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User's Manual for the Automated Paneling Technique (APT) and the Wing Body Aerodynamic Technique (WABAT) Programs

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USER'S MANUAL FOR THE
AUTOMATED PANELING TECHNIQUE (APT)
AND THE
WING BODY AERODYNAMIC TECHNIQUE (WABAT)
PROGRAMS

By: R. E. Studwell

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SUMMARY

This manual contains user instructions for the Tektronix Graphics Package of the Automated Paneling Technique (APT) and the Wing and Body Aerodynamic Technique (WABAT) Programs.

This manual describes responses to plot package messages which the user must make to activate plot package operations and options.

Modifications to the APT and WABAT input run streams, to affect the graphic interface, are also covered.

INTRODUCTION*

The Automated Paneling Technique (APT) program is a program which generates a series of panels for describing a rotorcraft airframe and/or wing. These panels are described in terms of X, Y, Z coordinates of panel corner points for a user specified axis system.

These panel data are then used as input for the wing and body aerodynamic technique (WABAT) program (Ref. 2) which, through a potential flow analysis, computes the airframe induced flow effects on the helicopter main rotor system.

The major input to the WABAT program is the airframe description data (panels). Although the APT program generates these panel data, the verification of the APT output, prior to a WABAT analysis, confronts the user with a formidable task. To help minimize this effort, a graphics package has been developed which will graphically depict the airframe panel data. The user can readily establish the acceptability of these for WABAT application from these pictorial views.

To aid the aerodynamicist and the designer in establishing 'clean' airframe shapes, especially at intersection points, this graphics package has the capability to superimpose on each panel the relative magnitude and direction of the local velocity fields. Although these velocity vectors are based on a potential flow analysis, without flow separation, approximate effects of shape changes on the flow field can be readily established from the graphic output.

To affect the interface between the APT, WABAT and graphics package, minor modifications to the input data requirements for the APT and WABAT programs had to be made. This report covers the revised input requirements of these programs along with the operating instructions of the graphics package.

*The research effort which lead to the results in this report was financially supported by the Structures Laboratory, USARTL, (AVRADCOM).

REVISED APT INPUT INSTRUCTIONS

The procedures for using the APT program described in Appendix A of Reference 1 have been modified. These modifications were required to provide a logical interface with the updated graphics package and direct linking, through output files, with the potential flow program (WABAT).

To avoid confusion in using this modified version, the input data requirements are reproduced in their entirety.

DESCRIPTION OF INPUT - (UNIT 10)

CARD NO.	COLUMNS	SYMBOL	DESCRIPTION
1	1-4	TYPE	Alphanumeric input of surface type. NL,N-non lifting, non symetrical NL,S-non lifting, symetrical L,S-lifting, symetrical END-end of data set.
	5-72		Any alphanumeric descriptive title.
2	1-10	XSC	X axis offset inches
	11-20	YSC	Y axis offset inches
	21-30	ZSC	Z axis offset inches
	31-40	XROT	X axis rotation degrees
	41-50	YROT	Y axis rotation degrees
			These inputs allow the user to describe a particular component in its own axis system and then translate and/or rotate this component into the airframe axis system. If translations or rotations are not required, a blank card must be used.
3	8-14	BLAST	Enter the location of the last input cross section for this body. The program accounts for a zero off-set in the "Z" direction so that actual body station values may be used.
	15-21	DSMN	Enter the minimum increment length acceptable for this body. This value is subject to change by later input, inches.

	22-28	DSMX	Enter maximum increment length acceptable for this body. This value is subject to change by later input and/or program requirements, inches.
	29-35	EF	By entering any number the user may expand or contract the input coordinates by the value of the number entered.
	36-42	XOVR	Any number in this location will override the maximum increment length criteria based on the separation distance of opposing increments.
4	1- 6	CTRANS	If no coordinate rotation option is required, enter "Z to Z". If a rotation is required, enter: "X to Z" - cross sections will be input at constant "X" locations from maximum to minimum values. "Y to Z" - cross sections will be input at constant "Y" locations from maximum to minimum values.

The preceeding cards are required for <u>every body shape</u> to be generated. The following cards are required for <u>every cross section input</u> location. The card number will be preceeded by "IS" to indicate they are required for each input cross-section.

<u>CARD NO.</u>	<u>COLUMNS</u>	<u>SYMBOL</u>	<u>DESCRIPTION</u>
IS 1	1- 3		Enter BS* to indicate the start of a new body station.
	8-14		Enter the body station at which the cross section to be described is located.
	15-21		Enter the number of segments used to describe the cross section. If the inputs for this BS are identical to the previous station, a zero should be entered. No segment inputs are required in this case.

22-28	DBS	Enter the number of body stations desired to be interpolated between the previously input station and this station.
29-35	DSMNC	If a change in the minimum surface distance is desired, enter the new DSMN. This change affects this input station and all succeeding stations.
36-42	DSMXC	If a change in the maximum surface distance is desired, enter the new DSMX. This change affects this input station and all succeeding stations.

One card is required to identify each segment used in describing the total cross section. The total number of "segment cards" should equal the value entered in columns 15 - 21 on card IS 1 (SEG). If this value is zero, the inputs are assumed identical to the previous segment inputs and no segment cards are required.

The segment cards have the following format:

CARD NO.	COLUMNS	SYMBOL	DESCRIPTION
SEG	1- 3		Enter the number of the segment. The segments should be numbered counter-clockwise from top to bottom.
SEG	5	NTYP	Enter the number designating the type of segment to be used. 0 - single point 1 - straight line 2 - circle 3 - super-ellipse (See Figure 3)
	8-14	X1	X1
	15-21	Y1	Y1
	22-28	X2	X2
	29-35	Y2	Y2

36-42	X3	X3 - If a specific number of increments are desired for a straight line segment, enter the number desired.
43-49	Y3	Y3
50-56	X4	X4
57-63	Y4	Y4
64-70	X5	X5
71-77	Y5	Y5
78-80	MREQ	A <u>negative</u> <u>integer</u> entered will cause the length of the first increment of that segment to approximate the product of the integer and the minimum surface distance specified.

A <u>positive</u> <u>integer</u> entered will cause the last increment of that segment to approximate the product of the integer and the minimum surface distance specified.

If the segment is specified as circular only a positive value is allowed and the segment is divided into the integer number of increments.

The required cards for the next body station follow the last segment card. If the body station entered is equal to the previous body station, the program assumes that the body station has been described by two different cross sections and the panels normal to the axis will be required at that station.

An "END" (Columns 1 - 3) card should be placed after the last inputs for each shape to be generated.

