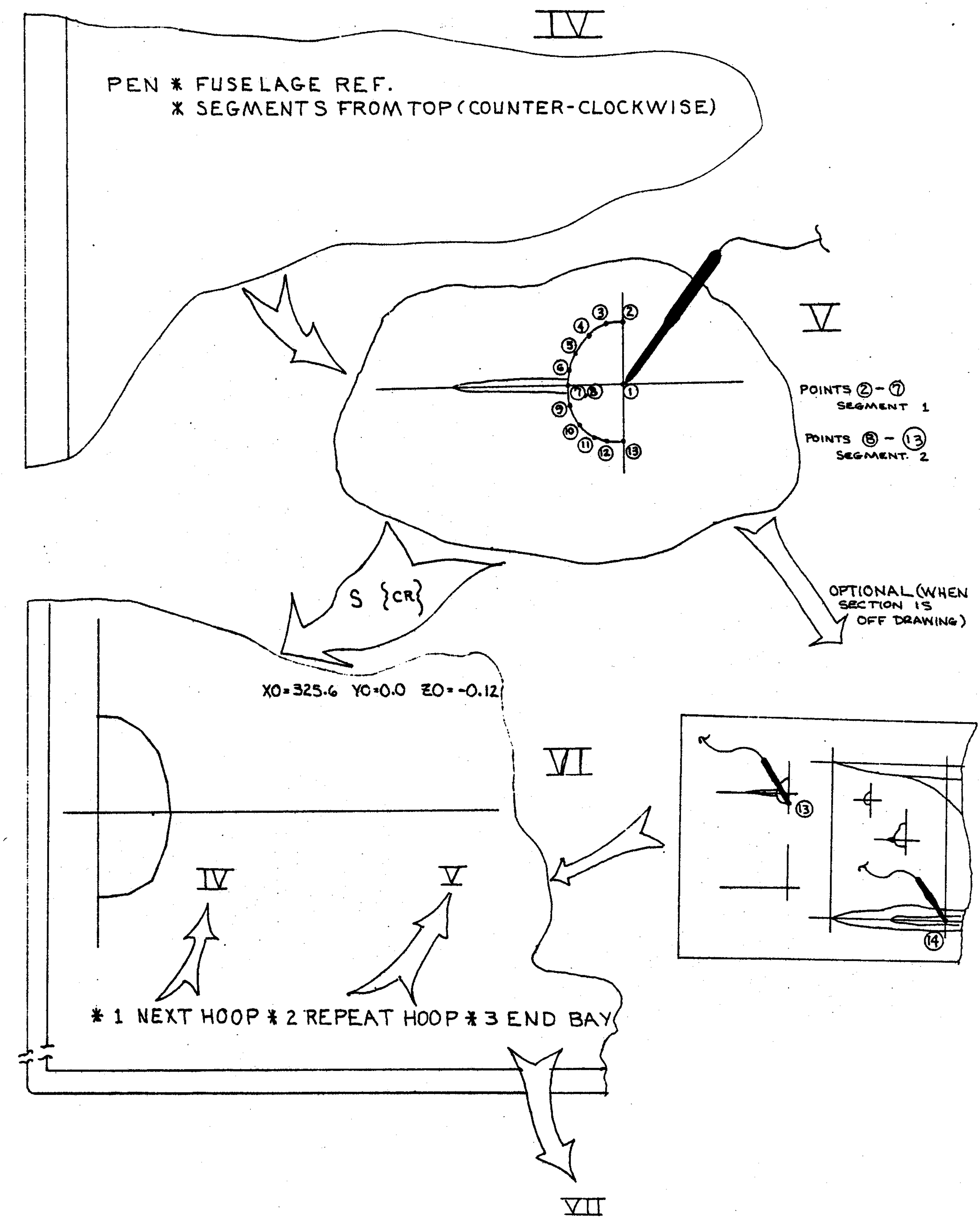
* INPUT COMPONENT NAME: "digit. comp."

TYPE 1 & 2
IV

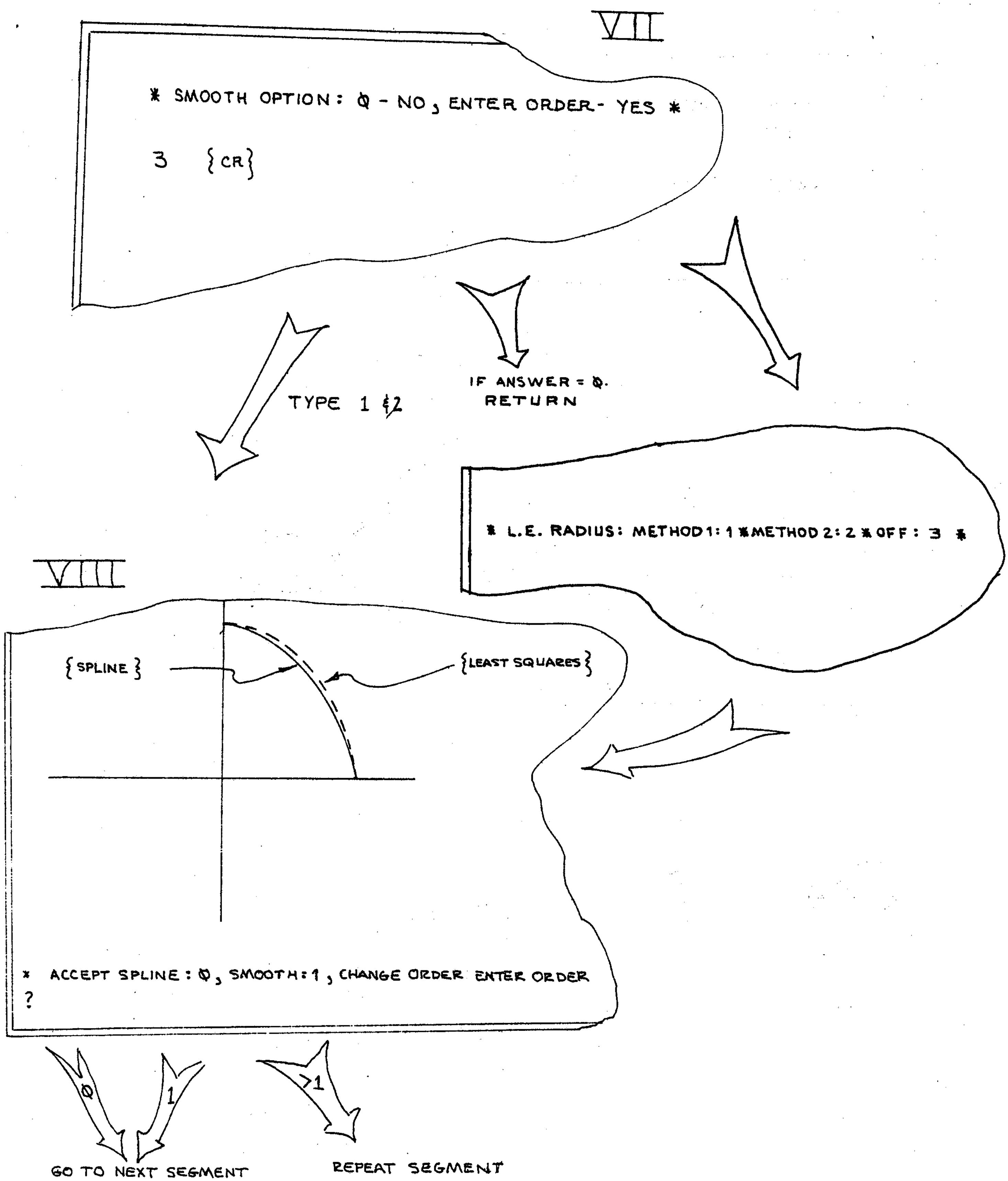
TYPE 3 & 4

* INPUT AR,SW,TAPER, SWEEP, DIHEDRAL - "4.0,500,0.3,55,0"

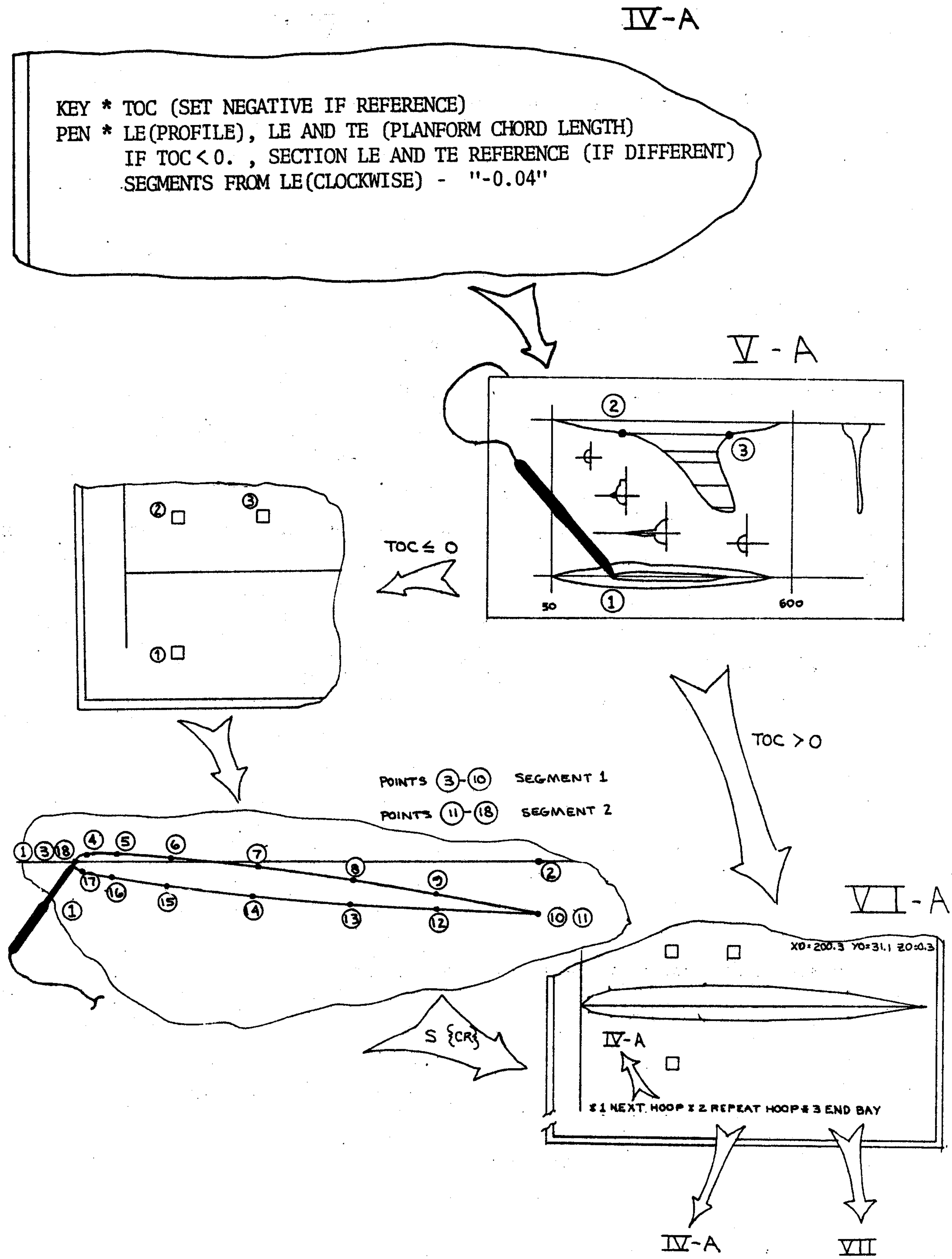
IV-A



INPUT OF TYPE 1 & 2 SECTIONS



CURVE FITTING & SMOOTHING OF SEGMENTS



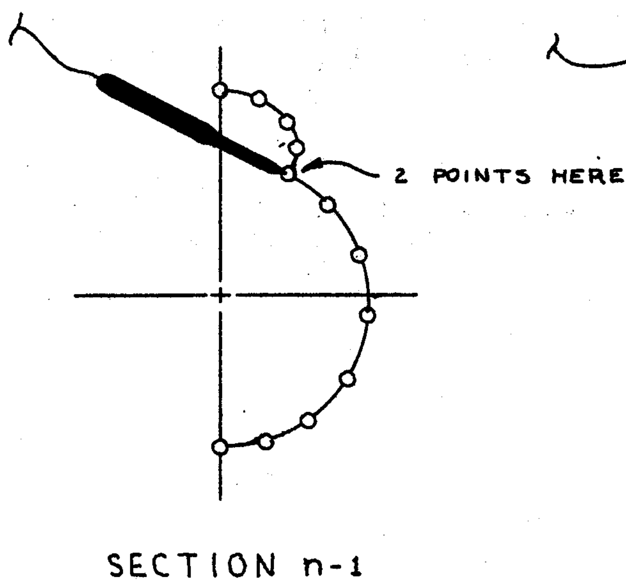
INPUT OF TYPE 3 & 4 SECTIONS

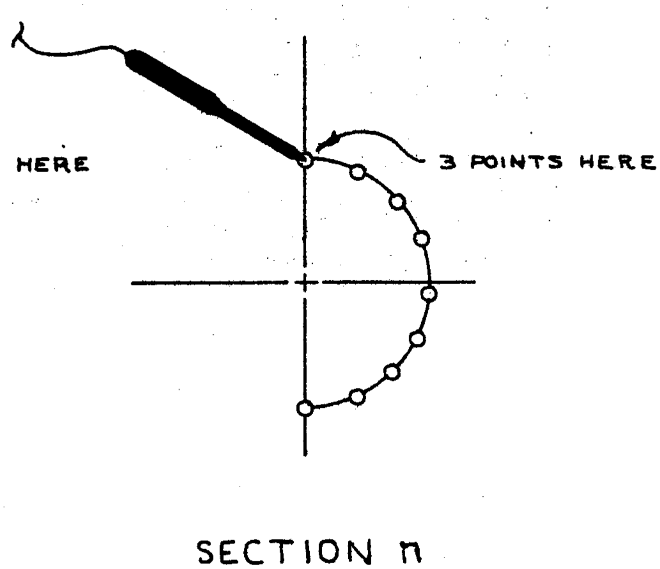
NOTES ON DIGITIZE

1) XO and XMAX do not have to extend the length of the tablet or encompass the entire configuration. They are simply two convenient points on the drawing.

2) The XO in the plan view and profile view must be the same X-station.

3) When a change in segments occurs, the user inputs two points. If two or more segments occur at the same point (i.e. segments of zero length such as would occur on the cross section at the end of a canopy. See below), the user should input a number of identical points equal to the number of segments, i.e. if three segments meet at the same point three points are put there.





The first and last points on a section do not require multiple points unless multiple segments converge there.

4) If the default airfoil (64A0XX) is used it will remain the reference airfoil unless changed by the input of a new airfoil section. The latest airfoil section always becomes the reference section. The default section can only be used if the planar component has two segments.

5) There are two leading edge radius algorithms in this program, based on a polynomial representation of the airfoil leading edge, in conjunction with the least-squares smoothing routine. The first method calculates the leading edge radius based on the input points nearest the leading edge. The second method is based on the 5-digit series airfoil radius:

$$R_{L.E.} = 1.019\ (t/c_{max})^2\ \text{CHORD}\ (1.4 - X_{MAX}/c\ )$$

where x_{max}/c is the fractional chord location of the maximum airfoil thickness.

6) The multipoint routine used to input points from the graphics tablet has two important keyboard features, S {CR} and R {CR}. The S {CR} tells the program that the cross-section is finished and the points should be entered for calculation. R {CR} tells the program that an input error, lost track of where I was, etc., occurred and it should start at the beginning of the loop again.

7) The maximum number of input points allowed per cross section is forty. This number includes the reference POINTS put in for a cross-section, such as indicating the center line for a body section or chord markers for an airfoil section.

FUNCTION DISPLAY

```
DISPLAY [,FILE] [,VIEW] [,COMP(1),....COMP(N)] [,ALL] [,ANG,YAW,PITCH,ROLL]
```

OPERANDS:

FILE: [PERM [P] DEFAULT FILE] [LOCAL [L]]

VIEW: [ORTHOGRAPHIC [O] DEFAULT] [THREE-VIEW [T]]

COMP(N): RECORD NUMBER IN PLACE OF COMP(N)
DEFAULT IS COMPONENT IN CORE

ANG: YAW,PITCH,ROLL. VIEWING ANGLES (ORTHOGRAPHIC ONLY)
DEFAULT ANGLES (-65, 25, -25)

ALL: ALL COMPONENTS IN FILE

FUNCTION: DISPLAY COMPONENT (S) IN ORTHOGRAPHIC PROJECTION OR THREE VIEW

Orthographic Projection:

General: Components displayed using the orthographic projection can be rotated and displayed from any angle. The order of angle specification is yaw, pitch, and then roll. Each view is scaled to fit the entire screen.

Single Component Display: When a single component is displayed the options are:

* 1 VIEW * 2 ENHANCE * Ø END

The view option is self explanatory, as is end. The enhance option controls the number and location of the longitudinal lines connecting each cross section which give it a solid body appearance. The enhance option produces the following response:

* PRESENTLY LINES AT : 1 5 10

* ENTER NO. ADDITIONAL LINES, LINE LOCATIONS *

The print out informs you that all point number one's in each cross-section have been joined with a display line, as are all the 5's and 10's. Twenty such lines are allowed. The user simply enters the number of lines he is going to input then a positive point location to add a line or a negative location to remove one.

Single components are only displayed in half view and a little block printed in the upper right hand corner. It is necessary to display newly input planar components at least once before cataloging them to fill in any blanks in the title block.

Multiple Body Displays: When more than one component is displayed (they can be the same component) both sides of the configuration are displayed. The only option available are the view and end option.

Three-View Displays:

The three view display offers two options, component translation, and cross section display, refer to figure DI-1 the three-view schematic.

Component translation notes:

1) Component number requested is the integer value next to the component name as indicated (in the schematic component 3, the VERTICAL, was selected for translation)

2) Translation modes 1, 2 and 3 are two step operations requiring a "from point" and a "to point ". The selected mode is entered with the "from point". Successive moves are possible in any of the first three modes and terminates with a 5 input on a "from point".

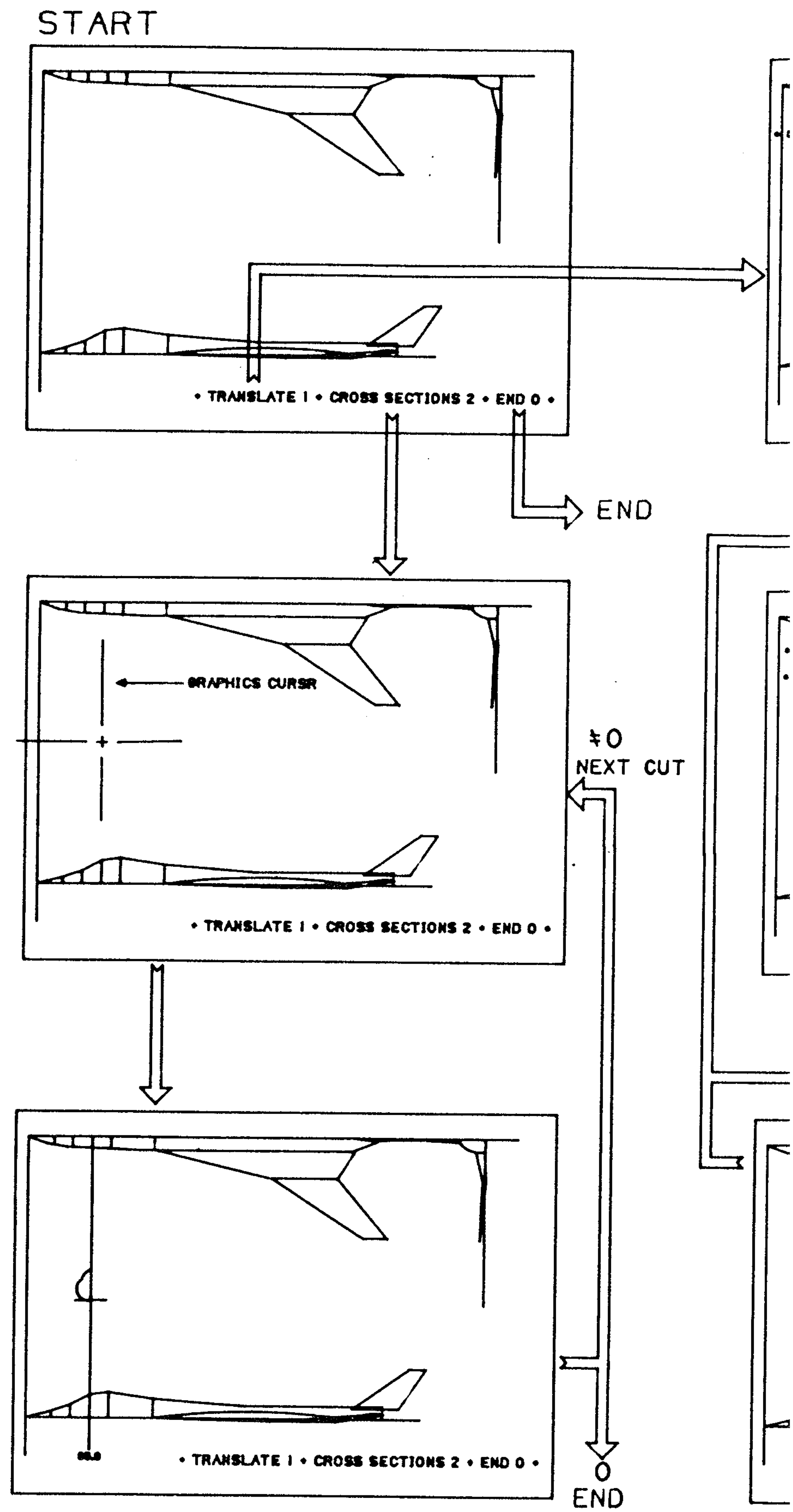
3) Translation mode four is a one-step process, the values of dx, dy, and dz are requested in the upper left hand corner under the component number line. The same results can be achieved as in modes 1, 2 and 3 and all end with the inputs requested in the lower right hand box of figure DI-1.

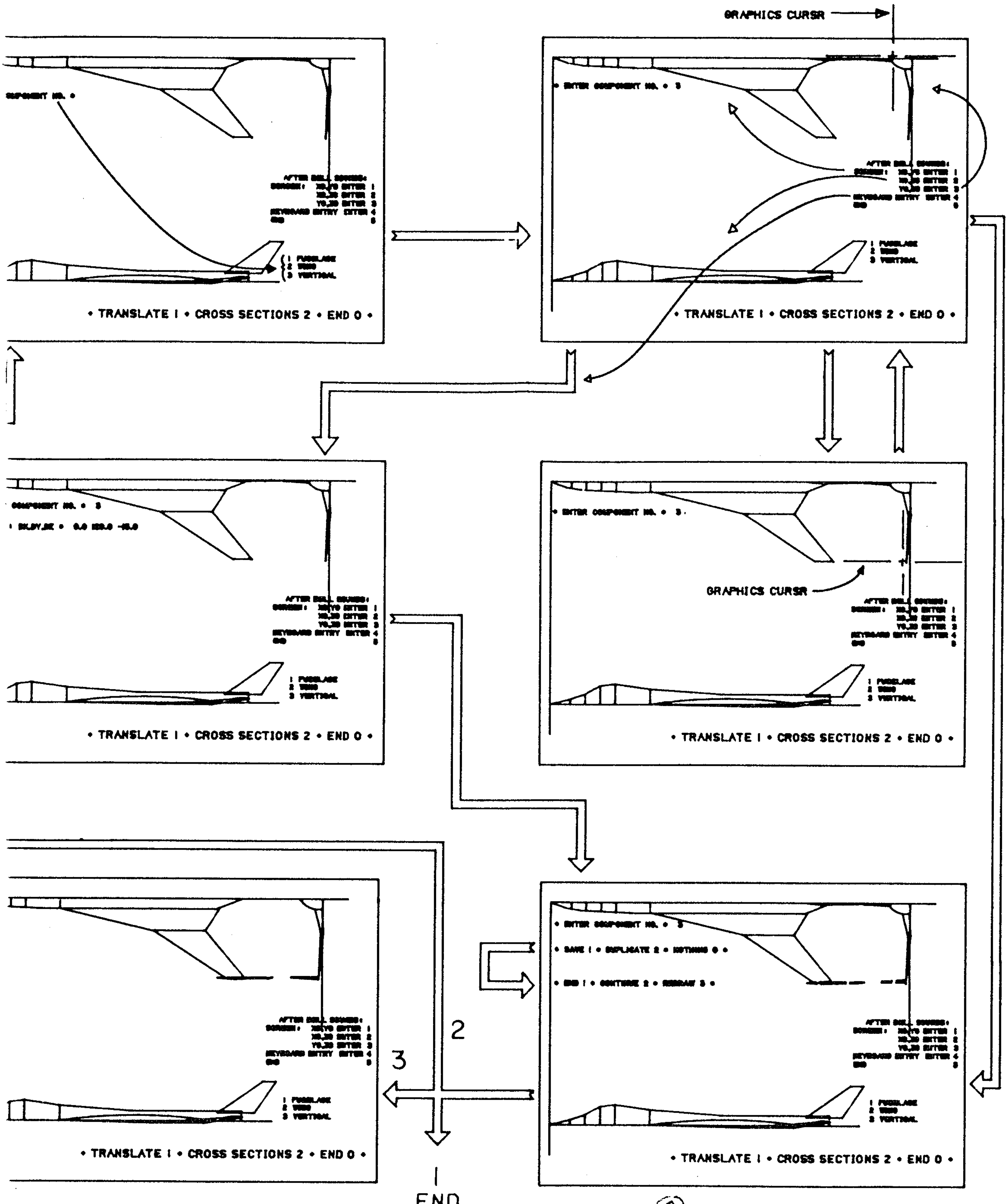
4) A saved component is placed in the location of that component in the file the initial display was made from (i.e. perm or local). A duplicate of the component (translated to its new location) will likewise be filed in the displayed file in the next available record location. A new number 0.10 higher than the old number is assigned to this new component.

5) You can continue on the same display or redraw the display if it has become too crowded. Redraw should not be used to just display since it assumes more translations are to take place.

Display Cross-Sections:

Cross section cuts are displayed by locating the graphics cursor at the desired x location and locating the y-cursor where the y = ∅.∅ line is desired. Entering a non-zero value from the keyboard produces a section at that location. A zero ends the routine and pages the screen; therefore a copy should be taken before hitting zero.


START
• TRANSLATE 1 • CROSS SECTIONS 2 • END 0 •
END
GRAPHICS CURSR
• TRANSLATE 1 • CROSS SECTIONS 2 • END 0 •
≠0
NEXT CUT
• TRANSLATE 1 • CROSS SECTIONS 2 • END 0 •
0
END



(2)

FIGURE DI-1. THREE VIEW INSTRUCTIONS

FUNCTION EDIT

EDIT[,FILE] [,COMPN] [,COMPREF] [,ROLL,ANG]

OPERANDS: RECORD NUMBER IN PLACE OF COMP

LEAVE OUT COMPN TO EDIT COMPONENT IN CORE

COMPREF - USED ONLY FOR OFFSET BODY.
DEFAULT IS NONE

ROLL, ANG - USED ONLY FOR OFFSET BODY
COMPONENTS, WHERE ANG IS THE VALUE OF ROLL DESIRED.
DEFAULT VALUE OF ANG IS 0 DEGREES

FILE - [PERM [P], DEFAULT FILE], [LOCAL [L]]

ABBREVIATION: NONE

FUNCTION: VISUAL EDIT FUNCTION. COMPONENT EDITING IS DONE USING
DISPLAYED VIEWS OF THE COMPONENT.

BODY COMPONENT EDITING

Figures ED-1a and ED-1b illustrate how the edit subroutine displays a body component. The options available are summarized in the upper right hand corner of the figure ED-1b and reproduced below.

INSTRUCTIONS

POSITION SPAN STATION
I: INTERPOLATE STATION
D: DROP STATION
C: CAMBER STATION
INITIAL Z
FINAL Z
Y: SMOOTH Y
Z: SMOOTH Z
B: SMOOTH BOTH
SPACE: END STATION INPUT

All options are initiated by locating the vertical graphics cursor (thin vertical line) at the fuselage station desired and entering the indicated key on the console. With the exception of options I and C only one keyboard entry per station is required.

EDIT OPTION I: Interpolates and enters a section at the indicated fuselage station. Duplicate stations are not allowed and will result in multiple rings of the "bell" on the console. (Figure ED-1c STEP III).

EDIT OPTION D: Section chosen will be deleted from the geometry description. If the station indicated does not correspond to an available section the multi-bell function will sound. (Figure ED-1e STEP III).

EDIT OPTION C: The vertical graphics cursor is positioned at the station to be cambered (it must be an available station). The horizontal cursor is moved to the initial Z location and a C is entered on the keyboard. The graphics cursor will go off and a triangle will appear at this Z location. When the graphics cursor appears again the final Z is located and a C is again entered on the keyboard. A triangle will appear at the final Z location and the new section will be displayed, just to the right of the old section, for comparison. The fuselage stations of the new sections are the same as those of the old sections(Figure ED-1c STEPS I and II).

EDIT OPTIONS Y, Z, and B: When the user selects these smoothing options, the system applies a piecewise smoothing algorithm of specified order. Smoothing will be done on Y- values if Y is selected, Z- values if Z is selected, or both Y and Z if B is selected. The system will request the maximum smoothing order at the lower left hand corner of the page. The system will reduce the order if the number of free points is less than the maximum order on any line segment.

EDIT OPTION SPACE: Depressing the space bar ends the section editing routine and returns control back to the main system.

