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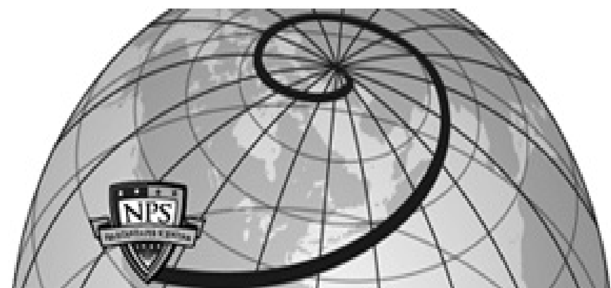

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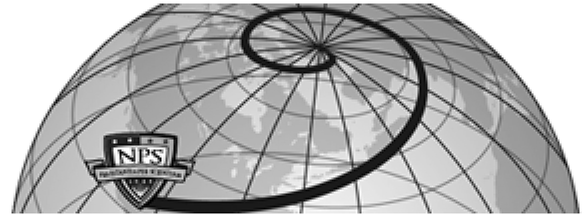

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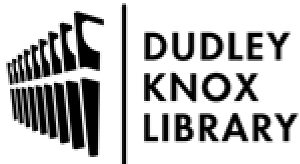

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An Integrated Hydrofoil and Propeller Design Tool for the Windows™ Environment

by

David R. Beckett

B., Mechanical Engineering
General Motors Institute, 1981

SUBMITTED TO THE DEPARTMENT OF OCEAN ENGINEERING IN PARTIAL FULFILLMENT OF THE REQUIREMENTS FOR THE DEGREES OF

NAVAL ENGINEER
AND
MASTER OF SCIENCE IN NAVAL ARCHITECTURE
AND MARINE ENGINEERING

AT THE
MASSACHUSETTS INSTITUTE OF TECHNOLOGY
JUNE 1996

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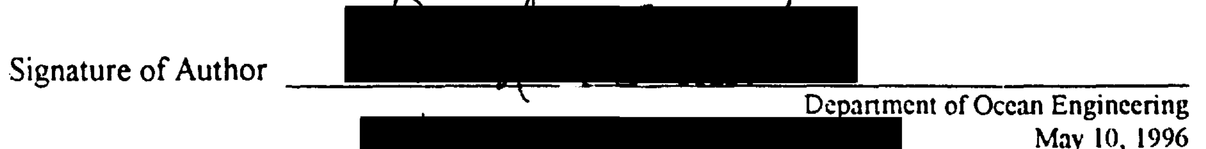

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An Integrated Hydrofoil and Propeller Design Tool for the Windows™ Environment

by

David R. Beckett

Submitted to the Department of Ocean Engineering
on May 10, 1996 in Partial Fulfillment of the
Requirements for the Degrees of Naval Engineer and
Master of Science in Naval Architecture
and Marine Engineering

ABSTRACT

An investigation of the feasibility and desirability of the employment of personal computers in hydrofoil and propeller design was performed. The feasibility and desirability of the employment of personal computers in hydrofoil and propeller design was demonstrated by the seamless linking of the MIT Propulsor Lifting Line Code and the MIT Propeller Blade Design Code into a single Microsoft Windows™ based application.

Thesis Supervisor: Justin E. Kerwin
Title: Professor of Ocean Engineering

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TABLE OF CONTENTS

Chapter	Title	Page
1.	Introduction	13
1.1	The history of screw propulsion.	13
1.2	The history of digital computers.	13
1.3	Personal computers.	14
1.4	The employment of personal computers in hydrofoil and propeller design.	15
2.	Hydrofoil Design Applications	18
2.1	The Hydrofoil Vortex Lattice Lifting Line Program.	18
2.1.1	A comparison of VLL and the Windows™ version of VLL.	18
2.2	The structure of a Windows™ program.	23
2.2.1	The WinMain function.	24
2.2.2	The MainWndProc function.	24
2.2.3	The WMCommand_Handler function.	25
2.2.4	Dialog functions.	25
2.2.5	Output functions.	25
2.3	The 2D Vortex/Source Lattice with Lighthill Correction Program.	26
2.3.1	A comparison of VLMLE and the Windows™ version of VLMLE.	27
3.	Propeller Design Applications	31
3.1	The MIT Propulsor Lifting Line Program.	31
3.1.1	A brief description of PLL.	31
3.2	The MIT Propeller Blade Design Code.	34
3.2.1	A brief description of PBD.	35
3.3	The Integrated PLL/PBD Windows™ application.	40
3.3.1	The Blade and Wake Viewer Windows.	43
3.3.2	Edit Dialog Boxes.	46
3.3.3	Running PLL.	52
3.3.4	The Output and Plot Viewer Windows.	57
3.3.5	Additional Capabilities.	60
3.3.6	The MIT-PLL Help Program.	61
3.3.7	The MIT-PLL Editor Program.	63
3.3.8	Running PBD.	69
4.	Conclusions and Further Work	77
4.1	Conclusions.	77
4.2	Further Work.	77

	Bibliography	80
A.	Hydrofoil Vortex Lattice Lifting Line Program Code	82
A.1	The VLL WinMain function.	83
A.2	The VLL MainWndProc function.	92
A.3	The VLL WMCommand_Handler function.	102
A.4	The VLL dialog functions.	122
A.5	The VLL output functions.	131
A.5.1	The VLL paint_data_box function.	132
A.5.2	The VLL paint_graphs function.	137
A.5.3	The VLL print_data_box and print_graphs function.	159
A.6	VLL program listings.	161
B.	2D Vortex/Source Lattice with Lighthill Correction Program Code	163
B.1	The VLMLE WinMain, MainWndProc, and WMCommand_Handler functions.	164
B.1.1	A comparison of the VLL and VLMLE WinMain functions.	165
B.1.2	A comparison of the VLL and VLMLE MainWndProc functions.	165
B.1.3	A comparison of the VLL and VLMLE WMCommand_Handler functions.	171
B.2	The VLMLE dialog and output functions.	180
B.3	The VLMLE FORTRAN program.	184
B.4	VLMLE program listings.	189
C.	PLL Program Code	191
C.1	The PLL WinMain, FrameWndProc, and WMCommand_Handler functions.	192
C.1.1	The PLL WinMain function.	193
C.1.2	The PLL FrameWndProc function.	200
C.1.3	The PLL WMCommand_Handler function.	208
C.2	The PLL MDI Child Window Procedure functions.	258
C.2.1	The PLL MDIChildBladeWndProc and MDIChildWakeWndProc functions.	259
C.2.2	The PLL MDIChildOutputWndProc function.	262
C.2.3	The PLL MDIChildPlotWndProc function.	266
C.3	The PLL dialog functions.	274
C.3.1	The Run Time Settings dialog box functions.	275
C.3.2	The Expanded Area Ratio dialog box functions.	278
C.3.3	The Glauert Coefficients dialog box functions.	280
C.3.4	The PBD Skew/Rake Settings dialog box functions.	282
C.3.5	The Steepness dialog box functions.	286
C.3.6	The Unload Coefficients dialog box functions.	289
C.3.7	The Default Settings dialog box functions.	291