A typical input setup for running the APT program is shown below. The graphical output for these input data is shown in Figure 1. Note, that to fully define the total object, several input data sets, defining the individual sections, may be required. These individual sections must each be complete. Stacking of these data on Unit 10 (input unit) is permissible.

```
NL,S       APT-PLOT CHECKOUT CASE.
   0.0        0.0        0.0          0.0         0.0
        50.00  1.0        7.5             10.0
ZTOZ
BS1      19.0     1.0      0.0
 1 0     0.0      67.5
BS2      22.0     2.0      0.0
 1 3     -1.0     72.6      0.0    72.6      8.7     70.6     11.1     67.4     11.1     65.4
 2 3     11.1     68.4     11.1    67.4      9.2     64.4      0.0     62.4     -1.0     62.4
BS3      30.0     2.0      0.0
 1 3     -1.0     77.000   0.0     77.000    13.8    75.2     19.90    67.7     19.90    65.7
 2 3     19.90    69.70    19.90   67.70     14.90   60.85    0.0      58.80    -1.0     58.80
BS4      40.0     2.0      0.0
 1 3     -1.0     81.10    0.0     81.10     16.00   79.75    25.80    67.90    25.80    66.90
 2 3     25.80    68.90    25.80   67.90     20.00   58.90    0.0      55.950   -1.0     55.950
BS5      50.0     2.0      0.0
 1 3     -1.0     84.55    0.0     84.55     19.40   82.80    29.80    68.60    29.80    67.60
 2 3     29.80    69.60    29.80   68.60     24.90   58.30    0.0      54.00    -1.0     54.0
END
NL,S       APT-PLOT CHECKOUT CASE.   SECTION 2
   0.0        0.0        0.0          0.0         0.0
        200.0   1.0        7.5             10.0
ZTOZ
BS1      50.0     2.0      0.0
 1 3     -1.0     84.55    0.0     84.55     19.40   82.80    29.80    68.60    29.80    67.60
 2 3     29.80    69.60    29.80   68.60     24.90   58.30    0.0      54.00    -1.0     54.0
BS2      200.0    2.0      0.0
 1 3     -1.0     84.55    0.0     84.55     19.40   82.80    29.80    68.60    29.80    67.60
 2 3     29.80    69.60    29.80   68.60     24.90   58.30    0.0      54.00    -1.0     54.0
END
NL,S       APT-PLOT CHECKOUT CASE.   SECTION 3
   0.0        0.0        0.0          0.0         0.0
        231.00  1.0        7.5             10.0
ZTOZ
BS1      200.     2.0      0.0
 1 3     -1.0     84.55    0.0     84.55     19.40   82.80    29.80    68.60    29.80    67.60
 2 3     29.80    69.50    29.80   68.60     24.90   58.30    0.0      54.00    -1.0     54.0
BS2      210.0    2.0      0.0
 1 3     -1.0     81.10    0.0     81.10     16.00   79.75    25.80    67.90    25.80    66.90
 2 3     25.80    68.90    25.80   67.90     20.00   58.90    0.0      55.950   -1.0     55.950
BS3      220.0    2.0      0.0
 1 3     -1.0     77.000   0.0     77.000    13.8    75.2     19.90    67.7     19.90    65.7
 2 3     19.90    69.70    19.90   67.70     14.90   60.85    0.0      58.80    -1.0     58.80
BS4      228.0    2.0      0.0
 1 3     -1.0     72.6      0.0    72.6      8.7     70.6     11.1     67.4     11.1     65.4
 2 3     11.1     68.4     11.1    67.4      9.2     64.4      0.0     62.4     -1.0     62.4
BS5      231.0    1.0      0.0
 1 0     0.0      67.5
END
   0
```

APT-PLOT CHECKOUT CASE.

PITCH -20 ROLL -25 YAW 45
ELEVATION ANGLE FROM OBS.POS. 0.0 DEG

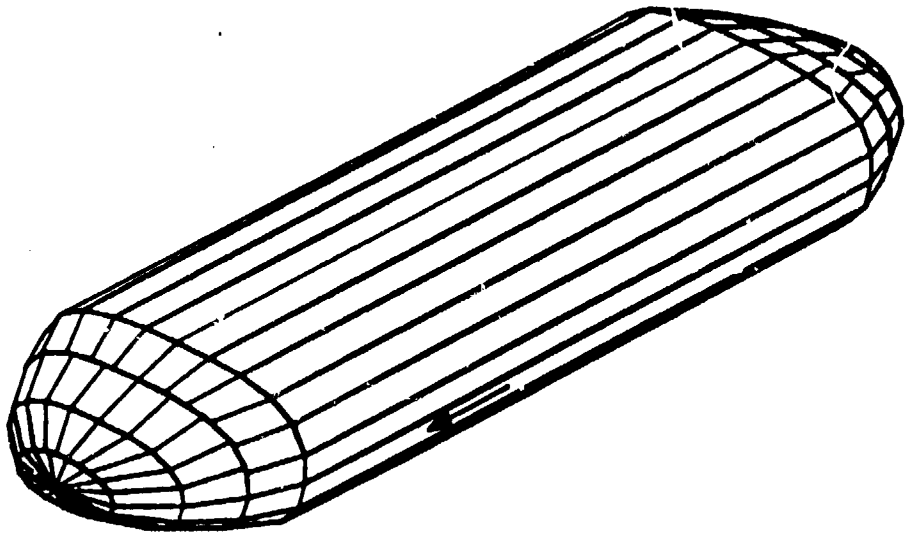


FIGURE 1

APT FILE REQUIREMENTS

Five files are required to operate the APT program. These files must be allocated as follows.

File 5 - Terminal Keyboard

File 6 - Terminal Screen

File 10 - Input Data Set

File 11 - Output Printer

File 16 - A read-write storeage file for storing the configuration data. These data are subsequently used for WABAT applications.

The analysis methods and axis system used for generating these shapes are covered in Reference 1.

REVISED WABAT INPUT INSTRUCTIONS

The procedures for using the WABAT program, described in Appendix A of Reference 2, have been modified. These modifications were required to create a logical interface between the APT, Graphic and WAPAT programs. The modifications to the input instructions primarily pertain to the input data cards. To avoid confusion in using this modified version, the input data requirements are described in their entirety.

The input requirements are broken down into card sets. This was done as certain cards and/or card sets may not be required depending on the program options selected.

CARD SET 1 (CS1)

This card set is required for every program execution.

CARD	COLUMNS	SYMBOL	DESCRIPTION
1	1-72	TITLE	Any alphanumeric title.
2	1-10	REFA	Desired reference area for force and moment coefficients.
	11-20	REFL	Desired reference length for moment coefficients, inches.
3	1-10	ALPHA	Angle of attack, deg (positive nose up)
	11-20	BETA	Angle of yaw, deg (positive nose right).
4	5	MONLY	1 - Perform Multhopp Analysis only 0 - Perform total analysis
	10	MPRNT	1 - Printer plots of Multhopp analyses requested. 2 - Plots and Multhopp influence coefficients requested. 0 - Neither requested.
	15	NGPRNT	1 - Panel unit vectors printed 2 - Panel coordinates in panel system printed. 0 - Neither printed.

CARD	COLUMNS	SYMBOL	DESCRIPTION
	20	NPRNT	1 - Solution matrix and constant matrix printed. 2 - Panel influence coefficient matrix printed for panels NCM1 to NCM2. 0 - Neither printed
	21-25	NCM1	(See above)
	26-30	NCM2	(See above)
	35	MPRNT2	1 - Multhopp loading functions printed. 2 - Multhopp wing geometry printed. 3 - Wing camber computations printed 4 - Full Multhopp influence coefficient matrix printed 0 - No additional printout
5	5	NSAV1	0 - Do not file geometry data -1 - Geometry data not on file - initiate file write of geometry data (This feature is used to store various geometric characteristics to avoid time-consuming computations if subsequent runs are anticipated for this shape). 1 - Geometry data on file - geometry data is to be read from file.
	10	NSAV2	0 - Do not file solution -1- Solutions to various flow conditions are not on file - initiate file write of solution. 1 - Solutions for various flow conditions are on file for required solution - calculate solution and write on file if solution is not currently on file.

The panel coordinate cards, described as cards 6-10 in Reference 2 are not required in this program version. These data are contained on file unit 16.

The following cards are input after the cards described previously. Since these cards represent panel or point rotation options, they are preceded by an "R".

CARD	COLUMNS	SYMBOL	DESCRIPTION
R1	5	IR	Body section containing points or panels requiring a specific rotation. A zero is required to exit from this option.
	6-10	NR	Number of panels or points requiring rotation. (Integer-right justified.)
	11-20 21-30 31-40	XR YR ZR	Location about which panels or points should be rotated.
	41-50	RX	Angle in degrees which points or panels should be rotated about X axis.
	51-60	RZ	Angle in degrees which points or panels should be rotated about input Z axis.

If panel node points are to be rotated, repeat the following card for each panel required up to "NR".

CARD	COLUMNS	SYMBOL	DESCRIPTION
R2	1-5	NP	Panel number for which rotations are required. A zero will exit to card R3. (Integer-right justified.)
	6-10 11-15 16-20 21-25	NOD_1 NOD_2 NOD_3 NOD_4	Panel node points which should be rotated. (Integer-right justified.)

If specific points on the body are to be rotated, repeat the following card for each desired point.

CARD	COLUMNS	SYMBOL	DESCRIPTION
R3	1-10 11-20 21-30	A_1 B_1 C_1	(X, Y, Z) coordinates of point to be rotated, inches.

CARD	COLUMNS	SYMBOL	DESCRIPTION
	31-40 41-50 51-60	A_2 B_2 C_2	(X, Y, Z) coordinates of next point to be rotated. inches

The program will continue to read cards R1 through R3 until a zero value has been entered for IR on card R1.