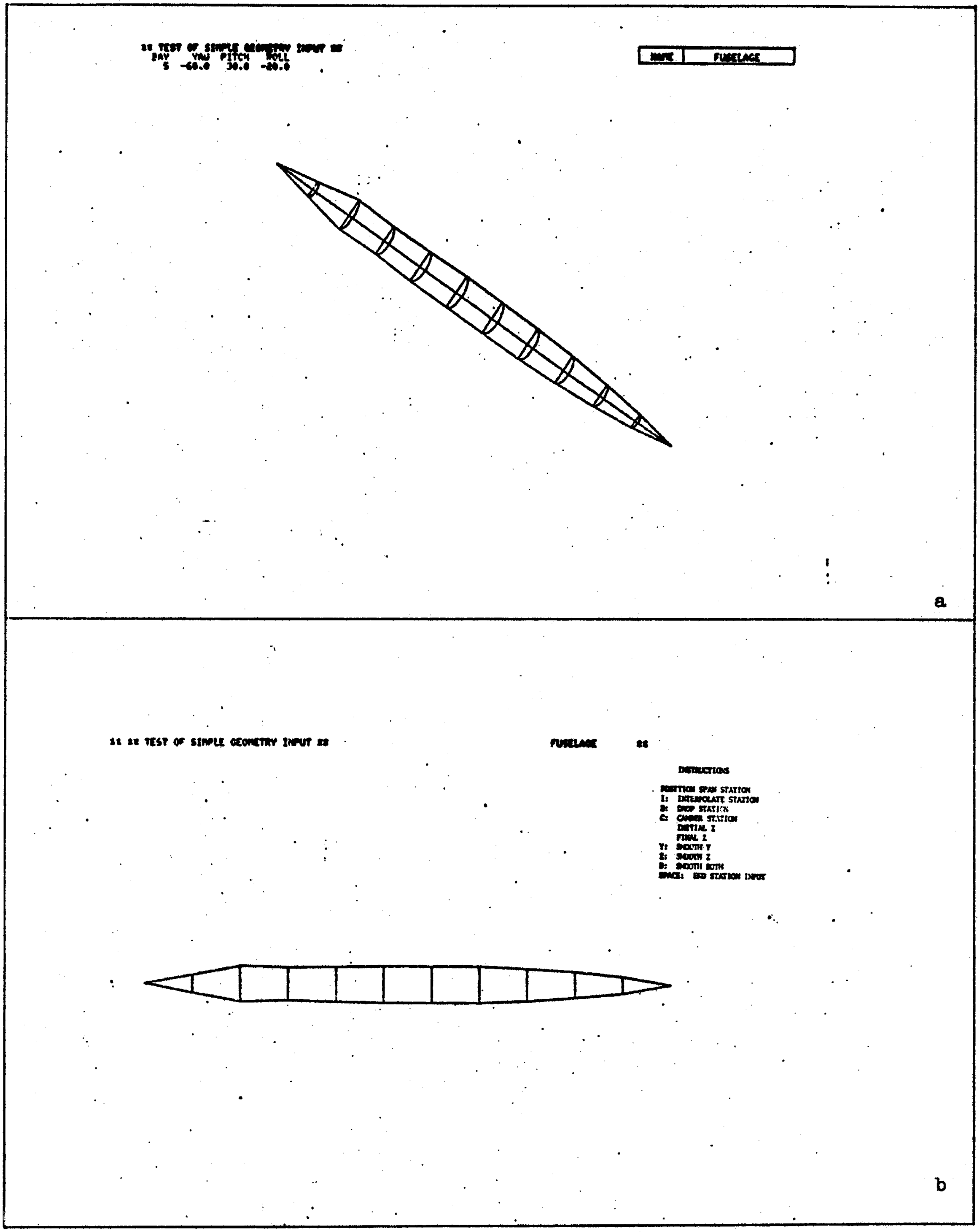
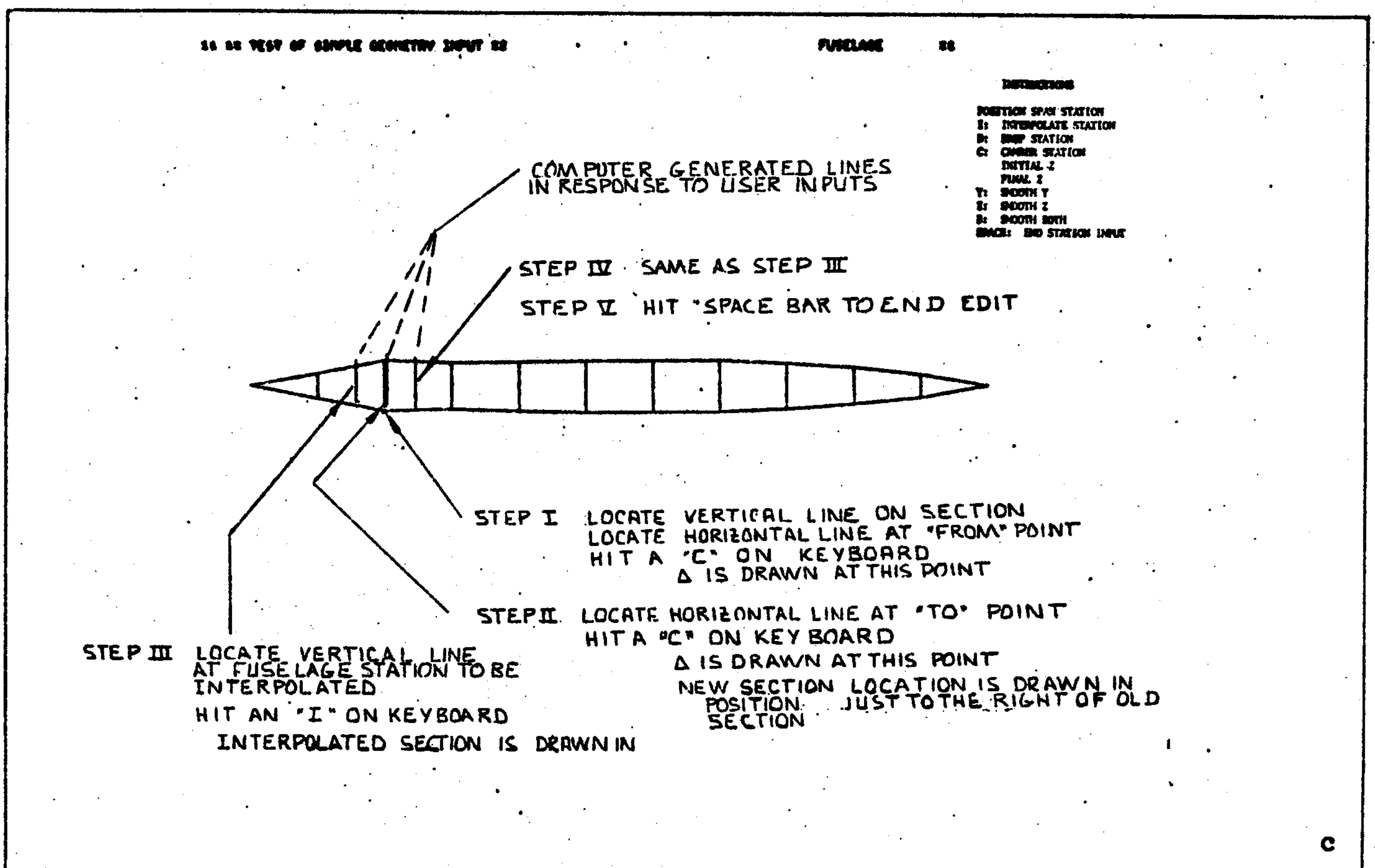


FIGURE ED-1. SIMPLE FUSELAGE BUILD-UP



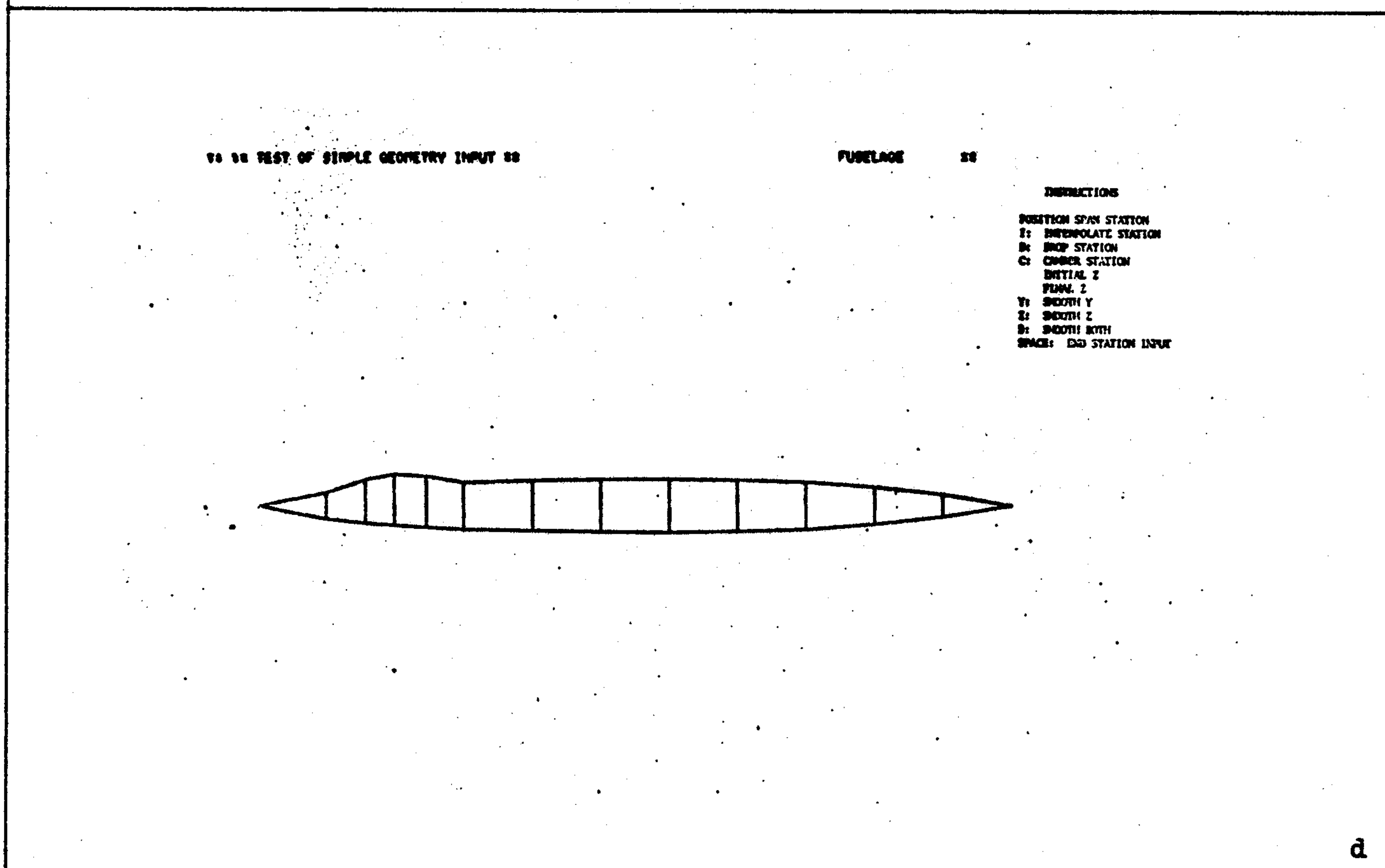
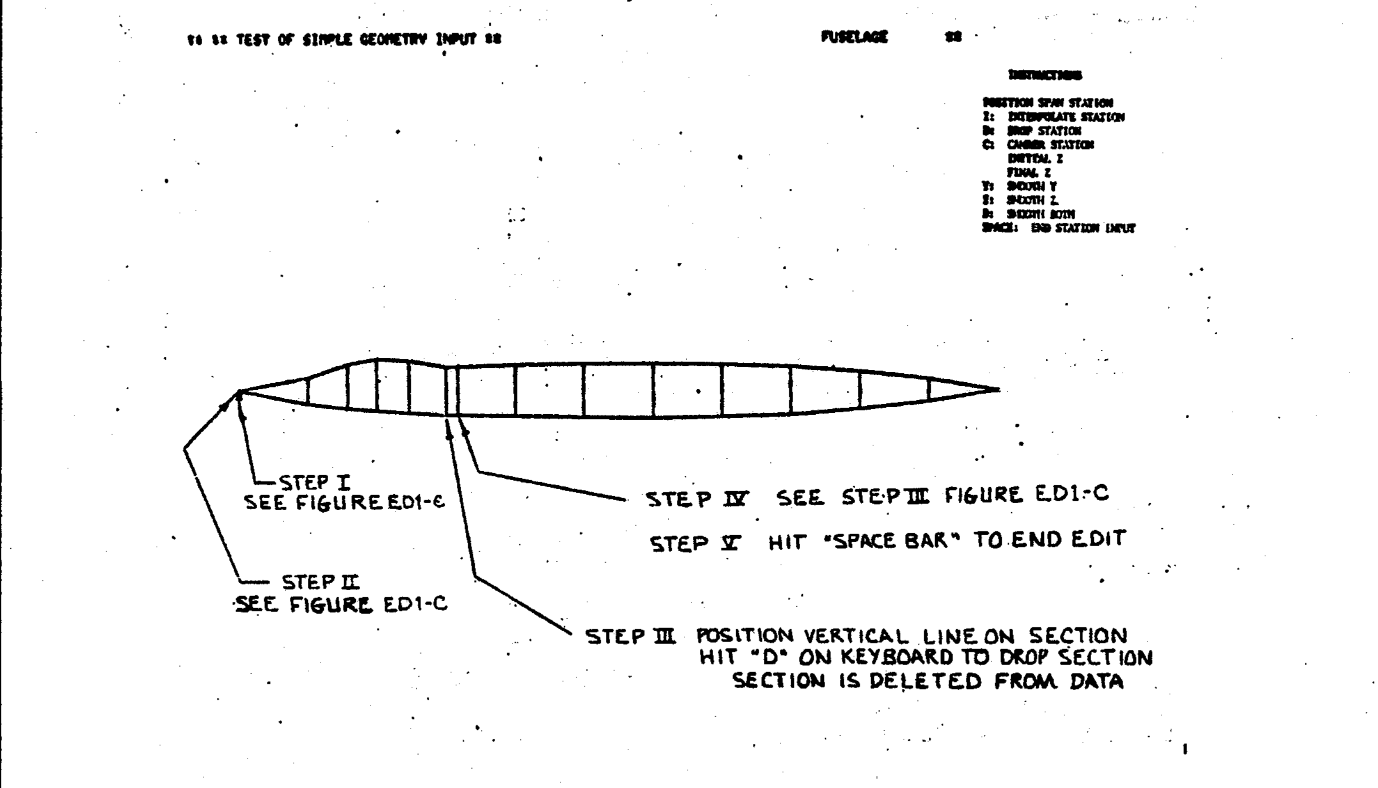
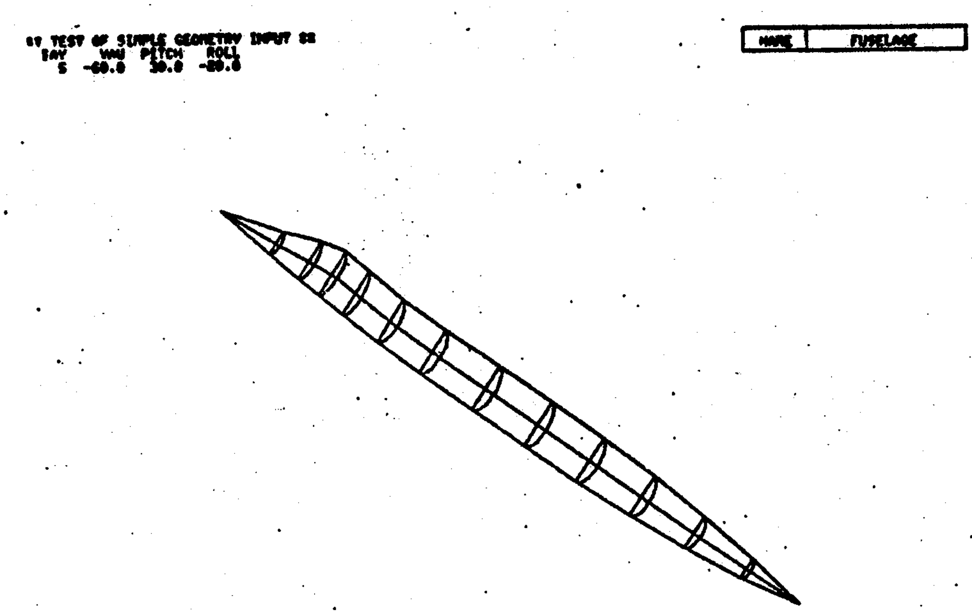


FIGURE ED-1 (CONTINUED)



e



f

FIGURE ED-1 (CONCLUDED)

SURFACE COMPONENT EDITING

The edit options for all surface components are the same, therefore the wing and vertical tail will be illustrated using the wing. The distinction made by edit between full surface and half surface components is the manner with which it handles the spanwise representation of either component. Full planar components are viewed in an X-Y plane or water-plane perspective. Half surface components are "unwrapped" and displayed in a true view, i.e. a curved half planar component would be edited spanwise along an s coordinate where s is perpendicular to the X axis and is measured from the root along the surface to the tip of the component.

The wing input is shown in its initial display in figure ED-2a. Because the number of spanwise lines which can be displayed for any component would confuse the display,only a few selected spanwise lines are used by the program to represent the shape of the component in question. This is also true of longitudinal lines displayed for body components.

When the user selects the edit option the program presents him with a view of the present status of the wing, its shape and its paneling figure ED-2b. The paneling on surface components is important if the user is interested in the lifting surface option of the program. The edit options available here are:

* OPTIONS: NO CHANGE 0 * CHORDWISE FIT SECTIONS 1 * CHANGE SPAN STATIONS 2 *

(+)

If the user intends to adjust the span stations, they are done first and option 2 is selected.

The instructions for planar edit appear in the upper right hand corner of the screen, figure ED-2c, and are reproduced below

INSTRUCTIONS

POSITION SPAN STATION
I: INTERPOLATE STATION
D: DROP STATION
E; CHORD ELONGATION
LOCATE L.E.
LOCATE T.E.
SPACE: END STATION INPUT

The graphics cursor will appear and section editing can begin. Options I, D, Space Bar are the same as for non-planar components and will not be repeated here. The hash marks at the bottom of the screen mark every 5% true span for the component as guides to inputing new sections.

Option E is for chord elongation or shrinking, requiring two inputs by the user, one for the leading edge and one for the trailing edge of the chord. The vertical cursor is located at an available section and the new leading edge of the section is located with the horizontal cursor (the multi-bell will sound if the station chosen is not available). An E is entered on the keyboard, the graphics cursor goes off and a triangle is drawn at the input point, figure ED-2c STEP I. The process is then repeated for the trailing edge and the bell will ring once when the process is complete, figure ED-2c STEP II. The elongation routine scales the thickness in direct proportion to the old and new chord lengths. The planform modification process performed on the example wing is shown in figure ED-2d where the new leading and trailing edge points are numbered in the order in which they were input. Note, however, that although this user made an orderly advance from wing root to tip, the order in which the sections are changed, dropped, or added is not important in this section of the edit routine.

When the user ends this section of edit the progrm again offers the choice of chordwise paneling the geometry:

```
* NO CHANGE 0 * CHORDWISE CONSTRAINTS 1 * EVEN SPACING 2 *
  HALF COS SPACING 3 * FULL COS SPACING 4 *
```

Examples of choices 2 thru 4 are shown in figure ED-3a, b, and c. Compare these with the aribtrary (chordwise constraints) result in ED-3d. The response, by the computer to choices 2 thru 4 is:

```
* ENTER NO. OF CHDWSE PANELS *
 * PRESENT NUMBER = 10 *
?
```

to which the user responds with the desired number of chordwise panels. The program will then plot a final view of the edited component showing the paneling for the component and ends the editing mode, as in figure ED-4f.

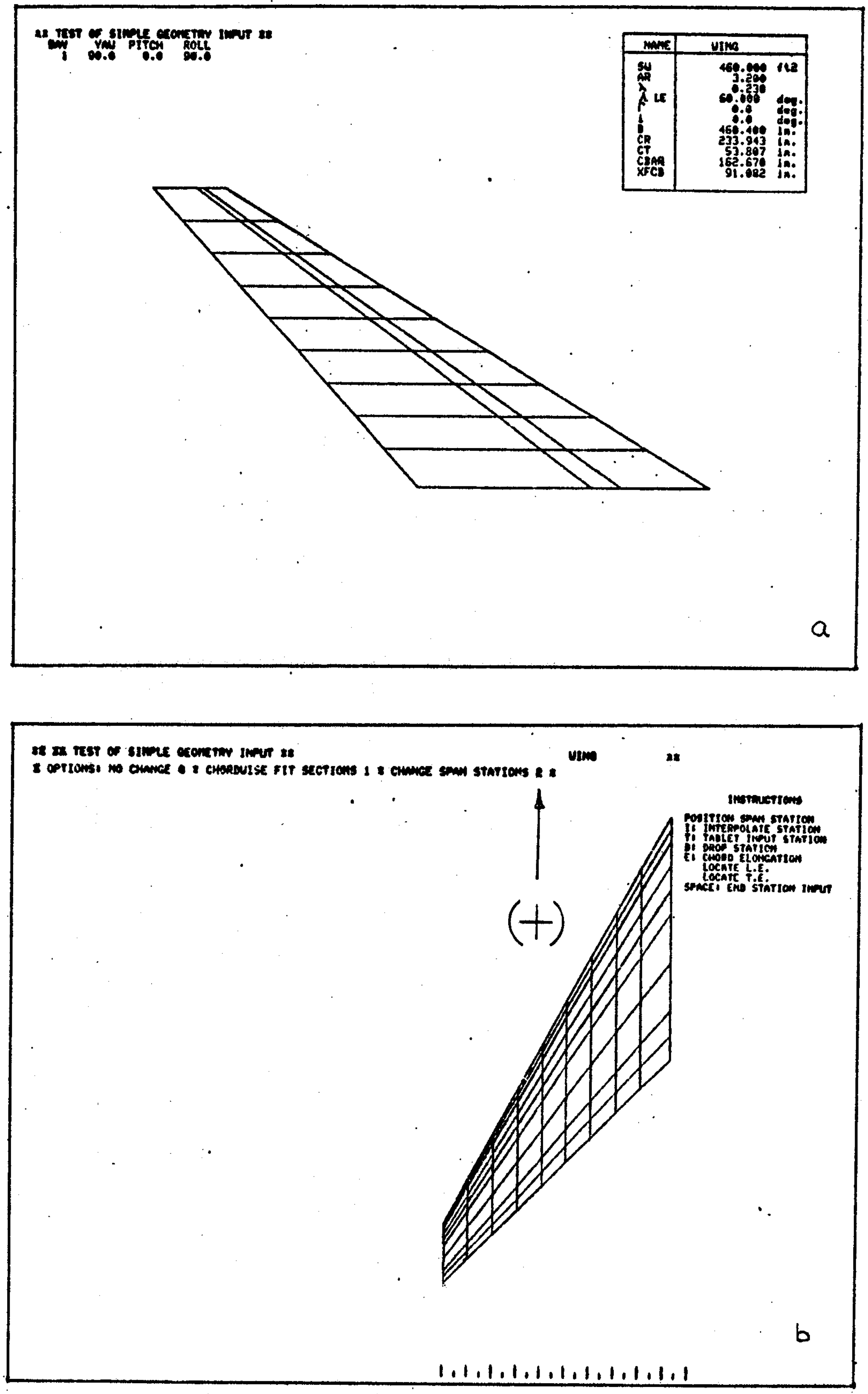


FIGURE ED-2. SURFACE COMPONENT SECTION EDITING

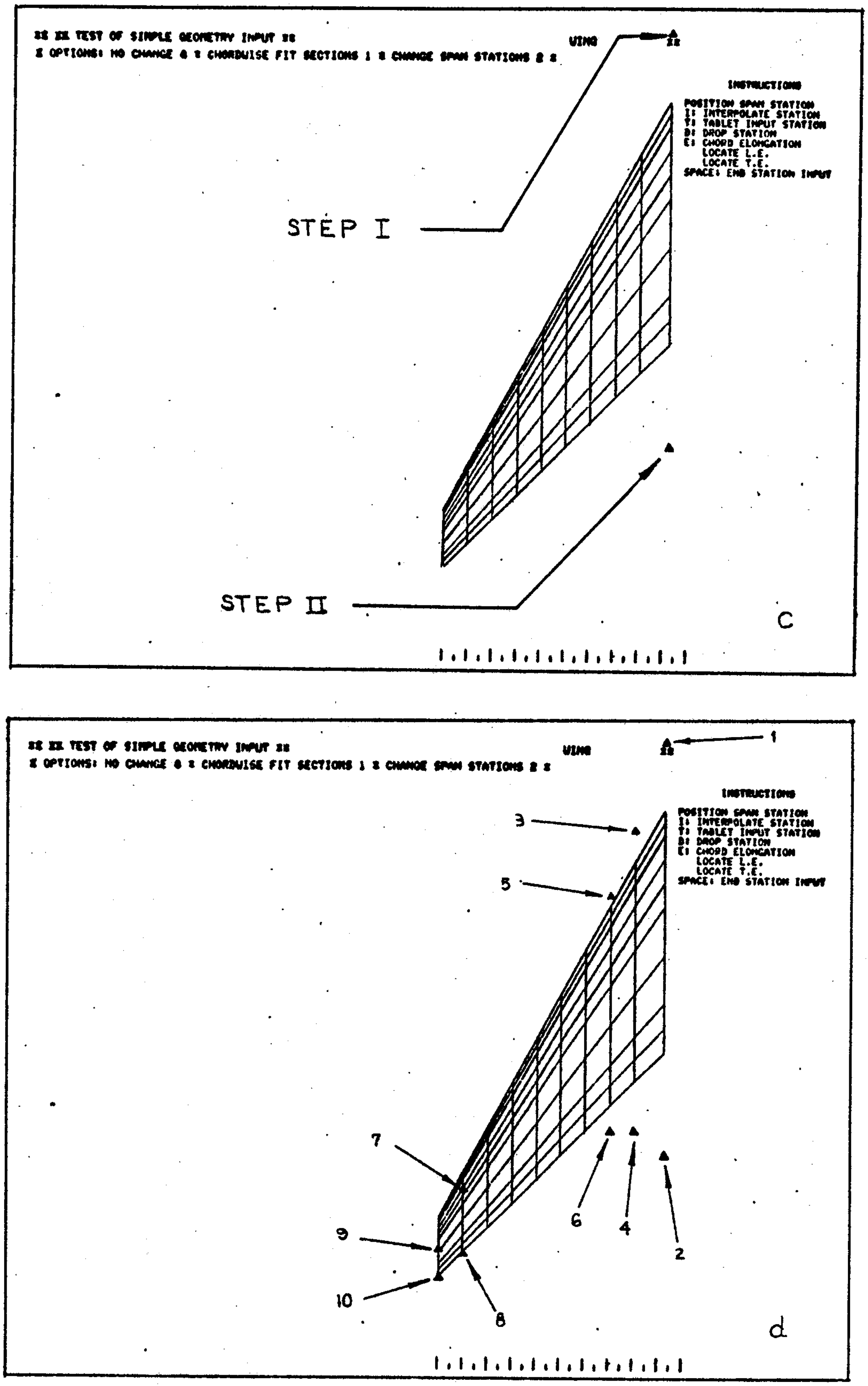


FIGURE ED-2. (CONCLUDED)

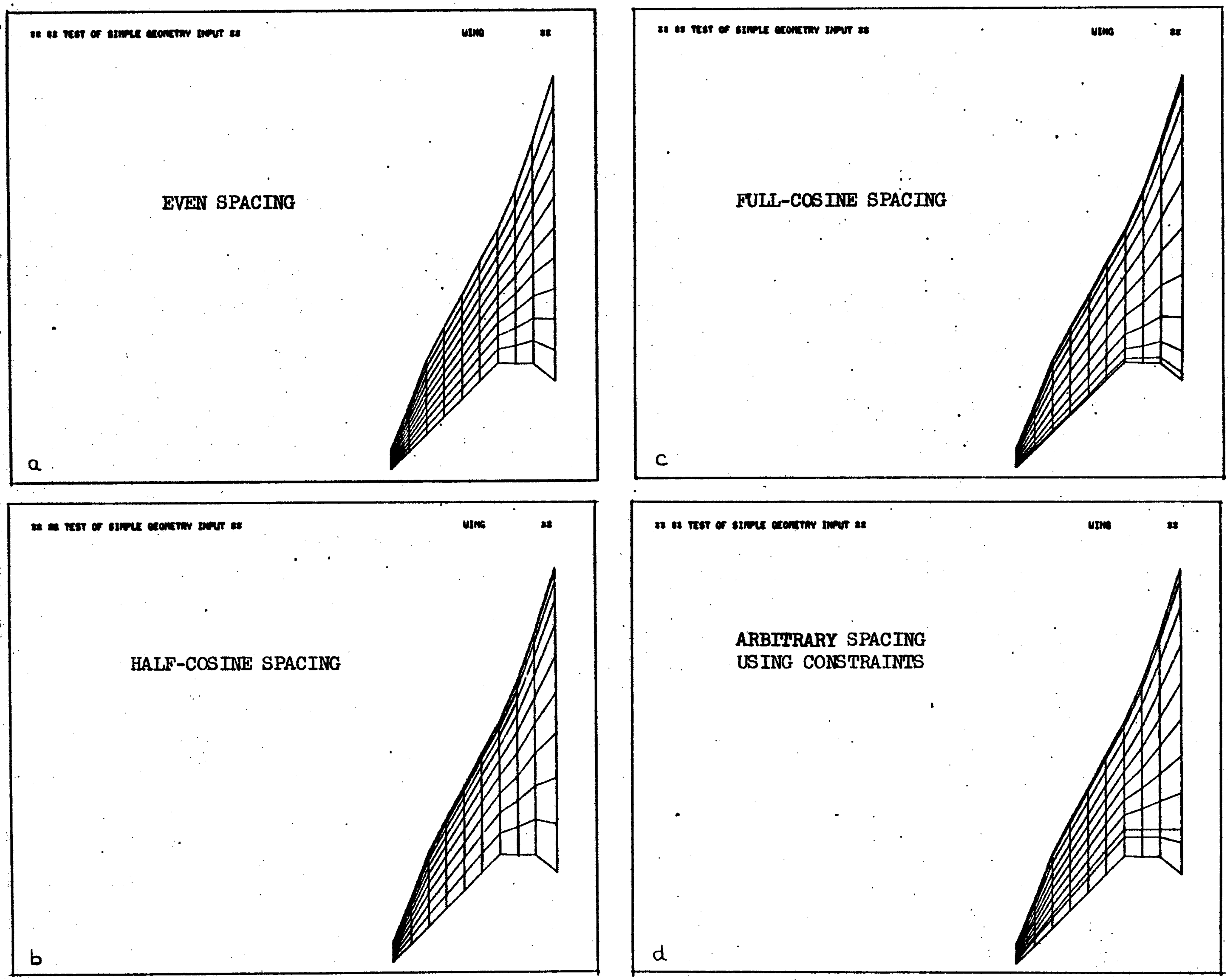


FIGURE ED-3. EXAMPLES OF CHORDWISE PANEL DISTRIBUTION METHODS

-EDIT-

CHORDWISE CONSTRAINTS

The user may elect to input his own chordwise constraints by selecting option 1. A chordwise constraint point is a user input point defining locations on any given section where the user requires specific boundaries to pursue the desired computational results. Constraints are imposed, for example, to produce arbitrary chordwise paneling or to indicate control surfaces on the component. A constraint line always runs from root to tip along a user described path. Constraint sections run between two constraint lines, the leading and trailing edges of the component being automatic constraint lines.

Some general rules concerning flap generation are:

1) Flaps are defined along a constant line input at the trailing edge of the surface. For example, a leading edge flap would be defined along with first input constraint line while a trailing edge flap would be defined after the trailing edge has been indicated.

2) A flap definition extends from the constraint line being input, forward to the previously input constraint line.

When choice 1 is selected, figure ED-3a, a shell of present surface definition is plotted with the instructions in the upper right hand corner, figure ED-3b and reproduced below:

INSTRUCTIONS

C: CONSTRAINT
I: INTERMEDIATE FLAP LINE
F: BEGIN FLAP
E: END FLAP
T: TRAILING EDGE
R: REFERENCE LINE
   2ND POINT
/: END CONSTRAINT SECTION

The chordwise hash marks are every 5% for reference purposes. The user is prompted here for the type of spacing desired in the first constraint section, Step 1, figure ED-3c:

* CONSTRAINT NO. : 1 ** EVEN SPACING 2 * COSINE SPACING 3 **,
(+)

where the cosine spacing here is half cosine spacing. The program then requests the number of panels to be placed in this constraint section, Step 2:

```
* NO. CHRDWSE PANELS THIS CONSTRAINT *
?
3      CR
```

The graphics cursor now appears to start constructing the first constraint. Note that Figure ED-3 illustrates the steps necessary to produce the work which is shown. The constraint line will end automatically when the maximum span statinn is selected or when a / is input from any section. When a slash is encountered the x/c and flap designation information will be derived from the previous input, i.e. / can never be the first input for a constraint line.

In figure ED-3c the user was mainly interested in achieving close spacing at the leading edge and constructed the first constraint line by:

1) Locating the graphics cursor at the 0.25 x/c location of the most inboard chord and entering a.c.

2) Leaving the graphics cursor alone when it re-appears and entering a /.

The constraint line is then drawn in solid and the computer generated intermediate lines are drawn with a double dashed line.

The second constraint is constructed, figure ED-3d by indicating an even spacing of 5 panels. The horizontal cursor is then located at the 0.80 x/c point of the fourth outboard section. The constraint points to be input define the leading edge of the aft control surfaces on the wing. They are input as follows:

1) Starting inboard at section 1 a C is entered at sections one through 4 leaving the horizontal cursor fixed throughout.

2) Following the C input at the fourth station a / is entered and the constraint is ended. (Note that outboard of section 4 constraint line 2 is at a constant x/c of 0.8, the same as it was at 4).

To finish the wing with constraint 3,the user indicates cosine spacing with, 2 panels, figure ED-3e. Since this constraint is along the trailing edge a T is entered when the graphics cursor comes on, indicating the trailing edge, releasing the need for the user to locate anything with the horizontal cursor. The user now proceeds, using the vertical cursor only, to locate the partitioning of the trailing edge control surfaces as follows:

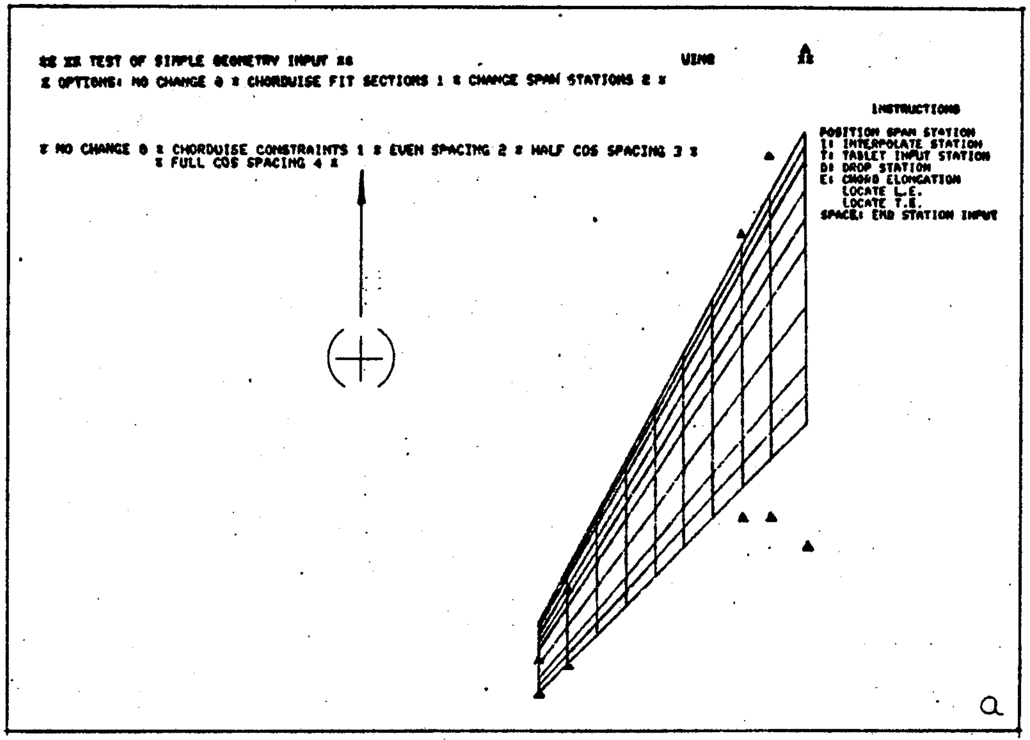
1) The first section is entered with a C

2) The second section is entered with an F indicating that a flap is starting.

3) The third section is skipped and an E is entered at the fourth indicating that a control surface is to be entered between sections 2 and 4.

4) An E is entered at section 5 and a second flap is entered by the program between 4 and 5 (An E following another E indicates that a new flap should be entered between these two span stations).

Similar operations are done at sections 7 and 9 to indicate two additional control surfaces from 5 to 7 and 7 to 9. After the E is entered at section 9, a slash is entered and the program fills in the remaining constraint section on the wing and ends this section of edit by ringing the bell and pausing with a PCC for a copy, if desired. The program then proceeds to plot a final view of the component showing all paneling.