C.3.8	The Duct Settings dialog box functions.	296
C.3.9	The PBD Settings dialog box functions.	298
C.3.10	The Project Settings dialog box functions.	302
C.3.11	The ABS Rules Strength Settings dialog box functions.	306
C.3.12	The PBD Plot Geometry dialog box functions.	308
C.3.13	The Optimization Data dialog box functions.	310
C.3.14	The About dialog box functions.	311
C.4	The PLL output functions.	313
C.4.1	The paintbld function.	315
C.4.2	The paintwake function.	329
C.4.3	The paintplot function.	340
C.4.4	The printplot function.	353
C.4.5	The paintout function.	354
C.4.6	The printout function.	359
C.4.7	The paint_graphs function.	361
C.4.8	The paint_hub function.	371
C.4.9	The paint_gsp function.	375
C.4.10	The paint_vcp function.	383
C.4.11	The paint_cmv function.	389
C.4.12	The paint_rdc function.	393
C.4.13	The write_output_file function.	402
C.4.14	The write_pbd_files function.	404
C.5	Miscellaneous PLL functions.	409
C.5.1	The WMVScroll_Handler function.	411
C.5.2	The WMKeydown_Handler function.	413
C.5.3	The write_input_file function.	414
C.5.4	The write_project_file function.	417
C.5.5	The write_pbdadmin_file function.	421
C.5.6	The write_default_file function.	425
C.5.7	The write_wakecalc_file function.	427
C.5.8	The write_ductforc_file function.	427
C.5.9	The write_absrules_file function.	428
C.5.10	The write_thattorq_file function.	429
C.5.11	The write_wkalcirc_file function.	430
C.5.12	The write_misc_files function.	430
C.5.13	The read_blade_file function.	433
C.5.14	The read_wake_file function.	437
C.5.15	The read_input_file function.	440
C.5.16	The read_project_file function.	445
C.5.17	The read_plot_file function.	455
C.5.18	The read_glauert_file function.	457
C.5.19	The read_unload_dat_file function.	457
C.5.20	The initialize function.	459
C.5.21	The delete_files function.	463

C.6	The PLL and PBD FORTRAN programs.	464
C.7	PLL program listings.	468
C.7.1	MIT-PLL program listings.	469
C.7.2	MIT-PLL Editor program listings.	471
C.7.3	MIT-PLL Help program listings.	473

LIST OF FIGURES

Figure	Title	Page
1-1	DOS Prompt	15
1-2	Typical Windows™ based application	16
2-1	VLL Sample Output	19
2-2	Windows™ VLL Sample Output	19
2-3	Windows™ VLL Data File	20
2-4	Windows™ VLL Geometry Dialog Box	21
2-5	Windows™ VLL with Help displayed	22
2-6	Windows™ Program Structure	24
2-7	Windows™ VLMLE Sample Output	27
2-8	Windows™ VLMLE Parameters Dialog Box	28
2-9	Windows™ VLMLE with Help displayed	30
3-1	Sample PLL Overall Input File	32
3-2	Sample PLL Blade Input File	32
3-3	Sample PLL Wake Input File	33
3-4	Sample PBD Administrative File	35
3-5	Sample PBD Velocity Input File	36
3-6	Sample PBD B-spline Control Polygon File	36
3-7	Sample PBD Circumferential Mean Blade Velocity File	37
3-8	Sample PBD Screen Output	39
3-9	Windows™ PLL	41
3-10	Windows™ PLL with Tiled Child Windows	42
3-11	Windows™ PLL with Iconified Child Windows	43
3-12	Windows™ PLL Blade Viewer	44
3-13	Windows™ PLL Wake Viewer	45
3-14	Windows™ PLL Multiple Component Project Settings Dialog Box	46
3-15	Windows™ PLL Multiple Component Default Settings Dialog Box	47
3-16	Windows™ PLL Duct Settings Dialog Box	48
3-17	Windows™ PLL ABS Strength Settings Dialog Box	49
3-18	Windows™ PLL PBD Settings Dialog Box	50
3-19	Windows™ PLL PBD Skew/Rake Settings Dialog Box	51
3-20	Windows™ PLL Runtime Settings Dialog Box	52
3-21	Windows™ PLL Optimization Data Dialog Box	53
3-22	Windows™ PLL Expanded Area Ratio Dialog Box	54
3-23	Windows™ PLL Glauert Coefficients Dialog Box	55
3-24	Windows™ PLL Steepness Dialog Box	56
3-25	Windows™ PLL Unload Coefficients Dialog Box	57
3-26	Windows™ PLL Output Viewer	58
3-27	Windows™ PLL Plot Viewer	59
3-28	Windows™ PLL File Pull Down Menu	61

3-29	Windows™ MIT-PLL Help Program	62
3-30	Windows™ MIT-PLL Help Program with Help Displayed	63
3-31	MIT-PLL Editor	64
3-32	MIT-PLL Edit Process	65
3-33	MIT-PLL Wake File Edit Process	66
3-34	MIT-PLL Stator File Edit Process	67
3-35	MIT-PLL Input File Edit Process	68
3-36	MIT-PLL Two Component - Ducted Input Dialog Box	69
3-37	MIT-PLL Output Viewer with PBD Output	70
3-38	MIT-PLL Plot Viewer with PBD Input Blade	71
3-39	MIT-PLL Plot Viewer with PBD Output Blade and Centerbody	72
3-40	MIT-PLL Plot Viewer with PBD Control Point Velocity Plot	72
3-41	MIT-PLL Plot Viewer with PBD Bound Circulation Contour Plot	73
3-42	MIT-PLL Plot Viewer with PBD Radial Circulation Distribution Plot	73
3-43	MIT-PLL Plot Viewer with Circumferential Mean Velocity Plot	74
3-44	MIT-PLL PBD Plot Geometry Dialog Box	75
3-45	MIT-PLL PBD Plot with Altered Orientation and Scale	76
A-1	Windows™ VLL with Error Warning displayed	113
A-2	Windows™ VLL with About dialog box displayed	120
A-3	VLL Geometry Dialog Box in BORLAND® Resource Workshop™	127

1. INTRODUCTION

1.1 The history of screw propulsion.

The first use of mechanical propulsion at sea dates back at least 2000 years. The Roman army recognized the advantages of independence from wind and current. Before the birth of Christ they used paddle-wheel driven, oxen powered boats to transport soldiers in the Mediterranean Sea. Mechanical propulsion took the next great leap forward in 1783 at Lyons, France, where a steam engine was used to propel a paddle-wheel driven barge on the Rhone river.

Archimedes and Leonardo da Vinci are both credited with the initial concepts of screw propulsion. Archimedes developed the idea of the screw pump, which provided inspiration to the developers of marine propulsion in the 19th century. Leonardo da Vinci produced sketches of a screw propeller that resembles the blades of a modern cooling fan.[1]

Modern screw propulsion appears to have been first proposed in England by Robert Hooke in 1680 and first used by Colonel John Stevens at New York in 1804.[2] Acting for the United States and British Royal Navies respectively, John Ericcson and Francis Pettit Smith made practical applications of screw propulsion in the early 1800's. Both men received patents for screw propulsion in 1836 and soon had successfully demonstrated the advantages of the screw propeller over alternative forms of mechanical propulsion.[3]

1.2 The history of digital computers.

The birth of the concept of the modern digital computer can be traced back almost

---

[1] J.S. Carlton, Marine Propellers and Propulsion (Oxford, England: Butterworth-Heinemann Ltd., 1994), p.3.

[2] Principles of Naval Architecture, John P. Comstock (New York: SNAME, 1967), p.370.

[3] Thomas C. Gillmer and Bruce Johnson, Introduction to Naval Architecture (Annapolis, Maryland: Naval Institute Press, 1982), p.230.

as far as the screw propeller. Charles Babbage, an English mathematician, proposed the "analytical engine". The analytical engine was to be a totally mechanical, steam-driven machine capable of performing the five basic data processing functions: data input, arithmetic processing, data storage, data output, and control of the operations. Although Babbage's engine failed because of the lack of adequate hardware, the concept formed the basis of the modern digital computer.[4]

The development of the computer accelerated in the 1940's. The Mark I computer, an electromechanical calculator was built at Harvard University by Dr. Howard Aiken in 1944. The Electronic Discrete Variable Computer (EDVAC) was built at the University of Pennsylvania between 1946 and 1952. The EDVAC was the first computer to allow instructions to be stored in memory rather than to be hard wired. The UNIVAC I was introduced as the first mass produced digital computer and the first to be used in business applications. International Business Machines Corporation (IBM) entered the business computer market 1950's.[5]

The design of marine propellers took a great step forward with the development of the high speed digital computer. The digital computer is particularly suited to the application of circulation theory to propeller design. It is a simple matter to employ a computer to perform the repetitive calculations inherent in the application of circulation theory to hydrofoil and propeller design.