Lifting section input (if required) follows the cards previously described. These cards are preceded by an "L" to designate that they are required only if the body contains lifting sections.

CARD	COLUMNS	SYMBOL	DESCRIPTION
L1	5	IV	Body section number requiring lifting section inputs.
	10	LV	Subsection 1 or 2.
	11-15	NSV	Number of trailing vortices for this subsection (enter zero for subsection 2 of symmetric section).
	16-20	NCV	Number of bound vortices for this subsection.
L2	8 fields (8F10.0)	AV	Spanwise positions of trailing vortices - entered outboard to inboard.
L3	8 fields (8F10.0)	BV	Chordwise positions of bound vortices - the last value designates the length of the trailing vortex. Entered from leading edge to trailing edge in percent chord.

The lifting section inputs must be repeated for each lifting section. Only card L1 is required for subsection 2 if the section is symmetric.

The following card(s) are input after the lifting section cards (if applicable). These cards are used to specify fluid ejection or suction for specific panels and will be preceded by an "F".

CARD	COLUMNS	SYMBOL	DESCRIPTION
F1	1-5	PNP	Panel number requiring fluid ejection or suction (Integer-right justified).
	6-15	PNV	Prescribed normal velocity for this panel entered as a ratio of free-stream velocity. Positive velocity is in direction of surface outward normal.

Card F1 may be repeated for a maximum of 50 panels. A zero value for PNP on card F1 is required to designate that no more panels require prescribed normal velocities.

CARD SET 2 (CS2)

CARD	COLUMNS	SYMBOL	DESCRIPTION
1	1-5(RJ)	M	Number of waterlines (Y = constant) along which surface pressures are to be calculated by interpolation between control points (Maximum 16).
1	6-10(RJ)	L	Number of bodylines along which surface pressures are to be calculated. (Range: 0°-360° unsymmetric, 0°-180° symmetric)
1	10-15(RJ)	NOB	Number of off-body points at which velocities are to be calculated. (Maximum 216). If the following option is used NOB represents the number of blade radial stations (Maximum 15).
1	16-20(RJ)	NPSI	Number of azimuth positions at which to calculate the normal, radial and tangential induced velocities at the rotor blade stations. NPSI = 360/ +1.

CARD	COLUMNS	SYMBOL	DESCRIPTION
1	25	KARD	7 - A harmonic analysis of the induced velocities will be performed. A file of the harmonics compatible with required programs will be generated. KARD must be requested on run card! 0 - No harmonic analysis.

CARD SET 3 (CS3)

If M = 0 on CS2, card set CS3 is not required.

CARD	COLUMNS	SYMBOL	DESCRIPTION
1	8F10.0	WL	Enter the waterline (Y value) along which surface pressures are desired (eight values per card), inches. CS3 is repeated until all waterlines are input.

CARD SET 4 (CS4)

If L = 0 on CS2 card set CS4 is not required.

CARD	COLUMNS	SYMBOL	DESCRIPTION
1	1-10	YWL	Enter the Y value from which the bodyline angles should be computed, inches.
2	8F10.0	BL	Enter the bodyline angles along which surface pressures are desired (eight values per card), degrees.

Repeat card 2 of CS4 until all bodyline angles are input.

CARD SET 5 (CS5)

If NOB = 0 or NPSI) CARD SET CS5 is not required.

CARD	COLUMNS	SYMBOL	DESCRIPTION
1	1-10	X	Coordinates of off-body point
	11-20	Y	at which velocities are
	21-30	Z	desired, inches.
			Repeat CS5 until the proper number of off-body points have been input.

CARD SET 6 (CS6)

If NPSI = 0 and NOB = 0 on CS2 the following card sets are required. If these are not required program continues to CS8.

CARD	COLUMNS	SYMBOL	DESCRIPTION
1	8F10.0	RAD	Nondimensional values for radial stations at which induced velocities are to be calculated. Entered from root to tip. (8 values per card)

CARD SET 7 (CS7)

1	1-10	XR	
	11-20	YR	Rotor hub center, inches
	21-30	ZR	
	31-40	RRT	Rotor radius in body input units, inches.
2	1-10	CONE	Rotor coning (degrees)
	11-20	ASG	Longitudinal shaft tilt (degrees)
	21-30	BSG	Lateral shaft tilt (degrees)
	31-40	ASF	Longitudinal flapping (degrees)
	41-50	BSF	Lateral flapping (degrees)
	1-10	XMU	Rotor advance ratio

CARD	COLUMNS	SYMBOL	DESCRIPTION
	11-20 21-30	AZ1 AZ2	Starting and ending azimuth positions for which induced velocities are desired, degrees. Azimuth increment determined by (AZ2-AZ1)/(NPSI - 1) where NPSI is input on CS2.

CARD SET 8 (CS8)

CARD	COLUMNS	SYMBOL	DESCRIPTION
1	1-4	ICAS	A card input of "STOP" will cause program to continue to CS9. Any other input will cause the program to revert to CS2 to calculate additional surface pressures required or off-body velocities.

CARD SET 9 (CS9)

CARD	COLUMNS	SYMBOL	DESCRIPTION
1	5	IALF	0 - Program will terminate 1 - A new flight condition is requested.
1	11-20	ALPHA	New Angle of attack, degrees
1	21-30	BETA	New angle of yaw, degrees

The WABAT program requires seven auxiliary tape or mass storage units. The units are referenced in the program as 7, 8, 9, 10, 11, 12, 15, and 17. The data stored on each unit are described below.

UNIT	DESCRIPTION
8,9,10	Influence coefficients for all panels and vortex lattice systems are stored on and re-read from these units. These are working storage units and are required for every job executed.
11	This unit is used to store the solution for various angles of attack and/or yaw. This unit is required only if NSAV2 on Card 5 of the input deck equals -1 or 1. If the body is to be analyzed in yawed flow a yawed flow condition should be used to initiate solution filing.

UNIT	DESCRIPTION
12	Unit 12 is used to store various geometric data required for the analysis such as panel unit vectors and panel coordinates in panel system. This unit is required only if NSAV1 on Card 5 is -1 or 1. (Note: if NSAV1 equals 0, the value of NSAV2 is irrelevant).
15	Harmonics of fuselage induced inflow at the rotor disk are written to this file. The format of the data is consistent with that required by the UTRC Prescribed Wake Rotor Inflow Analysis (see Reference 3).
16	Unit 16 contains the input configuration data. These data are generated by the APT program and stored on this unit.
17	This unit is used to store the calculated relative velocities, magnitude, direction and location for subsequent plotting. This unit must be allocated for each run and a different file name used for each case, if the data is to be retained.

Because of the user oriented way in which the panels are described, this aerodynamic technique requires a significant amount of storage. Consequently, only a total of 500 panels may be used to model a given body (250 if yawed flow is desired for a symmetric section). This total includes all surface panels and vortex lattice panels.

A typical input setup for the WABAT program is shown below. Graphical output for this test case is shown in Figure 2.