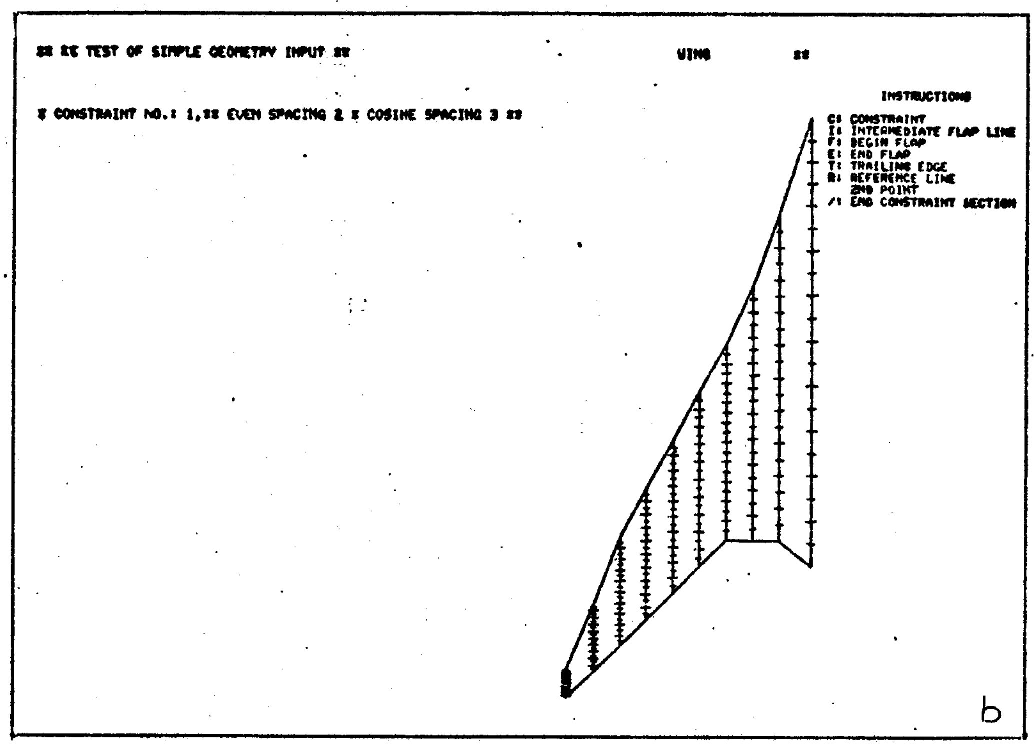
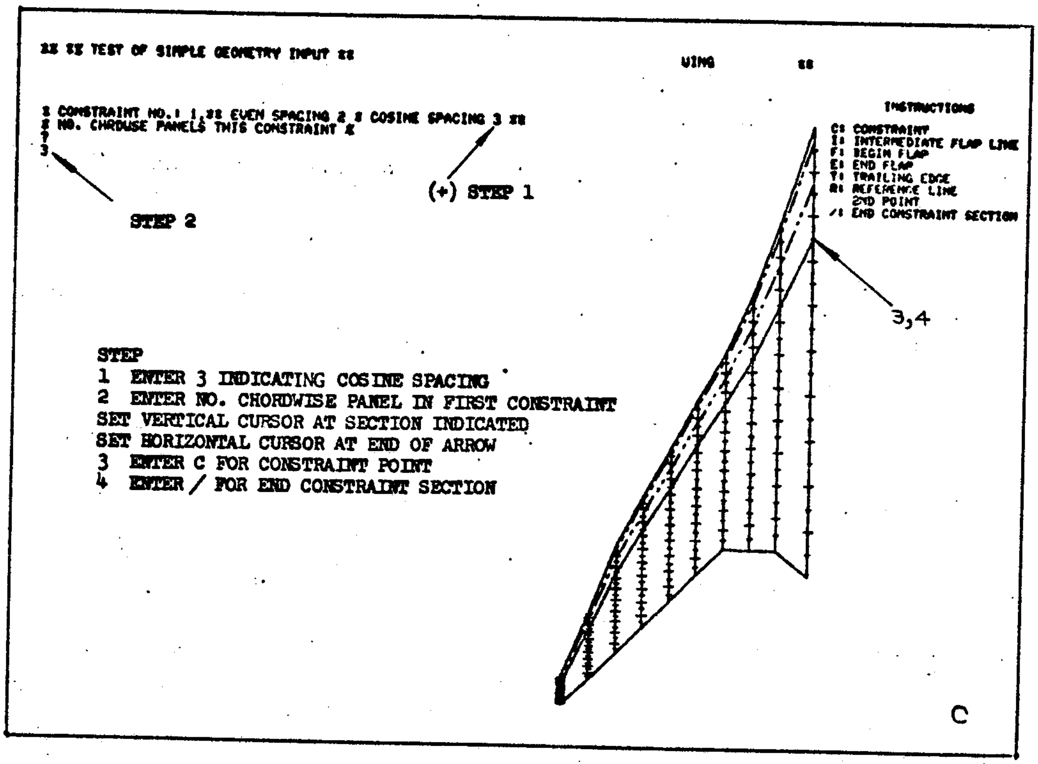


FIGURE ED-4. SURFACE COMPONENT CHORDWISE CONSTRAINT EDITING



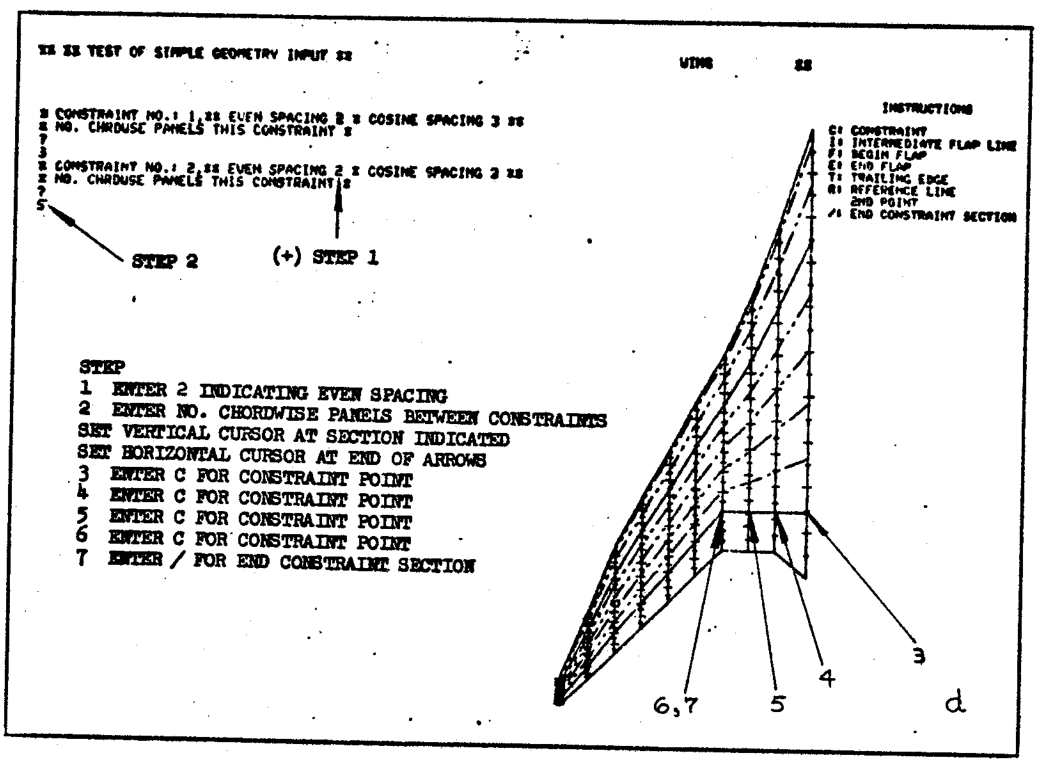
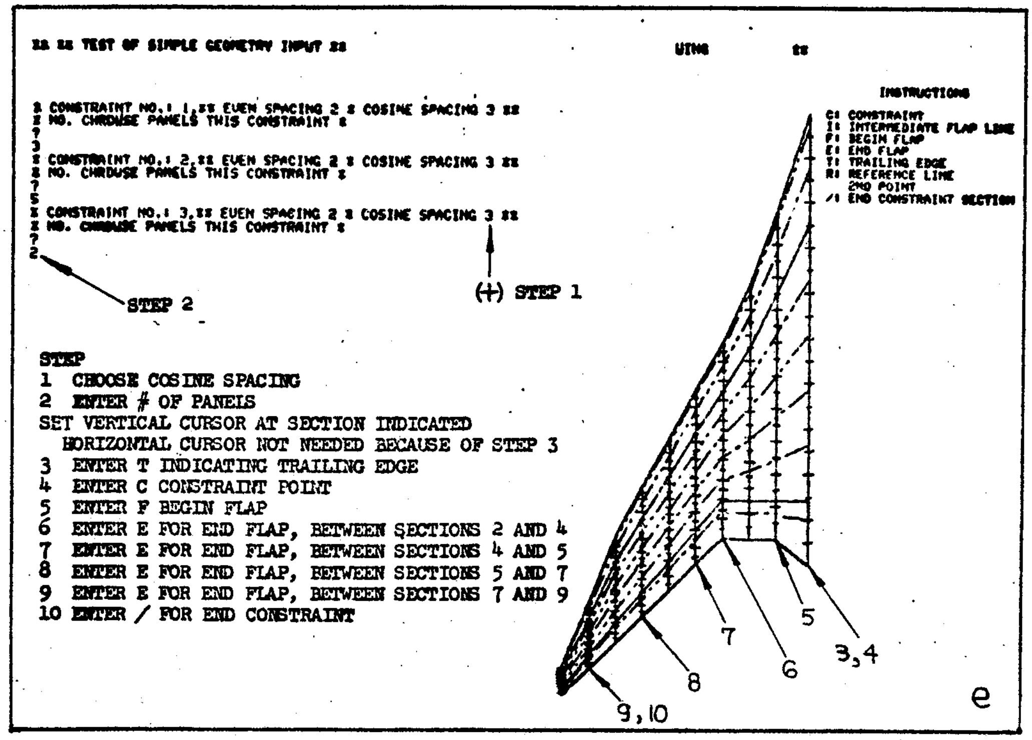


FIGURE ED-4. (CONTINUED)



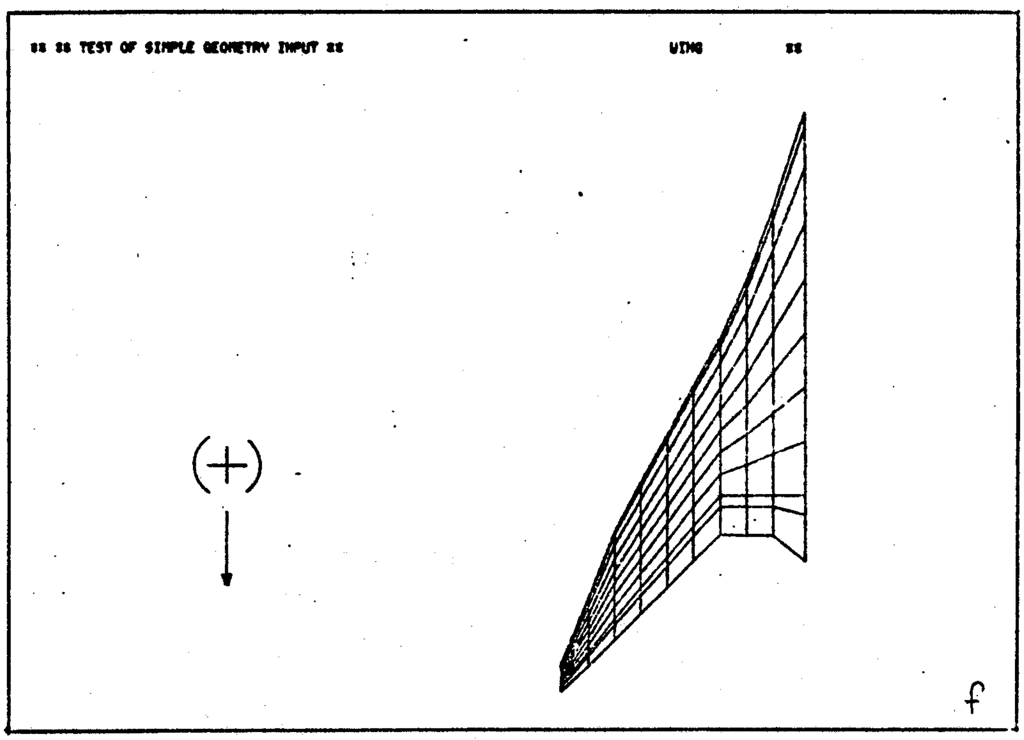


FIGURE ED-4. (CONCLUDED)

FUNCTION EXIT

EXIT

OPERANDS: NONE

ABBREVIATION: NONE

FUNCTION: CLOSE FILES AND EXIT FROM SYSTEM

FUNCTION FILES

```
FILES [,FILE]
```

OPERANDS: FILE - PERM [P] [DEFAULT FILE]
LOCAL [L]

ABBREVIATION: FILE

FUNCTION: LIST OUT COMPONENTS STORED IN EITHER PERMANENT OF LOCAL FILE

-FORCES-

FUNCTION FORCES

FORCES

OPERANDS: NONE

ABBREVIATION: FORC

FUNCTION: DISPLAY TOTAL FORCES FROM PROGRAM CALCULATIONS. AT LEAST ONE ANALYSIS FUNCTION MUST HAVE BEEN COMPUTED TO PRODUCE REASONABLE RESULTS.

-FORCES SUB-FUNCTIONS-

COM [, COM2] [, COM3] [, SA = VAL] [,SO = VAL]

OPERANDS: ALL ARE VERSUS MACH NUMBER

COM,COM2,COM3:

CLO:	C_{L_o}
CMO:	C_{M_o}
CMA:	C_{M_α}
CLA:	C_{L_α}
CMCL:	dC_m/dC_L
CLP:	C_{L_p}
CLQ:	C_{L_q}
CMP:	C_{m_p}
CMQ:	C_{m_q}
CLDS1*	$\partial C_L/\partial\delta_{S_1}$
CMDS1*	$\partial C_m/\partial\delta_{S_1}$
CLDS2*	$\partial C_L/\partial\delta_{S_2}$
CMDS2*	$\partial C_m/\partial\delta_{S_2}$
CYB:	C_{Y_β}
CNB:	C_{n_β}
CRB:	C_{ℓ_β}
CYP:	C_{Y_p}
CYR:	C_{y_r}
CNP:	C_{n_p}
CNR:	C_{n_r}
CRP:	C_{ℓ_p}
CRR:	C_{ℓ_r}
CYDA1**	$\partial C_y/\partial\delta_{A_1}$
CNDA1**	$\partial C_n/\partial\delta_{A_1}$
CRDA1**	$\partial C_\ell/\partial\delta_{A_1}$
CDP:	VISCOUS DRAG
CDM:	WAVE DRAG
KØP:	C_{D_i}/C_L^2 0% SUCTION
K1P:	C_{D_i}/C_L^2 100% SUCTION
KS#:	C_{D_i}/C_L^2 USING SUCTION VARIATION #
SA:	ABSCISSA SCALE FACTOR 0.0 FREE SCALING.DEFAULT 0.0
SO:	ORDINATE SCALE FACTOR 0.0 FREE SCALING.DEFAULT 0.0

ABBREVIATION: NONE

FUNCTION: FUNCTIONS SPECIFIED ABOVE ARE ALL PLOTTED VERSUS MACH NUMBER. THREE DERIVATIVES MAY BE SPECIFIED PER DISPLAY.

KØP,K1P,KS#,CDP,CDM ARE PLOTTED ALONE

*DS1 REFERS TO SYMMETRIC FLAP 1
**DA1 REFERS TO ANTI-SYMMETRIC FLAP 1

```
COM [,MACH] [,SA = VAL] [,SO = VAL]
```

OPERANDS: ALL ARE VRS CL

COM:

CDIØ - C_{D_i} 0% SUCTION
CDI1ØØ - C_{D_i} 100% SUCTION
CDI# - C_{D_i} SUCTION VARIATION
WHERE # IS SUCTION CURVE

SUC# - SUCTION CURVE #
CDTØ [,NV] - $C_{D_{TOTAL}}$ 0% SUCTION
CDT1ØØ [,NV] - $C_{D_{TOTAL}}$ 100% SUCTION
CDT# [,NV] - $C_{D_{TOTAL}}$ WITH SUCTION VARIATION #
NV - VISCOUS DRAG CASE NUMBER [DEFAULT-1]

MACH: MACH NUMBER, MUST BE AN INTERPOLATED MACH NUMBER

SA: ABSCISSA SCALE FACTOR
0.0 FREE SCALING . DEFAULT 0.10

SO: ORDINATE SCALE FACTOR
0.0 FREE SCALING . DEFAULT 0.0

FUNCTION: DISPLAY DRAG POLARS AND SUCTION VARIATIONS VERSUS LIFT COEFFICIENT.

FUNCTION INTERFERENCE

```
INTERFERENCE, [,FILE]COM REC1 ,COM2 REC2 ,..COMN RECn
```

OPERANDS: COM1: COMPONENTS TO BE USED FOR REFERENCE.AT LEAST ONE COMPONENT MUST BE SPECIFIED
[REC1] RECORD NUMBER MAY BE USED INSTEAD OF COMPONENT NUMBER

FILE: [PERM [P] , DEFAULT] ,[LOCAL [L]]

ABBREVIATION: INTE

FUNCTION: USING SELECTED COMPONENTS THE OPERATOR CREATES INTERFERENCE SHELL, JET FLAPS, AND FLAT PLATE GEOMETRIES.

NOTES:

1) Panel building with this function is a recurrent two-step process requiring at least two passes to produce a geometric figure constituting a planar-body. The recurrent process takes place in steps II through IV as depicited in figure IN-1.

2) The three types of boundary conditions, i.e., interference, standard, and jet flap, are treated somewhat differently with the graphics cursors as explained below.

Interference lines: End points are determined by the values indicated by the vertical cursor for the first input line. There after the vertical cursor can be moved aside and only the horizontal cursor is used.

Standard lines: Ends points of standard lines must be located for each line using the vertical cursor.

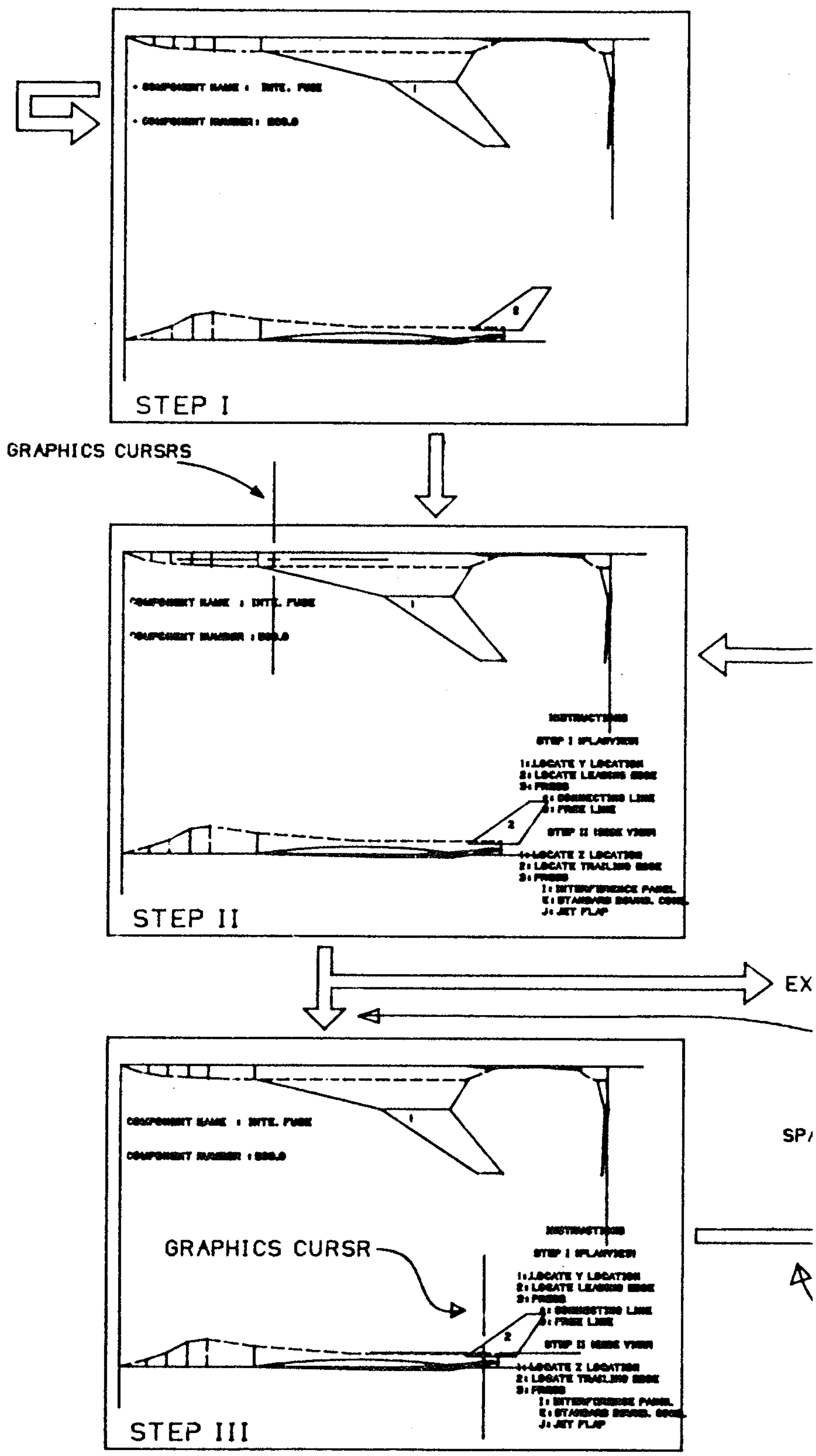
Jet Flap lines: Only the leading edge of the line must be located and each line must attach to a displayed chord. The length of the line is requested as a multiple of the attachment chord length (Step IV for jet flaps only in figure IN-1).

3) Components in the display not qualifying for planar attachment are dashed in and can be used as reference guides only. Component such as fuselage, nacelles etc. are used for this purpose.

4) Lines are input by locating the graphics cursors at the X-leading edge, Y location and entering an attachment component number (component numbers to use are printed at the approximate centroid in a full view of each component; for example wings in the top view, verticals in the side view) to input the point. When the cursors appear again locate the X-trailing edge, Z location and input the point by entering the boundary condition flag (I, E, or J). Do not mix boundary conditions. After the X, Z point is entered the bell will ring and a line will be drawn in the top and side views based on the points received. Jet flaps draw a line of representative length in the top view only.

5) Interference shells must be numbered within 10.0 of the slender body they are associated with.

Interference shells numbered within 10.0 will be combined into one component in the lifting surface solution.


STEP I
GRAPHICS CURSRS
STEP II
EX
SP
GRAPHICS CURSR
STEP III

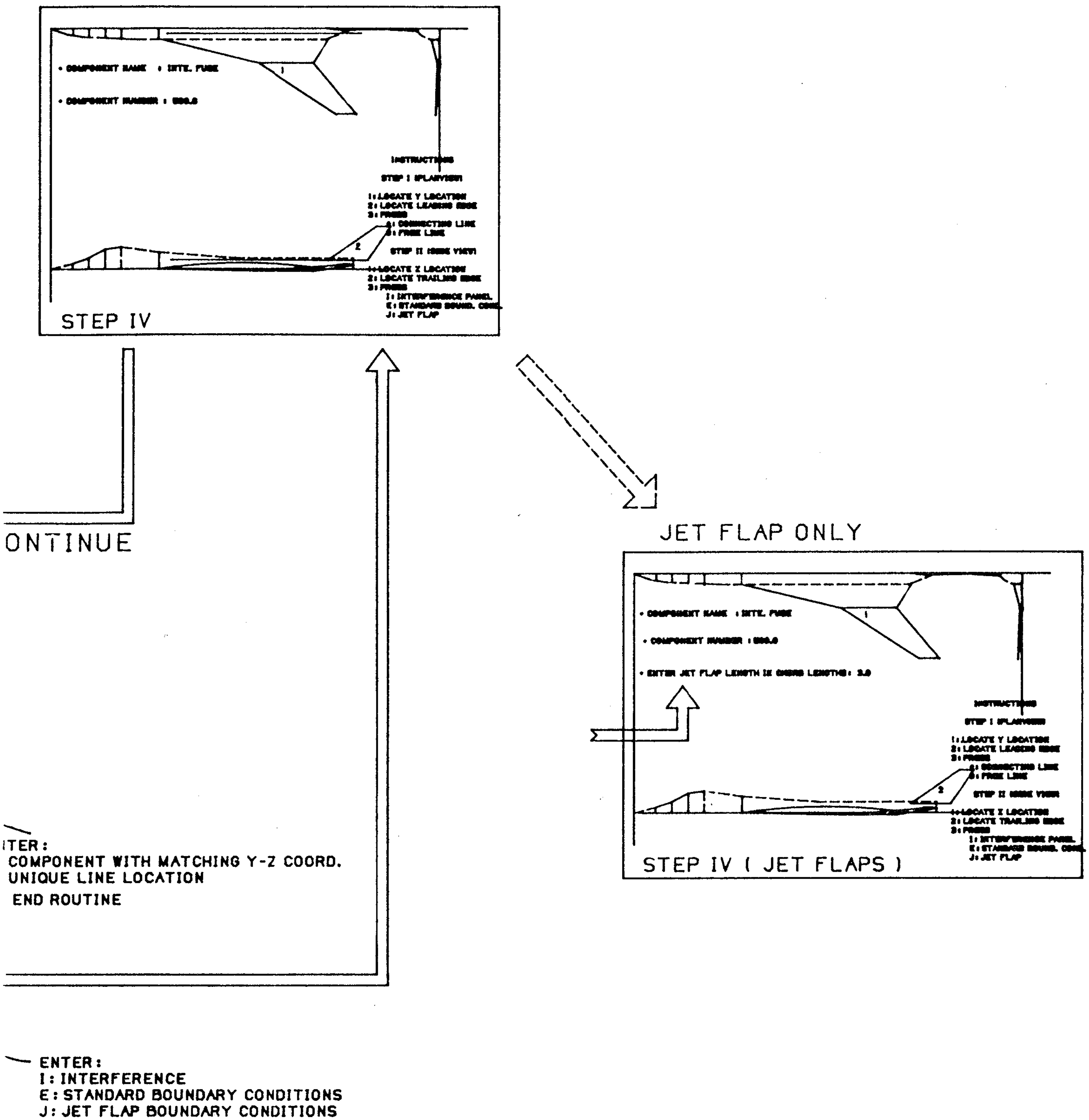


FIGURE IV-1. INTERFERENCE FUNCTION SCHEMATIC

FUNCTION LIST

LIST [,FILE][,COMP]

OPERANDS: RECORD NUMBER IN PLACE OF COMP

LEAVE OFF COMP TO EDIT COMPONENT IN CORE

FILE: [PERM [P] DEFAULT],[LOCAL [L]]

ABBREVIATION: NONE

FUNCTION: SECTION LISTING AND EDITING. SECTIONS CAN BE DISPLAYED, INSERTED, DELETED.SPECIFIC POINTS CAN BE CHANGED AND SECTIONS CAN BE ROTATED (BODY COMPONENTS ONLY).

SUB-COMMAND A, B, DA, AND DB

```
[SEC,]DA=VAL   [,N1,N2] [,N3] [,V]
```

OPERANDS:

SEC - SECTION NUMBER. DEFAULT: CURRENT SECTION

=VAL - VALUE OF ANGLE FOR ROTATION
+ COUNTER-CLOCKWISE
- CLOCKWISE
(MUST HAVE "=" SIGN IN FRONT OR DECIMAL POINT IN VAL)

N1,N2 - START POINT AND END POINT
IF N1 IS GREATER THAN N2 ROTATION TAKES PLACE ON POINTS NOT BETWEEN N1 AND N2

N3 - POINT TO ROTATE ABOUT, DEFAULT IS N1

V - VERIFY INPUT VALUE

DEFAULT IF N1,N2,N3 ARE LEFT OFF:
ALL POINTS IN SECTION ARE ROTATED ABOUT POINT 1.

ABBREVIATION: NONE

FUNCTION A: INCLINE BODY SECTIONS TO SHAPE INLETS, AND NOZZLE CONTOURS. SECTION RETAINS SAME CROSS-SECTION IN Y-Z PLANE

A = DA = INCLINE ABOUT Y-AXIS

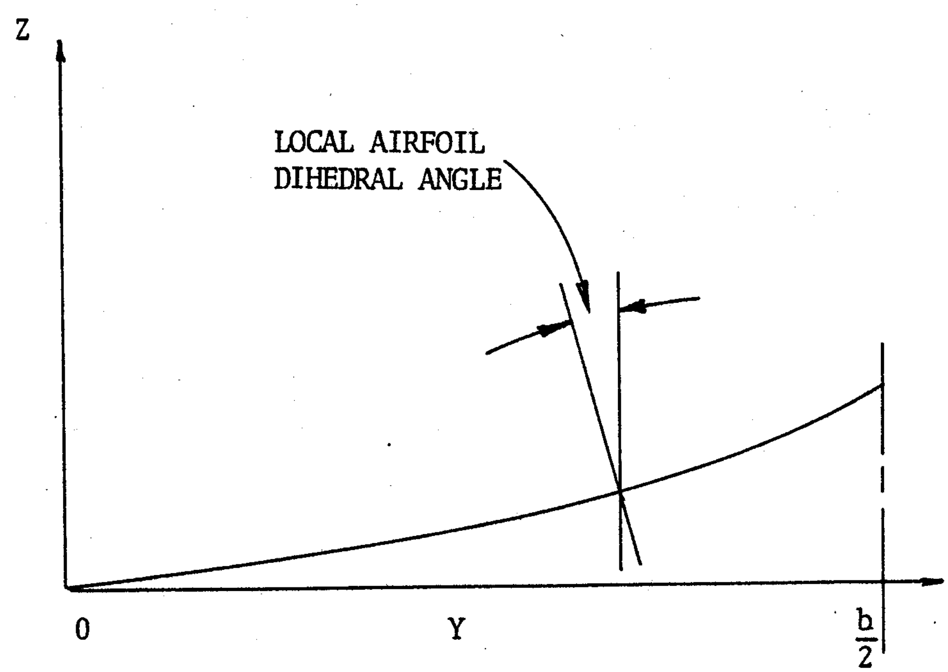
B = DB = INCLINE ABOUT Z-AXIS

-LIST / A,B,DA,DB-

FUNCTION B: TWIST AIRFOIL AND ADJUST DIHEDRAL

A = DA = TWIST ANGLE, ADDED TO WHAT EVER TWIST IS ALREADY PRESENT

B = DB = ABSOLUTE DIHEDRAL ANGLE OF AIRFOIL. DB = 0.0 RETURNS SECTION TO ZERO DIHEDRAL



SUB-COMMAND DELETE

```
DELETE,N1 [,N2] [,V ]
```

OPERANDS:

N1 - SECTION TO DELETE

N2 - DELETE SECTIONS FROM N1 TO N2

V - VERIFY INPUT SECTION

ABBREVIATION: DE

FUNCTION: DELETE SECTIONS FROM COMPONENT GEOMETRY.

SUB-COMMAND DUPLICATE

```
DUPLICATE=VAL,N1[,V]
```

OPERANDS: =VAL - STATION FOR NEW SECTION
- x FOR NON-PLANAR
- Y FOR TYPE-4 (OR WING), $Y > 1.0$
- η FOR TYPE-3, 4, 5, 6

N1 - STATION TO BE DUPLICATED

V - VERIFY INPUT SECTION

ABBREVIATION: DU

FUNCTION: DUPLICATE STATION N1 AT LOCATION VAL.

SUB-COMMAND DX, DY, AND DZ

```
[SEC,] DX =VAL [,N1][,N2] [,V]
```

OPERANDS:

	SEC	-	SECTION NUMBER. DEFAULT: CURRENT SECTION
	=VAL	-	VALUE TO BE ADDED TO X (MUST HAVE "=" SIGN IN FRONT OR DECIMAL POINT IN VAL)
	N1	-	POINT TO HAVE INCREMENT ADDED
	N2	-	ALL POINTS FROM N1 TO N2 ARE TO HAVE INCREMENT ADDED
	V	-	VERIFY INPUT VALUE

DEFAULT WHEN N1, N2 ARE LEFT OFF IS "ALL"

ABBREVIATIONS: NONE

FUNCTION: ADD INCREMENTAL VALUE TO X, Y, OR Z OF A GIVEN SECTION USING SUB-COMMAND DX,PY, OR DZ, RESPECTIVELY

SUB-COMMAND INSERT

```
INSERT =VAL [,V ]
```

OPERANDS:	VAL -	X	STATION OF NON-PLANAR
		Y	STATION OF TYPE-4 (OR WING), Y > 1.0
		η	STATION OF TYPE-3, 4, 5, OR 6
	V -		VERIFY INPUT SECTION

ABBREVIATION: IN

FUNCTION: CURVE FIT A NEW SECTION AT INPUT STATION. SPLINE FIT ROUTINE USES AN ALGORITHM DESIGNED TO FOLLOW BREAKS IN THE COMPONENT.