1.3 Personal computers.

While the first generation of digital computers made use of vacuum tube technology and performed data processing operations in milliseconds, the second generation employed transistor technology and performed operations in microseconds. Third generation computers using integrated-circuit technology reduced computation

---

[4]Marvin R. Gore and John W. Stubbe, Computers and Information Systems (New York: McGraw-Hill Book Company, 1984), pp.18-19.
[5]Gore and Stubbe, p.20.

times to nanoseconds. Improved technology at rapidly lowering cost allowed Commodore and Apple in 1977 to introduce computers designed for home and non-professional use. IBM followed with the IBM PC (personal computer) in 1981.[6]

The state of the art of the personal computer user interface for the years that immediately followed the introduction of the IBM PC was the familiar DOS prompt, shown in figure 1-1.

Figure 1-1. DOS Prompt

The DOS prompt continued its dominance of the personal computing world until well after the release of Windows™ 1.01 by the Microsoft Corporation in 1985. The release of Windows™ 1.01 was quickly followed by the release of subsequent, more capable versions. This coupled with rapidly developing hardware enabled Microsoft Corporation to establish Windows™ as the dominant operating environment for personal computers in the late 1980's and early 1990's.

Windows offers multitasking, memory management, device-independent graphics, and a consistent user interface. Once a user masters his or her first Windows™ application, it is a small task to master the next. Figure 1-2 depicts a typical Windows application. Windows™ users find the control-menu box, the title, menu, and tool bars, the maximize and minimize buttons, and the horizontal and vertical scroll bars both familiar and intuitively useful. Even the most ardent purist will eventually come to prefer the responsiveness of Windows™ to the puritan harshness of figure 1-1.

[6] Lawrence Press, Ph.D., The IBM PC and Its Applications (New York: John Wiley & Sons, Inc., 1984), p.329.

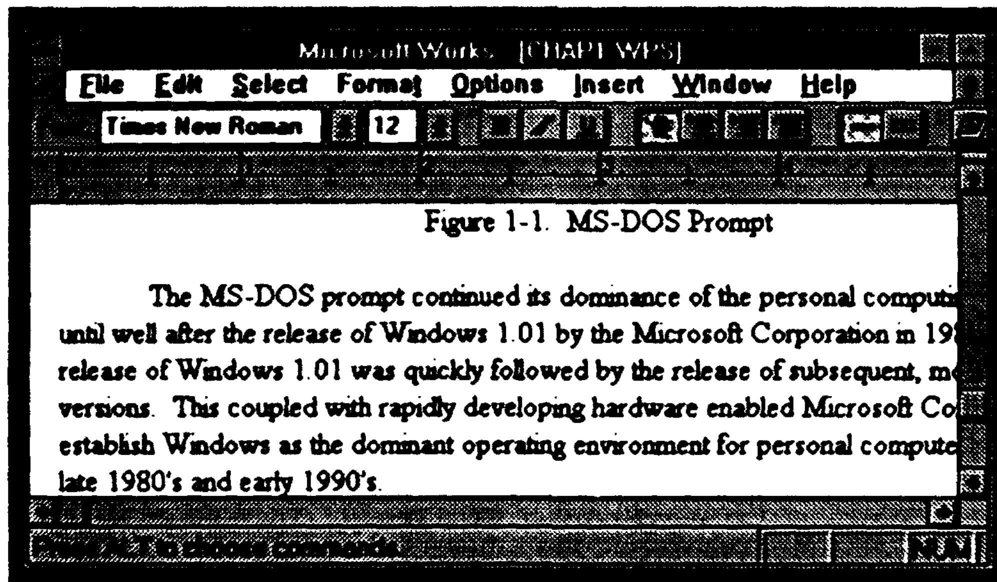

Figure 1-2. Typical Windows™ based application

1.4 The employment of personal computers in hydrofoil and propeller design.

It is the intended purpose of this thesis to demonstrate the feasibility and desirability of the employment of personal computers in hydrofoil and propeller design. The approach will be incremental in nature. First, Windows™ applications based upon relatively simple, traditional FORTRAN codes from the MIT Hydrofoils and Propellers course will be designed. The intent of these initial applications is to serve as a vehicle for developing the tools that will be required in implementing more complex codes.

The second step in this process will be to implement the MIT Propulsor Lifting Line Code (PLL) in a Windows™ application. PLL is a tool used for the preliminary design of marine propulsors. It can be used in the design of propulsors with a relatively high degree of complexity. PLL can serve as the starting point of a "blank sheet of paper" design and can be used in conjunction with codes used to design blade shapes, to analyze cavitating propellers, and to analyze steady and unsteady propeller forces.

The third step will be to implement the MIT Propeller Blade Design Code (PBD) as a part of the PLL Windows™ application. PBD is a vortex-lattice combined design and

analysis code. It is capable of the design and analysis of multi-stage open and ducted propellers. The integrated application will provide a seamless link between PLL and PBD.

2. HYDROFOIL DESIGN APPLICATIONS

2.1 The Hydrofoil Vortex Lattice Lifting Line Program.

The Hydrofoil Vortex Lattice Lifting Line Program[7](VLL) is a FORTRAN code that demonstrates a vortex lattice numerical approximation of a straight lifting line. VLL calculates the exact and numerical values of induced velocity, total lift, and total induced drag for a circulation distribution defined by five Glauert coefficients[8]. The program also calculates percent error values for lift, drag, and the ratio of lift to drag squared. Output is provided in the form of text written to the screen and a plot file which may be used with a suitable graphics program.

VLL was selected for the initial step in demonstrating the feasibility and desirability of the employment of personal computers in hydrofoil and propeller design. It was selected for two reasons. First, the program is relatively short and could be easily converted from FORTRAN to the C programming language. Second, the implementation of VLL in the Windows™ environment would result in immediately recognizable improvements in the user interface, in terms of input, output, on-line help and portability.

2.1.1 A comparison of VLL and the Windows™ version of VLL.

Figure 2-1 is a sample of the screen output provided by VLL.

---

[7] Justin Kerwin, 13.04 Lecture Notes -Hydrofoils and Propellers (Cambridge, Massachusetts: Massachusetts Institute of Technology, 1995), p.48.

[8] H. Glauert, *Elements of Aerofoil and Airscrew Theory* (Cambridge University Press, 1926).