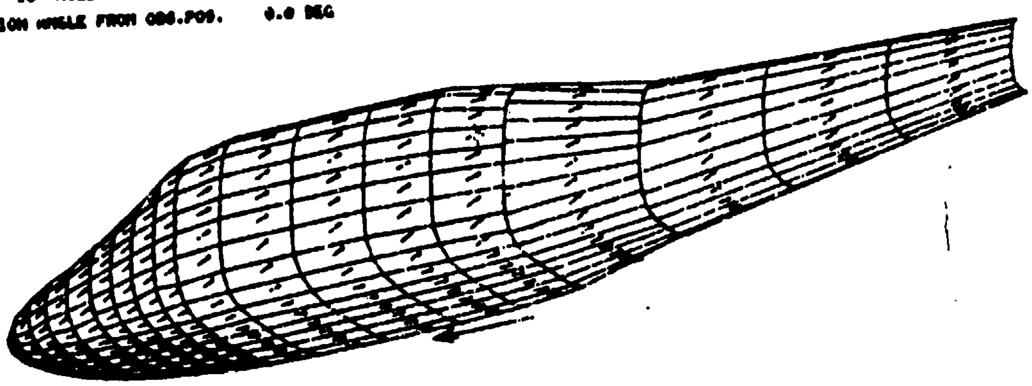
The details of the potential flow analysis are provided in Reference 2.

```
TYPICAL AIRFRAME
    144.0      12.0
    -4.15       0.0
  0
 -1    -1                                                                0000000
  0                                                                      0000000
  0                                                                      0000000
  0     0   15    13     7                                                
    0.092      0.162     0.241     0.350     0.450     0.528     0.590     0.655
    0.724      0.790     0.848     0.901     0.944     0.967     0.988
      0.0      157.0     200.0     264.0
    3.408      -2.00       0.0    -0.003     0.006
   0.3372        0.0     360.0
STOP
  0
```

FIGURE 2

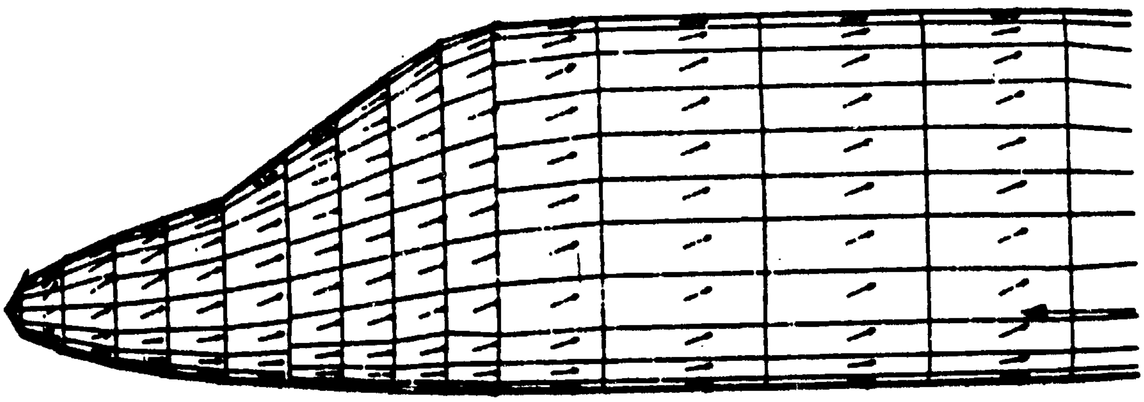
S-76 FUSELAGE W/O PYLON

PITCH -10 ROLL 30 YAW 120
ELEVATION ANGLE FROM OBS.POS. 0.0 DEG



S-76 FUSELAGE W/O PYLON

PITCH 0 ROLL 0 YAW 30
ELEVATION ANGLE FROM OBS.POS. 0.0 DEG



OPERATION OF GRAPHICS PACKAGE

The APT-WABAT Graphics Package is an interactive program. This program can only be run if an output file from an APT run or an input file for the APT program exists. If flow field data from the WABAT program is to be superimposed on the airframe, the WABAT output file, for the airframe in question, must also be available. This Graphics program was developed for application with Tektronix 4000 series storeage tube interfaces.

Being an interactive program, it is by necessity a conversational program. That is, the program will ask the user various questions as to what he wants to do. The resultant graphic output will depend on the responses the user provides.

At the outset, it should be pointed out that the response to all questions ending with a question mark (?) is Y for yes, return key for No. All digital inputs are in I1 format unless otherwise specified.

To understand the questions and inputs required, the various program operating paths are described below. Initial session program activation will cause the message 'clear screen hit return to continue' to appear several times. When this message appears, clear the screen then transmit the return key. After the plot package is activated all screen erasures become automatic.

Initially the program will request the program routing option. This will appear on the screen as:

SELECT OPTION

1. Calculate panels
2. Regenerate existing data
3. Terminate

CAUTION If you are adding to data on Unit 16, you must select Option 2 first.

The program has the capability to generate the panel data, using the APT program, on an interactive basis. The APT input data must be on a file to use this option. Assuming these data are available, the selection of Option 1, key in of 1, will activate APT and generate the panel data. As the caution message states, if panel data from previous runs have been stored on unit 16, the panel data file, Option 2 must be selected prior to Option 1. Failure to do so will cause the new panel data to overwrite and destroy the existing data on Unit 16.

Selection of Option 2 will provide a perspective view of the panel data stored on the panel file.

After the option is selected the program will solicit for the 'baud' rate. This input refers to the rate of data transmission between the computer main frame and the terminal device. For a baud rate of 1200 the rate of transmission is 120 bits/second (BPS) 2400 is 240 BPS, etc. This solicitation is displayed only once during a given session and it must be keyed in correctly in I4 format. Transmission of the wrong baud rate could adversely affect the graphic output. If it is keyed in incorrectly, the only recovery is to start execution over. Users are advised to determine the baud rate prior to program execution.

After the baud rate is transmitted the question 'include all lines?' will appear. The graphics package has basic hidden line capability. A 'No' response will only draw that portion of the data which is visible to the viewer from the vantage point selected, (normal viewing). If the user desires to see all the lines a 'yes', Y input, response is required.

The next question, 'draw one side only?' refers to how much of the body should be drawn. The APT panel data is generally generated for the right half of the section, from Buttock Line 0. If the user desires to see only the semi-section a response of yes would be input. Note that although the APT data is generated for the right body side, the transformations used in the graphics package will make it appear as the left body half. A no response will provide the user with a total body view.

The graphics package has been developed to provide the user with a perspective view of the data. To provide this the user must specify the vantage point desired. The following list is provided for the vantage point selection.

```
          PRESENT POSITIONS ARE..

     1..YAW ANGLE....     30.0       2..ROLL ANGLE....      0.0
     3..PITCH ANGLE..      0.0       4..SIGHT PLANE...10000.0
     5..SCALE FACTOR..     1.00      6..LONG. OFFSET..      0.0
     7..VERT. OFFSET.      0.0       8..ELEVATION ANGLE     0.0
     9..B.L. OFFSET..      0.0

          Key in index no. and value if change is desired

          I1 G12.5 FORMAT
     HIT RETURN TO CONTINUE
```

The yaw, roll and pitch selections refer to the airframe angles with respect to the design axis system. The sign convention used is:

Positive Yaw - Nose Right
Positive Roll - Right Bank
Positive Pitch - Nose Up

The sight plane distance, the distance between the viewer and object, has the same units as the data input and is always positive.

The program is designed to always maximize the drawing size to the view screen with a scale factor of 1. These drawings can be displayed at reduced or increased size by changing input 5. Note that if the scale factor is greater than 1, parts of the object could be truncated at the screen frame boundaries.

The longitudinal and vertical offset along with the elevation angle and buttock line offset, item 6, 7, 8 and 9 allow the user to shift the viewpoint position. The default view point is the origin of the design axis system (0, 0, 0). Since the total object is placed to the left and above the station and waterline design axis, left hand system, items which are symmetrical about the buttock line will appear offset when using this viewpoint. These inputs, 6, 7, 8 and 9, allow the user to shift the viewpoint to any station, waterline and/or buttock line for viewing. Use of the elevation angle, item 8, is similar to offsetting the waterline viewpoint. The elevation angle is assumed positive when the origin of the design axis system is above the viewer.

The user can change any or all of the 9 items on this list. The items can be selected in random order. When all desired changes are made, transmission of the return key will allow the program to continue.

The next solicitation block, shown below, provides a translation option.