-SUB-COMMAND LIST

```
[SEC,] LIST [,ROT] [,SP] [,SD]
```

OPERANDS:

SEC - SECTION NUMBER, LEAVE OFF FOR CURRENT SECTION

ROT - ROTATE SECTION ABOUT Z-AXIS (MUST HAVE DECIMAL POINT IN VALUE) DEFAULT IS FACE ON VIEW

SP - SUPPRESS PRINT OUT OF POINT X, Y, AND Z VALUES.DEFAULT IS PRINT

SD - SUPPRESS DISPLAY OF SECTION . DEFAULT IS DISPLAY

ABBREVIATION: L

FUNCTION: LIST OUT SECTION DISPLAY AND X, Y, Z PRINT-OUT. MULTIPLE POINTS ARE NOTED BY BREAKS IN NUMBERING ON THE SECTION DISPLAY.

SUB-FUNCTION SAVE

```
SAVE [,COMPN]
```

OPERANDS: COMPN - SAVE AS NEW NUMBER.
DEFAULT IS COMP

ABBREVIATION: S

FUNCTION: SAVE WORK DONE IN FILE COMPONENT WAS TAKEN FROM.
NEW COMPONENTS ARE SAVED IN PERMENANT FILE.

SUB-COMMANDS X, Y, AND Z

```
[SEC,] X [=VAL] [,N1] [,N2] [,N3] [,V ]
```

OPERANDS:

SEC - SECTION NUMBER. DEFAULT: CURRENT SECTION

=VAL - REPLACEMENT VALUE OF X MUST HAVE "=" SIGN IN FRONT OR DECIMAL POINT IN VAL)

N1 - POINT TO BE GIVEN NEW VALUE

N2 - ALL POINTS FROM N1 TO N2 ARE TO BE SET TO VAL

N3 - ALL POINTS FROM N1 TO N2 ARE TO BE SET THE VALUE OF POINT N3

V - VERIFY INPUT VALUE

DEFAULT WHEN N1, N2, N3 ARE LEFT OFF IS "ALL"

ABBREVIATION: NONE

FUNCTION: REPLACE PRESENT VALUES OF X, Y, OR Z OF A GIVEN SECTION USING SUB-COMMAND X, Y, OR Z, RESPECTIVELY.

FUNCTION LOADS

LOADS

OPERANDS: NONE

ABBREVIATION: LOAD

FUNCTION: DISPLAY CHORDWISE AND SPANWISE DISTRIBUTIONS

THE SET-UP AND/OR THE SOLUTION TO THE LIFTING SURFACE FUNCTION MUST BE EXECUTED BEFORE THIS OPTION IS SPECIFIED.

-LOADS SUB FUNCTIONS-

COM [,ADD] [,ANGLE=VAL,....ANGLE=VAL] [,S=SEC1 [,SEC2]] [,M=VAL] [,SA=VAL,SO=VAL]

OPERANDS:

COM:	CP	-	C_p UPPER AND LOWER VRS X/C
	CPN	-	$C_{P_{NET}}$ VRS X/C
	U	-	U/V_∞ VRS X/C
	Z/C	-	Z CAMBER/C VRS X/C
	Z/T	-	Z THICKNESS/C VRS X/C
	CLC	-	C_ℓ C/C_{AVG} VRS SPAN (η)
	CN	-	C_n VRS SPAN
	CNC	-	$C_n C/C_{AVG}$ VRS SPAN
	CM	-	X/C C.P. VRS SPAN
	END	-	[E] END
ADD:	ADD ANGLES LISTED TO THOSE PRESENTLY SET TO A NON-ZERO VALUE		
ANGLE:	BA	-	BASIC LOAD VAL=0.0 OR 1.0
	A	-	ANGLE OF ATTACK (α) IN DEGREES
	B	-	ANGLE OF SIDESLIP (β) IN DEGREES
	P	-	ROLL RATE IN RAD/SEC
	Q	-	PITCH RATE IN RAD/SEC
	R	-	YAW RATE IN RAD/SEC
	T	-	THICKNESS VAL=0.0 OR 1.0
	DA#	-	ANTISYMMETRIC CONTROL SURFACE DEFLECTION NUMBER #
	DS#		SYMMETRIC CONTROL SURFACE DEFLECTION NUMBER #
S:	SEC1 TO SEC2 SECTIONS OR COMPONENTS		
M:	MACH NUMBER		
SA:	ABSCISSA SCALING FACTOR 0.0 FREE SCALING.DEFAULT 0.10		
SO:	ORDINATE SCALING FACTOR 0.0 FREE SCALING.DEFAULT 0.0		

ABBREVIATIONS: NONE

FUNCTION: SET UP FOR PLOTS OF QUANTITIES WHICH CAN BE ILLUSTRATED AS CHORDWISE AND SPANWISE DISTRIBUTIONS.

SETS OF ANGLES AND SECTIONS CAN BE PRE-SET USING ADD AND S.THEN PLOTS CAN BE SELECTED FOR DIFFERENT COM'S AND MACH NUMBER.

FUNCTION PURGE

PURGE

OPERANDS: NONE

ABBREVIATION: PURGE

FUNCTION: RELEASES ALL COMPONENTS IN THE LOCAL FILE.

FUNCTION RENAME

RENAME,COMP[REC] [,FILE]

OPERANDS: COMP - COMPONENT NUMBER OR RECORD NUMBER REC

FILE - PERM [P] , [DEFAULT FILE] LOCAL [L]

ABBREVIATION: RENA

FUNCTION: CHANGE COMPONENT NAME

ADDITIONAL RESPONSES: OLD NAME: "COMPONENT NAME" ENTER NEW NAME-
NEW NAME.

FUNCTION RENUMBER

```
RENUMBER,OLDCOMPN[REC] ,NEW COMPN [,FILE]
```

OPERANDS: OLD COMPN: OLD COMPONENT NUMBER, OR RECORD NUMBER [REC]

NEW COMPN: NEW COMPONENT NUMBER

FILE: [PERM [P] , [DEFAULT FILE]] [LOCAL [L]]

ABBREVIATION: RENU

FUNCTION: CHANGE THE COMPONENT NUMBER.

FUNCTION SAVE

```
SAVE[,FILE]
```

OPERANDS: FILE - PERM [P] [DEFAULT FILE]
LOCAL[L]

ABBREVIATION: SAVE

FUNCTION: RETURN COMPONENT IN CORE TO ITS RECORD LOCATION IN REQUESTED FILE. IF NO COMPONENT WITH THE SAME NUMBER IS FOUND.THE COMPONENT WILL BE CATALOGED.

FUNCTION SLENDER

```
SLENDER,COM1 [REC1] ,...,COMN [RECN] [,FILE]
```

OPERANDS: COM1: COMPONENTS TO BE BLENDED INTO SLENDER BODY GEOMETRY. ONE OR MORE MUST APPEAR
[REC1] RECORD NUMBER MAYBE USED INSTEAD OF COMPONENT NUMBER

FILE: [PERM [P] , DEFAULT] , [LOCAL [L]]

ABBREVIATION: SLEN

FUNCTION: CONVERTS UP TO 6 SELECTED COMPONENTS INTO A SINGLE SLENDER BODY FOR ISOLATED BODY CALCULATIONS. THIS FUNCTION MUST BE USED TO CREATE COMPONENTS FOR THE ISOLATED BODY SOLUTION.

ADDITIONAL RESPONSES

* SLENDER BODY SIMULATION
* ENTER COMPONENT NAME -"SLENDER BODY"

* INPUT COMPONENT NUMBER -"700.0"

* COMPONENT PARAMETERS FOR SLENDER BODY COMBINATION

* ENTER FACTOR,NPASS -"0.7,2"

FACTOR: FRACTION OF DISTANCE TO NEXT POINT ON PRESENT CROSS SECTION TO BE COMPARED AGAINST DISTANCE TO POINTS ON OTHER CROSS SECTIONS WHEN GENERATING OUTLINES. ONLY NECESSARY WHEN TWO COMBINING COMPONENTS ARE CUT AT THE SAME CROSS SECTION

NPASS: NUMBER OF POINTS ON CROSS SECTION THAT SHOULD BE SKIPPED AFTER OUTLINE PASSES FROM ONE COMPONENT TO ANOTHER.

-STATUS-

FUNCTION STATUS

$$\boxed{\text{STATUS}}$$

OPERANDS: NONE

ABBREVIATION: STAT

FUNCTION: RETURNS THE NUMBER AND NAME OF THE COMPONENT IN CORE

-TERMINAL-

FUNCTION TERMINAL

TERMINAL

OPERANDS: NONE

ABBREVIATION: TERM

FUNCTION: USING KEYS GIVEN BY THE PROGRAM,THE OPERATOR INPUTS SIMPLE COMPONENT GEOMETRIES CONSISTING OF GEOMETRICALLY SIMILAR SECTIONS.

-TERMINAL-

ADDITIONAL RESPONSES AND INPUT:

* 1 FPLAN * 2 HPLAN * 3 FELIP * +- 4 HELIP * 5 RECT * +-6 TRIANG * 7 END -

THE USER INPUTS THE NUMBER INDICATING THE TYPE OF COMPONENT FORM DESIRED:

1 : TYPE 4 FULL SURFACE

2 : TYPE 3 HALF SURFACE

3 : TYPE 1 OR 2 FULL ELLIPSE

4 : TYPE 1 OR 2 HALF ELLIPSE + -

5 : TYPE 1 OR 2 RECTANGLE

6 : TYPE 1 OR 2 TRIANGLE +Δ -∇

7 : END

* INPUT COMPONENT NAME: "FUSELAGE" (16 CHARACTERS MAXIMUM)

* INPUT COMPONENT NUMBER:"100." (>50)

<u>SURFACE COMPONENT INPUT</u>: (EXAMPLE SHOWN IS FOR A TYPE 4 INPUT)

* FULL PLANAR: X(CBAR/4),YO(ROOT),ZO(ROOT)-"250.,30,0."

* AR,S,TAPER,SWEEP (DEG),DIH(DEG)-"4.5,250.,0.32,45, 45.0"

* IAF (1,2,3,4, OR 5), (T/C)IN, (T/C)OUT-"2,0.04,0.05"

WHERE IAF VALUES ARE:

1 : 65A0XX

2 : 64A0XX

3 : SUPERCRITICAL

4 : HEX - AIRFOIL

5 : B1-CONVEX AIRFOIL

<u>BODY COMPONENT INPUT:</u> (EXAMPLE IS A CENTERLINE ELLIPSE)

* NON PLANAR COMPONENT XRO, YRO, ZRO -"0.,0,0."

* NCS,X(1),A(1),A/B(1),.,.,X(NCS),A(NCS),A/B(NCS)
-"4,0.,0.,1.,200.,1000.,0.6,400.,2500.,0.8,600.,1500.,1.5"

MAXIMUM HEIGHT ABOVE COMP. REF. LINE: 36.4183

MAXIMUM HALF BREATH OF COMPONENT : 21.8510

FUNCTION TIME

TIME

ABBREVIATION: NONE

FUNCTION: GIVES WALL TIME, CPU TIME, AND APPROX. COST SINCE START AND SINCE LAST CALL.

FUNCTION TITLE

```
TITLE [,FILE]
```

OPERANDS: FILE - PERM [P] [DEFAULT FILE]
LOCAL [L]

ABBREVIATION: TITL

FUNCTION: INPUT OR CHANGE TITLE OF REQUESTED FILE

ADDITIONAL RESPONSES: OLD TITLE: TITLE
ENTER NEW TITLE

TITLE ,[P=L] , [L=P]

P = L - PERM TITLE = LOCAL TITLE
L = P - LOCAL TITLE = PERM TITLE
(space) (CR) - RETAIN PRESENT TITLE

-UNITS-

FUNCTION UNITS

```
UNITS [,FILE]
```

OPERANDS: FILE: PERM [P] [DEFAULT FILE]
LOCAL [L]

ABBREVIATION: UNIT

ADDITIONAL INPUTS:

UNITS 1-METERS 2-ENGLISH 3-CENTIMETERS - "UNI"

UNI - NUMBER INDICATING UNITS DESIRED

GLOSSARY

CARD: Data description using card input. Geometric definitions are similar to those used in TERMINAL.

Component: A geometric description of a vehicle or portion of a vehicle which by itself can be considered a complete unit.

Cross-Section: A cut through a component made perpendicular to the principle axis of the component. Planar components have a principle axis defined by the leading edge trace in the Y-Z plane. Non-planar components have a principle axis defined in the x direction.

Digitize: To define components with cross-sections of the component using a graphics tablet and an appropriate input device.

Interference: Refers to a paneled component used in conjunction with isolated body, i.e. interference shell. Interference shells default to surface components when an isolated body is not present.

Body: Refers to components such as a fuselage, nacelles, etc.

Surface: Refers to components such as wing, tail, etc.

Slender: Refers to a component constructed from a single or set of body components using the function SLENDER.

Terminal: Refers to components constructed by inputting simple geometry definitions such as cross-sectional and width/height for body components and $\mathcal{R}, S, \lambda, \Gamma, \Lambda_{LE}$ for surface components.

APPENDIX I

DATA DESCRIPTION
FOR CARD INPUT GEOMETRY

NUMBER		IDENTIFICATION	DESCRIPTION DO NOT KEY PUNCH
1	TITLE OF GE	73–80	TITLE (72 Characters)
13	OMETRY FILE		
25			
37			
49			
61			

NUMBER		IDENTIFICATION	DESCRIPTION DO NOT KEY PUNCH
1	20	73–80	
13	3.0		NC - No. of Components (< 50)
25	100.0		COMPONENT NUMBER 1
37	300.0		
49	500.0		
61			

NUMBER		IDENTIFICATION	DESCRIPTION DO NOT KEY PUNCH
1	- 70	73–80	
13			COMPONENT NUMBER 50
25			
37			(Last card before first component data must have a minus sign
49			in column 1
61			

NUMBER		IDENTIFICATION	DESCRIPTION DO NOT KEY PUNCH
1		73–80	
13			(Last card of each component must have a minus sign in column 1)
25			
37			
49			
61			

		NUMBER	IDENTIFICATION	DESCRIPTION DO NOT KEY PUNCH
1		100.00		COMPONENT NUMBER (> 50.0)
13		FUSELAGE		COMPONENT NAME (16 Characters)
25				
37				BODY COMPONENTS
49			73 80	
61				
1		100		
13		18.0		NCS Number of cross section (≤18)
25				X_O
37	112			Y_O Relative origin of component
49			73 80	Z_O 1:C.L. Full ellipse, 2:off-set full ellipse
61		1.0		CTYPE -1:C.L. Half ell., -2:off-set half ell. 5:C.L. Rect, 6:off rect, 7-C.L. TRIA, 8,-off triang.
1		105		RLC (Locations 105-199 are for section data)
13		0.0		A_1 cross sectional area
25		0.0		D_1 h/2 (full height of Δ and ⌓)
37				X_R
49			73 80	Y_R Section origin relative to X0,Y0,Z0
61				Z_R
1	-	190		RLC + NCS*5
13		500.0		A_{NCS}
25		12.62		D_{NCS}
37		741.0		X_R
49		0.0	73 80	Y_R
61	-	6.2		Z_R

	NUMBER	IDENTIFICATION	DESCRIPTION DO NOT KEY PUNCH
1	300.00		COMPONENT NUMBER (> 50.0)
13	WING		COMPONENT NAME (16 Characters)
25			
37			SURFACE COMPONENTS
49		73 80	
61			
1	100		
13	2.0		NCS Number of cross sections ≤ 17 sections
25	0.0		X_o
37	113 0.0		Y_o Relative origin of component
49	0.0	73 80	Z_o
61	4.0		CTYPE 4.0 wing [full surface]; 3.0 vert. [half surface]
1	105		1.0-65A, 2.0-64A, 3.0-supercritical
13	2.0		AIRFOIL TYPE 4.0-HEX, 5.0 B1-CONVEX, 0.0-USER INPUT Z/C'S
25	0.0		UPPER SURFACE Flag; if (DA(105) = 0.0 set = 1.0
37	0.0		LOWER SURFACE Flag; if symmetric leave 0.0
49		73 80	NO. X/C'S INPUT; if DA(105) = 0.0
61			
1	110		
13	4.0		AR
25	350.0		S
37	0.34		TAPER
49	55.0	73 80	SWEEP
61			DIHEDRAL

	NUMBER	IDENTIFICATION	DESCRIPTION DO NOT KEY PUNCH	
1	115		RLC 115 - 199 are for section data	
13	0.60		T/CMAX . x 10.0	
25	210.0		CHORD	CONSECUTIVELY, ONE
37	165.0		X_R	CARD PER CROSS SECTION
49	23.0	73 80	Y_R Coord. of L.E. relative to $X_o, Y_o Z_o$	2ND SECTION IS CARD
61	0.0		Z_R	120, 3RD 125, ETC.
1	200		RLC 200 - 219 are for x/c's	
13	0.0		X/C_1	
25	0.1		X/C_2 (fill in only if UPPER SURFACE flag is > 0.0)	
37				
49		73 80		
61				
1	215			
13				
25				
37				
49		73 80		
61	1.0		X/C_{20}	
1	220		DA(220-399) Are for upper and lower surface Z/C's. The upper Z/C's of one section are followed directly by the Z/C's for the lower surface.	
13	0.0			
25	0.002			
37	0.008			
49		73 80	(fill in only if UPPER SURFACE flag is >0.0)	
61				

Col	NUMBER	IDENTIFICATION	DESCRIPTION DO NOT KEY PUNCH
1	400		
13	1.0		NO. OF FLAPS ON SURFACE (≤ 6)
25	10.0		NO. PANELS ON FLAP #1
37			NO. PANELS ON FLAP #2
49		73 80	
61			
1	405		
13			
25			NO. PANELS ON FLAP #6
37			
49		73 80	
61			
1	410		
13	9.0		PANEL # OF FIRST PANEL OF FLAP #1
25	10.0		
37	19.0		
49	20.0	73 80	
61	29.0		
1	- 495		
13			
25			
37			
49		73 80	PANEL # OF LAST PANEL OF LAST FLAP
61			

115

Col.		NUMBER	IDENTIFICATION	DESCRIPTION DO NOT KEY PUNCH
1		500.00		COMPONENT NUMBER > 50.0
13	I	NTERFERENCE		COMPONENT NAME (16 characters)
25		SHL		
37				INTERFERENCE SHELLS
49			73 80	
61				
1		100		
13		4.0		NCS (Number of cross sections) (18 max)
25				X_O
37				Y_O Relative location of component origin
49	116		73 80	Z_O
61	–	4.0		CTYPE
1		105		RLC (Locations 105-199 are for section data)
13				-
25		500.0		C Chord length
37		100.0		X_R
49		0.0	73 80	Y_R Section origin relative to X_O, Y_O, and Z_O
61		20.0		Z_R
1	–	120		RLC + NCS*5
13				-
25		500.0		C_{NCS}
37		100.0		X_R
49		0.0	73 80	Y_R
61	–	20.0		Z_R

```
GEOMETRY FILE TITLE                                                             100
       20       3.00     100.00      300.00      500.00                         200
   100.00 FORWARD FUSELAGE                                                      300
      100       8.00                                         1.0                400
      105       0.00       0.00         0.0         0.0      0.0                500
      110       5.00      78.00       15.00         0.0      4.0                600
      115       8.25     210.00       30.00         0.0      8.0                700
      120      11.10     386.00       50.00         0.0     11.0                800
      125      13.00     490.00       78.00         0.0     13.0                900
      130      25.00    1020.00       95.00         0.0      7.0               1000
      135      28.00    1758.00      115.00         0.0      8.5               1100
      140      29.00    1900.00      130.00         0.0      9.0               1200
   300.00 INBOARD WING                                                         1300
      100       5.00       0.00       18.00       -8.00       4.00             1400
      105       0.00       1.00        1.00       11.00                        1500
      110       1.00     100.00        0.00       70.00       0.00             1600
      115       0.11     800.00        0.00        0.00       0.00             1700
      120       0.12     726.00       74.00       12.00       0.00             1800
      125       0.12     633.00      167.00       24.00       0.00             1900
      130       0.14     500.00      300.00       36.00       0.00             2000
      135       0.17     400.00      400.00       48.00       0.00             2100
      200       0.00       0.10        0.20        0.30       0.40             2200
      205       0.50       0.60        0.70        0.80       0.90             2300
      210       1.00                                                           2400
      220     0.0000     0.0219      0.0563      0.0588     0.0569             2500
      225     0.0550     0.0538      0.0544      0.0569     0.0606             2600
      230     0.0625     0.0000      0.0094      0.0156     0.0213             2700
      235     0.0275     0.0338      0.0400      0.0463     0.0525             2800
      240     0.0325     0.0031      0.0062      0.0372     0.0606             2900
      245     0.0592     0.0585      0.0572      0.0565     0.0572             3000
      250     0.0599     0.0620      0.0640     -0.0062     0.0110             3100
      255     0.0193     0.0262      0.0331      0.0393     0.0455             3200
      260     0.0517     0.0585      0.0324      0.0021     0.0174             3300
      265     0.0521     0.0553      0.0553      0.0545     0.0537             3400
      270     0.0550     0.0537      0.0585      0.0569     0.0537             3500
      275    -0.0174     0.0126      0.0237      0.0316     0.0395             3600
      280     0.0458     0.0521      0.0585      0.0585     0.0284             3700
      285     0.0000    -0.0080      0.0140      0.0240     0.0360             3800
      290     0.0480     0.0590      0.0640      0.0660     0.0650             3900
      295     0.0620     0.0570      0.0080      0.0280     0.0370             4000
      300     0.0460     0.0520      0.0590      0.0660     0.0720             4100
```

Sample Listing of a Card Image Data File

305	0.0500	0.0210	-0.0070	-0.0075	0.0313	4200
310	0.0438	0.0563	0.0663	0.0800	0.0825	4300
315	0.0825	0.0800	0.0750	0.0713	0.0075	4400
320	0.0425	0.0488	0.0550	0.0613	0.0825	4500
325	0.0875	0.0775	0.0488	0.0188	0.0100	4600
500.00	INTERFERENCE SHL					4700
100	4.00	100.00	0.00	0.00	-4.00	4800
105		300.00	0.00	0.00	20.00	4900
110		300.00	0.00	19.00	8.00	5000
115		300.00	0.00	19.00	-8.00	5100
120		300.00	0.00	0.00	-20.00	5200

(Cont.) Sample Listing of a Card Image Data File

APPENDIX II

PROGRAM COMPILATION, LOADING AND SIZE

The Preliminary Aerodynamic Analysis System is comprised of three major programs. The input/output (GEOMETRY) routine which is interactive and the slender body (SLENDER) and lifting surface (LIFTING) programs which are designed to run batch. The names in parenthesis refer to the CDC file names which will be used to identify the source codes of the three programs in what follows.

GEOMETRY is loaded with a segmented load which reduces the core requirements for the loaded program to approximately 70K octal on the CDC 175 system. In addition, the coding itself must be linked with libraries containing TEKTRONIX PLOT-10 and GRAPHICS TABLET enhanced graphics software. Listing II-1 illustrates the BATCH submitted job control listing (JCL) to compile and link the GEOMETRY source code into an executable load deck which can be run on a TEKTRONIX 4014 graphics terminal. Listing II-2 illustrates the segmentation listing (SEGMENT) used in the link. The resulting load deck (listing II-1) is cataloged as LANGLOAD and is now available for interactive execution.

LIFTING is loaded with a segmented load to reduce the core needed to run the program in batch. The JCL needed to compile and link LIFTING is shown in listing II-3. The segmentation list is shown in listing II-4. The resulting load deck is filed under LIFTLOAD for later batch execution. LIFTLOAD has an operating core size of approximately 114 K octal.

SLENDER is loaded directly by compiling and linking the program, see listing II-5. The resulting load deck is then stored as SLENLOAD for later batch execution. SLENLOAD has a core size of approximately 100 K octal.

```
100=PEDAJ,T120,IO200,CM120000,P4.
110=ACCT(DIVAN      0018422401*0111013)
120=REQUEST,PAD1,*PF.
130=ATTACH,ONE,LANGLEY,ID=D0500.
140=FTN,I=ONE,B=LOA1,L=0.
150=MAP,PART.
160=ATTACH,PLOT10,PLOT10LIB,ID=APLOT10,SN=SYSAPP.
170=LIBRARY,PLOT10.
180=ATTACH,SEG,SEGMENT,ID=D0500.
190=SEGLOAD(I=SEG,B=PAD1,LO=DT)
200=LOAD(LOA1).
210=NOGO.
220=CATALOG,PAD1,LANGLOAD,ID=D0500,RP=100.
240=DISPOSE,OUTPUT,PR=IAJ.
250=EXIT.
260=DISPOSE,OUTPUT,PR=IAJ.
```

Listing II-1 JOB CONTROL LISTING for Compilation and Linking of Geometry Program, GEOMETRY

```
100=START   TREE    MAIN
110=MAIN    INCLUDE MAIN
120=        LEVEL
130=EXEC    TREE    GEOEX
140=GEOEX   INCLUDE GEOEX
150=DIGITI  TREE    DIGIT
160=DIGIT   INCLUDE DIGIT,ORIG,TABOFF,TABARM,MULPNT,TABOFF,GETPNT
170=SAVE    TREE    SAVEB
180=SAVEB   INCLUDE SAVEB
190=VIEW    TREE    VIEW3-(INTERF,TRANS,INSTR2,AREA)
200=VIEW3   INCLUDE VIEW3
201=INTERF  INCLUDE INTERF
202=TRANS   INCLUDE TRANS
203=INSTR2  INCLUDE INSTR2
204=AREA    INCLUDE AREA,LIMIT,SHIFT
210=VIEW3   GLOBAL  V3
220=EDIT    TREE    SECT-(EDITP,EDITN,LIST)
230=SECT    INCLUDE SECT
240=SECT    GLOBAL  ED
250=EDITP   INCLUDE EDITP,PLOTOT
260=EDITN   INCLUDE EDITN
270=LIST    INCLUDE LIST,EDPUT
280=DISPL   TREE    DISP
290=DISP    INCLUDE DISP,DISPS,INFO,GREEK
300=SLENDR  TREE    SLEND
310=SLEND   INCLUDE SLEND
320=TERM    TREE    ICON
330=ICON    INCLUDE ICON,EMLORD,MATRIX,TRAP,XYZ,WCAD,DECRD
340=ANALY   TREE    ANAL
350=ANAL    INCLUDE ANAL
360=ANAL    GLOBAL  PLOT,CDAT,CFIX,CFLO,CLIM-SAVE
361=GRAPH   TREE    PLOTT-(LOADS,FORC)
362=PLOTT   GLOBAL  PLOTT-SAVE
380=LOADS   TREE    CPPR-(PLEXC,CPWING)
390=CPPR    INCLUDE CPPR
400=PLEXC   INCLUDE PLEXC
410=CPWING  INCLUDE CPWING,LABEL
420=FORC    TREE    FORCE-(TOTAL,SHEET,FOREX)
425=FORCE   INCLUDE FORCE
430=TOTAL   INCLUDE TOTAL,DRGPOL
440=        LEVEL
450=LOOK    TREE    LOOKUP-(SPLINE,FITT)
460=LOOKUP  INCLUDE LOOKUP,FIT
470=SPLINE  INCLUDE SPLINE
480=FITT    TREE    HSHLDR-FITWT
490=HSHLDR  INCLUDE HSHLDR
500=FITWT   INCLUDE FITWT
510=DRAG    TREE    CPLOT-(WAVE,VISCO)
520=CPLOT   INCLUDE CPLOT
530=CPLOT   GLOBAL  CXXX
```

Listing II-2 Segmentation Listing of Permanent File SEGMENT (See Listing II-1 line 180) Used to Link GEOMETRY Program

```
540=WAVE    TREE    WDRAG-(DQWS,XYZR-(AREAW,XACALW))
550=WDRAG   INCLUDE WDRAG
560=WDRAG   GLOBAL  CTHE,COPT
570=DQWS    INCLUDE DQWS,SDQ,COD
580=XYZR    INCLUDE XYZR,LIMITW
590=AREAW   INCLUDE AREAW,SHIFTW
600=XACALW  INCLUDE XACALW
610=VISCO   TREE    VDRG-(AREAS,WSVP,IDATA,TLU)
620=VDRG    INCLUDE VDRG
630=VDRG    GLOBAL  COUT,CLUN
640=AREAS   INCLUDE AREAS,LIMITS,SHIFTS,WET
650=WSVP    INCLUDE WSVP
660=IDATA   INCLUDE IDATA
670=TLU     INCLUDE TLU
680=LIFT    TREE    LSET
690=LSET    INCLUDE LSET,SMOOTH
700=PLOT    TREE    PLOTIT
710=PLOTIT  INCLUDE PLOTIT,GRID,SCALIT,MAXIT,CODIM
712=EMLOR   TREE    EMLO
714=EMLO    INCLUDE EMLO,ISIMEQ
720=        END
..
```

Listing II-2 Completed. Segmentation Listing of Permanent File SEGMENT (See Listing II-1 line 180) Used to Link GEOMETRY Program

```
100=PEDAJ,T120,IO200,CM240000,P4.
110=ACCT(DIVAN      0018422401*0111013)
120=REQUEST,UDPL,*PF
130=ATTACH,ONE,UDPFORT,ID=D0500.
140=FTN,I=ONE,B=LOA1,L=0.
150=MAP,PART.
160=ATTACH,SEG,SEGUDP,ID=D0500.
170=SEGLOAD(I=SEG,B=UDP1,LO=DT)
180=LOAD(LOA1).
190=NOGO.
200=CATALOG,UDP1,UDPLOAD,ID=D0500,RP=100.
210=DISPOSE,OUTPUT,PR=IAJ.
220=EXIT.
230=DISPOSE,OUTPUT,PR=IAJ.
```

Listing II-3 JOB CONTROL LISTING for Compilation and Linking of Lifting Surface Program, UDPFORT

```
100=START   TREE    UDP
110=UDP     INCLUDE UDP,PAGE,CODIM,FILL
120=        LEVEL
130=MAT     TREE    MATRIX-(VORTEX,SOURCE)
140=MATRIX  INCLUDE MATRIX,BMTX
150=MATRIX  GLOBAL  VWI-SAVE
160=VORTEX  INCLUDE VORTEX
170=SOURCE  INCLUDE SOURCE
180=BOD     TREE    BOUND
190=BOUND   INCLUDE BOUND
200=JT      TREE    JET
210=JET     INCLUDE JET
220=SOL     TREE    SOLVE
230=SOLVE   INCLUDE SOLVE,MSOL,REVERS
240=FOR     TREE    FORCE-(PRESS,INTEG,DRAG-(TRIM,VTX))
250=FORCE   INCLUDE FORCE
260=PRESS   INCLUDE PRESS
270=INTEG   INCLUDE INTEG,BDYLD,JETLD
280=DRAG    INCLUDE DRAG
290=TRIM    INCLUDE TRIM
300=VTX     INCLUDE VTX,NORMAL
310=WAV     TREE    WAVE
320=WAVE    INCLUDE WAVE
330=PRI     TREE    PRINT
340=PRINT   INCLUDE PRINT
```

Listing II-4 Listing of Permanent File SEGUDP (See Listing II-3, line 160) Used to link UDPFORT Program

```
100=PEDAK,T120,IO200,CM120000,P4.
110=ACCT(DIVAN      0018422401*0111013)
120=REQUEST,SLEN,*PF.
130=ATTACH,ONE,SLENDER,ID=D0500.
140=FTN,I=ONE,B=LOA1,R=0.
150=MAP,PART.
160=LOAD(LOA1).
170=NOGO(SLEN).
180=CATALOG,SLEN,SLENLOAD,ID=D0500,RP=999.
190=DISPOSE,OUTPUT,PR=IAJ.
200=EXIT.
210=DISPOSE,OUTPUT,PR=IAJ.
```

Listing II-5 JOB CONTROL LISTING for Compilation and Linking of Slender Body Program, SLENDER

APPENDIX III

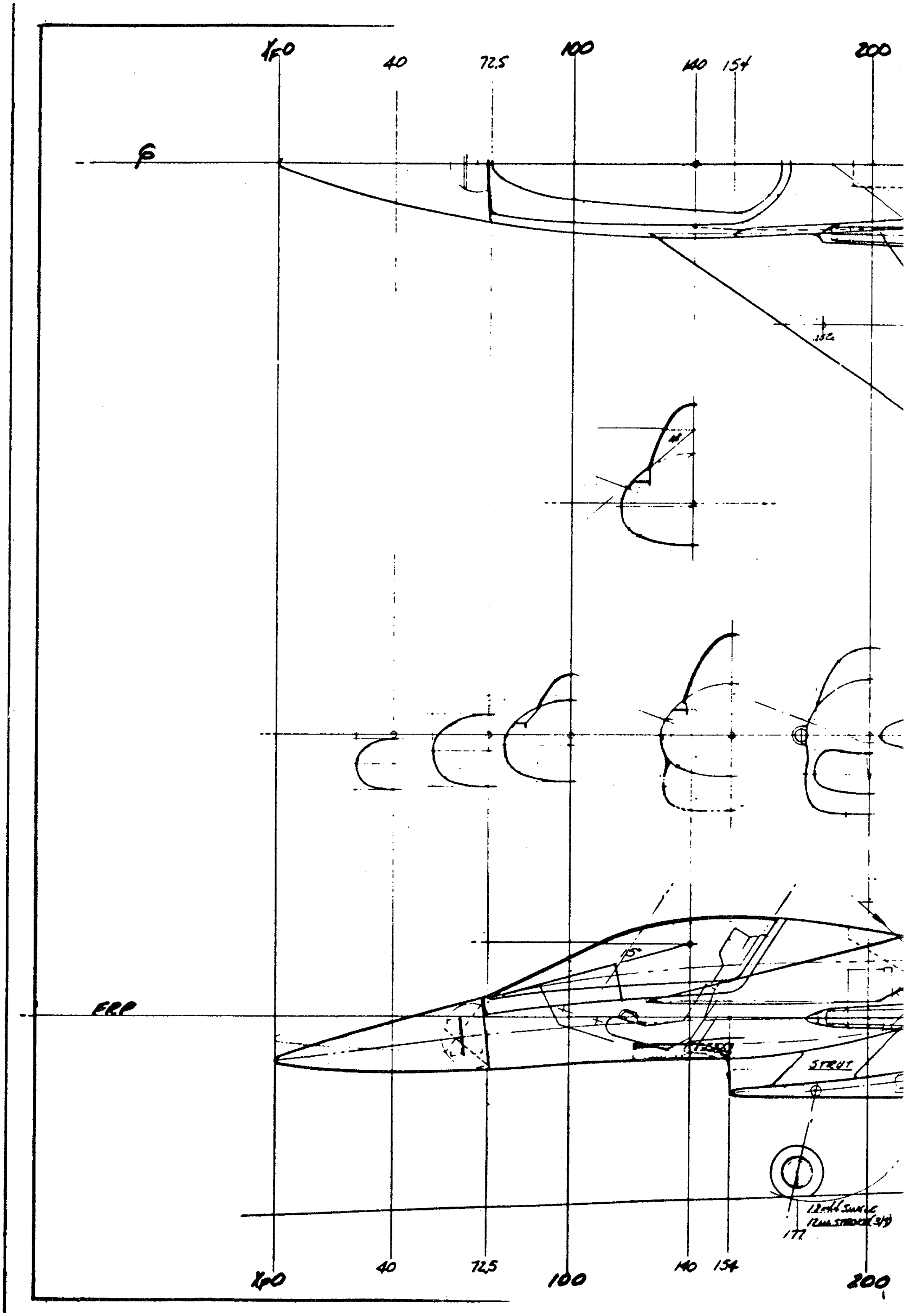
SAMPLE SESSIONS OF SYSTEM OPERATION

The four sessions presented illustrate typical program operations involved in aircraft configuration input, editing,analysis and display of results. There are also examples on how to store and retrieve files created using the programs of this system.