VORTEX LATTICE LIFTING LINE-LINE SOLUTION WITH 10 ELEMENTS

CIRCULATION COEFFICIENTS A(J)
1.000000
COSINE SPACED VORTICES AND CONTROL POINTS

YV	YC	GAMMA	W(EX)	W(NUM)	G(NUM)
-0.5000	-0.4938	+0.3129	-1.0000	-0.9959	+0.3142
-0.4755	-0.4455	+0.9080	-1.0000	-0.9959	+0.9117
-0.4045	-0.3536	+1.4142	-1.0000	-0.9959	+1.4200
-0.2939	-0.2270	+1.7820	-1.0000	-0.9959	+1.7894
-0.1545	-0.0782	+1.9754	-1.0000	-0.9959	+1.9835
+0.0000	+0.0782	+1.9754	-1.0000	-0.9959	+1.9835
+0.1545	+0.2270	+1.7820	-1.0000	-0.9959	+1.7894
+0.2939	+0.3536	+1.4142	-1.0000	-0.9959	+1.4200
+0.4045	+0.4455	+0.9080	-1.0000	-0.9959	+0.9117
+0.4755	+0.4938	+0.3129	-1.0000	-0.9959	+0.3142
+0.5000					

PERCENT ERROR IN NUMERICAL SOLUTION:
COMPUTING DOWNWASH FOR GIVEN CIRCULATION
LIFT: -.4 DRAG -.8 DRAG/LIFT**2 .0

COMPUTING CIRCULATION FOR GIVEN DOWNWASH
LIFT: .0 DRAG .0 DRAG/LIFT**2 .0

Figure 2-1. VLL Sample Output

Figure 2-2 is a sample of the output of the Windows™ version of VLL. It is for the same case as the output depicted in figure 2-1 above.

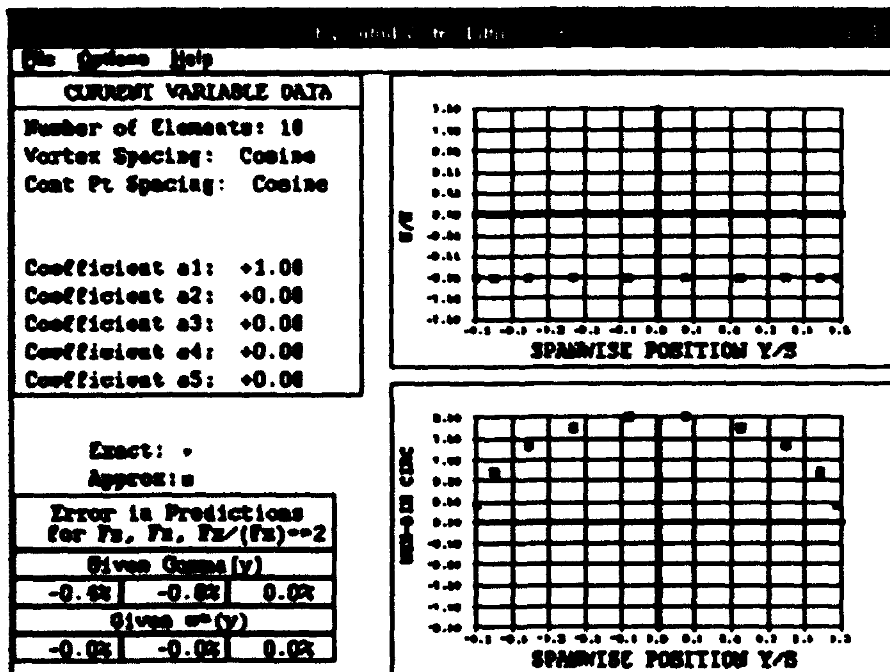

Figure 2-2. Windows™ VLL Sample Output

Figures 2-1 and 2-2 both display virtually the same information. Careful inspection reveals that the Glauert coefficients, the number of elements used, and percent errors are immediately available in text format. The remaining data, with the exception of the spanwise position of the lattice vortices is presented in graphical format. The Windows™ program also creates an output file similar to figure 2-1 for each run. The section of the output file corresponding to figure 2-1 is shown in figure 2-3.

```
VORTEX LIFTING LINE-LINE SOLUTION WITH 10 ELEMENTS

CIRCULATION COEFFICIENTS
1.000000  0.000000  0.000000  0.000000  0.000000
Cosine spaced vortices and control points
N      YV       YC       GAMMA    W(EXACT)      W(NUM)   G(NUM)
1      -0.5000  -0.4938  +0.3129  -1.0000       -0.9959  +0.3142
2      -0.4755  -0.4455  +0.9080  -1.0000       -0.9959  +0.9117
3      -0.4045  -0.3536  +1.4142  -1.0000       -0.9959  +1.4200
4      -0.2939  -0.2270  +1.7820  -1.0000       -0.9959  +1.7894
5      -0.1545  -0.0782  +1.9754  -1.0000       -0.9959  +1.9835
6      +0.0000  +0.0782  +1.9754  -1.0000       -0.9959  +1.9835
7      +0.1545  +0.2270  +1.7820  -1.0000       -0.9959  +1.7894
8      +0.2939  +0.3536  +1.4142  -1.0000       -0.9959  +1.4200
9      +0.4045  +0.4455  +0.9080  -1.0000       -0.9959  +0.9117
10     +0.4755  +0.4938  +0.3129  -1.0000       -0.9959  +0.3142
       +0.5000
PERCENT ERROR IN NUMERICAL SOLUTION:
COMPUTING DOWNWASH FOR GIVEN CIRCULATION
LIFT:  -0.4  DRAG:  -0.8  DRAG/LIFT**2  0.0

COMPUTING DOWNWASH FOR GIVEN DOWNWASH
LIFT:  -0.0  DRAG:  -0.0  DRAG/LIFT**2  0.0
```

Figure 2-3. Windows™ VLL Data File

It is clear by inspection of the output provided by the two programs that the Windows™ version of VLL offers tangible improvements in the output provided. It also offers improvements in the area of data input. The FORTRAN version of VLL provides for user input in the traditional terminal interactive mode. Upon execution, the program prints a series of prompts to the screen. The program accepts and screens user input, and then processes the input essentially in a batch mode. The screen and file output are produced immediately prior to termination of the executable.

Upon execution of the Windows™ version of VLL, the main window is created. The values of the data input manually in the FORTRAN program are automatically initialized. The user may elect to alter the default values for any or all of the Glauert coefficients, the number of vortex elements in the lattice, or the spacing of the vortices or control points. This is accomplished by using the Options pull down menu and invoking the appropriate dialog box. Figure 2-4 depicts the main window with the Geometry dialog box active.

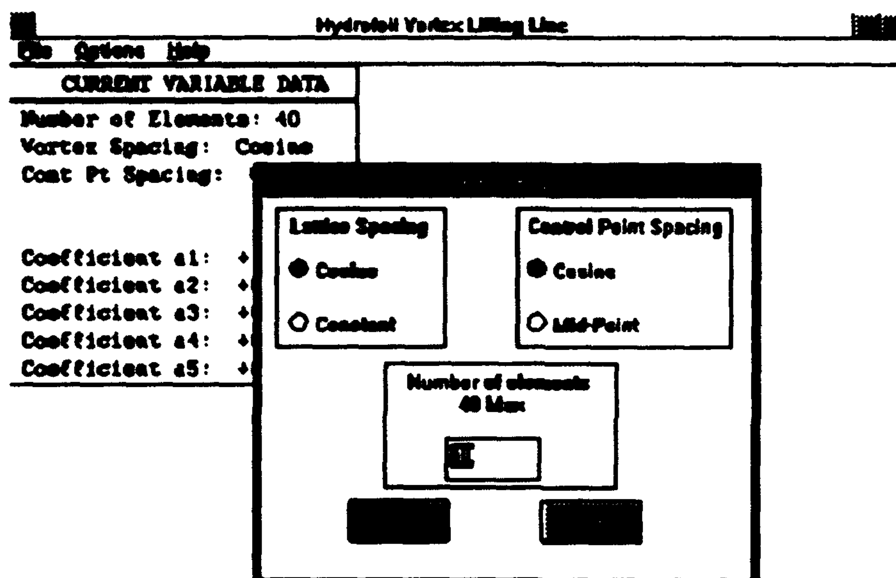

Figure 2-4. Windows™ VLL Geometry Dialog Box

After the input data has been altered, the output is calculated and displayed by selecting the Run option from the File pull down menu. This action causes output similar to figures 2-2 and 2-3 to be created. Unlike the FORTRAN version, the executable does not terminate, but rather remains running, awaiting further user input. The user may elect

to further alter the input, terminate the program, print a copy of the screen output to the system printer, or view the on-line help available by using the Help pull down menu.