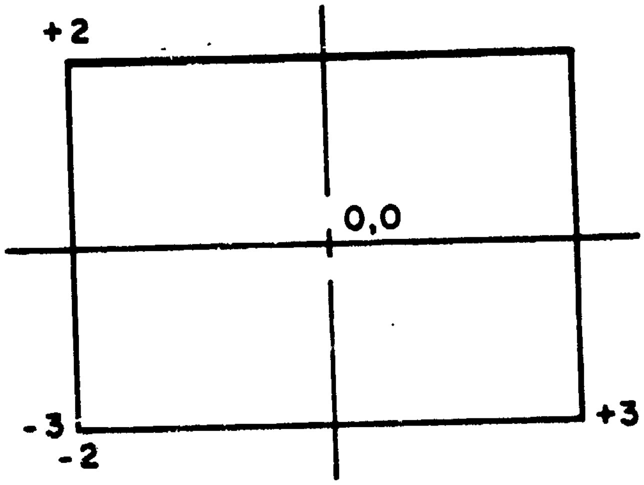
```
TRANSLATION OPTION.....0
**    0 = T==  R            1 = R==  T        **
KEY IN OPTION.        I1 FORMAT
```

This block is only pertinent when the viewpoint is shifted, items 6, 7, 8 and/or 9, above. The default option is to translate the axis and then rotate the body about the new axis system. If the user desires to first rotate the body about its design axis system and then translate the axis system, a key in of 1 is required. A different view of the object will be obtained depending on the option selected.

The statement:

```
     PRESENT VIEW CENTER IS AT
1...HORIZONTAL       0.0   AND 2...VERTICAL     0.0
HORIZONTAL SHIFT RIGHT IS +.  VERTICAL SHIFT UP IS +,
KEY IN INDEX NO. AND NEW VALUE
I1 G12.5 FORMAT
HIT RETURN TO CONTINUE
```

will then be written to the screen. This statement refers to the screen location of the object. The 0.0 - 0.0 horizontal and vertical positions are at the center of the screen. To better understand these inputs consider the viewport shown in the following sketch.



For this application the viewport has the dimensions +/-3 horizontally and +/-2 vertically. When a scale factor of 1.0 is used the program will scale the object so that the object's geometric center is at 0.0 and the object placed in the viewport to maximize the size, with equal resolution, within the viewport boundaries. Now let it be assumed the object fills the screen in the horizontal direction, with scale factor =1.. Let it be assumed that the user wants to see a blow up of the left side of the object and keys in a scale factor of 2.0. On a reference basis the object will now take on a size of +/-6 with all sections of the object outside the viewport boundaries of +/-3 clipped. If the user wants to see the left side of the object, it (the object) must be moved to the right. Thus, if the object was shifted +3.0, the object's reference dimensions would be -3 to +9 which would position the left side of the object within the viewport. This same concept is used for the vertical direction. Note that the amount of shift X, Y, +/- depends on the scale factor used and what portion of the object is to be viewed. Transmission of the return key, after these data have been entered, or if no change is desired, will allow the program to continue.

After a screen clear, the following solicitation will appear:

PRESENT OBJECT BOUNDARIES ARE...

1..STATION MIN......	19.0	2..STATION MAX....	450.0
3..BUTT LINE MIN....	-42.0	4..BUTT LINE MAX..	42.0
5..WATER LINE MIN...	49.00	6..WATER LINE MAX.	121.00

KEY IN INDEX NO. & VALUE IF CHANGE IS DESIRED

```
I1 G12.5 FORMAT
HIT RETURN TO CONTINUE
```

This block provides the user with the capability of isolating any desired portion of the object for display. The object does not have to be stored as separate elements, as is the case with exploded views. The user can isolate the section desired by keying in the index number and the minimum and maximums of the boundaries desired.

As an example, if the user only wants to see the object between stations 100 and 200, he would key in

```
1     100.
      Return Key
2     200.
      Return Key
```

Any and all items can be changed, in random order. Transmission of the return key, after these data have been entered, or if no change is desired, will allow the program to draw the object. When the drawing is complete the program will go into a hold state. This hold state is to permit the user to review the display, make a copy, etc. The user must transmit the return key for program continuation.

Typical graphic outputs, showing the results of these input data are shown in Figures 3 and 4. Figure 3 shows the results of the pitch-roll-yaw options.

Figure 4 shows the effect of increasing the scale factor and viewport shifting.

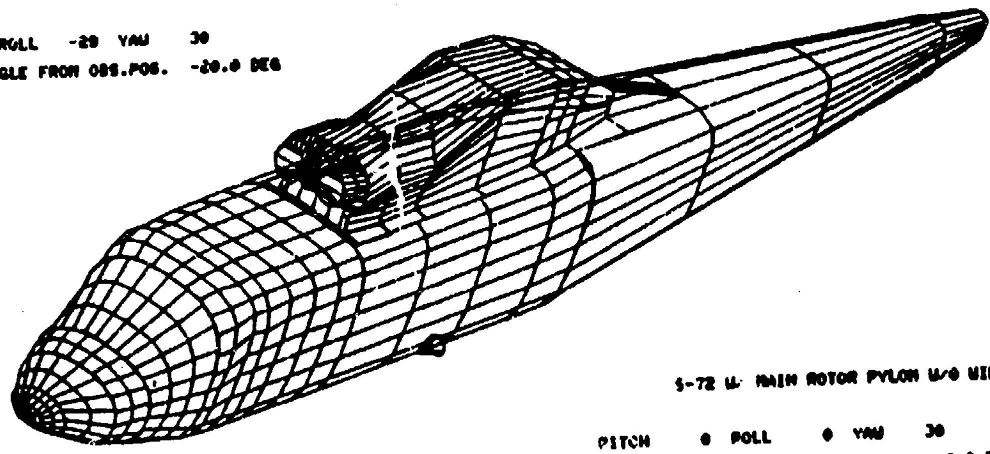
After program continuation of question 'exploded view' will appear. The program design permits the user to separate the various component parts of the airframe, nose cap, main rotor pylon etc. for better visualization of these components. This option is only available when the panel data file is broken up into components with title card separation. Refer to section on airframe buildup for details. A key in of Yes (Y) will permit an exploded view.

FIGURE 3

S-72 W/ MAIN ROTOR PYLON W/O WING

PITCH -10 ROLL -20 YAW 30

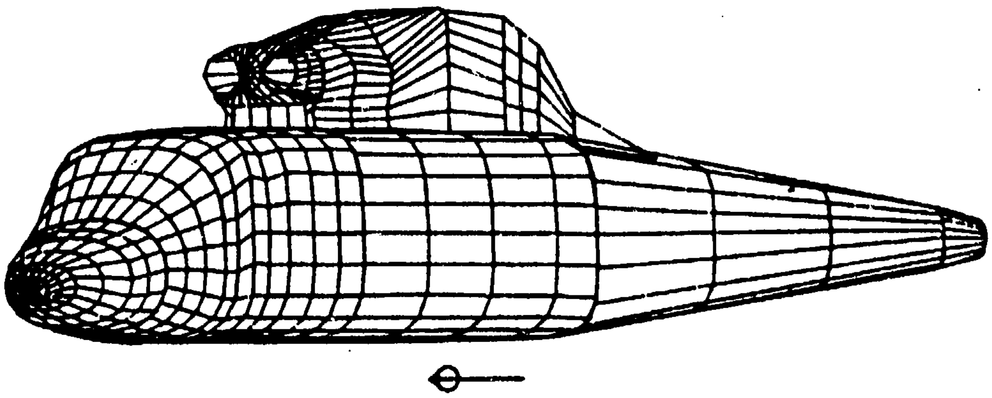
ELEVATION ANGLE FROM OBS.POS. -20.0 DEG



S-72 W/ MAIN ROTOR PYLON W/O WING

PITCH 0 ROLL 0 YAW 30

ELEVATION ANGLE FROM OBS.POS. 0.0 DEG



S-72 W/ MAIN ROTOR PYLON W/O WING

PITCH 0 ROLL -20 YAW 180

ELEVATION ANGLE FROM OBS.POS. 0.0 DEG

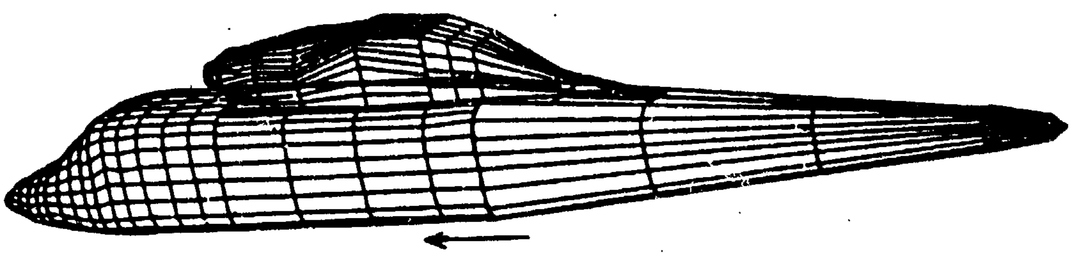
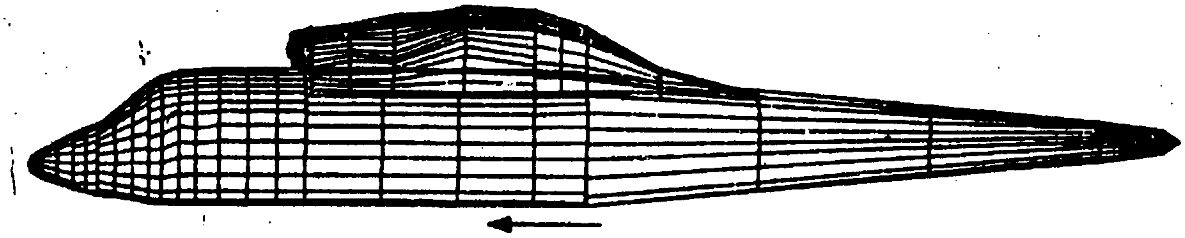