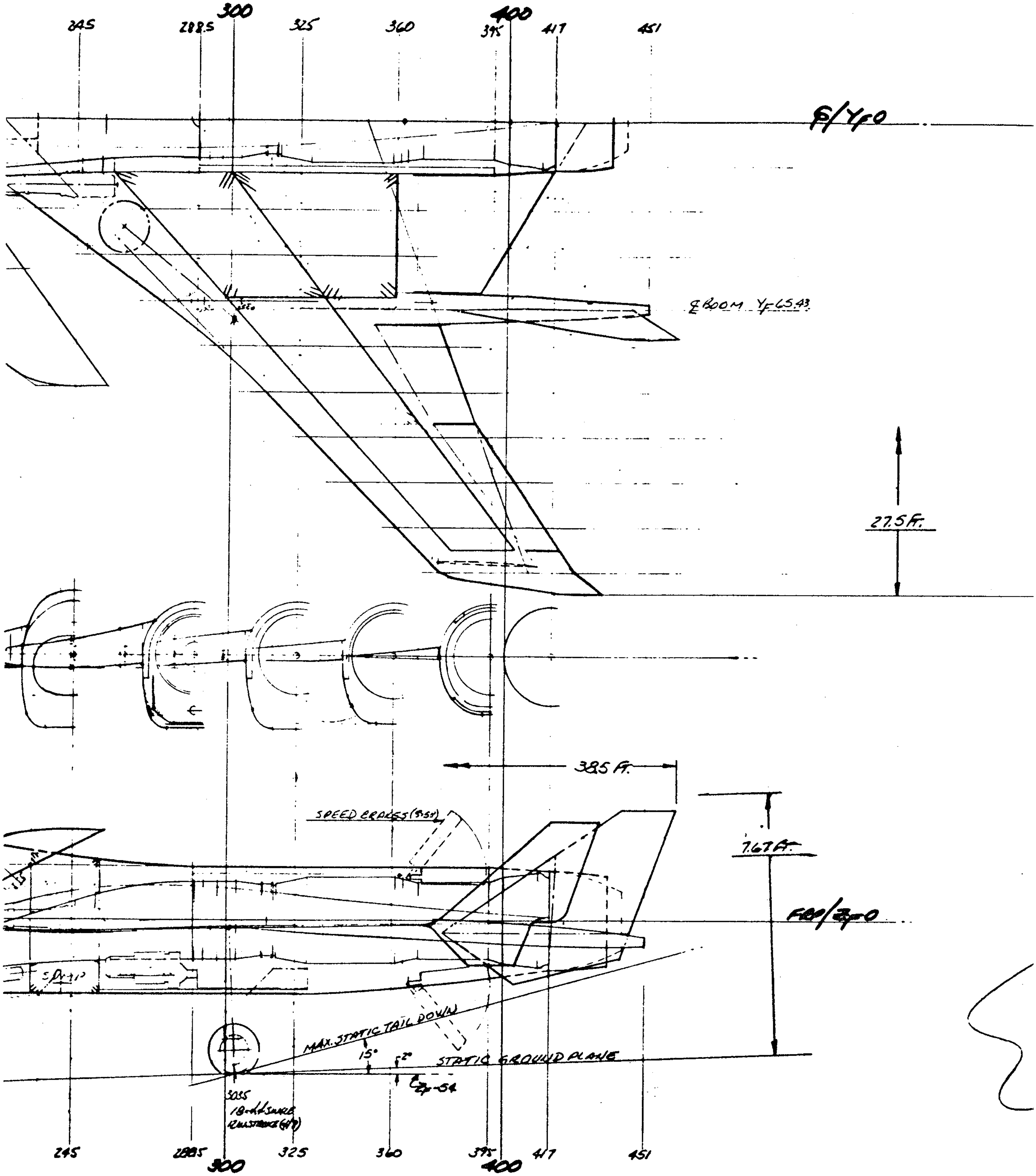
The figure on the following page illustrates the type of drawing required for a configuration. A side view and plan view are necessary along with cross section cuts at various axial station, drawn to the same scale as the top and side views. These sections are digitized to simulate the vehicle fuselage.

Of the four sessions which follow, the first three are for the fighter of Figure III-I. The last session is for a small trainer design to illustrate typical lifting surface displays.

A



6



245
288.5
300
325
360
395
400
417
451
℄/Y_F0
℄ BOOM Y_F 65.43
27.5 FT.
38.5 FT.
SPEED BRAKES
7.67 FT.
FRL/Z_F0
FLAP
MAX. STATIC TAIL DOWN
15°
2°
STATIC GROUND PLANE
245
288.5
300
325
360
395
400
417
451

GEOMETRIC DATA

ITEM	WING (REFERENCE)	CANARD (TRUE EXPOSED)	VERTICAL TAIL UPPER	VERTICAL TAIL LOWER	WING TIP FIN UPPER	WING TIP FIN LOWER
S	180 ft²	54 ft²	13.8 ft²	5.27 ft²	8.35 ft²	2.78 ft²
Æ	3.85	2.286	1.0386	0.2426	1.092	0.496
λ	0.25	0.341	0.2144	0.6438	0.35	0.42
Λ_{LE}	45°	54.4°	55°	55°	50°	45°
Γ	0°	20°	75°	90°	80°	90°
Airfoil	AERO. DEFINITION	AERO DEFINITION	64A004	64A004	AERO. DEFINITION	AERO DEFINITION
b	315.819	149.939	45.422	13.574	36.233	14.089
C_R	131.250	77.493	68.100	69.100	49.150	40.032
C_T	32.851	26.418	19.366	43.808	17.202	16.819
$\bar{c}$	91.824	[illegible]	48.258	56.832	35.739	30.003
$\bar{Y}$ or $\bar{Z}$	63.162	31.342	18.498	6.296	15.209	6.035

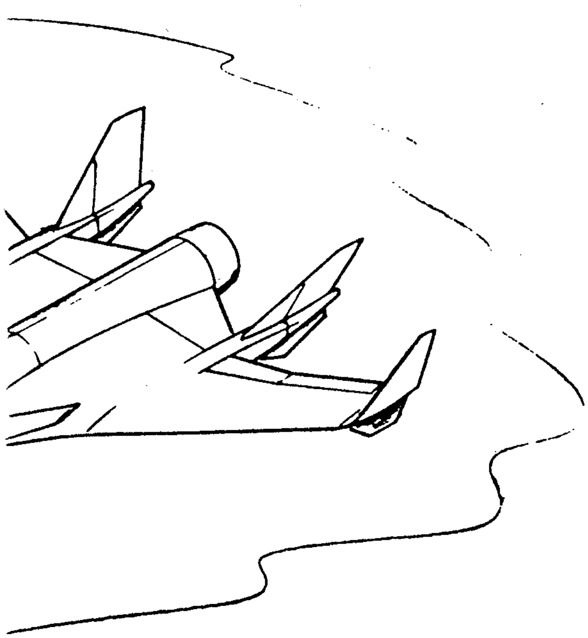


FIGURE III-I TYPICAL CONFIGURATION DEFINITION

D650-1

CONFIGURATION INPUT AND EDITING

```
COMMAND- ATTACH,LANG,LANGLOAD,ID=D0500.
 PF CYCLE NO. = 001
COMMAND- CONNECT,INPUT,OUTPUT.
COMMAND- ETL,120
COMMAND- SCREEN,132
COMMAND- REWIND,LANG
COMMAND- LANG

* INPUT TERMINAL CHARACTER SPEED : 30
```

To initiate the input/output program (LANGLOAD) the user first attaches the machine language file (COMMAND 1). The input and output files must be connected to the terminal (COMMAND 2). If the system has a default execution time limit, the user should over ride that (COMMAND 3). To take advantage of full screen writing the user may have to set the screen size (COMMAND 4). The user then rewinds the machine file (COMMAND 5) and executes the program (COMMAND 6).

The program will then request the transmission speed of the terminal in characters per second (bottom line).

```
DISPOSITION OF PERM FILE (NEW/OLD):
old
DISPOSITION OF PLOT FILE (NEW/OLD):
old
**OK**
title

OLD TITLE:
CONFIGURATION CONCEPT A/A FIGHTER
ENTER NEW TITLE
l=p
**OK**
digitize
```

The program requests the dispostion of the permanent geometry file (old is this instance).

The program requests the dispostion of the output or PLOT file (old in this instance).

The keyword **OK** indicates the ready or "OK" of the program.

The user then requests the title of the permanent file (the default file). The system responds and the user enters "l=p" to set the local title equal to the permanent file title.

In the last line the user has requested the digitizer. In this case a new component since a number was not specified.

```
* KEY * XO,XMAX *
?
0 400
 PEN * PLANFORM XO, PROFILE XO, PROFILE XMAX *
AXIS OK * 1 YES * 2 NO
 ** INPUT BAY PARAMETERS
 KEY * TYPE(1,2,3 OR 4),NSEG,NOUT(1),...,NOUT(NSEG)
?
1 5 1 1 -1 1 -1
INPUT COMP NUMBER:
?
100.0
INPUT COMPONENT NAME:
aft fuselage
```

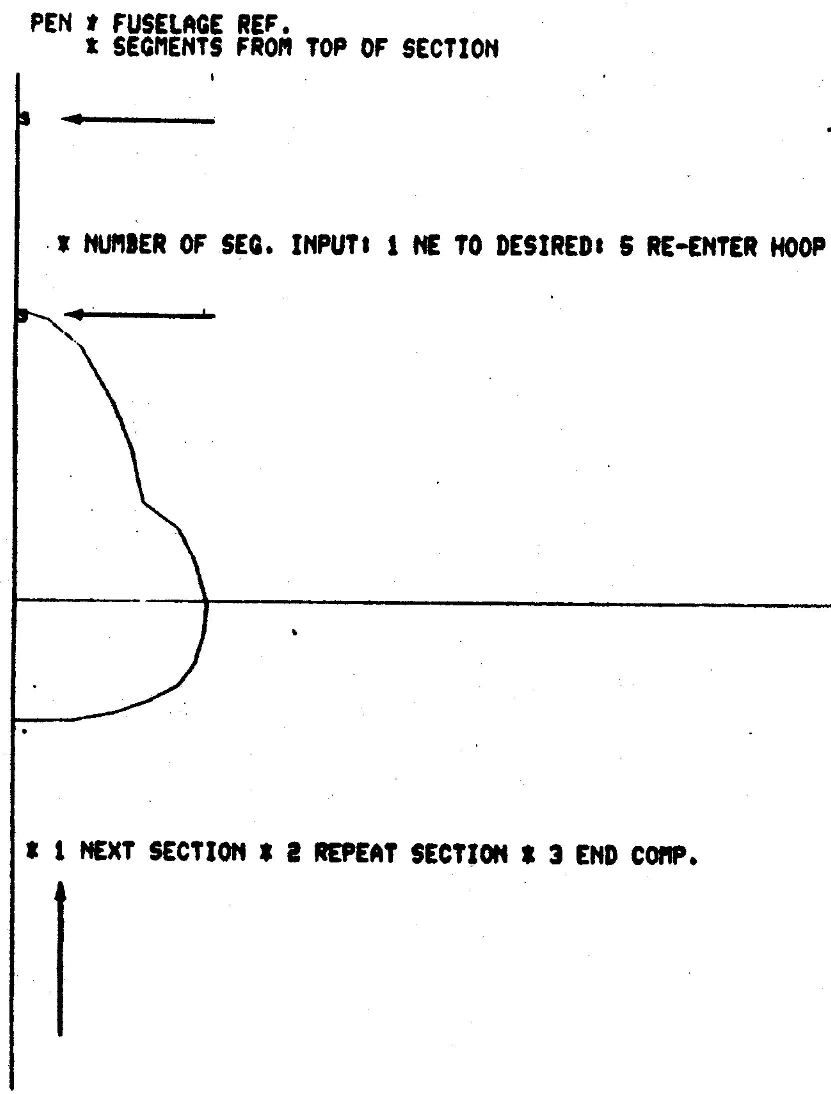
In the digitize function the program requests a scaleable length, indicated by the input of XO,XMAX as the limits on the fuselage reference axis. These limits need not encompass all cross sections to be digitized but can be any two convenient locations on the reference line.

The program now asks the user to digitize the (XO, y = 0) point of the plan view, (TOP), the (XO,Z = 0) point of the profile view (SIDE) and the (XMAX, Z = 0) point of the profile view. The routine will display the three input points and the user can check them for consistency and orthogonality.

The program now requests input of the component type, the number of segments per cross section (NSEG), and the wetted flag for each segment (NOUT = 1 wetted, -1 un-wetted). In the example a type 1 (centerline body) with 5 segments; segments 1, 2 and 4 wetted, 3 and 5 unwetted has been selected.

The program now requests input of the component number and name.

```
* HOOP: 1 NO. SEG.:   5, PTS/SEG.:    8    4    1    4    5
XO=  153.415 YO=     0.0   ZO=   33.382
```



The user digitizes points around each cross section, entering S(CR) after each completed cross section.**

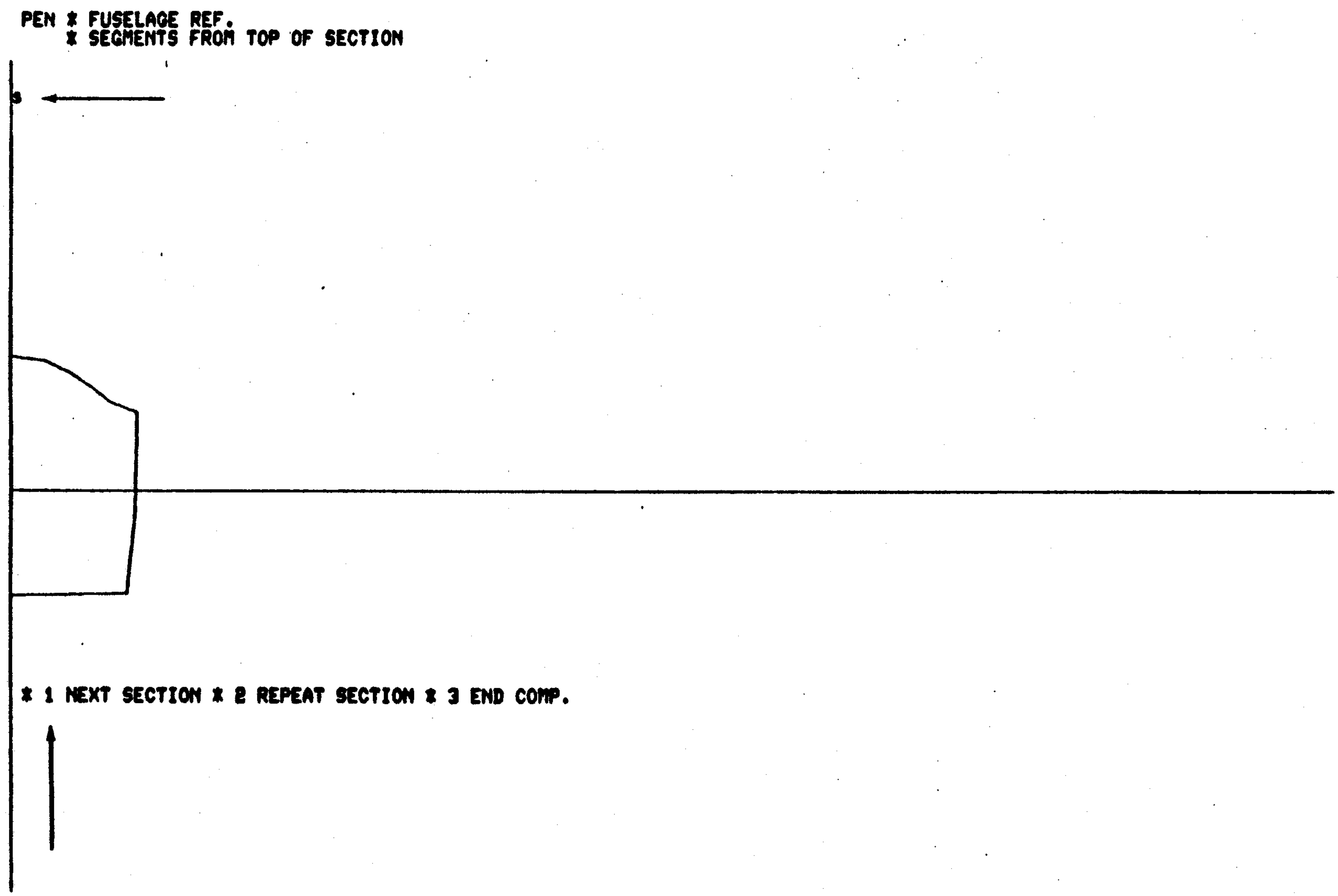
In this case the first try at the cross section resulted in an incorrect number of input segments (denoted by double points digitized by user) and the diognostic seen between the two horizontal arrows was printed and the tablet was turned on automatically so the section could be re-digitized.

The input was corect this time and a cross section display (left side of screen) and tabulation of input data (upper right of screen) are displayed on the tube.

The user now responds to the lower left hand instruction; in this case and in the next figure the option to digitize. The next section is selected. In the third figure of this set the user selects the end option or (3)

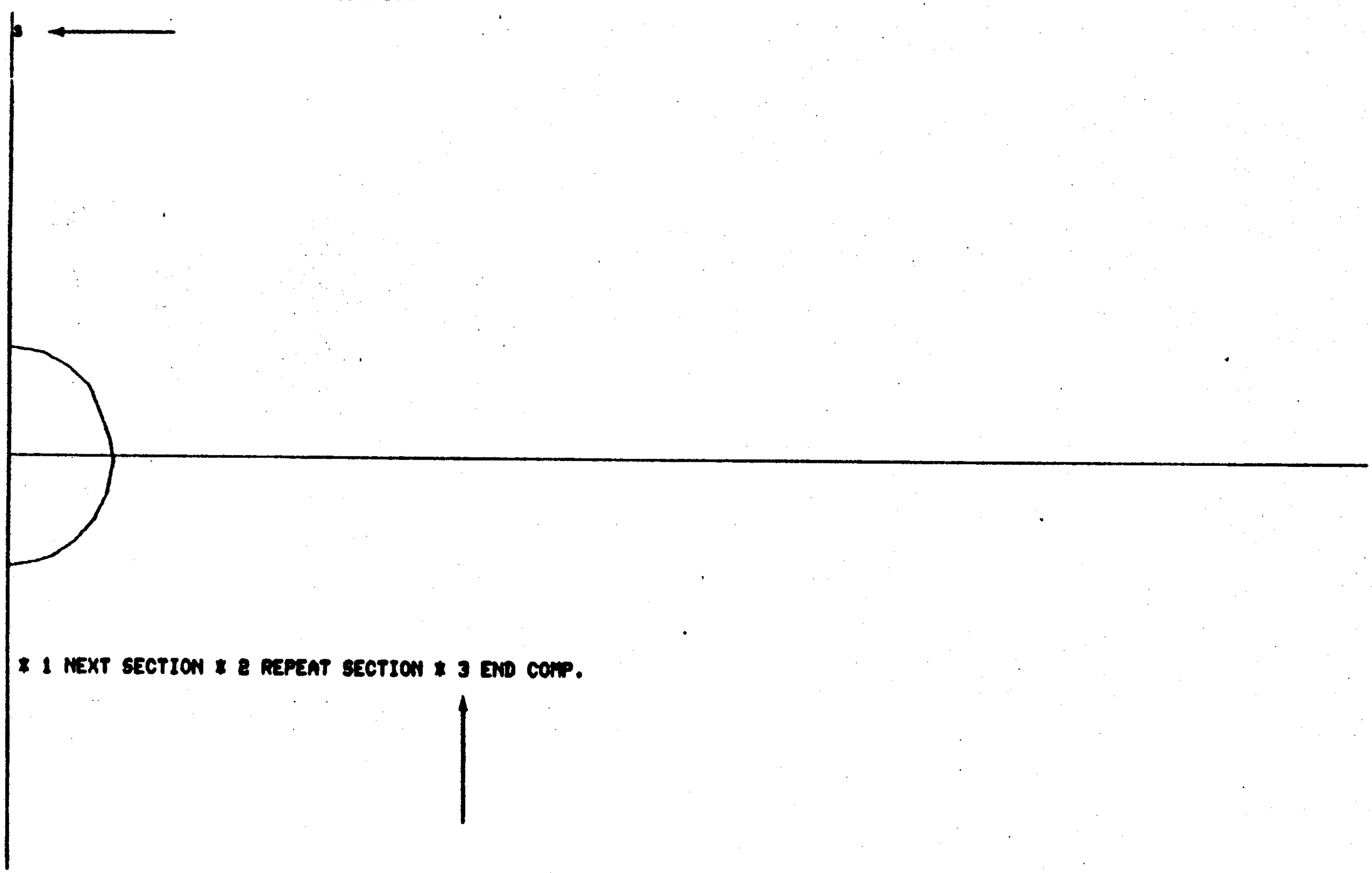
** The digitizing routine the user may supply may not contain the S(CR) to end digitizing and the user's actions may need to be adjusted accordingly.

* HOOP: 2 NO. SEG.: 5, PTS/SEG.: 1 6 2 2 2
X0= 287.752 Y0= 0.0 Z0= 18.787



% HOOP: 3 NO. SEQ.: 5, PTS/SEQ.: 1 7 1 7 1
XO= 451.068 YO= 0.0 ZO= 14.790

PEN % FUSELAGE REF.
% SEGMENTS FROM TOP OF SECTION



```
* SMOOTH OPTION: 0-NO, ENTER ORDER-YES *
?
0
**OK**
catalog

COMPONENT   100.00 ALREADY EXISTS
ENTER NEW NUMBER OR 0.0 TO RE-USE OLD LOCATION-
?
700.
**OK**

time

WALL TIME :  11.79  CPU TIME :   0.92
DELTA WALL:   0.22  DELTA CPU:   0.01
**OK**
files
FILE: PERM
REC   COMP NO.     NAME          TYPE

  1    100.00    FOR FUSELAGE      1
  2    101.00    AFT FUSE          1
  3    103.00    NACELLE           1
  4    200.00    INBD WING         4
  5    201.00    OUTBD WING        4
  6    300.00    LOWER TIP FIN     3
  7    301.00    UPPER TIP FIN     3
  8    400.00    LOWER VERT        3
  9    401.00    UPPER VERT        3
 10    500.00    VERT PYLON        2
**OK**
digi
```

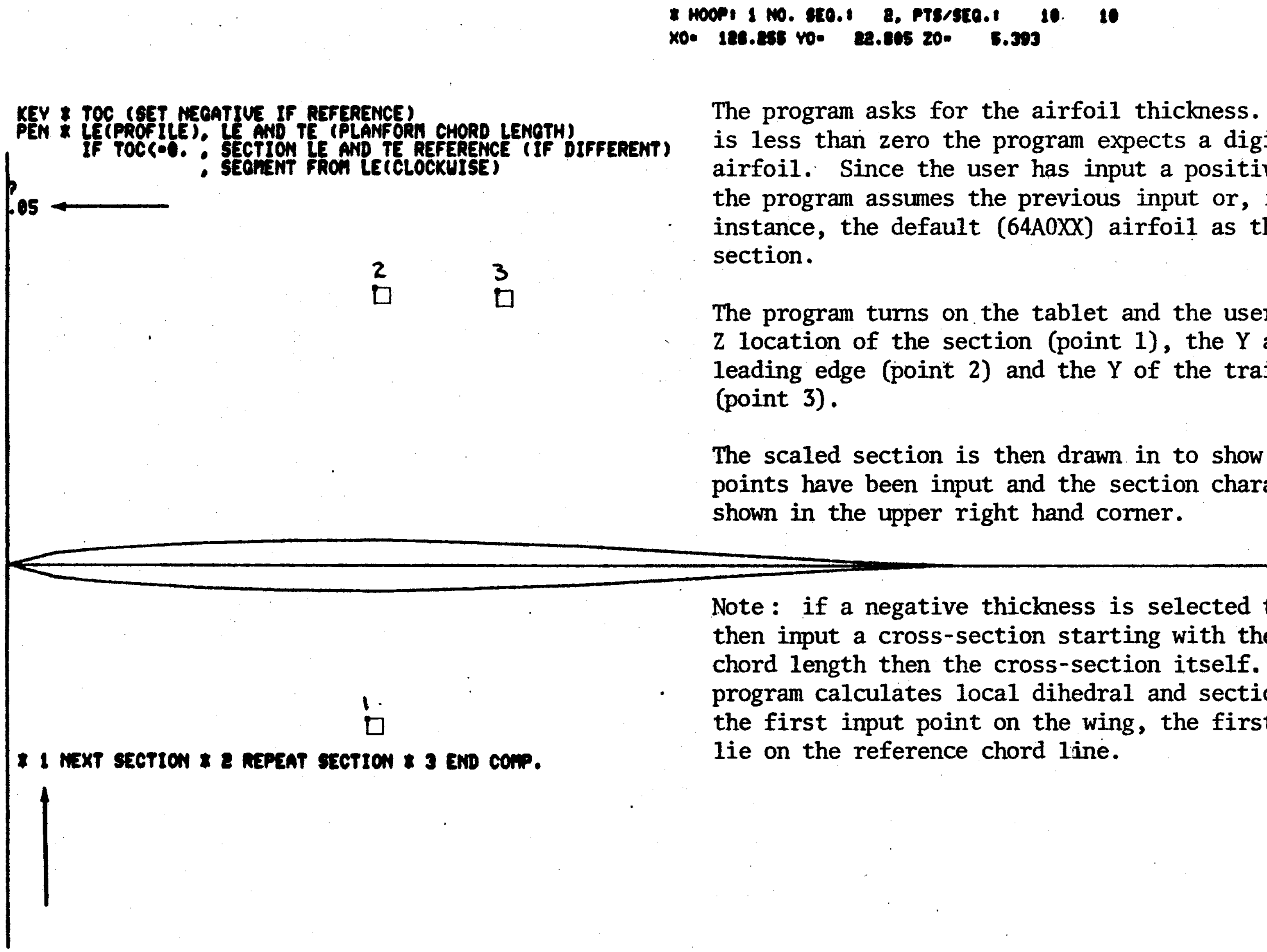
The program inquires whether the user wants to smooth the input points of each segment or simply spline fit. In this instance the user has selected the spline fit only (Ø)

The program returns to the **OK** mode and the user indicated he wishes to catalog the new component. The program responds that the component already exists and the user enters a new number (700.0) to avoid writing over the old location.

The user requests the time for this session,then asks for a listing of the files in the permanent file. The user then requests the digitizer again.

```
** INPUT BAY PARAMETERS
KEY * TYPE(1,2,3 OR 4),NSEG,NOUT(1),...,NOUT(NSEG)
?
4 2 1 1
INPUT COMP NUMBER:
?
600.0
INPUT COMPONENT NAME:
canard
INPUT AR,SW,TAPER,SWEEP,DIHEDRAL
?
2.886,54.0,0.341,54.4,20.0
```

An axis is already know so the program starts in with the new component input. This time he has selected a type 4 (wing) with 2 segments, both wetted. The program then responds by requesting the trapezoidal wing data for title blocks and analysis.



The program asks for the airfoil thickness. If TOC is less than zero the program expects a digitized airfoil. Since the user has input a positive thickness the program assumes the previous input or, in this instance, the default (64A0XX) airfoil as the desired section.

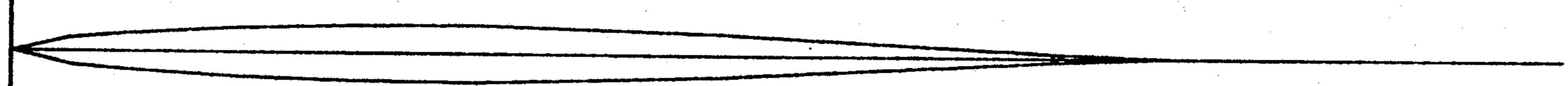
The program turns on the tablet and the user inputs the Z location of the section (point 1), the Y and X of the leading edge (point 2) and the Y of the trailing edge (point 3).

The scaled section is then drawn in to show that the points have been input and the section characteristics are shown in the upper right hand corner.