The on-line help provided by the FORTRAN version of VLL is limited to that provided with the input prompts. The Windows™ version provides a general description of the program, specifics regarding the use of each item on the pull down menus, and information about the authors of the program. Figure 2-5 shows the VLL screen with the Options|Geometry help message box displayed.

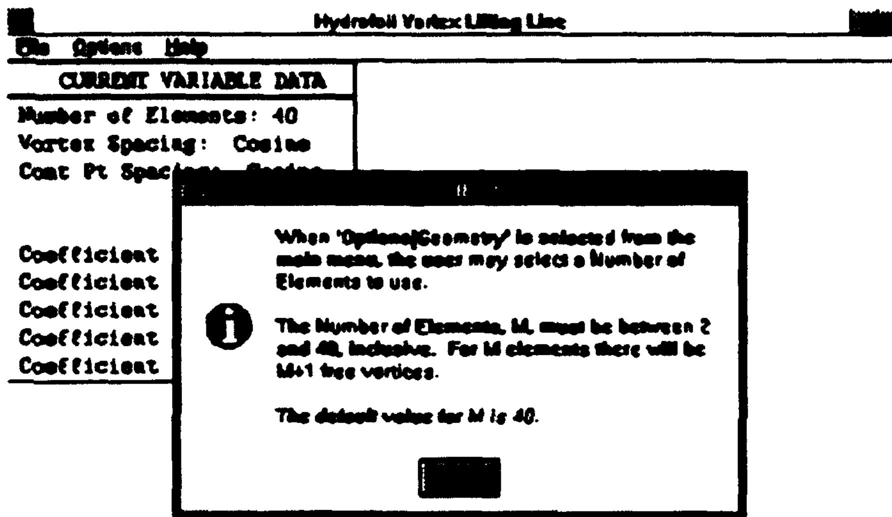

Figure 2-5. Windows™ VLL with Help displayed

Portability is another advantage of programming for the Windows™ environment. Windows provides the interface between the executable file and the screen or printer, obviating the need to write multiple device drivers. The programs described in this thesis are designed to run on any IBM compatible PC with adequate memory under Windows™ 3.1. They also may be run under Windows™ 95.

2.2 The structure of a Windows™ program.

The advantages inherent in programming in the Windows™ environment do not come without a price. The FORTRAN version of VLL consists of about ten pages of code in two files. The Windows™ version, on the other hand, consists of on the order of 75 pages of code in a dozen files. Some of the difference is explained by the addition of graphical output, but the largest factor is explained by the structure of a Windows™ program.

The most basic of Windows™ programs requires at least two functions. The first is the WinMain function and the second is the MainWndProc function. Adding the functionality of a main menu requires an additional function, the WMCommand_Handler function. The addition of each dialog box requires two more functions, one to initialize the box and one to process the input from the dialog box.

In addition to the functions that are part of the Windows™ program structure, the VLL program also uses separate functions to perform the hydrodynamic computations and to write output to the screen and printer.

The first three sections of Appendix A provide detailed descriptions of the VLL WinMain, MainWndProc, WMCommand_Handler functions. Appendix A.4 describes the VLL dialog functions and the sub-sections of Appendix A.5 describe the output functions that are used in VLL. All of the function, header, resource, and definition files that make up the VLL program are contained in Appendix A.6.

Figure 2-6 below shows the interrelationships between the functions described below and the output hardware.

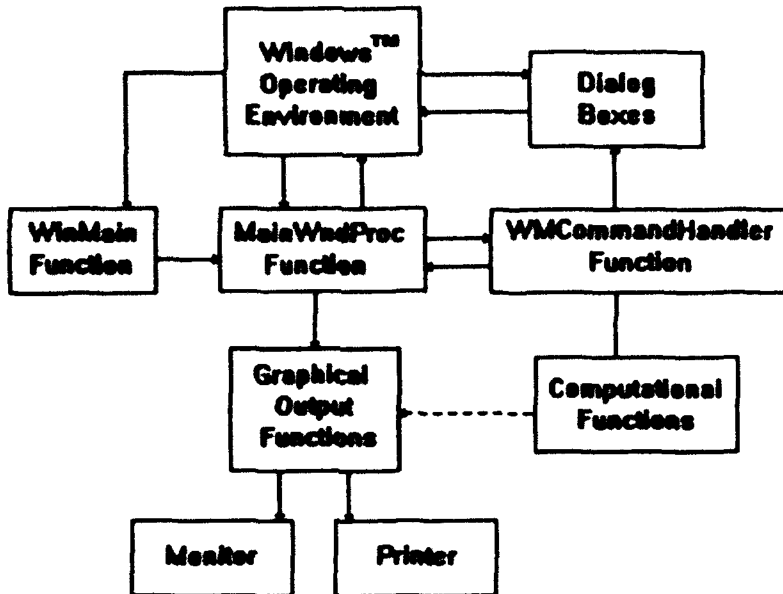

Figure 2-6. Windows™ Program Structure

2.2.1 The WinMain function.

The WinMain function is the main entry point for an application. Typically the WinMain function performs the following tasks:

-set up a window class structure

-register a window class using that structure

-create and display a window based on the registered class

-enter a message loop that receives and processes messages from Windows™.

The WinMain function for VLL is described in detail in Appendix A.1.

2.2.2 The MainWndProc function.

The second function required in a Windows™ program is the MainWndProc function. The MainWndProc function is referred to as the window procedure. It is actually a callback function that uses a switch in processing and responding to Windows™ messages. The MainWndProc for VLL is described in detail in Appendix A.2.

2.2.3 The WMCommand_Handler function.

The WMCommand_Handler function provides the functionality of a main menu for a Windows™ program. It consists of a switch that handles messages sent to the application by the Windows™ environment in response to user selections from the main menu. The WMCommand_Handler function used by VLL is described in detail in Appendix A.3.

2.2.4 Dialog functions.

Dialog boxes are a convenient means for allowing the application user to provide input to the program. The use of a single dialog box requires that two functions be added to the functions described above. The first is a callback function, similar to the MainWndProc. The purpose of the function is initialize the data displayed in the dialog box when it is created, and to refer messages received by the dialog box to the second function.

The second function is similar to the WMCommand_Handler function. The purpose of this function is to handle messages received by the dialog box, usually messages from an "OK" or "CANCEL" button. The user interaction with the dialog box, other than the "OK" or "CANCEL" buttons is typically handled by the Windows™ environment. The dialog functions used in VLL are described in detail in Appendix A.4.

2.2.5 Output functions.

Application programs in the Windows™ environment provide the user with the advantages of a graphical user interface (GUI) and the programmer with the advantages of the graphical device interface (GDI). The GDI provides over 50 graphics routines in the application program interface (API). These functions allow the programmer to generate

output without becoming involved in the specifics of a particular piece of hardware.[9]

The VLL program uses four separate functions to provide output. Two provide output to the monitor and two provide output to the system printer. Each pair consists of a function that draws the current variable data and a function that draws the graphs and the percent error table. The output functions are described in detail in Appendix A, section 5.1 through 5.3.