FIGURE 4

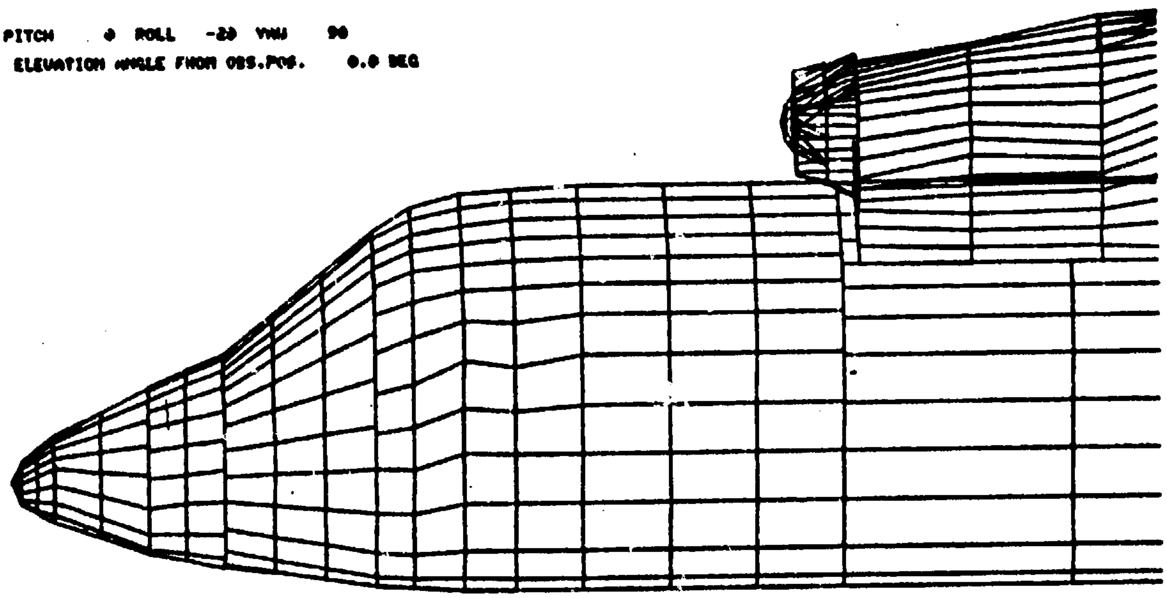
S-72 W/ MAIN ROTOR PYLON W/O WING

PITCH 0 ROLL -20 YAW 90
ELEVATION ANGLE FROM OBS.POS. 0.0 DEG



S-72 W/ MAIN ROTOR PYLON W/O WING

PITCH 0 ROLL -20 YAW 90
ELEVATION ANGLE FROM OBS.POS. 0.0 DEG



The next question 'tufts?' will then appear. This program capability is only available when a WABAT output file computed for the panel data being used is included in the run stream. Assuming this file is available, the key in of Yes, 'Y', will superimpose the local velocity vector on each airframe panel. The length of these velocity vectors represent the ratio of the local resultant velocity to the free stream velocity and point in the direction of the local flow. These data are strictly based on the WABAT analysis output data. When this option is selected, a unit reference vector representing the free stream velocity is drawn in the upper left corner of the viewport. Caution must be used when comparing this unit vector to the airframe tuft lengths. The airframe tufts are resolved into the airframe axis system and then into the view position requested. The vector, in the upper left corner, is the unresolved unit length of the free stream velocity. A direct comparison of lengths can only be made when the airframe is positioned so that the tuft is normal to the viewer. If tufts are desired the user must answer yes (Y) everytime the question is asked. CAUTION. The response to 'tufts?' must be 'No' when in the 'APT' panel generation mode.

After this question is answered and an exploded view was requested the following message will appear.

```
          HOW MANY SECTIONS?  9 MAX.

                KEY IN DELTA STATION   WATERLINE    BUTT LINE
          SECTION 1  F4. FORMAT
     STA !  WL  !  BL
   1234    1234   1234
```

The input is in I1 format and a maximum of 9 sections are permitted. The user can then key in the desired separation distances in terms of station, waterline and buttock line offsets. These inputs are in 3F4. format. Note that a 'line up' guide is provided for proper field alignment. The input numbers must line up with this 1234 guide for proper offset execution. This guide will be repeated for all sections requested.

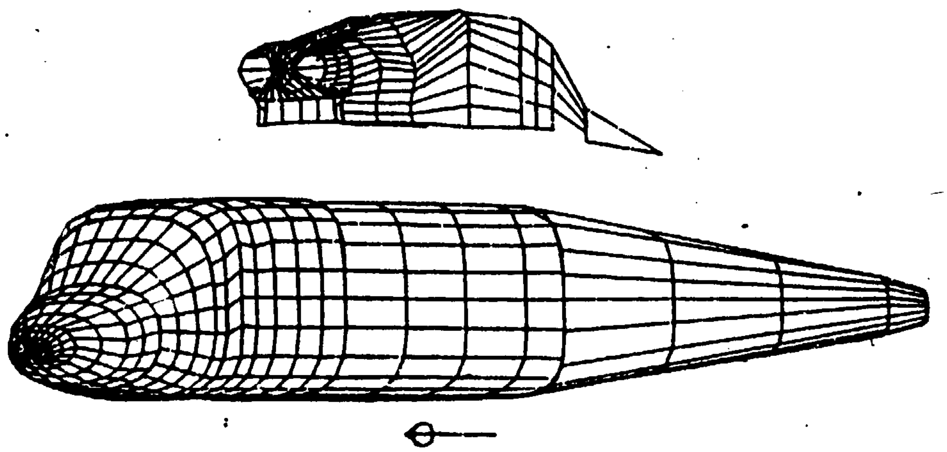
CAUTION. The station offset inputs are internally accumulated, the waterline and buttock line inputs are not. What this means is, if airframe section 2 is to be shifted 10 inches stationwise and section 3 was not, then section 2 would overlap section 3 by 10 inches. The internal station accumulator will prevent this. Considering the possible combinations of components along with waterline and buttock line shifts preclude the setting up of a logical internal accumulator for these options. Thus it is left to the user, who should have full knowledge of the component order on the file, to set up these shift distances to prevent the overlap conditions.

It must be noted that once the exploded view option is turned on, the graphic output will remain as an exploded view until the user re-selects the option for a different shift arrangement. That is, when the question 'exploded view?' appears for a second or subsequent time, a 'No' response will retain the same offset relationship of the component parts as originally requested. A typical exploded view is shown in Figure 5. Figure 6 shows the effect of 'tufting', local velocity vectors superimposed on the object.