Note: if a negative thickness is selected the user would then input a cross-section starting with the reference chord length then the cross-section itself. Since the program calculates local dihedral and section twist about the first input point on the wing, the first point should lie on the reference chord line.

```
* HOOP: 2 NO. SEQ.:   2, PTS/SEQ.:    10    10
XO=  230.251 YO=   93.438 ZO=   30.892

KEY * TOC (SET NEGATIVE IF REFERENCE)
PEN * LE(PROFILE), LE AND TE (PLANFORM CHORD LENGTH)
      IF TOC<=0. , SECTION LE AND TE REFERENCE (IF DIFFERENT)
                 , SEGMENT FROM LE(CLOCKWISE)
?
.045
```



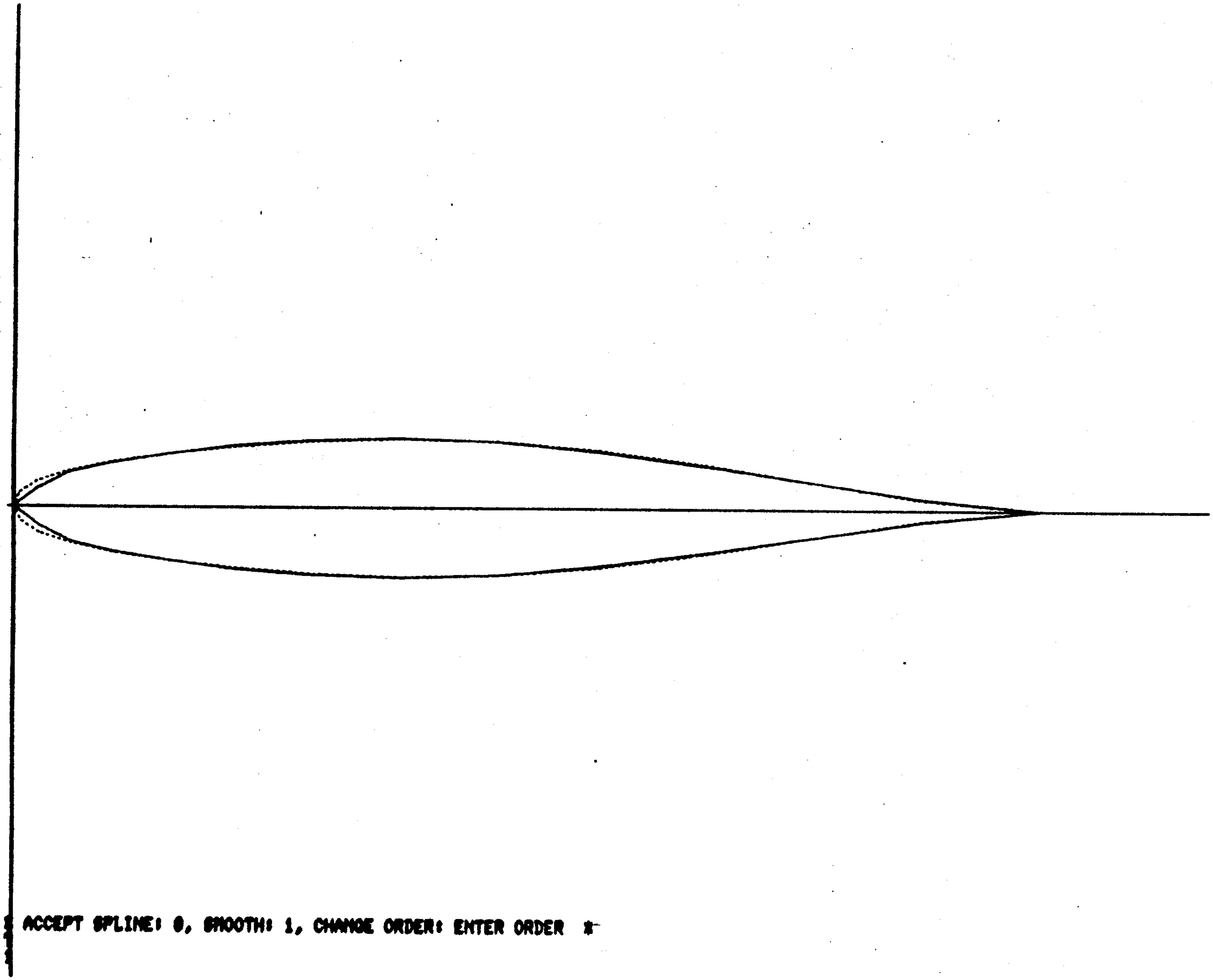
```
* 1 NEXT SECTION * 2 REPEAT SECTION * 3 END COMP.
```

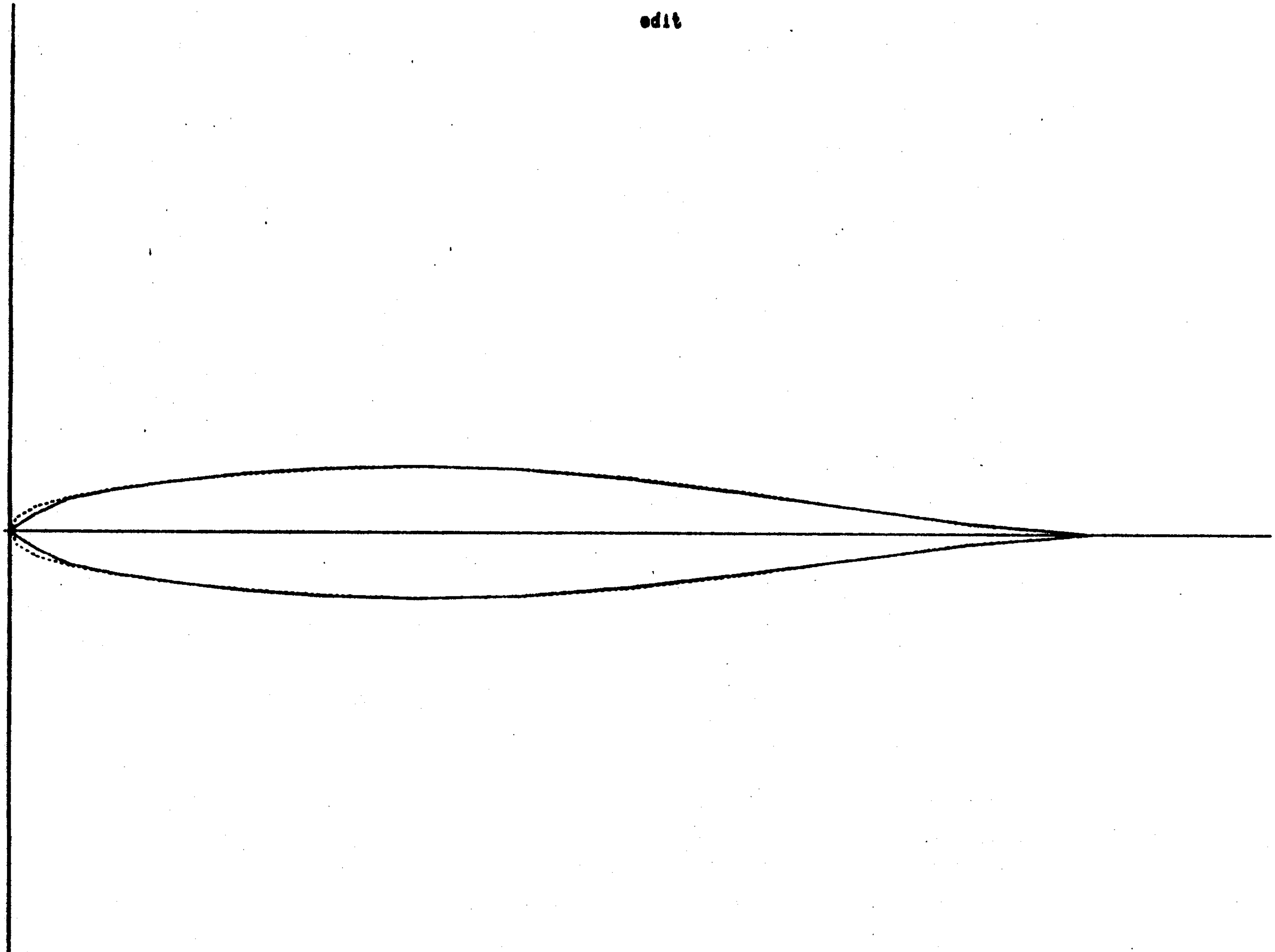
```
* SMOOTH OPTION: 0-NO, ENTER ORDER-YES *
?
3
* L.E. RADIUS: METHOD 1: 1 * METHOD 2: 2 * OFF : 3 *
```

The user now selects to smooth the input sections, in this case to better calculate the leading edge, by inputting a "3" for third order smoothing.

Airfoil section can be fit with a leading edge radius polynomial built into the smoothing routine. In this instance the user selected option 2 which allows the routine to determine the leading edge radius.

The next two figures present the display showing the smooth fit and the spline fit which the user can select from. (1, or Ø). In this case the user selected the smooth in all instances and then went directly into edit (lower left and top middle of second figure) on the new component.


ACCEPT SPLINE: 0, SMOOTH: 1, CHANGE ORDER: ENTER ORDER *

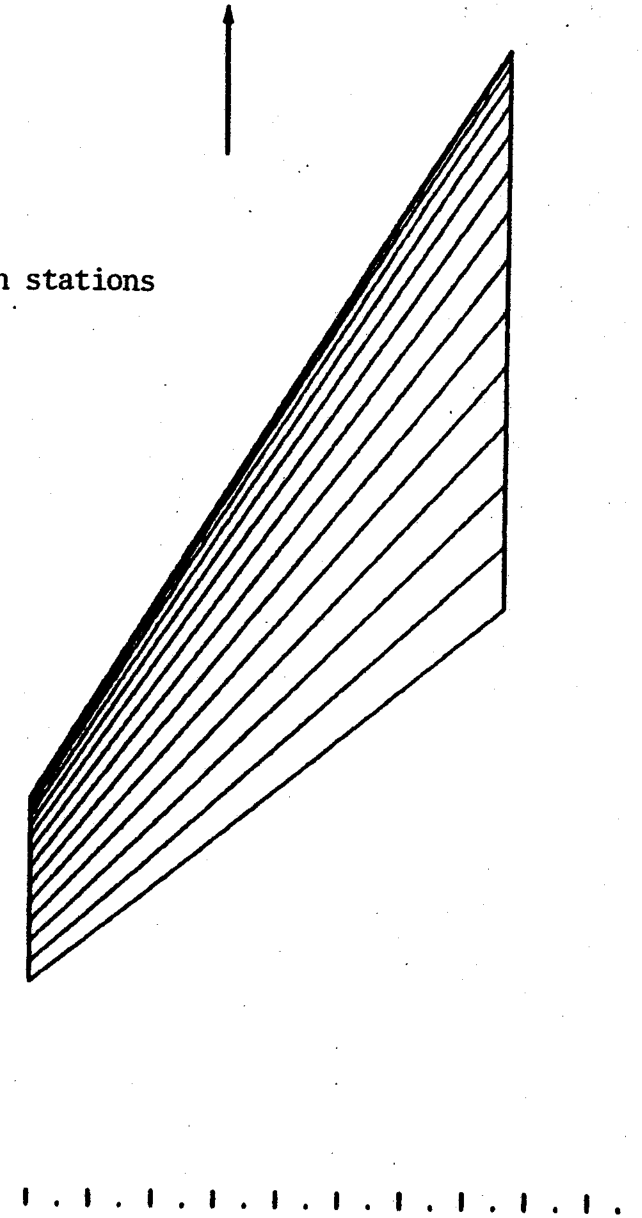


* ACCEPT SPLINE: 0, SMOOTH: 1, CHANGE ORDER: ENTER ORDER *

OK

** CONFIGURATION CONCEPT A/A FIGHTER CANARD **
* OPTIONS: NO CHANGE 0 * CHORDWISE FIT SECTIONS 1 * CHANGE SPAN STATIONS 2 *

The user selects the option to change span stations in the component (option 2).



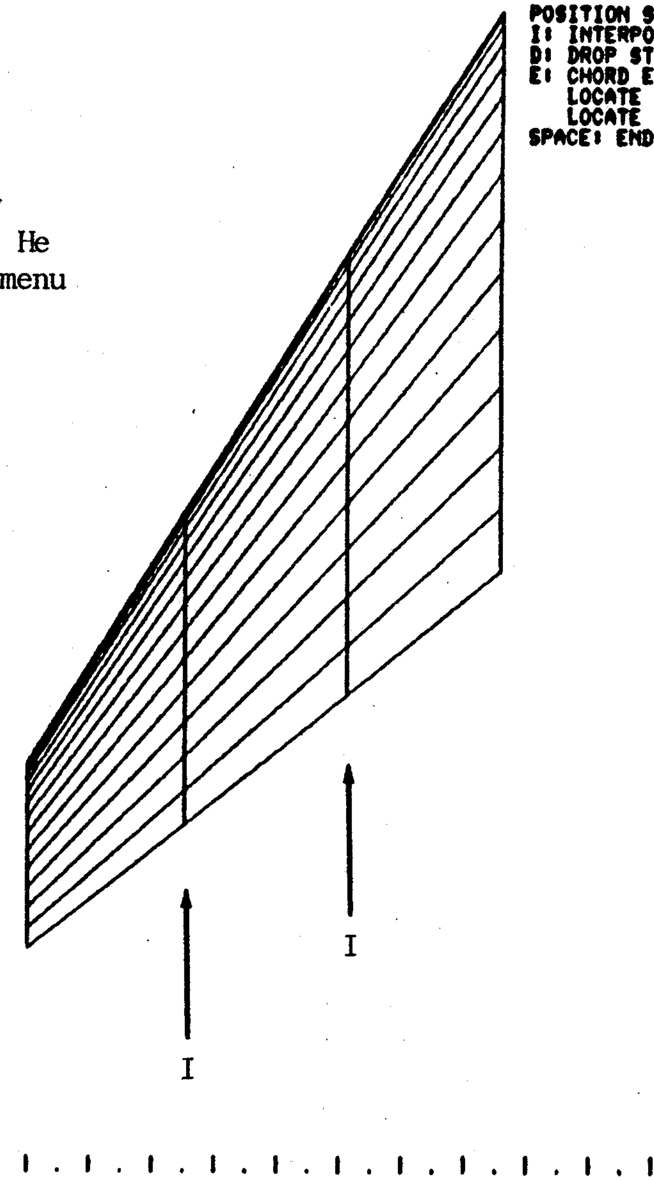
** CONFIGURATION CONCEPT A/A FIGHTER CANARD **

* OPTIONS: NO CHANGE 0 * CHORDWISE FIT SECTIONS 1 * CHANGE SPAN STATIONS 2 *

INSTRUCTIONS

POSITION SPAN STATION
I: INTERPOLATE STATION
D: DROP STATION
E: CHORD ELONGATION
LOCATE L.E.
LOCATE T.E.
SPACE: END STATION INPUT

In this figure the analyst has interpolated new sections at $2y/b = 0.45$ and 0.75 respectively. He then hits the space bar to end the option (see menu in upper right hand corner).



** CONFIGURATION CONCEPT A/A FIGHTER CANARD **

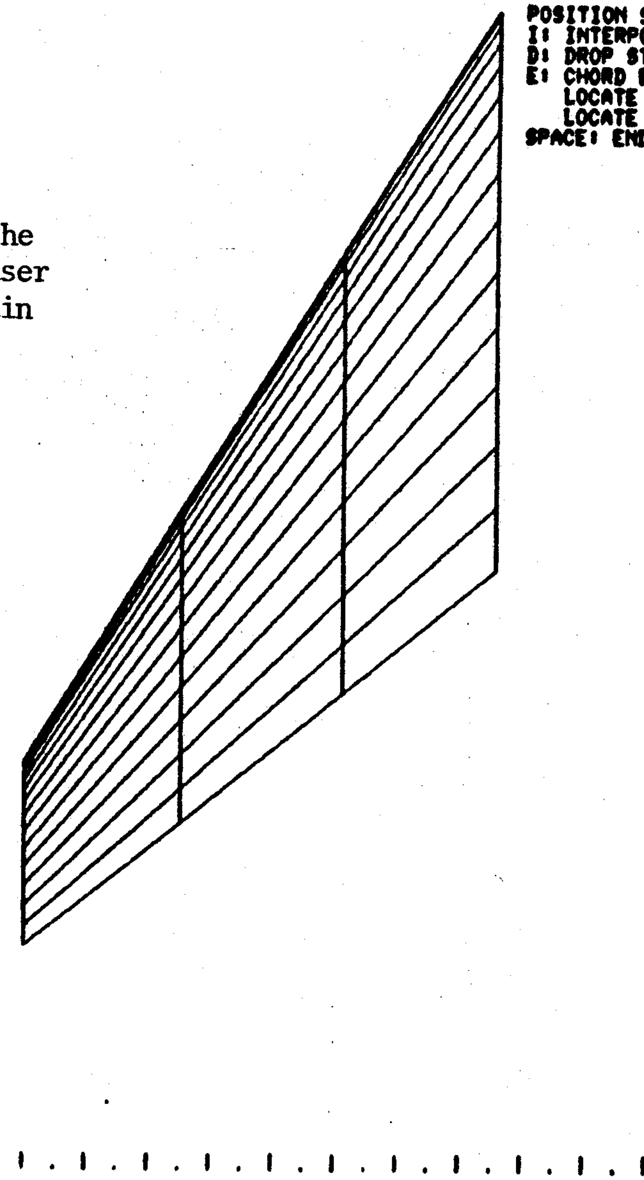
* OPTIONS: NO CHANGE 0 * CHORDWISE FIT SECTIONS 1 * CHANGE SPAN STATIONS 2 *

* NO CHANGE 0 * CHORDWISE CONSTRAINTS 1 * EVEN SPACING 2 * HALF COS SPACING 3 *
* FULL COS SPACING 4 *

INSTRUCTIONS

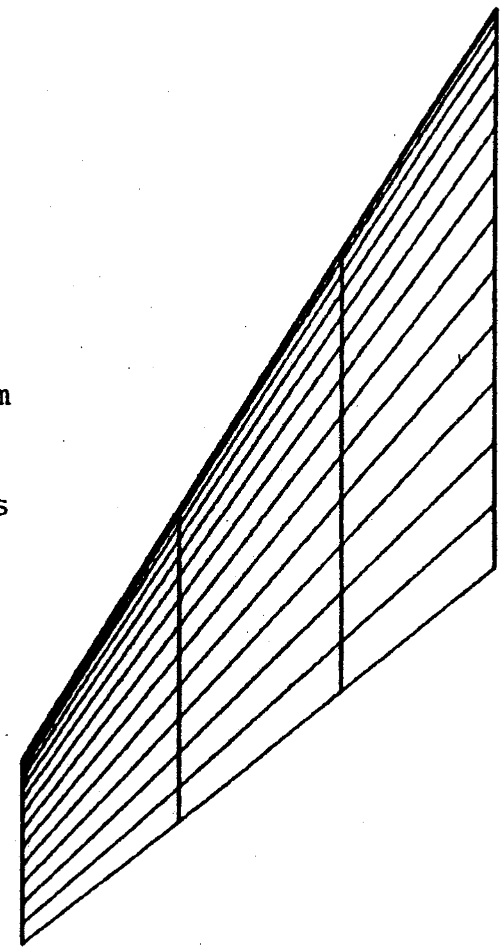
POSITION SPAN STATION
I: INTERPOLATE STATION
D: DROP STATION
E: CHORD ELONGATION
LOCATE L.E.
LOCATE T.E.
SPACE: END STATION INPUT

In this figure the analyst has been given the option for chordwise fitting to which the user responds with a "ϕ" since he wishes to retain the airfoil definition he has.



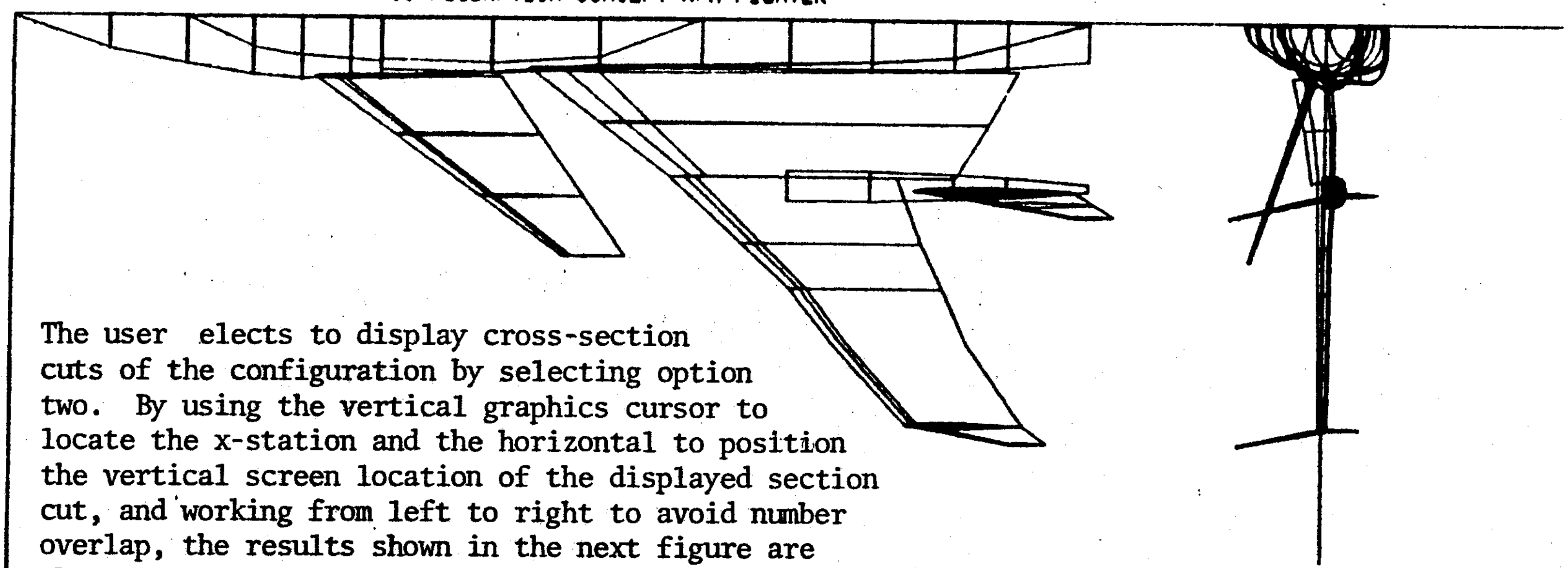
```
**     CONFIGURATION CONCEPT A/A FIGHTER                         CANARD          **
```

```
**OK**
catalog
**OK**
disp,three,all
```



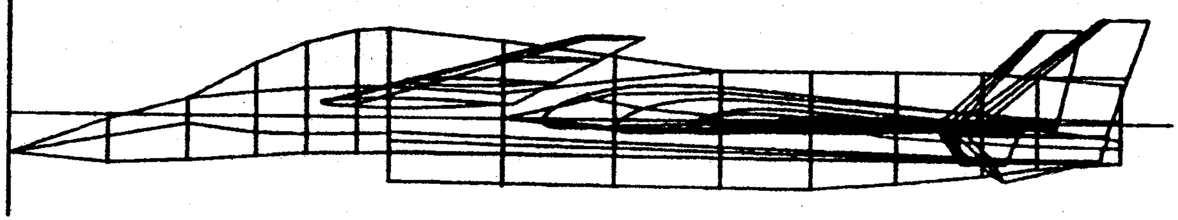
In this final figure of the series the program has displayed a view showing the final work performed on the component and returns the users to the **OK** mode. The user catalogues the component then asks for a three view display of all the components.

CONFIGURATION CONCEPT A/A FIGHTER

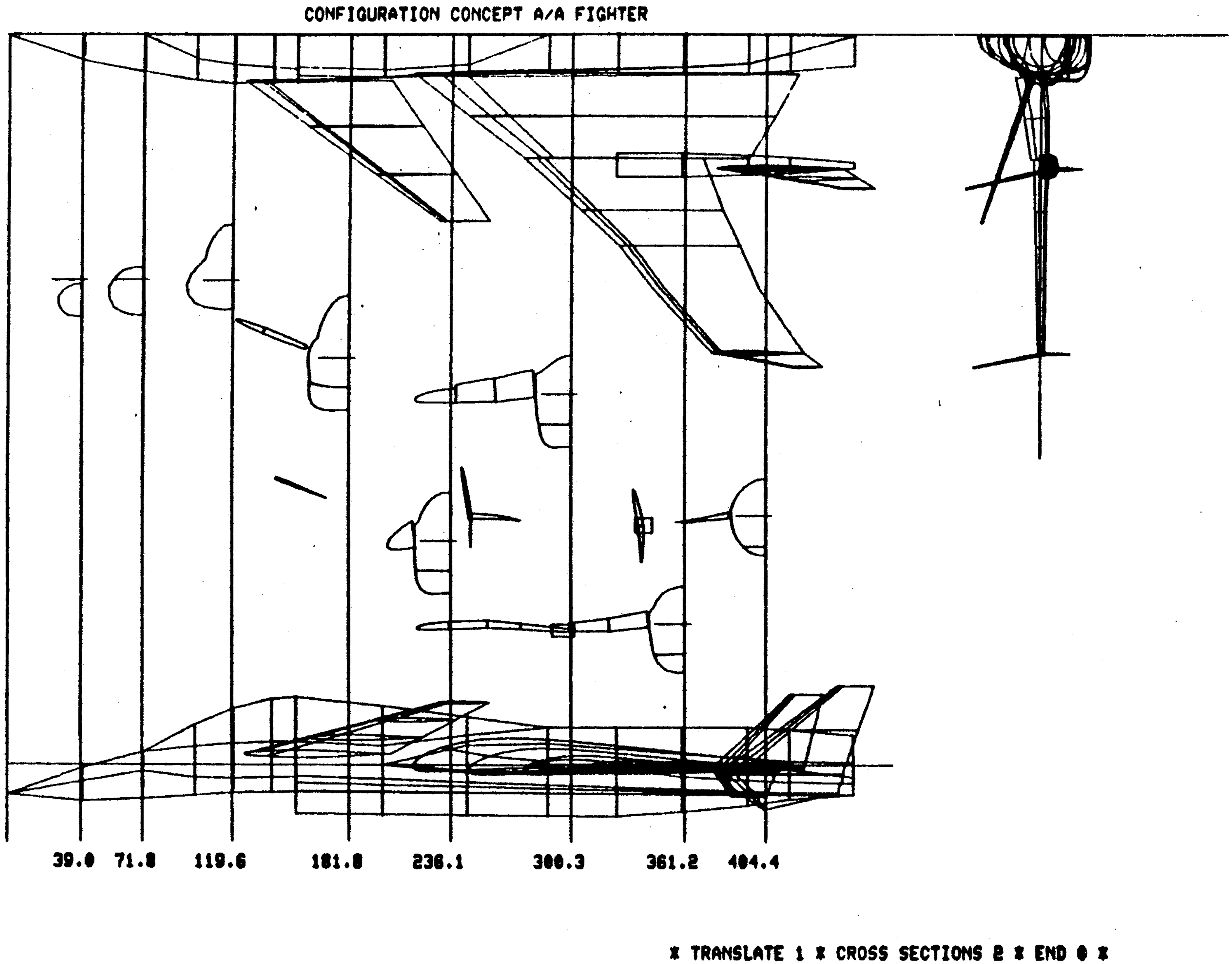


The user elects to display cross-section cuts of the configuration by selecting option two. By using the vertical graphics cursor to locate the x-station and the horizontal to position the vertical screen location of the displayed section cut, and working from left to right to avoid number overlap, the results shown in the next figure are obtained.

The user ends the option and clears the screen by entering a zero "ø" to end the three-view.



* TRANSLATE 1 * CROSS SECTIONS 2 * END 0 *


CONFIGURATION CONCEPT A/A FIGHTER
39.0
71.8
119.6
181.8
236.1
300.3
361.2
404.4
* TRANSLATE 1 * CROSS SECTIONS 2 * END 0 *

```
**OK**
files
FILE: PERM
REC   COMP NO.      NAME             TYPE

  1    100.00    FOR FUSELAGE         1
  2    101.00    AFT FUSE             1
  3    103.00    NACELLE              1
  4    200.00    INBD WING            4
  5    201.00    OUTBD WING           4
  6    300.00    LOWER TIP FIN        3
  7    301.00    UPPER TIP FIN        3
  8    400.00    LOWER VERT           3
  9    401.00    UPPER VERT           3
 10    500.00    VERT PYLON           2
 11    600.00    CANARD               4
**OK**
interference 1 2 200,600
```

The program returns to **OK** and the user asks for a list of components (files).

He now requests four components to be used in making an interference shell, records 7 and 2 and components 200 and 600 (Note the mixing of records and components)

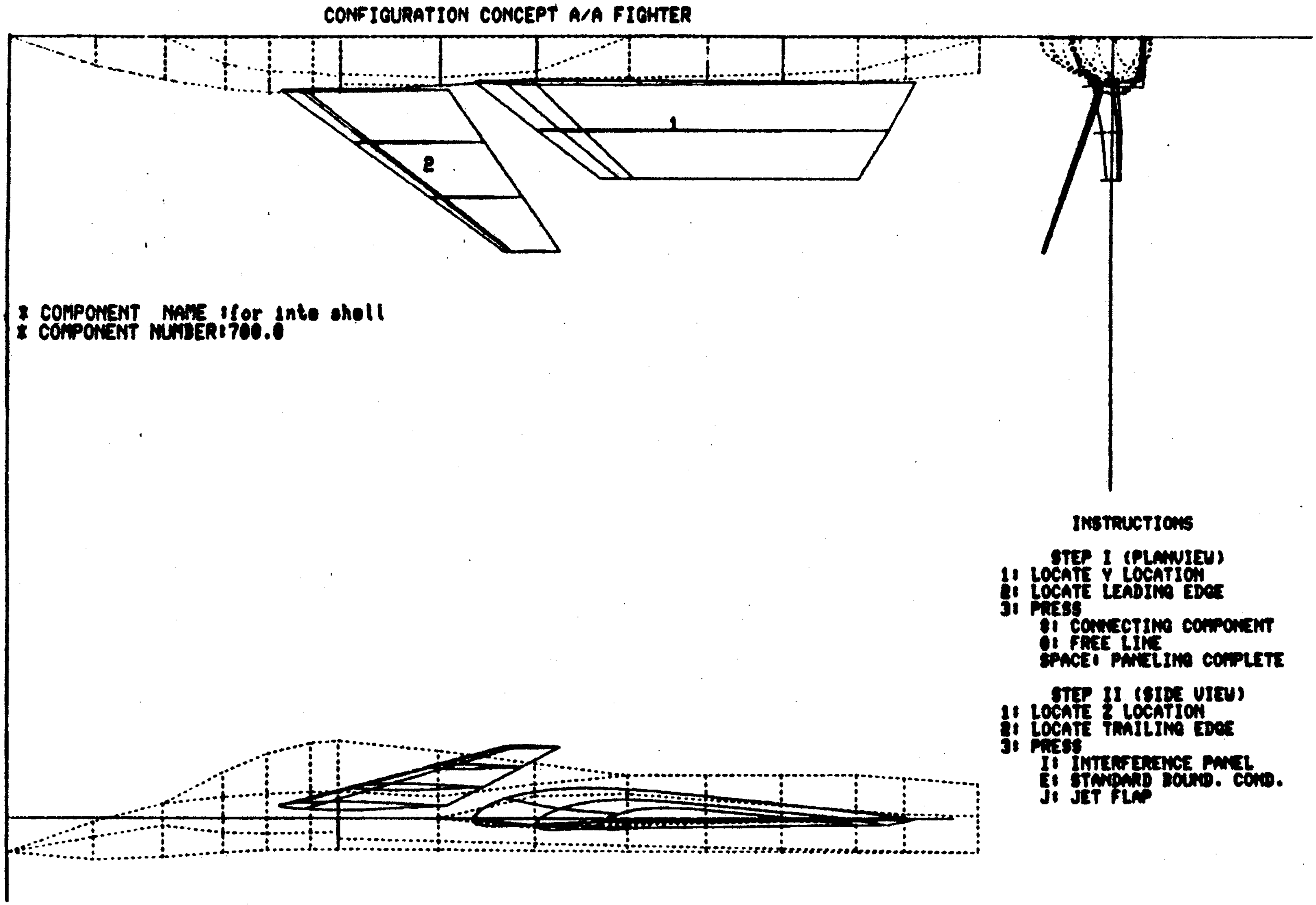
In the next figure the user has been supplied with a three view with bodies dashed in as references only. Surfaces in this view can be used to line up or "connect" construction lines of the inteference shell to.

The user first locates X leading edge and Y in the planview and the number of the connecting or alignment component (numbers displayed at centoid of surface components, or a "Ø" for a free line.

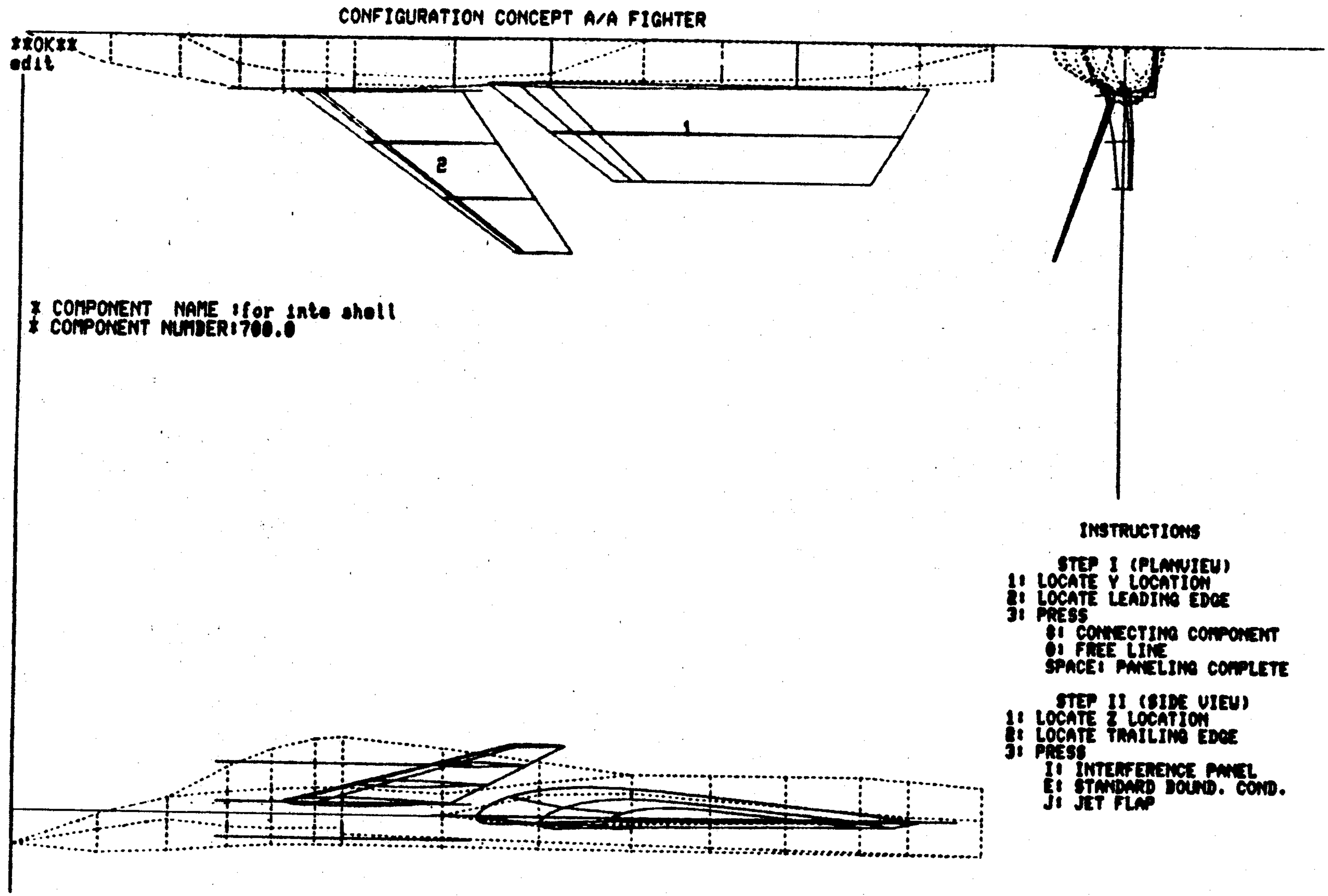
The user next locates X trailing edge and Z and presses the type of surface he is constructing, (I, E, or J) the program will than display the constructed span line in the two views.

On subsequant passes to construct additonal lines, the user need only locate Y and Z if an interference shell is selected since X leading and trailing edge are fixed by the first line. With the standard boundary condition the X's must always be input and with a jet flap the leading edge X must match a connecting body the trailing edge X is a function of a user input length of the connecting chord.