2.3 The 2D Vortex/Source Lattice with Lighthill Correction Program.

The 2D Vortex/Source Lattice with Lighthill Correction Program(VLMLE) is a FORTRAN code that demonstrates a vortex lattice numerical approximation for the two dimensional hydrofoil problem. It is a version of the VLM2D FORTRAN program[10], revised by Kerwin to include a Lighthill leading edge correction[11]. The leading edge correction prevents the infinite tip velocity predicted by linear theory for angles of attack other than the ideal angle of attack. VLMLE takes inputs of the number of panels, ideal lift coefficient, angle of attack relative to the ideal angle of attack, and thickness to chord ratio. The program calculates the pressure distribution over the upper and lower surfaces of the foil assuming a NACA-66(Mod) thickness form with a NACA a=0.8 mean camber line. It writes the computed total lift coefficient to the screen and provides an output file that can be used in conjunction with a suitable graphics program.

The implementation of VLMLE in a Windows™ application was chosen as an intermediate step in demonstrating the feasibility and desirability of the employment of personal computers in hydrofoil and propeller design. It was chosen for two reasons. First, the program seemed suitable to adaptation as a stand alone executable called by a Windows™ application. Second, as with VLL, the Windows™ environment offered

[9] Paul Perry, Turbo C++ for Windows Programming for Beginners(Indianapolis, Indiana: Sams Publishing, 1993)p.350.

[10] Justin Kerwin, 13.04 Lecture Notes -Hydrofoils and Propellers (Cambridge, Massachusetts: Massachusetts Institute of Technology, 1995), p.161.

[11] M.J. Lighthill, "A New Approach to Thin Aerofoil Theory", Aero Quart 3,193-210.

immediately recognizable improvements in terms of the user interface, input/output, on-line help and portability.

2.3.1 A comparison of VLMLE and the Windows™ version of VLMLE.

The screen output provided by VLMLE is limited to the computed total lift coefficient. Figure 2-7 is a sample of the output of the Windows™ version of VLMLE.

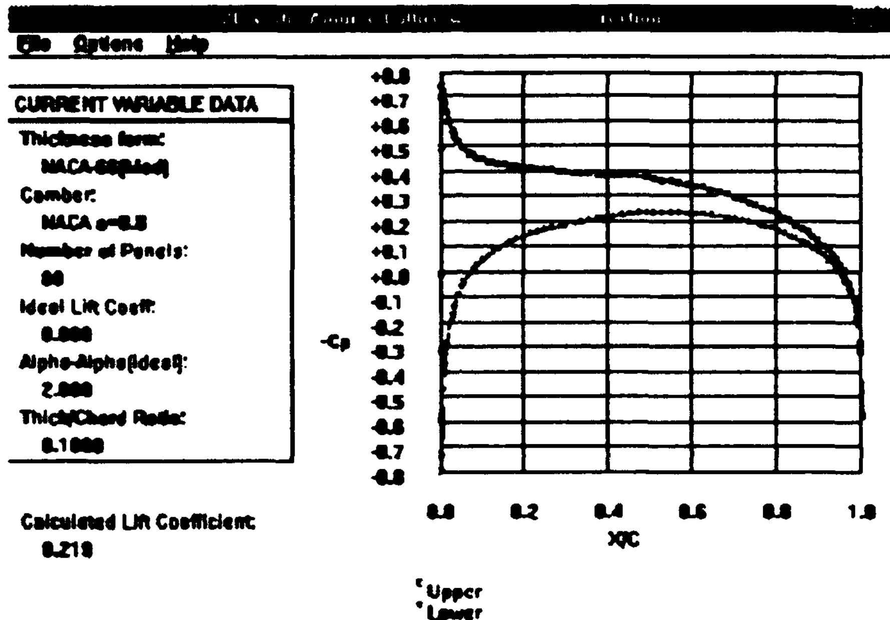

Figure 2-7. Windows™ VLMLE Sample Output

An inspection reveals that the input data, number of panels, ideal lift coefficient, angle of attack relative to ideal angle of attack, and thickness to chord ratio may be reviewed in the Current Variable Data area. The negative of the pressure coefficient on the upper and lower surface is plotted versus position on the foil non-dimensionalized with the chord on the graph, and the computed total lift coefficient is written under the Current Variable Data area. The Windows™ version also provides the graphics output file produced by the FORTRAN version.

The FORTRAN version of VLMLE provides for user input via a series of prompts to the screen. The program accepts and screens user input, and then processes the input in a batch mode. The screen and file output are produced immediately prior to termination of the executable.

Upon execution of the Windows™ version of VLMLE, the main window is created. The values of the data input manually in the FORTRAN program are automatically initialized to selected default values. The user may elect to alter the default values for the number of panels or thickness to chord ratio by selecting Options|Geometry on the main menu and interacting with the Geometry dialog box. The user also may elect to alter the ideal lift coefficient or angle of attack by selecting Options|Parameters on the main menu and interacting with the Parameters dialog box. Figure 2-8 depicts the main window with the Parameters dialog box active.

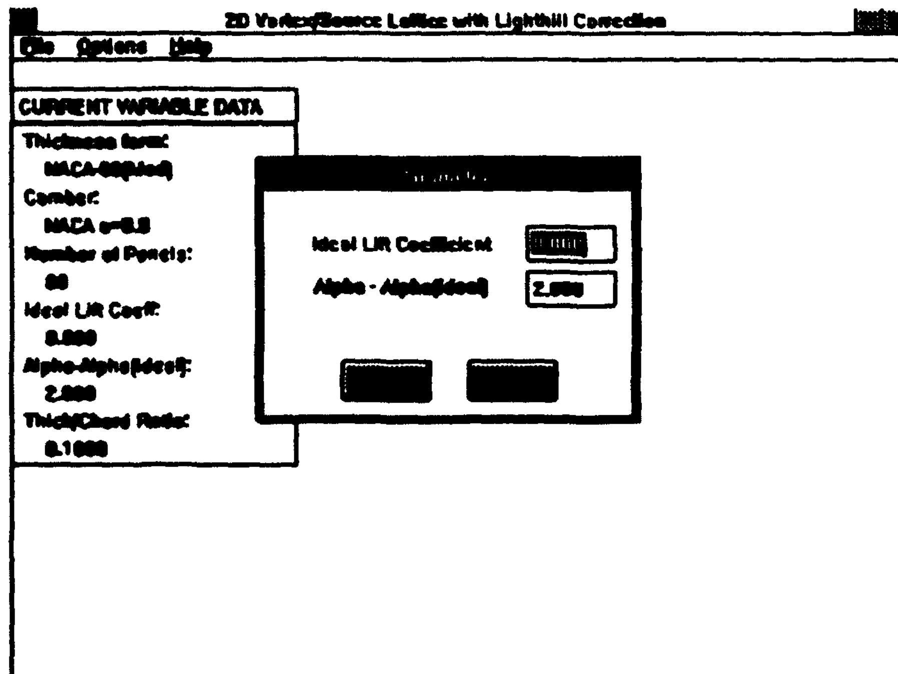

Figure 2-8. Windows™ VLMLE Parameters Dialog Box

After the input data has been altered, the output is calculated and displayed by selecting the Run option from the File pull down menu. Unlike VLL, the Windows™ version of VLMLE does not perform the actual hydrodynamic calculations but rather writes an input file containing the parameters normally provided by the user in the terminal interactive mode. The Windows™ program then calls a modified FORTRAN version of VLMLE. The modified FORTRAN VLMLE executable reads the input data file written by the Windows™ program, performs the calculations, and writes the normal output file and an additional output file formatted for use by the Windows™ program. The FORTRAN executable also writes a dummy file immediately prior to termination. The purpose of the dummy file is to notify the Windows™ program that the hydrodynamic calculations are complete and that the necessary output has been generated. The Windows™ program periodically checks for the existence of the dummy file. When it is found to exist, the formatted output file is opened and the output is written to provide a view similar to figure 2-7. After this is accomplished, the program remains running, awaiting further input. The user may elect to further alter the input, terminate the program, print a copy of the screen output to the system printer, or view the on-line help available by using the Help pull down menu.