FIGURE 5

S-72 W/ MAIN ROTOR PYLON W/O WING

PITCH 0 ROLL 0 YAW 30
ELEVATION ANGLE FROM OBS.POS. 0.0 DEG



S-72 W/ MAIN ROTOR PYLON W/O WING

PITCH 0 ROLL 0 YAW 0
ELEVATION ANGLE FROM OBS.POS. 0.0 DEG

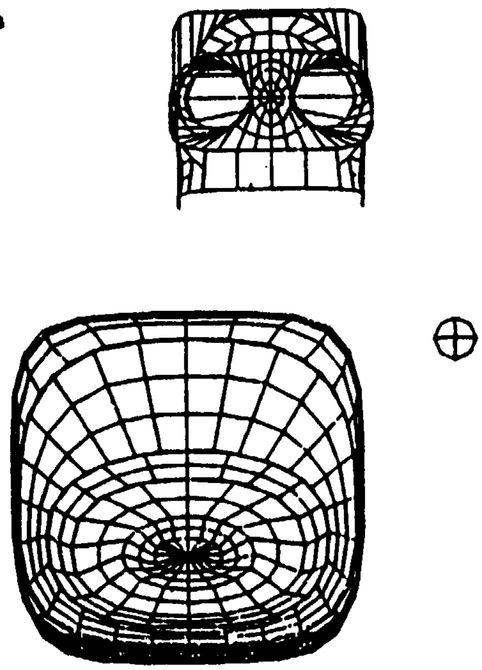


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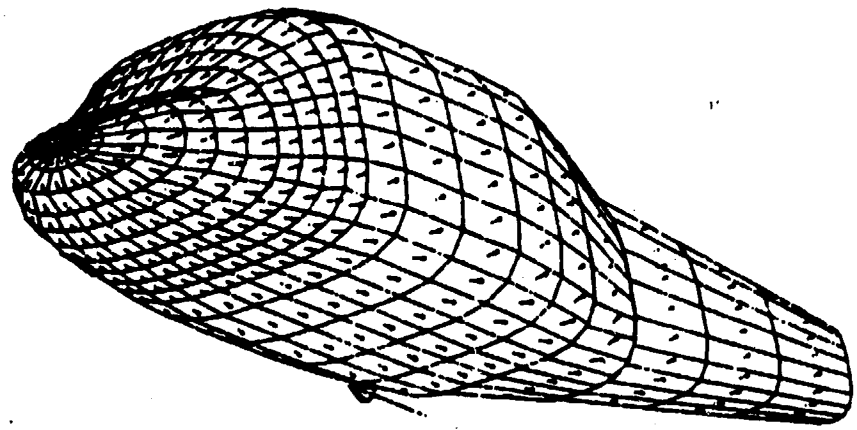
FIGURE 6

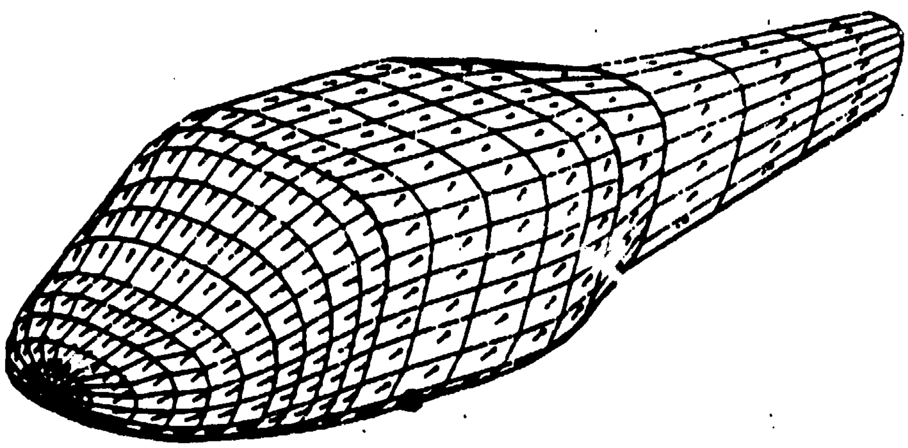
S-76 FUSELAGE W/O PYLON

PITCH 10 ROLL 20 YAW 30
ELEVATION ANGLE FROM OBS.POS. 0.0 DEG



S-76 FUSELAGE W/O PYLON

PITCH -10 ROLL -20 YAW 30
ELEVATION ANGLE FROM OBS.POS. 0.0 DEG



The next question which will appear, depending on the option(s) selected is: 'CHANGE VIEW ANGLE?'. A key in of 'No' will cycle the program to the top, 'SELECT OPTION' section. A 'Yes' (Y) response will yield the question 'CHANGE BOUNDARIES?'. CAUTION: The object boundaries will remain at the current setting unless a 'Yes' (Y) response is made. The program will then cycle to the 'PRESENT CONDITIONS ARE' section, permitting the user to reposition the object, etc.

A key in of 3 at the 'SELECT OPTION' section will terminate the program.

AIRFRAME BUILD UP

The APT/Graphic interface was designed to permit interactive coupling of the APT program and the graphics package. This coupling permits the user to rapidly verify the APT input data set by visually reviewing the output panel data on an interactive basis. The development of a detailed airframe requires several sets of APT input data which in turn requires several APT runs. The process developed here permits the user to set up all required APT input data as a sequential set on an input data file. The user would then interactively run the APT/Graphic program. Assuming this run is the initial run for this configuration, the user would select Option 1 from the program option list. The program will first calculate the panels and second graphically display the results. A return to the option selection list followed by a selection of Option 1 would generate and display the second airframe section on the input file. This process can be repeated for all sections contained on the input file. While this process will only display the component piece, the sequence can be interrupted between any component set and the individual pieces assembled by selecting Option 2 in lieu of 1 when the option selection list is displayed. The component - display cycle can be re-entered after assembly, if desired. The user can terminate the program at any time in the cycle, from the option selection list.

Now, let us assume that a user created four component sections in a given session and then terminated the run. Now, at a later date he wants to complete the model. The user would then set up an APT input file containing the data for the remaining pieces. He must not repeat the component data that have already been created. Upon program execution the user must select Option 2 first, assemble and display all available components. This must be done to properly position the panel file. After these data have been assembled, the user can go into the generate-display cycle, Option 1, from the option selection list.

When the model is completed, the panel data file that has been generated can be added, unedited, to the WABAT input run stream. The use of this process provides the user with graphic display of the exact model that the WABAT program is to analyze. The WABAT program must be run in a batch mode due to high CPU time requirements.

When the WABAT analysis is completed, the local flow field can be superimposed on the model through use of the same APT/ Graphic program with the 'tuft' selection option.

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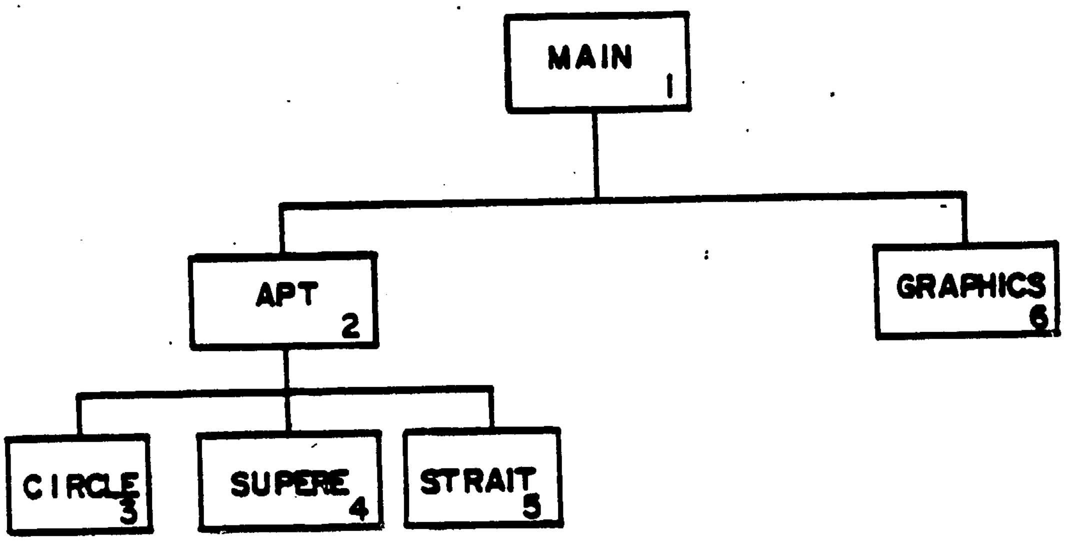
PROGRAM STRUCTURE

The APT/Graphic program was designed to permit an overlay structure so as to be able to work within a $32K_{10}$ computer region. The base structure used is depicted below.