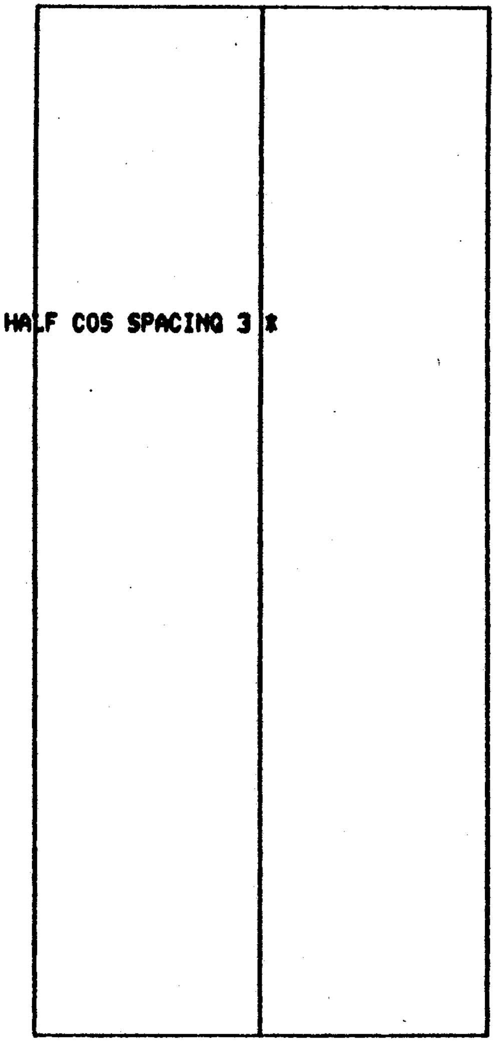
The resulting line construction is shown in the following figure, a space used in the first step ending the routine (see menu in middle right side of page).



CONFIGURATION CONCEPT A/A FIGHTER
2
1
% COMPONENT NAME :for inte shell
% COMPONENT NUMBER:700.0
INSTRUCTIONS
STEP I (PLANVIEW)
1: LOCATE Y LOCATION
2: LOCATE LEADING EDGE
3: PRESS
S: CONNECTING COMPONENT
0: FREE LINE
SPACE: PANELING COMPLETE
STEP II (SIDE VIEW)
1: LOCATE Z LOCATION
2: LOCATE TRAILING EDGE
3: PRESS
I: INTERFERENCE PANEL
E: STANDARD BOUND. COND.
J: JET FLAP


CONFIGURATION CONCEPT A/A FIGHTER
OK
edit
1
2
* COMPONENT NAME :for inte shell
* COMPONENT NUMBER:700.0
INSTRUCTIONS
STEP I (PLANVIEW)
1: LOCATE Y LOCATION
2: LOCATE LEADING EDGE
3: PRESS
S: CONNECTING COMPONENT
0: FREE LINE
SPACE: PANELING COMPLETE
STEP II (SIDE VIEW)
1: LOCATE Z LOCATION
2: LOCATE TRAILING EDGE
3: PRESS
I: INTERFERENCE PANEL
E: STANDARD BOUND. COND.
J: JET FLAP

```
** CONFIGURATION CONCEPT A/A FIGHTER                    FOR INTE SHELL   **
```



```
* NO CHANGE 0 * CHORDWISE CONSTRAINTS 1 * EVEN SPACING 2 * HALF COS SPACING 3 *
               * FULL COS SPACING 4 *
* ENTER NO. OF CHDWSE PANELS *
* PRESENT NUMBER=  1 *
?
5
```

The user goes into edit for the interference shell selecting even spacing for the shell which comes with one panel from construction.

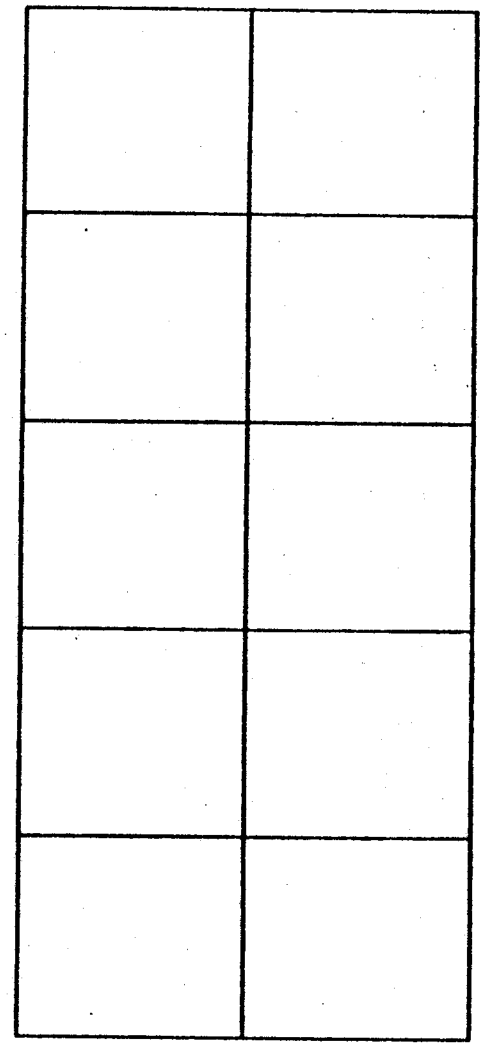
The display of the final view is shown in the following figure with the five evenly spaced panels inserted.

The user then catalogues the shell and asks to construct the aft shell, which is similar and not shown here.

The final view for this shell is shown in the following figure. The command input at the middle of this figure is to display the interference shells and the wing and canard to illustrate the connections between surface components. This is seen in the last and final figure in this series.

** CONFIGURATION CONCEPT A/A FIGHTER FOR INTE SHELL **

```
**OK**
catalog
**OK**
inte,1,2,200.,700.
```

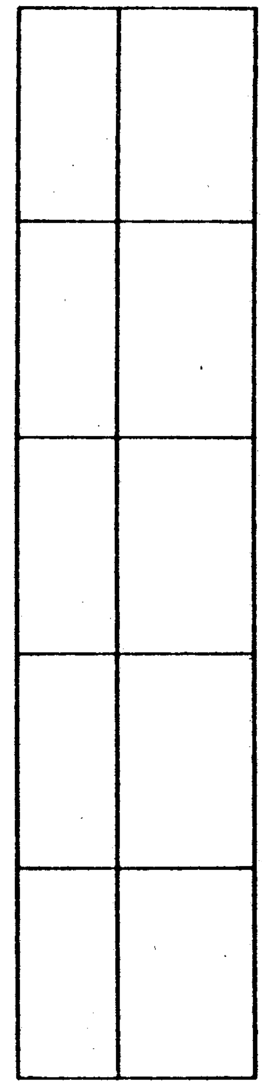


** CONFIGURATION CONCEPT A/A FIGHTER

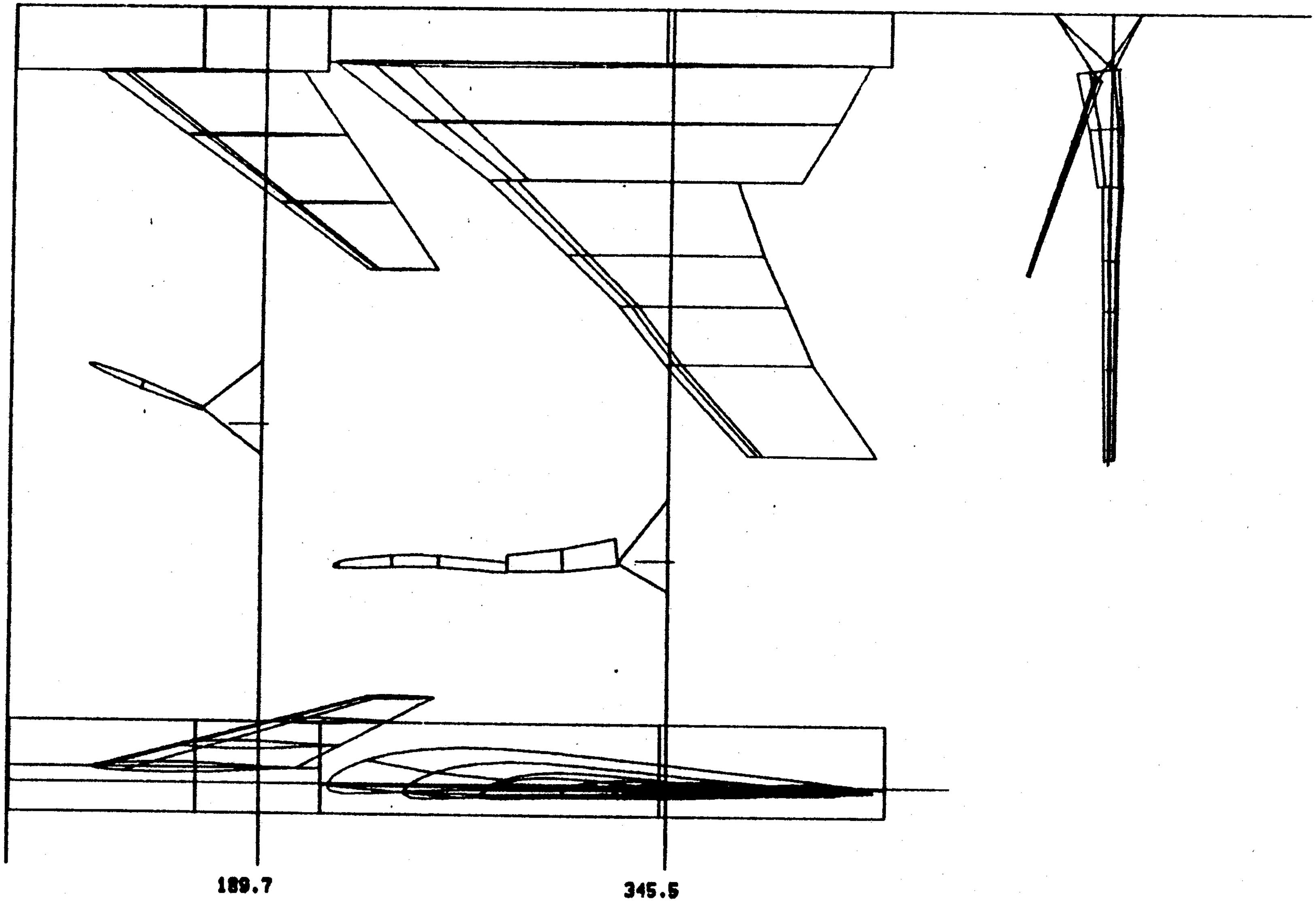
```
**OK**
catalog
**OK**
files
FILE: PERM
REC   COMP NO.     NAME            TYPE

  1    100.00   FOR FUSELAGE       1
  2    101.00   AFT FUSE           1
  3    103.00   NACELLE            1
  4    200.00   INBD WING          4
  5    201.00   OUTBD WING         4
  6    300.00   LOWER TIP FIN      3
  7    301.00   UPPER TIP FIN      3
  8    400.00   LOWER VERT         3
  9    401.00   UPPER VERT         3
 10    500.00   VERT PYLON         2
 11    600.00   CANARD             4
 12    700.00   FOR INTE SHELL     5
 13    702.00   AFT INTE SHELL     5
**OK**
disp,t,200,201,11,12,13
```

*AFT INTE SHELL **



CONFIGURATION CONCEPT A/A FIGHTER



* TRANSLATE 1 * CROSS SECTIONS 2 * END 0 *

```
NORMAL JOB COMPLETION

COMMAND- catalog,tape1,geometry,id=$$$$$$,rp=999,cn=open,ex=file.

 NEW CYCLE CATALOG, CY=001
COMMAND- catalog,tape3,plotfile,id=$$$$$$,rp=999,cn=open,ex=file.

 NEW CYCLE CATALOG, CY=001

COMMAND-logout
```

In this frame the user has exited from the system and is cataloging his geometry and plot files for later use. The use of mass storage files necessitates storing the files so they can be extended if necessary on future runs. The addition of

$$C_N = \text{open, ex=file}$$

to the end of the catalog statement assures that this will occur.

SESSION II

WAVE DRAG AND VISCOUS DRAG ANALYSIS

```
COMMAND- attach,lang,langload,id=$$$$$$.
 PF CYCLE NO.=001
COMMAND- connect,input,output.
COMMAND- attach,tape1,geometry,id=$$$$$$,pw=open,file.
 PF CYCLE NO.=001
COMMAND- attach,tape3,plotfile,id=$$$$$$,pw=open,file.
 PF CYCLE NO.=001

COMMAND- attach,tape4,wavedrag,id=$$$$$$.      (OPTIONAL ENTRY SEE FOOTNOTE)
 PF CYCLE NO.=001

COMMAND- rewind,lang.
COMMAND- lang.

* INPUT TERMINAL CHARACTER SPEED :  30
```

The user attaches the program load file, the geometry file and plot file from the previous session. If a lifting surface solution had been performed the user might also want to attach the file containing pressures for the wave drag due to lift solution, however this is optional.

(FILE WAVEDRAG (TAPE4) ONLY NEEDED WHEN A UDP SOLUTION HAS BEEN OBTAINED AND WAVE DRAG DUE TO LIFT IS REQUIRED FROM ANALYSIS)

```
DISPOSITION OF PERM FILE (NEW/OLD):
old
DISPOSITION OF PLOT FILE (NEW/OLD):
old
**OK**
titl,l
```

The user informs the program that both the perm file (geometry) and plot file already exist and to read in their contents record.

```
OLD TITLE:

ENTER NEW TITLE
l=p
**OK**
```

The title of the perm file is requested and the local file title is set equal to the perm file title (ℓ = p).

```
files
FILE: PERM
REC   COMP NO.      NAME               TYPE

 1     100.00     FOR FUSELAGE          1
 2     101.00     AFT FUSE              1
 3     103.00     NACELLE               1
 4     200.00     INBD WING             4
 5     201.00     OUTBD WING            4
 6     300.00     LOWER TIP FIN         3
 7     301.00     UPPER TIP FIN         3
 8     400.00     LOWER VERT            3
 9     401.00     UPPER VERT            3
10     500.00     VERT PYLON            2
11     600.00     CANARD                4
12     700.00     FOR INTE SHELL        5
13     702.00     AFT INTE SHELL        5
**OK**
atta,1,2,3,4,5,6,7,8,9,10,11
**OK**
file,l
FILE: WORK
REC   COMP NO.      NAME               TYPE

 1     100.00     FOR FUSELAGE          1
 2     101.00     AFT FUSE              1
 3     103.00     NACELLE               1
 4     200.00     INBD WING             4
 5     201.00     OUTBD WING            4
 6     300.00     LOWER TIP FIN         3
 7     301.00     UPPER TIP FIN         3
 8     400.00     LOWER VERT            3
 9     401.00     UPPER VERT            3
10     500.00     VERT PYLON            2
11     600.00     CANARD                4
**OK**
analy
```

The files in the perm file are listed and components in records 1-11 are attached. Note: an easier way would be to attach all components and delete the last two from the local file.

```
ANALY**
m,0.6,1.2,1.6,1.8
ANALY**
wavedrag
ANALY**
viscous
ANALY**
calculate
* REFERENCE QUANTITIES:
   SREF       SPAN       CBAR       XCG       YCG       ZCG
 25920.00   315.899    91.898   320.459     0.0      -1.094
* ENTER 1 TO CHANGE * 0 TO LEAVE ALONE
?
0
 SCALE(TO FULL SIZE)
?
20.
 KEY * 1,2 OR 3
  1  * PLOT * NX,X(1),...,X(NX)
  2  * PLOT * NX,XB,XE
  3  * NO PLOT * NX=51 (ALL SURFACE FLAGED)
?
3
```

The keyboard ANALY** indicates the analysis function and the user inputs the Mach numbers to be used in this exercise. Note the use of Mach 0.60 for wave drag to include the empirical drag divergence interpolation in the transonic regime.

The user requests wave drag and viscous drag solutions, executes these solutions by entering "calculate" or "C". The program displays the reference data which it has stored giving the user an opportunity to change the data, then enters the first analysis routine, viscous drag.

The scale requested is based on vehicle inches/drawing inch, of digitized configuration. A modern fighter for example would be 20 scale (20 inches/inch), the value entered here.

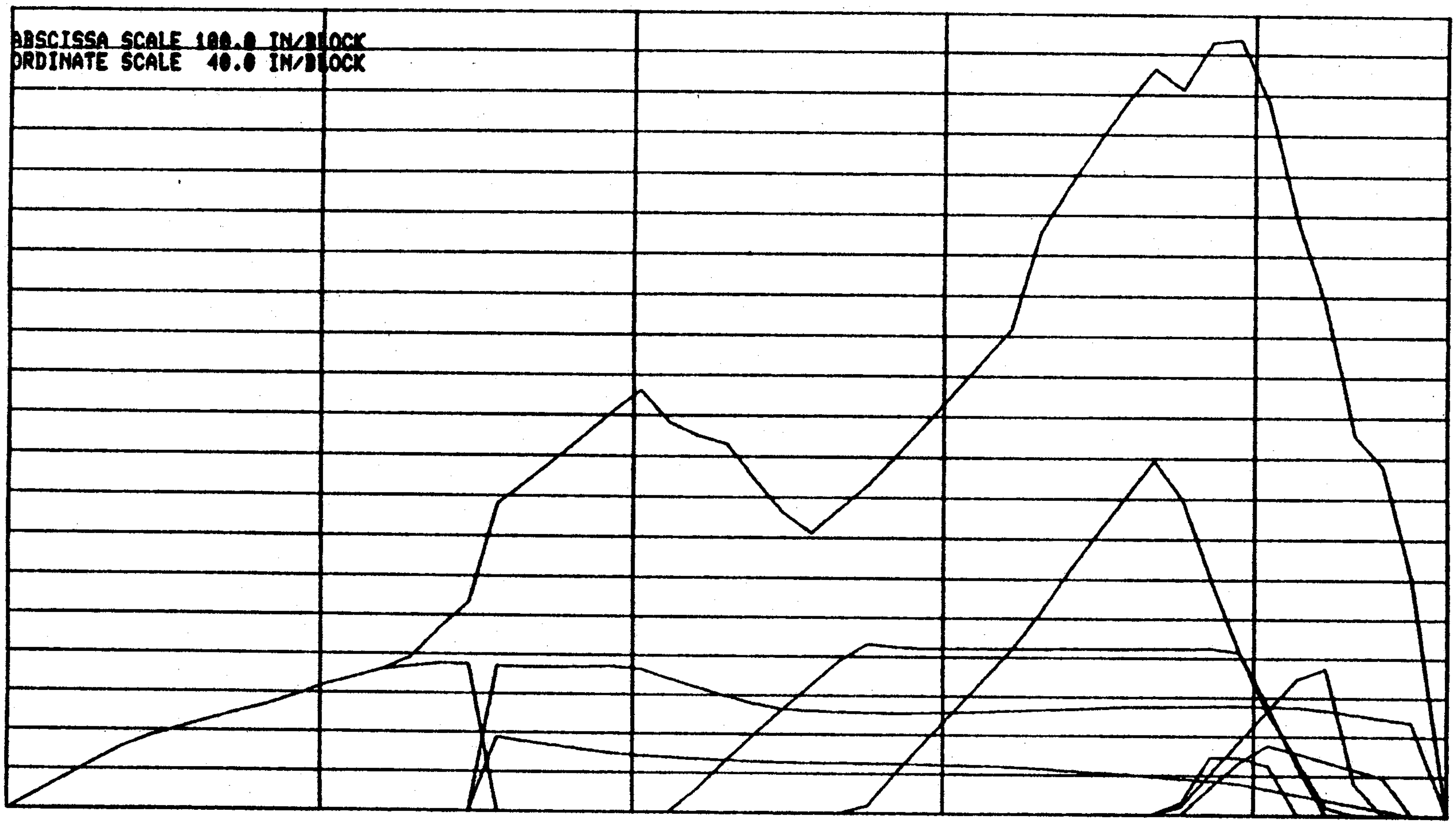
The use of the word plot here refers to seeing selected cross section cuts to remove perimeter segments that are unwetted. In most cases the third option (51 cuts) gives an accurate estimation of wetted area for viscous drag estimates.

The display shown in the next two figures are the perimeter versus X-station and the cross sectional area versus X-station. The scales listed for each plot are valid except for the top horizontal line and right vertical line and were selected based on a fighter sized vehicle.

The third figure in this series shows the component data necessary to run viscous drag. The skin roughness is estimated with a sand grain height (in feet). The pressure, temperature and, Mach (disp) (the Mach number for which a component drag listing will be made, 0.0 will get all, 999, for none). The information for components is requested for each unique component set, the three components of the fuselage were joined together because they were consecutively numbered (101, 102, 103 see files listing). Note also that the routine has automatically ignored interference shells (as will the wave drag) since they are not pertinent vehicle components. The viscous and wave drag programs also ignore jet flaps and slender bodies so the user can combine all the necessary components in the work file to do wave drag,viscous drag,and lifting surface analysis at one time.

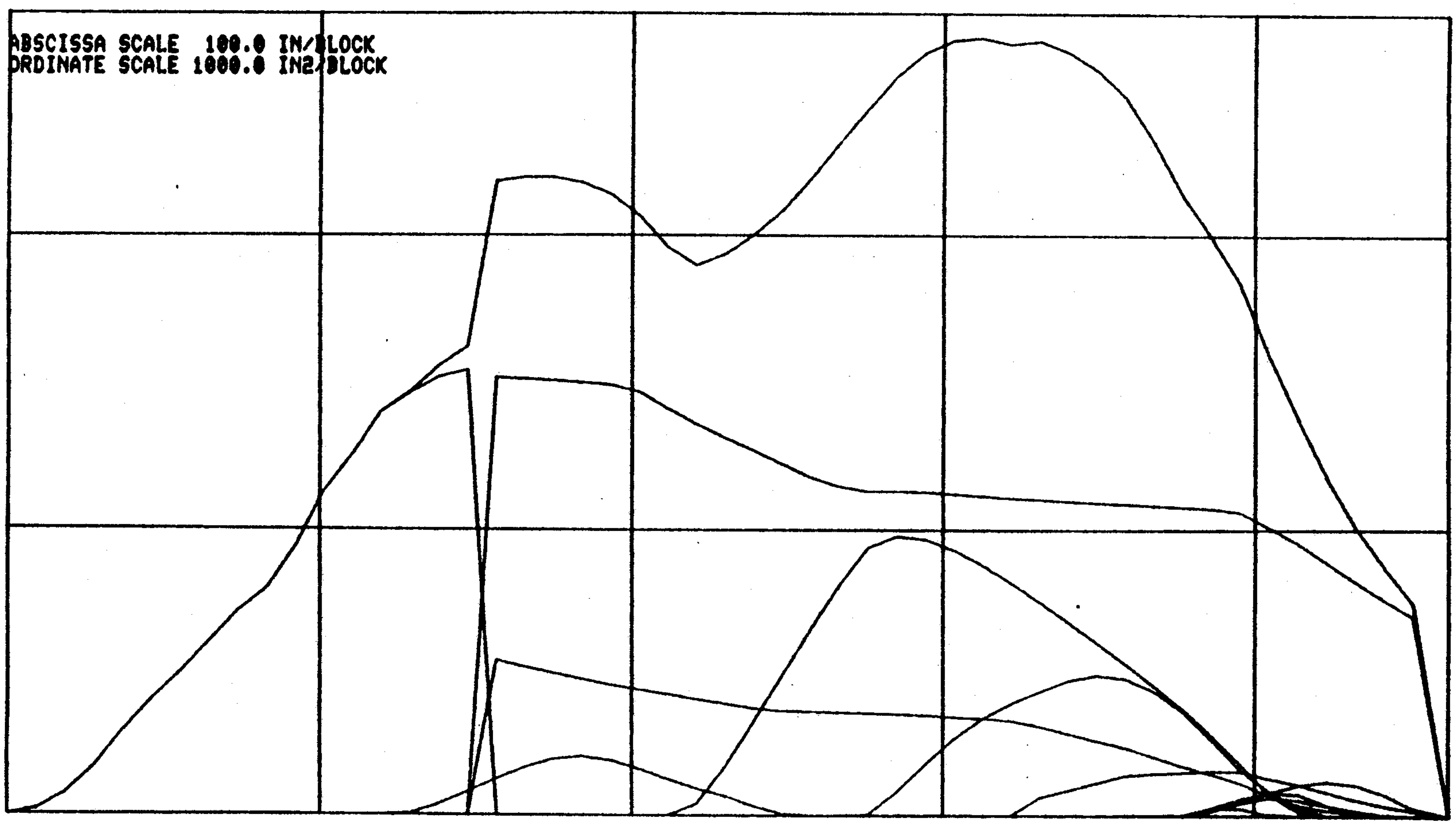
CONFIGURATION CONCEPT A/A FIGHTER

BAY	WETTED AREA
1	14576.4
2	35026.6
3	13255.7
4	28261.9
5	26046.1
6	1619.0
7	5012.5
8	3204.7
9	7685.1
10	7539.4
11	15702.3
TOTAL	157928.5



CONFIGURATION CONCEPT A/A FIGHTER

BAY	VOLUME
1	117651.7
2	354085.9
3	87975.2
4	109873.2
5	41168.7
6	538.4
7	2529.4
8	2108.4
9	5249.7
10	13128.8
11	13638.1
TOTAL	747947.4



```
* 0 EXIT * 1 SF DRAG * 2 EDIT
?
1
 SKIN FRICTION DRAG INPUT
 ENTER SAND GRAIN HEIGHT (KS(FT))
?
0.000022
 ENTER PRESS(PSF),TEMP(PSF),AND DISPLAY MACH NUMBER(0.0 FOR ALL, 999. FOR NONE)
 ENTER 0.0,0.0,0.0 AFTER LAST CASE (8 OR LESS)
ENTER PRESS,TEMP,MACH(DISP) FOR CASE 1
?
21:6.2,518.7,0.6
ENTER PRESS,TEMP,MACH(DISP) FOR CASE 2
?
1455.6,483.0,1.2
ENTER PRESS,TEMP,MACH(DISP) FOR CASE 3
?
973.30,447.4,1.8
ENTER PRESS,TEMP,MACH(DISP) FOR CASE 4
?
0,0,0
 FOR FUSELAGE      ENTER: XTRANS/LENG, FLAT PLATE 1 * AXIS-BODY 2 *
?
0.01,2
 INBD WING         ENTER: XTRANS/LENG, CK, FLAT PLATE 1 * AIRFOIL 2 *
?
0.01,1.2,2
 OUTBD WING        ENTER: XTRANS/LENG, CK, FLAT PLATE 1 * AIRFOIL 2 *
?
0.01,1.2,2
 LOWER TIP FIN     ENTER: XTRANS/LENG, CK, FLAT PLATE 1 * AIRFOIL 2 *
?
0.01,1.2,2
 UPPER TIP FIN     ENTER: XTRANS/LENG, CK, FLAT PLATE 1 * AIRFOIL 2 *
?
0.01,1.2,2
 LOWER VERT        ENTER: XTRANS/LENG, CK, FLAT PLATE 1 * AIRFOIL 2 *
?
0.01,1.2,2
 UPPER VERT        ENTER: XTRANS/LENG, CK, FLAT PLATE 1 * AIRFOIL 2 *
?
0.01,1.2,2
 VERT PYLON        ENTER: XTRANS/LENG, FLAT PLATE 1 * AXIS-BODY 2 *
?
0.01,1.2,2
 CANARD            ENTER: XTRANS/LENG, CK, FLAT PLATE 1 * AIRFOIL 2 *
?
0.01,2.0,2
```

CONFIGURATION CONCEPT A/A FIGHTER

MACH: 0.600 PRESS: 2116.200 PSF TEMP: 518.700 R SREF: 180.000 SQ. FT. KS: 0.000022 FT.

COMPONENT	COMP TYPE	WET SURF AREA	COMP LENGTH	T/C MAXI.	X/L TRANS.	REYNOLDS NO.	CDF SMOOTH	CDF ROUGH	CDF USED
FOR FUSELAGE	3.0	436.519	37.591	0.157	0.010	1.80119E+08	0.00508	0.00510	0.00510
INBD WING	2.0	108.909	15.409	0.074	0.010	6.56360E+07	0.00140	0.00142	0.00142
INBD WING	2.0	84.088	11.857	0.073	0.010	5.05034E+07	0.00112	0.00114	0.00114
OUTBD WING	2.0	62.717	7.162	0.068	0.010	3.05052E+07	0.00090	0.00092	0.00092
OUTBD WING	2.0	34.598	5.860	0.062	0.010	2.49596E+07	0.00051	0.00052	0.00052
OUTBD WING	2.0	34.537	5.060	0.062	0.010	2.15540E+07	0.00052	0.00053	0.00053
OUTBD WING	2.0	46.875	4.413	0.062	0.010	1.87964E+07	0.00072	0.00074	0.00074
LOWER TIP FIN	2.0	10.725	2.238	0.040	0.010	9.53303E+06	0.00018	0.00018	0.00018
UPPER TIP FIN	2.0	34.575	2.788	0.045	0.010	1.18738E+07	0.00056	0.00058	0.00058
LOWER VERT	2.0	6.253	2.216	0.040	0.010	9.44060E+06	0.00010	0.00011	0.00011
LOWER VERT	2.0	15.525	5.040	0.040	0.010	2.14678E+07	0.00023	0.00023	0.00023
UPPER VERT	2.0	34.661	4.583	0.045	0.010	1.95194E+07	0.00052	0.00053	0.00053
UPPER VERT	2.0	19.285	2.602	0.045	0.010	1.10825E+07	0.00032	0.00033	0.00033
VERT PYLON	1.0	52.357	10.599	0.0	0.010	4.51442E+07	0.00065	0.00066	0.00066
CANARD	2.0	46.699	5.772	0.049	0.010	2.45847E+07	0.00070	0.00072	0.00072
CANARD	2.0	37.348	4.344	0.048	0.010	1.85050E+07	0.00059	0.00060	0.00060
CANARD	2.0	24.160	2.895	0.046	0.010	1.23332E+07	0.00040	0.00041	0.00041

** TOTAL WET SURFACE AREA = 1089.83
** TOTAL SKIN FRICTION DRAG = 0.01471

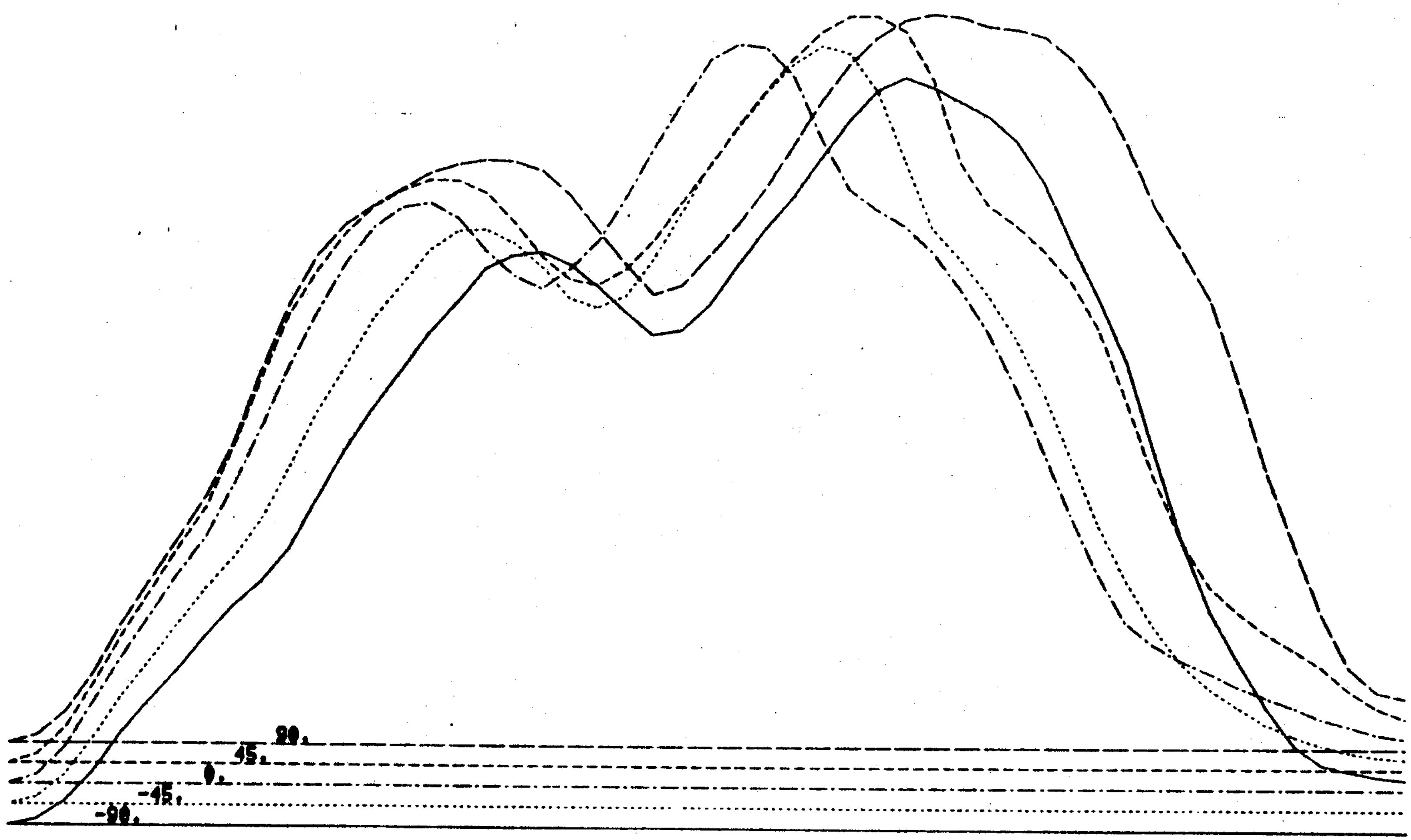
```
* 0 EXIT * 1 SF DRAG * 2 EDIT
?
0
```

After the viscous solution is concluded the user has the opportunity to edit the cross sectional data used in the calculations and/or add additional solutions to those already calculated.