The on-line help provided by the FORTRAN version of VLMLE is limited, as in VLL, to that provided with the input prompts. The Windows™ version provides a general description of the program, specifics regarding the use of each item on the pull down menus, and information about the authors of the program. Figure 2-9 shows the VLL screen with the Options|Parameters help message box displayed.

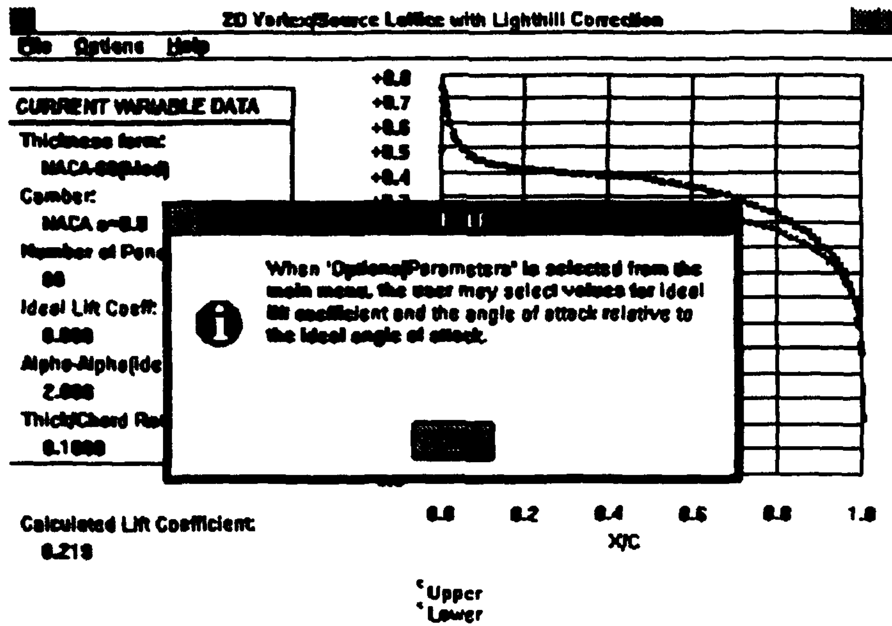

Figure 2-9. Windows™ VLMLE with Help displayed

The Windows™ version of VLMLE will run on any IBM compatible PC with Windows™ 3.1 or Windows™ 95.

3. PROPELLER DESIGN APPLICATIONS

3.1 The MIT Propulsor Lifting Line Program.

The MIT Propulsor Lifting Line Program is a FORTRAN code that is used for the preliminary design of marine propulsors. It can be used in the design of propulsors with a relatively high degree of complexity. PLL can serve as the starting point of a "blank sheet of paper" design and can be used in conjunction with codes used to design blade shapes, to analyze cavitating propellers, and to analyze steady and unsteady propeller forces.

PLL was selected for the second step in demonstrating the feasibility and desirability of the employment of personal computers in hydrofoil and propeller design for two reasons. First, the program is the starting point for propeller designs and can be used in conjunction with other codes that further refine the design. Second, the implementation of PLL in the Windows™ environment was estimated to be the most difficult step in the construction of and integrated propeller design software package.

3.1.1 A brief description of PLL.

The FORTRAN version of PLL is designed as an interactive program. The user is prompted for input data and may provide it in the form of keyboard input or prepared data files. The program also provides the capability of writing input files for later use based on the keyboard input provided. The three basic files used in a typical PLL run are the overall input file, the blade input file, and the wake input file. A pre-swirl stator circulation file may be used in a project which includes a non-axisymmetric pre-swirl stator. Figure 3-1 is a sample overall input file.

```
                    PROPELLER LIFTING LINE RUN:     1/31/1996
                         OVERALL INPUT FILE
50.500000 . . . . . . . . . .Ship speed (ft/sec)
1.991000 . . . . . . . . . .Fluid Density
10.000000 . . . . . . . . . .Shaft centerline depth (ft)
1 . . . . . . . . . .Number of components
N . . . . . . . . . .No image hub to be used
N . . . . . . . . . .No image duct to be used
N              Component 1 is not a ringed propeller
5 . . . . . . . . . .Number of blades on component 1
10.000000 . . . . . . . . . .Diameter of component 1 (ft)
sample.bld           File containing blade inputs for comp. 1
10.000000 . . . . . . . . . .Diameter of wake for component 1 (ft)
sample1.wak             File containing wake inputs for comp. 1
```

Figure 3-1. Sample PLL Overall Input File

The overall input file provides information regarding the ship operating conditions, the number and nature of the propulsor components, and the files that describe the blade and wake inputs. Figure 3-1 is an overall input file for a single five bladed propeller with no ring or duct.

A blade input file is shown in figure 3-2 below.

```
      PROPELLER LIFTING LINE RUN: SAMPLE RUN #1            00/00/94
******************** BLADE INPUT FILE ********************
NUMBER OF RADII FOR INPUTS:
 11
NONDIMENSIONSAL RADII FOR INPUTS:
 0.2000 0.2500 0.3000 0.4000 0.5000 0.6000 0.7000 0.8000 0.9000 0.9500 1.0000
CHORD/DIAMETER AT EACH RADIUS:
 0.1740 0.1970 0.2290 0.2750 0.3120 0.3370 0.3470 0.3340 0.2800 0.1200 0.050
THICKNESS/DIAMETER AT EACH RADIUS:
 0.0348 0.0329 0.0310 0.0271 0.0233 0.0194 0.0156 0.0117 0.0079 0.0060 0.0040
2-D SECTIONAL DRAG COEFFICIENT AT EACH RADIUS:
 0.0080 0.0080 0.0080 0.0080 0.0080 0.0080 0.0080 0.0080 0.0080 0.0080 0.0080
NONDIMENSIONAL CIRCULATION AT EACH RADIUS:
 0.0000 0.0000 0.0000 0.0000 0.0000 0.0000 0.0000 0.0000 0.0000 0.0000 0.0000
```

Figure 3-2. Sample PLL Blade Input File

The blade input file provides non-dimensional information regarding the blade chord, thickness, two dimensional sectional drag coefficient, and circulation at a number of radii spanning the blade from hub to tip.

A sample wake input file is shown in figure 3-3 below.

```
     PROPELLER LIFTING LINE RUN: SAMPLE RUN #1
********************** WAKE INPUT FILE ********************
NUMBER OF RADII FOR INPUTS:
 11
NUMBER OF HARMONIC COEFFICIENTS (axial, radial, tangential):
  1  0  0
NONDIMENSIONAL RADII FOR INPUTS:
 0.2000 0.2500 0.3000 0.4000 0.5000 0.6000 0.7000 0.8000 0.9000 0.9500 1.0000
AXIAL COSINE HARMONIC COEFFICIENTS:
 0.4520 0.4530 0.4540 0.4760 0.5160 0.5870 0.6710 0.7570 0.8140 0.8350 0.8470
AXIAL SINE COEFFICIENTS:
 0.0000 0.0000 0.0000 0.0000 0.0000 0.0000 0.0000 0.0000 0.0000 0.0000 0.0000
```

Figure 3-3. Sample PLL Wake Input File

The wake input file provides a description of the inflow wake in terms of harmonic coefficients of the circumferentially varying inflow at a specified set of radii.[12]

After initial input is made in order to provide a description of the proposed blade, wake, and operating conditions, the user is allowed to review and alter the current PLL settings. The current settings include switches that determine whether PLL will optimize circulation and chord length, whether or not PLL will perform a wake alignment or compute the drag coefficient, and what circulation distribution will be used for ducts. Numerical values for number of panels, hub vortex radius, tip thickness, Lagrange multiplier, maximum lift coefficient, maximum thickness to chord ratio, and minimum root chord are also included in the current settings.