The largest leg of this structure is 1, 2, 4 controlling program size.

PROGRAM INSTALLATION

For installation of the APT program on a CDC computer, a segmentation structure is recommended. The control card input for this type installation is shown in Figure 7.

The job control language for execution of the APT/PLOT program is shown in Figure 8.

Installation of the WABAT program for the CDC operative system is shown in Figure 9.

The job control language for execution of the WABAT program is shown in Figure 10.

```
* /JOB
* /NOSEQ
  APTLINK,T1400,CM300000.
  USER,-------.
  CHARGE,------,LRC.
  RFL(300000)
  GET,FILE11.
  FTN(I=FILE11,R=0,L=TAPE1,B=APTGO,A)
  REPLACE(APTGO)
  ATTACH(LIBFTEK/UN=LIBRARY)
  SEGLOAD(B=APTABS)
  LDSET(LIB=LIBFTEK,PRESET=ZERO,MAP=SBEX/LMAP)
  LOAD(APTGO)
  NOGO.
  REPLACE(APTABS)
  DAYFILE,JCLOUT.
  REPLACE,JCLOUT.
  REPLACE(TAPE1=FORT11)
  REPLACE,LMAP.
  EXIT.
  DAYFILE,JCLOUT.
  REPLACE,JCLOUT.
  REPLACE(TAPE1=FORT11)
  REPLACE,LMAP.
* /EOR
   WABPLT GLOBAL XPLOT,HDG,TERM
         TREE   WABPLT-(WABADO-(CIRCLE,SUPERE,STRAIT),WOPADO)
         END    WABPLT
* /EOF
```

* For card images operation:

1. delete /JOB and /NOSEQ instructions (first 2 cards).
2. replace /EOR with a 6/7/8 multiple punch card.
3. replace /EOF with a 6/7/8/9 multiple punch card.

FIGURE 7. CDC JCL FOR INSTALLATION OF APT PROGRAM.

```
. . . OPERATIONAL MODE 1 - RUN INITIAL PANEL CONFIGURATION . . .

GET,APTABS.
GET,TAPE10=INPUT1.          <===    APT INPUT DATA
APTABS.

. . . ANSWER QUESTIONS - SEE TEXT . . . . . .
. . . AFTER NORMAL PROGRAM TERMINATION . . . .

REPLACE,TAPE16=PDATA1.      <===    PANEL OUTPUT DATA FOR WABAT PROGRAM
REWIND,TAPE11.                   |
COPYSBF,TAPE11,LIST.        <=== |  USE THESE INSTRUCTIONS TO
DELIVER.BLDG ____ JOHN DOE  <=== |  OBTAIN HARD COPY OUTPUT
ROUTE,LIST,DC=LP.                |
GOOD BYE

. . . OPERATIONAL MODE 2 - ADD DATA TO INITIAL PANEL CONFIGURATION . . .

GET,APTABS.
GET,TAPE10=INPUT2.          <===    APT INPUT DATA
APTABS.

. . . ANSWER QUESTIONS - SEE TEXT . . . . . .
. . . AFTER NORMAL PROGRAM TERMINATION . . . .

APPEND,PDATA1,TAPE16.
GET,PDATA1.
PACK,PDATA1.
REPLACE,PDATA1.
REWIND,TAPE11.                   |
COPYSBF,TAPE11,LIST.        <=== |  USE THESE INSTRUCTIONS TO
DELIVER.BLDG ____ JOHN DOE  <=== |  OBTAIN HARD COPY OUTPUT
ROUTE,LIST,DC=LP.                |
GOOD BYE

. . . OPERATIONAL MODE 3 - VERIFY WABAT OUTPUT VELOCITY FLOW FIELD . . .

GET,APTABS.
GET,TAPE16=PDATA1.          <===    PANEL INPUT DATA
GET,TAPE17=TUFTS.           <===    VELOCITY FLOW FIELD INPUT DATA
                                    FROM WABAT PROGRAM

APTABS.

. . . ANSWER QUESTIONS - SEE TEXT . . . . . .
. . . AFTER NORMAL PROGRAM TERMINATION . . . .

GOOD BYE
```

FIGURE 8. CDC JCL FOR EXECUTION OF APT PROGRAM.

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```
* /JOB
* /NOSEQ
  WABLINK,T1400,CM300000.
  USER,-------.
  CHARGE,------,LRC.
  RFL(300000)
  GET,FILE12.
  FTN(I=FILE12,R=0,L=TAPE1,B=WABGO,A)
  REPLACE(WABGO)
  ATTACH(ALTMLIB/UN=LIBRARY)
  SEGLOAD(B=WABABS)
  LDSET(LIB=ALTMLIB,PRESET=ZERO,MAP=SBEX/LMAP)
  LOAD(WABGO)
  NOGO.
  REPLACE(WABABS)
  DAYFILE,JCLOUT.
  REPLACE,JCLOUT.
  REPLACE(TAPE1=FORT12)
  REPLACE,LMAP.
  EXIT.
  DAYFILE,JCLOUT.
  REPLACE,JCLOUT.
  REPLACE(TAPE1=FORT12)
  REPLACE,LMAP.
* /EOR
   WABAT GLOBAL TRANS,COOR,CENT,NORM,EXTRA,SLV,AREA,ANGLE,NFLU,LSM
   WABAT GLOBAL PRTOT,IPUT,PNVL,FILE,FORC,DTAPE
   WABAT GLOBAL BOD,CONTL,SORC
         TREE   WABAT-(INPUT,MLSM,SOLVE,OUPUT)
         END    WABAT
* /EOF
```

* For card images operation:

1. delete /JOB and /NOSEQ instructions (first 2 cards).
2. replace /EOR with a 6/7/8 multiple punch card.
3. replace /EOF with a 6/7/8/9 multiple punch card.

FIGURE 9. CDC JCL FOR INSTALLATION OF WABAT PROGRAM.

```
* /JOB
* /NOSEQ
  WABRUN,T1400,CM300000.
  USER,-------.
  CHARGE,------,LRC.
  RFL(300000)
  GET,WABABS.
  GET,TAPE5=WABAT1.          <=== INPUT DATA
  GET,TAPE16=PDATA1.         <=== PANEL INPUT DATA FROM APT PROGRAM
  WABABS,TAPE5.
  DAYFILE,JCLOUT.
  REPLACE,JCLOUT.
  REPLACE(OUTPUT=OUTWAB)
  REPLACE(TAPE15=HARMDAT)    <=== INFLOW HARMONICS OUTPUT FOR F389 PROGRAM
  REPLACE(TAPE17=TUFTS)      <=== VELOCITY FLOW FIELD DATA FOR APT PROGRAM
  EXIT.
  DAYFILE,JCLOUT.
  REPLACE,JCLOUT.
  REPLACE(OUTPUT=OUTWAB)
  REPLACE(TAPE15=HARMDAT)    <=== INFLOW HARMONICS OUTPUT FOR F389 PROGRAM
  REPLACE(TAPE17=TUFTS)      <=== VELOCITY FLOW FIELD DATA FOR APT PROGRAM
  DMD(200)
* /EOF

* For card images operation:

     1. delete /JOB and /NOSEQ instructions (first 2 cards).
     2. replace /EOF with a 6/7/8/9 multiple punch card.
```

FIGURE 10. CDC JCL FOR EXECUTION OF WABAT PROGRAM.

REFERENCES

1. Sheehy, T.W. A Description and Guide to the Use of the Fuselage Geometry Definition Program (Y179A), SER-50866, June 7, 1974.

2. Sheehy, T.W. An Aerodynamic Analysis Technique for Arbitrary Rotorcraft/Aircraft Configurations, SER-50964, June 1976.

3. Egolf, T.A. and Landgrebe, A.J., A Prescribed Wake Rotor Inflow and Flow Field Prediction Analysis - User's Manual and Technical Approach, NASA CR-165894, 1982.