In this instance the user chose to end and the program proceeds into the next analysis routine selected (wave drag in this case) or returns to ANALY** if analysis is completed.

Although each supersonic Mach number requested is displayed in the manner shown in the next two figures only M = 1.2 is shown here to add some compactness to this manual. Cross sectional area cuts as a function of roll angle are displayed first (ever fourth roll angle calculated is displayed) and then a listing of drag as a function of roll angle, total drag and drag coefficient are printed.

CONFIGURATION CONCEPT A/A FIGHTER



CONFIGURATION CONCEPT A/A FIGHTER
MACH= 1.200 ALPHA= 0.0

NO.	THETA	D/Q
1	-90.000	787.6387
2	-75.000	613.7737
3	-60.000	659.5117
4	-45.000	677.2495
5	-30.000	693.3437
6	-15.000	678.8940
7	0.0	686.0936
8	15.000	766.6033
9	30.000	811.3738
10	45.000	921.1738
11	60.000	951.4426
12	75.000	928.7405
13	90.000	1064.8210
** TOTAL WAVE DRAG		772.3147
** TOTAL COEFFICIENT		0.029796

ANALY**
ex
OK
forces

Wave drag is always the last program to be executed and on completion returns the user to ANALY**. The user may add other solutions, eliminate an incorrect solution or in this instance exit and obtain displays of the force and drag results stored in the plot file.

In the next figure the title sheet accompaning each call to FORCES is shown illustrating the solutions available, interpolated Mach numbers, solution Mach numbers, reference data, and viscous solution input data. If a lifting solution is also stored control surface solutions, if any, are indicated, and whether the drag data is trimmed or untrimmed.

CONFIGURATION CONCEPT A/A FIGHTER

REF. AREA	SPAN	CBAR
25980.00 FT2	315.8987 IN	91.897
XCG	YCG	ZCG
320.46 IN.	0.0 IN	-1.093

VISCOUS SOLUTION CASES

SAND GRAIN HEIGHT: 0.000022 FT

CASE	TEMP	PRESS
1	518.7	2116.2
2	483.0	1455.6
3	447.4	973.3

MACH NUMBERS INTERPOLATED:

0.0	0.10	0.20	0.30	0.40	0.50	0.60	0.70
0.75	0.77	0.80	0.82	0.85	0.88	0.90	0.93
0.95	0.98	1.00	1.10	1.20	1.30	1.40	1.60
1.80							

MDD (IF APPLICABLE): 0.950

SOLUTIONS WHICH ARE AVAILABLE:

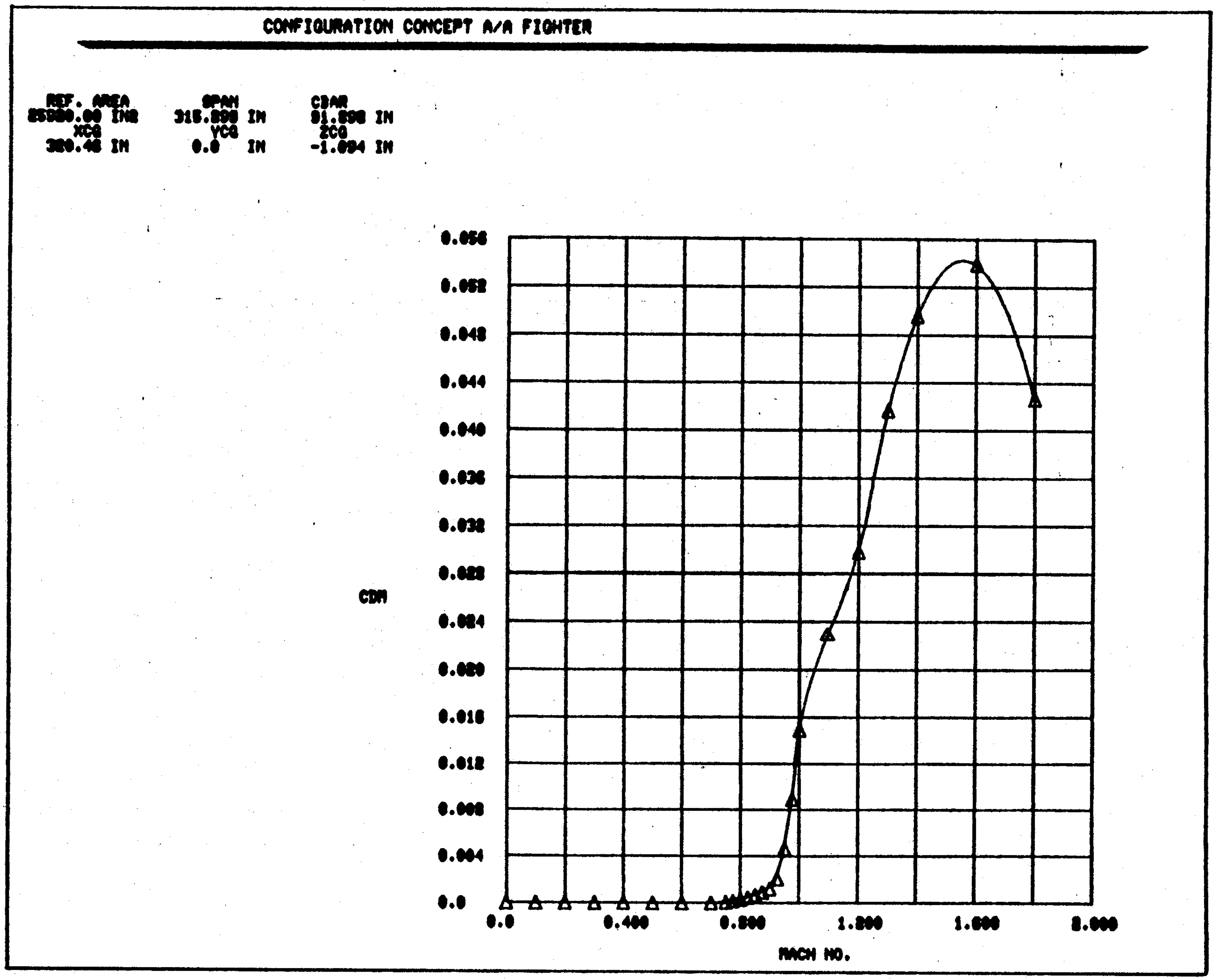
VISCOUS DRAG
WAVE DRAG

MACH NUMBERS IN SOLUTION:
0.60 1.20 1.60 1.80

```
FORC**
cdm
```

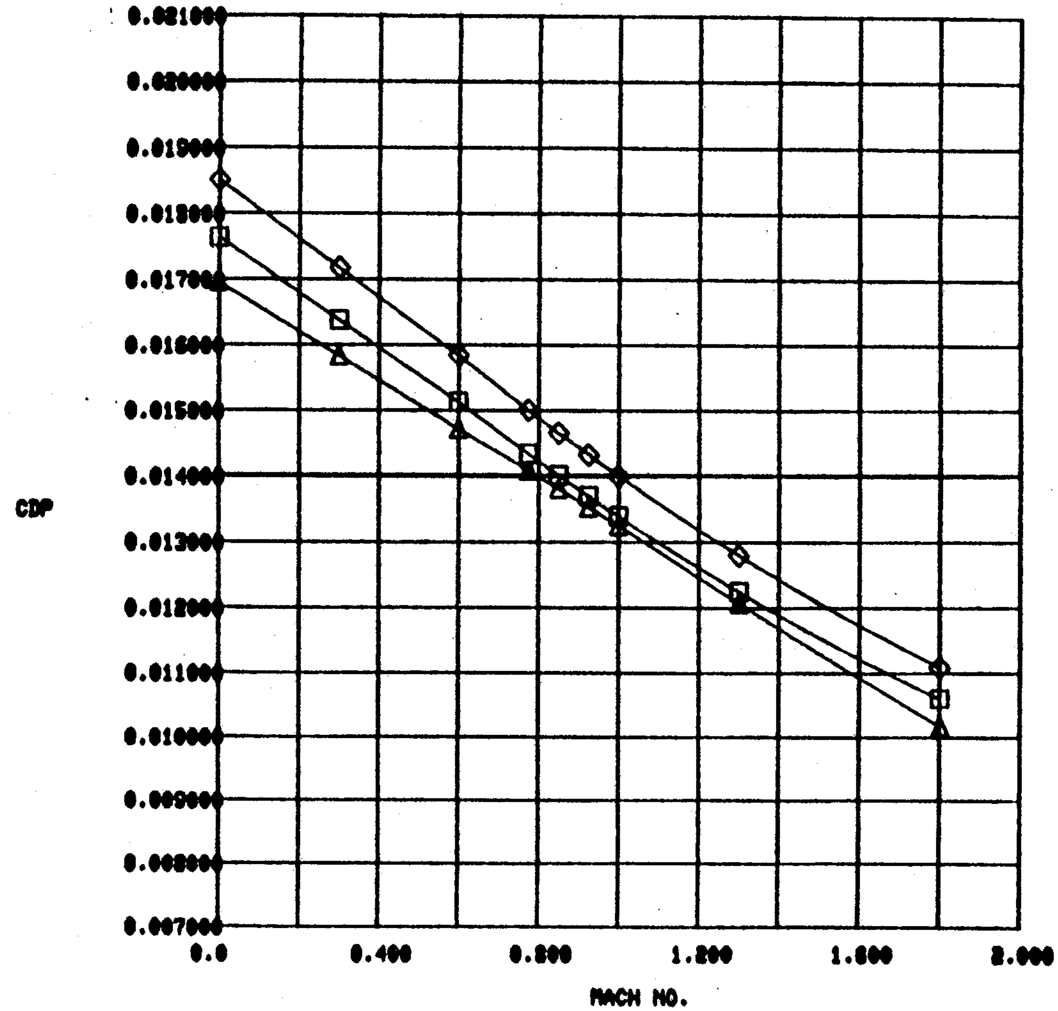
The keyword for FORCES is FORC**. The user selects one set of plots at a time and always returns to FORC**.

The user first selected wave drag versus Mach number, then viscous drag, which exhausted the solutions stored in the plot file.


CONFIGURATION CONCEPT A/A FIGHTER
REF. AREA
25980.00 IN2
SPAN
315.898 IN
CBAR
81.898 IN
XCG
380.46 IN
YCG
0.0 IN
ZCG
-1.094 IN
CDM
0.0
0.004
0.008
0.012
0.016
0.020
0.024
0.028
0.032
0.036
0.040
0.044
0.048
0.052
0.056
0.0
0.400
0.800
1.200
1.600
2.000
MACH NO.

CONFIGURATION CONCEPT A/A FIGHTER

REF. AREA	SPAN	CBAR
25920.00 IN2	315.899 IN	91.898 IN
XCG	YCG	ZCG
380.46 IN	0.0 IN	-1.094 IN



SYM	TEMP (R)	PRESS (LBS/FT2)
△	518.7	2116.2
□	483.0	1455.6
◇	447.4	973.3

SAND GRAIN HEIGHT:0.000022 FT.

```
FORC**
e
**OK**
time

WALL TIME :  31.44  CPU TIME :  33.80
DELTA WALL:  31.44  DELTA CPU:  33.80
**OK**
exit
```

The user ends FORCES returning to **OK** where he checks the elapsed time and CPU time since the session started and exists the program.

SESSION III

```
DISPOSITION OF PERM FILE (NEW/OLD):
old
DISPOSITION OF PLOT FILE (NEW/OLD):
old
**OK**
files
FILE: PERM
REC    COMP NO.     NAME                TYPE

  1     100.00     FOR FUSELAGE           1
  2     101.00     AFT FUSE               1
  3     103.00     NACELLE                1
  4     200.00     INBD WING              4
  5     201.00     OUTBD WING             4
  6     300.00     LOWER TIP FIN          3
  7     301.00     UPPER TIP FIN          3
  8     400.00     LOWER VERT             3
  9     401.00     UPPER VERT             3
 10     500.00     VERT PYLON             2
 11     600.00     CANARD                 4
 12     700.00     FOR INTE SHELL         5
 13     702.00     AFT INTE SHELL         5
 14     900.00     JET FLAP               6
 15     701.00     SLENDER BODY           7
 16     800.00     INBD WING PANELE       4
 17     801.00     OUTBD WING PANEL       4
**OK**
atta 6 7 8 9 11 12 13 15 16 17
**OK**
files,l
FILE: WORK
REC    COMP NO.     NAME                TYPE

  1     300.00     LOWER TIP FIN          3
  2     301.00     UPPER TIP FIN          3
  3     400.00     LOWER VERT             3
  4     401.00     UPPER VERT             3
  5     600.00     CANARD                 4
  6     700.00     FOR INTE SHELL         5
  7     702.00     AFT INTE SHELL         5
  8     701.00     SLENDER BODY           7
  9     800.00     INBD WING PANELE       4
 10     801.00     OUTBD WING PANEL       4
**OK**
```

In this session the user is executing with the old permanent and plot files in order to do a lifting surface set-up.

The user lists the components in the permanent file then attaches the components he wishes to use for his analysis. Note that sometime between this session and the previous on the user edited the two wing components (200.00, 201.00) in this case repaneling the fine chordwise definition into one more reasonable for the lifting surface solution. The edited wing component were then saved as 800.00 and 801.00 respectively.

```
**OK**
analy
MY RECORDS SHOW THE FOLLOWING CALCULATIONS:
 WAVEDRAG

AGAINST MACH NUMBERS:
    0.60      1.20
ANALY**
lift
ANALY**
c
* REFERENCE QUANTITIES:
  SREF       SPAN       CBAR       XCG       YCG       ZCG
 25920.00   315.899    91.898   320.459     0.0      -1.094
* ENTER 1 TO CHANGE * 0 TO LEAVE ALONE
?
0
```

The user enters ANALYSIS and is told the previous solutions (Wave Drag) and the Mach numbers used (0.6, 1.2).

The user elects to retain the same Mach numbers and asks for the lifting set up then goes into ANALYSIS program calculation (c).

```
* CALCULATE  LIFTING  MATRIX  * 1 YES * 0 NO:1
* CALCULATE  THICKNESS MATRIX * 1 YES * 0 NO:0



* ENTER 3 DRAG CALC. ANGLES

?
1 5 10

     * INITIAL COMPONENT INCIDENCE ANGLE *
* INPUT WHEN CURSOR STOPS UNDER INITIAL DEFLECTION *

  COMP. NO.     COMP. NAME     INITIAL DEFLECTION

     1      AFT INTE SHELL           0.0
     2      UPPER TIP FIN            0.0
     3       UPPER VERT              0.0
     4       CANARD                  0.0
     5       OUTBD WING PANEL        0.0
```

The lifting set up is a set of numerical answers to questions posed by the computer and is organized to provide the user with a record of his input.

The graphics cursor appears at the end of the set up to give the user a chance to review his input for correctness and take a copy if he wishes.

```
NORMAL JOB COMPLETION
COMMAND- purge,tape1
COMMAND- purge,tape3
COMMAND- catalog,tape1,geometry,id=$$$$$$,rp=999,cn=open,ex=file.
 NEW CYCLE CATALOG,CY=001
COMMAND- catalog,tape3,plotfile,id=$$$$$$,rp=999,cn=open,ex=file.
 NEW CYCLE CATALOG,CY=001
COMMAND- catalog,tape11,panelfile,id=$$$$$$,rp=999.
 NEW CYCLE CATALOG,CY=001
COMMAND- logout
```

Following job completion the user replaces the old permanent geometry and plot files with the updated files by first purging the old files and then cataloging them again as new files. Some CDC facilities do not operate with this type of file management system and different methodologies for updating the Mass Storage files used in TAPE1 and TAPE3 will be required.

The user can submit a batch job to run the slender body and lifting surface solutions using the data listing on the following figure.

```
1ØØ=PEDAK,T2ØØ,IO2ØØ,CM12ØØØØ,P4.
11Ø=ACCT(DIVAN      ØØ184224Ø1*Ø111Ø13)
12Ø=REQUEST,TAPE15,*PF.
13Ø=REQUEST,TAPE6,*PF.
14Ø=ATTACH,TAPE4,PANELFILE,ID=DØ5ØØ.
15Ø=ATTACH,SLEN,SLENLOAD,ID=DØ5ØØ.
16Ø=MODE,Ø.
17Ø=ATTACH,TAPE2,SCIFFGEOM,ID=DØ5ØØ.
18Ø=REWIND,SLEN.
19Ø=SLEN.
2ØØ=RETURN,SLEN,TAPE4,TAPE2.
21Ø=ATTACH,TAPE7,PANELFILE,ID=DØ5ØØ.
22Ø=ATTACH,TAPE14,PLOTFILE,ID=DØ5ØØ.
23Ø=ATTACH,UDP,UDPLOAD,ID=DØ5ØØ.
24Ø=REWIND,UDP.
25Ø=UDP.
26Ø=RETURN,TAPE9,TAPE1Ø,TAPE11,TAPE12,TAPE13.
27Ø=CATALOG,TAPE6,UDPOUTPUT,ID=DØ5ØØ,RP=2Ø.
28Ø=CATALOG,TAPE15,WAVEIN,ID=DØ5ØØ,RP=2Ø.
29Ø=CATALOG,TAPE14,PLOTFILE,ID=DØ5ØØ,RP=2Ø.
3ØØ=EXIT.
31Ø=DISPOSE,TAPE6,PR=IAJ.
```

The listing shown here was designed to execute the slender body solution then the lifting surface solution. If no slender body is present the slender body program automatically stops and goes directly to the lifting solution so this one control listing will perform all the necesary solutions.

The output products of the program execution's are, a detailed listing of program output (UDPOUTPUT on line 270), the wave drag due to lift pressure data file (WAVEIN) on line 280) and the updated plot file (PLOTFILE on line 290).

```
**OK**
titl

OLD TITLE:
D585-24 TRAINER CONFIGURATION
ENTER NEW TITLE
l-p
**OK**
anal
MY RECORDS SHOW THE FOLLOWING CALCULATIONS:
 LIFTING
 WAVEDRAG
 ISO BODY

AGAINST MACH NUMBERS:
    0.50      0.80
ANALY**
e
**OK**
forces
```

In this example the user is already into his session when he decides to investigate the solutions already present in the plot file, in this case for a single engine trainer concept.

By enter ANALYSIS he finds that solutions exist for lifting surface, wave drag and that the isolated body solution was run with the lifting surface. By executing wave drag the user includes the transonic drag rise equations in his total drag solution.

The user exits from ANALYSIS and enters FORCES to see displays of stability derivatives and drag. The next figure shows the summary sheet which is always displayed at the start of the FORCES function.

D685-24 TRAINER CONFIGURATION

REF. AREA	SPAN	CBAR
14400.00 FT2	300.0000 IN	50.939
XCG	YCG	ZCG
121.00 IN.	0.0 IN	-28.640

DEFLECTING SURFACES
DS: SYMMETRIC DA: ANTI-SYMMETRIC

HORIZONTAL	DS1
VERTICAL	DA2

TRIMMING FLAP: DS1

MACH NUMBERS INTERPOLATED:
0.0 0.10 0.20 0.30 0.40 0.50 0.60 0.70
0.75 0.77 0.80

MDD (IF APPLICABLE): 0.900

SOLUTIONS WHICH ARE AVAILABLE:

WAVE DRAG
LIFTING SURFACE

MACH NUMBERS IN SOLUTION:
0.50 0.80

FORC**
cmcl,cla,cma

The keyword for the FORCES function is

FORC**

The user requests displays of

dC_m/dC_L

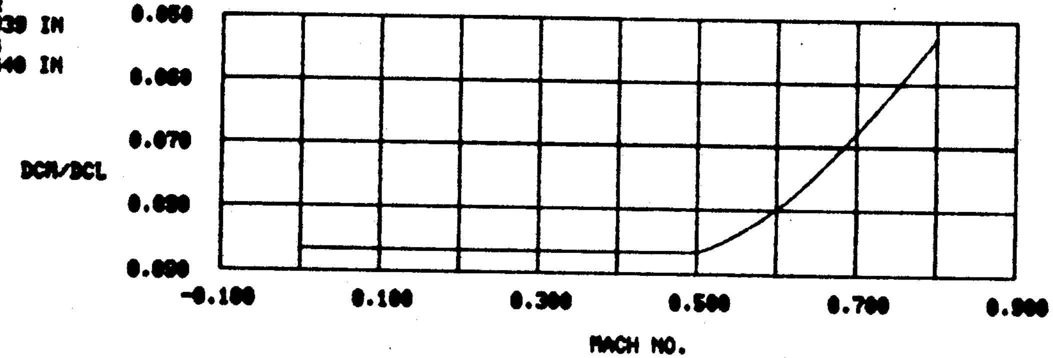
C_{L_α}

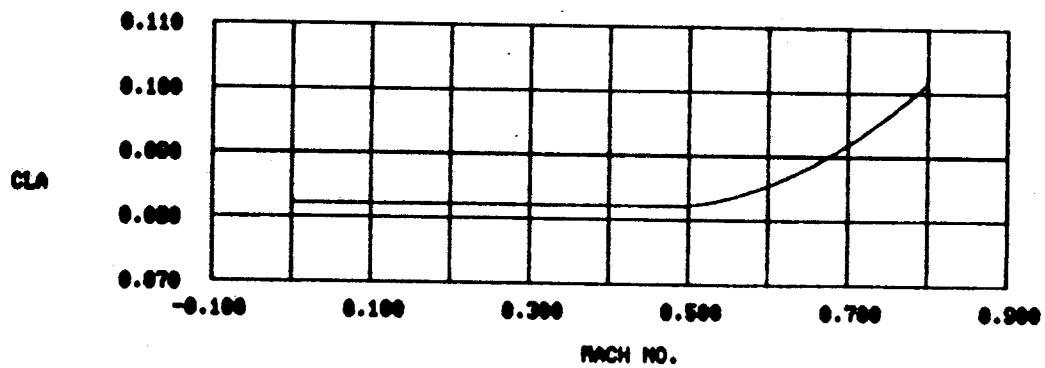
C_{m_α}

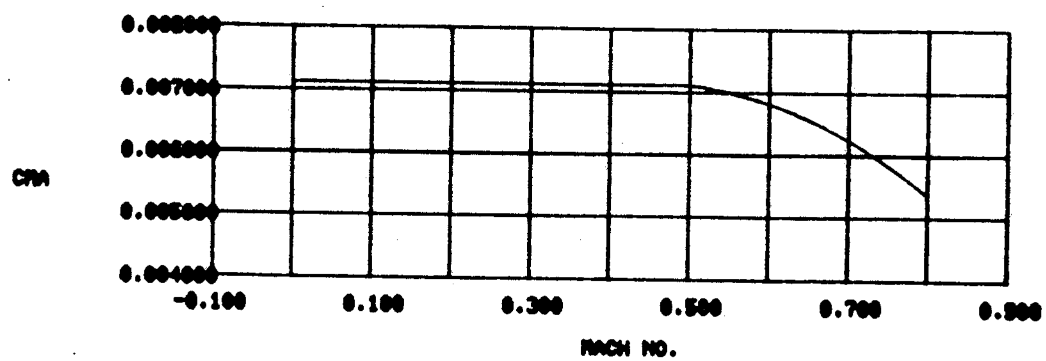
All of which will be displayed versus Mach number, shown in the following figure.

D585-24 TRAINER CONFIGURATION

REF. AREA	SPAN	CBAR
14400.00 IN2	300.000 IN	50.930 IN
XCG	YCG	ZCG
121.00 IN	0.0 IN	-26.640 IN

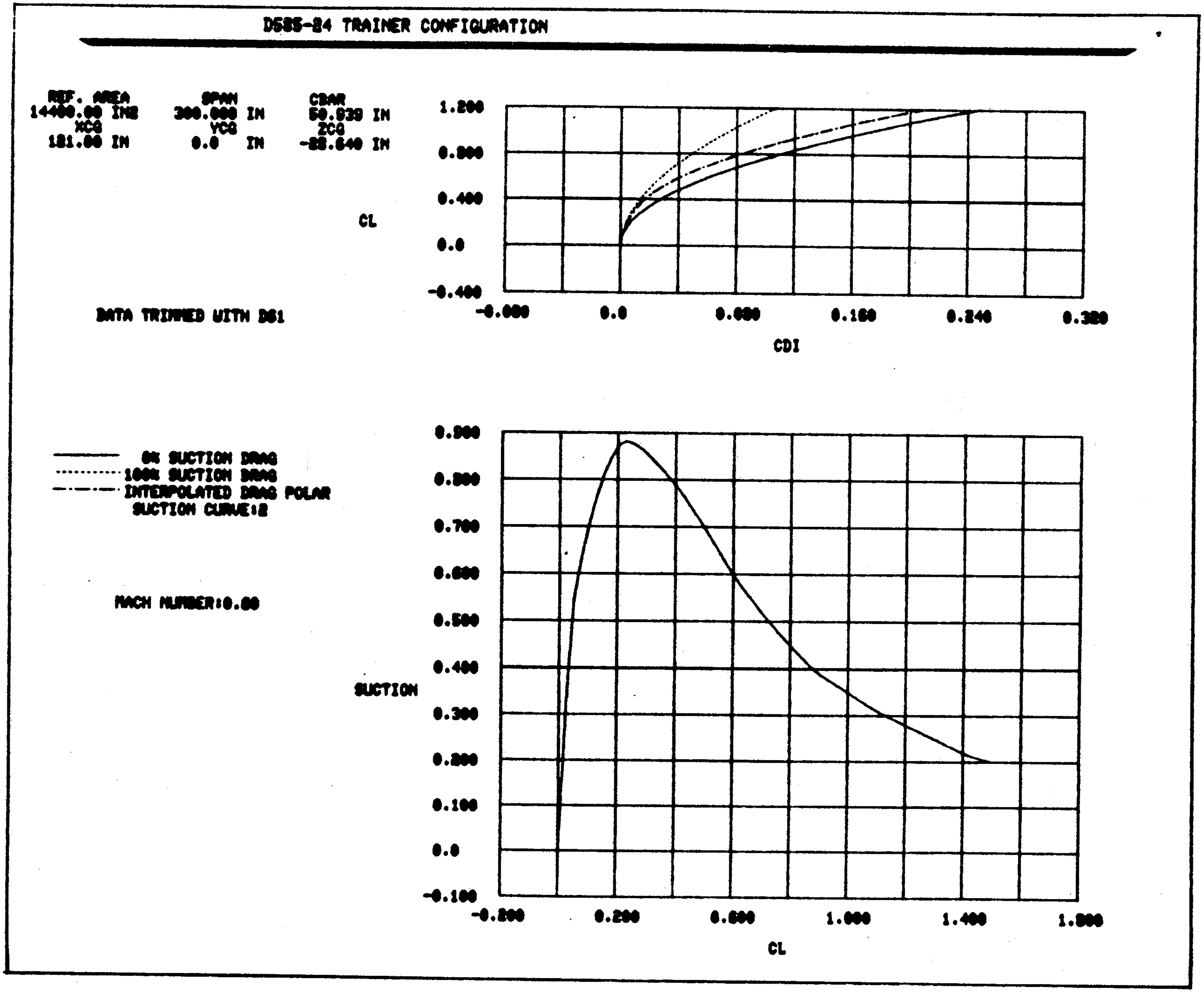






```
FORCXX
cdi2,m=0.6
```

The user now requests a display of induced drag versus lift for 0.60 Mach number and the second suction variation stored in the Program (Cdi 2)


D585-24 TRAINER CONFIGURATION
REF. AREA 14400.00 IN2
XCG 181.00 IN
SPAN 300.000 IN
YCG 0.0 IN
CBAR 50.939 IN
ZCG -88.640 IN
CL
1.200
0.800
0.400
0.0
-0.400
-0.080
0.0
0.080
0.160
0.240
0.320
CDI
DATA TRIMMED WITH DS1
0% SUCTION DRAG
100% SUCTION DRAG
INTERPOLATED DRAG POLAR
SUCTION CURVE:2
MACH NUMBER:0.80
SUCTION
0.900
0.800
0.700
0.600
0.500
0.400
0.300
0.200
0.100
0.0
-0.100
-0.200
0.200
0.600
1.000
1.400
1.800
CL

APPENDIX IV

SYSTEM SUBROUTINE DESCRIPTIONS

ANALY: Set-up and executive to ANALYSIS function. Interprets user inputs,then schedules analysis programs or set-up program for sequential execution.

AREA, AREAS,AREAW: Similar routines designed to determined cross sectional cuts for selected Mach angles and roll angles. AREA and AREAS are preset to Mach = 1.0, ROLL = 0.0 degrees.

COD,CODIM: Second order curve fit routines which appear in different segments of the program structure.

CPLOT: Provides a simple unlabeled ordinate versus abscissa plot for specified number of input points

CPPR: Set up for spanwise and chordwise plots. Sums combinations of user input parameters (α, β, P, Q, R, etc) and display chordwise or spanwise loads for those conditions. Also displays twist, camber and thickness distributions.

CPWING: Summing routine called by CPPR to calculate chordwise increments.

DECRD: Card image numerical processing routine. Interprets card image values for correctness and fills input array leaving blank locations unchanged.

DIGIT: Digitizing routine for cross-sectional input. Builds new components with sequential sections or re-digitizes old components with arbitrarily ordered sections.

DISP: Orthographic projection of two or more components in a file.

DISPS: Orthographic projection of single component. Also displays pertinent data for component and allows adjustment of longitudinal display lines.

DQWS: Calculates total wave drag for input configuration, prints out result, and stores total drag coefficient.

EDITN: Body component visual editor. Displays component to be edited and uses graphics cursor to edit component.

EDITP: Surface component visual editor. Functions as spanwise editor and is used for paneling components for lifting surface solutions. Principle method of entry is graphics cursor.

EDPUT: Executive routine for LIST function. Interprets alphanumerics so LIST can perform the indicated function.

EMLORD: Calculates Eminton-Lord isolated body optimum area distribution at selected output stations.

FIT: Checks input curves for breaks and splines or least squares individual segments.

FITWT: Least squares curve fitting routine designed with fixed endpoints and special polynomial leading edge fit for airfoils with leading edge radius.

FORCE: Set-up for total coefficient and drag coefficient display.

FOREX: Executive for FORCE, interprets user inputs into commands and numerical values.

GETPNT: Modified Tektronix routine for inputing a point off the digitizing tablet.

GEOEX: Principle executive interpreter. Reduces alphanumeric and numeric inputs into control numerics for MAIN program execution.

GREEK: Produces graphical constructions of Λ, Γ and λ for TYPE 3 and 4 title block under DISPS.

GRID: Provides five standard grids and numbering used under subroutine PLOTIT

HSHLDR: Linear least square equation solution routine.

ICON: Simple geometry menu sub-program. Request numerical inputs, then routes program to routines designed to interpret request.

IDATA: Viscous drag input-menu sub-program. Request data for cases and completes geometric definition for viscous solution.

INFO: Calculates and displays component data out of DISPS.

INSTR1: Menu display for EDIT functions.

INSTR2: Menu display for INTERFERENCE and THREE-VIEW functions

INTERF: Graphical input of interference shells and jet flaps using graphics cursors.

LABEL, LABEL7: Label subroutines for plots from LOAD and FORCE functions respectively.

LIMIT, LIMITS, LIMITW: Calculates component limits needed for subroutines AREA, AREAS, and AREAW respectively.

LIST: Cross section and keyboard editing routine. Display true view of cross sections and/or point listing.

LSET: Converts surface components into panel description. Ques user for flap data, and initial data concerning lifting surface solutions.

MATRIX: Sets up boundary conditions and solves EMLORD coefficients.

MAXIT: Determines parametric minimums and maximums under subroutine PLOTIT.

MULPNT: Combines with GETPNT for multiple point digitizing from tablet.

ORIG: Places a graphical square at specified points on the screen.

PLEXC: Executive interpreter for CPPR subroutine.

PLOTIT: Graphical plot routine for LOADS and FORCES function. Will plot data on five grids. Axis names have been pre-set in the routine.

PLOTOT: Simple display of planar components for EDIT function.

SAVEB: Interprets and curve fits digitized data from subroutine DIGIT. Prompts user for necessary information.

SCALIT: Selects scaling values used is subroutine PLOTIT.

SDQ: Calculates wave drag for single roll angle.

SECT: Utility routine for section deleting and interpolation; all component types.

SHEET: Displays the title sheet at the initiation of FORCES function.

SHIFT,SHIFTS,SHIFTW: Reorganizes points in cross section cuts made by AREA, AREAS, and AREAW for proper integraion.

SLEND: Routine which combines body components to form one slender body.

SPLINE: Third order open ended spline routine, used as principle routine for section fitting, curve integrations and differentiation.

SYMM,SYM: Symbol making routines used in various sections of program.

TABARM: Turns terminal control from the keyboard to the tablet.

TABINT: Initializes tablet variables for tablet input.

TABOFF: Turns off digital tablet control.

TLU: Linear interpolation routine used in viscous flow solutions.

TOTAL: Interprets output from analysis programs, adds empirical data where necessary, and stores the results.

TRANS: Inputs component translations from keyboard or graphics cursors, then translates components.

TRAP: Calculates simple wing geometry and sets up data to be converted to component geometry formats.

VDRAG: Viscous drag set-up routine.

VIEW3: Three view projection routine used for three views and interference shells.

WCAD: Card image component interpreter.

WDRAG : Main set-up routine for wave drag calculation.

WET: Calculates wetted area and volume for components in viscous drag routines.

WSVP: Viscous drag solution routine. Uses data from subroutine.
IDATA. Prints and stores answers.

XACALW: Computes minimums and maximums for combined components in wave drag.

XYZ,XYZR: Routines to re-organize component description from one form to another similar more descriptive form. XYZ converts card data to the component descriptions, XYZR changes geometry for wave drag calculations.