When the user is satisfied with the settings, PLL proceeds with the hydrodynamic calculations, periodically prompting the user to make selections regarding the computation of the effective wake, tunnel operation, thrust estimates, torque ratios, and thrust distributions. When the hydrodynamic calculations are completed, the user may make selections from the PLL main menu. The user may choose to unload a component, try a different value of thrust or RPM, evaluate the effect of a non-axisymmetry stator, look at

[12] William B. Coney, MIT-PLL User's Manual (Cambridge, Massachusetts; Massachusetts Institute of Technology, 1988), p. 69.

output or plots, run optimization again with a different pitch distribution, try another thrust or RPM with a new effective wake, adjust chord length to match an expanded area ratio, perform a strength computation, reset blade input values with current blade outputs, review or alter the current settings, reoptimize with a new propeller diameter, determine optimum RPM or diameter, perform a blade stress computation, modify the thickness distribution, or exit the program.

Output from the FORTRAN version of PLL includes text files that present summary and detailed data for each of the propulsor components, duct geometry data, velocity profiles far downstream of the propulsor, and files that describe the forces, velocity harmonics, and circulation distribution for non-axisymmetric stators. A file that compares axisymmetric and non-axisymmetric results is also provided. Plotted output is also available through the use of plot files with suitable graphics programs. Plotted data includes axial inflow velocity, advance angle, tangential inflow velocity, chord and thickness distributions, circulation distribution, axial and tangential induced velocity, hydrodynamic advance angle, and local thrust, torque, and lift coefficients.

PLL is a capable and complex computer program. A detailed discussion of the program, including the theory behind the code, the input to the program, running the program, and output from the program is available in the *MIT-PLL Propulsor Lifting Line* Code User's Manual by William B. Coney.

3.2 The MIT Propeller Blade Design Code.

The third step in demonstrating the feasibility and desirability of the employment of personal computers in hydrofoil and propeller design is the integration of the MIT Propeller Blade Design Code as a part of the PLL Windows™ application. PBD is a vortex-lattice combined design and analysis code. It is capable of the design and analysis of multi-stage open and ducted propellers. The integrated Windows™ application provides a seamless link between PLL and PBD.

3.2.1 A brief description of PBD.

The FORTRAN version of PBD is designed to run in a batch mode. The user is required to provide three input files, four in the case of the coupled analysis mode. The three file types required are the B-spline control polygon file, the axisymmetric flow solution in the region of the propeller, and a main administrative file. The coupled analysis mode also uses a circumferential mean induced velocity file, usually produced by a previous PBD run. Figure 3-4 is a sample main administrative file.

```
PBD14 TURB1.PBD                                   :no hub, no duct
turb1.bsn                                         : OR TRY PBDOUT.BSN
rotor.vel                                         : OR TRY restart.vel
 4 11 11                                          :nblade nkey, mkey
 2                                                :ispn
 10 1 2 3 4 5 6 7 8 9 10 11 12 13 14 15 16 17 18 19 20 21 22 23 24 25 26 27 28 29 30 31 32 33 34 35 36
37 38 39 40                                            :mctrp
 0 0.0 0 0.0                                      :ihub,hgap,iduc,dgap
 9 1 0 0                                          :nx,ngcoeff,mltype,mthick
 2                                                :imode
 0                                                :nwimax
 1 0.001 0.00 0 1                                 :niter,tweak,bulge,radwgt,nufix
 1 0.02                                           :nplot,hubshk
 0.0085                                           :Cdrag
 0.900  1.000  1.500  0.100                       :ADVCO XULT XFINAL DTPROP
 0.0300                                           :Circ Coef.
 0.2  0.3  0.4  0.5 0.6 0.7 0.8 0.9 1.0           :r/R
 0.02 0.02 0.02 0.02 0.02 0.02 0.02 0.02 0.02     :t/d
 0.  0.  0.  0. 0. 0. 0. 0. 0.                    :UA
 0.  0.  0.  0. 0. 0. 0. 0. 0.                    :UAU
 0.  0.  0.  0. 0. 0. 0. 0. 0.                    :UT
 0.  0.  0.  0. 0. 0. 0. 0. 0.                    :UTU
```

Figure 3-4. Sample PBD Administrative File

The administrative file specifies the B-spline and velocity input files. It also specifies fineness of the vortex lattice, the mode in which the job is to be run, the thickness and circulation distributions, the maximum number of wake iterations, parameters related to iteration of the blade shape, the velocity field at the propeller and at the ultimate wake, and several other parameters.

Figure 3-5 is a portion of a sample velocity file.

```
TITLE = "PBD10 VELOCITY INPUT"
VARIABLES = X,R,UA,UR,UT
ZONE T="Inflow", I= 5, J= 5, F=POINT
-3.0000 0.2000    1.0    0.0000    0.0000
-1.5000 0.2000    1.0    0.0000    0.0000
 0.0000 0.2000    1.0    0.0000    0.0000
 1.5000 0.2000    1.0    0.0000    0.0000
 3.0000 0.2000    1.0    0.0000    0.0000
-3.0000 0.5000    1.0    0.0000    0.0000
-1.5000 0.5000    1.0    0.0000    0.0000
 0.0000 0.5000    1.0    0.0000    0.0000
 1.5000 0.5000    1.0    0.0000    0.0000
 3.0000 0.5000    1.0    0.0000    0.0000
-3.0000 0.7000    1.0    0.0000    0.0000
-1.5000 0.7000    1.0    0.0000    0.0000
 0.0000 0.7000    1.0    0.0000    0.0000
 1.5000 0.7000    1.0    0.0000    0.0000
 3.0000 0.7000    1.0    0.0000    0.0000
-3.0000 0.9000    1.0    0.0000    0.0000
-1.5000 0.9000    1.0    0.0000    0.0000
 0.0000 0.9000    1.0    0.0000    0.0000
 1.5000 0.9000    1.0    0.0000    0.0000
 3.0000 0.9000    1.0    0.0000    0.0000
```

Figure 3-5. Sample PBD Velocity Input File

The velocity input file contains induced velocity data for at least four stations axially extending from upstream of the propeller to at least the axial position downstream where all flow quantities are constant. At least four radial positions must be specified.

A portion of a sample B-spline control polygon file is shown below in Figure 3-6.

```
ZONE T="B-spline polygon", I= 7 J= 7 F=POINT
-0.08451        0.18184 -0.08317        0.19996 0.0    0.0    0.0
-0.06695        0.18725 -0.07201        0.20062 0.0    0.0    0.0
-0.01607        0.19667 -0.04289        0.20129 0.0    0.0    0.0
0.05758 0.20073 -0.00762        0.20087 0.0    0.0    0.0
0.13445 0.19920 0.02392 0.20063 0.0    0.0    0.0
0.19527 0.19608 0.03901 0.19993 0.0    0.0    0.0
0.21722 0.19502 0.04442 0.20001 0.0    0.0    0.0
-0.06826        0.43067 -0.19016        0.47078 0.0    0.0    0.0
-0.05537        0.44320 -0.16389        0.47253 0.0    0.0    0.0
-0.00784        0.46552 -0.09462        0.47504 0.0    0.0    0.0
0.06414 0.47301 -0.00015        0.47301 0.0    0.0    0.0
0.13809 0.46351 0.09282 0.47271 0.0    0.0    0.0
0.20626 0.44465 0.14939 0.46908 0.0    0.0    0.0
```

Figure 3-6. Sample PBD B-spline Control Polygon File

The file consists of an I by J matrix of B-spline control polygon vertices. The first three columns are the Cartesian coordinates of the points. The values in the fourth column are the distance from the centerline of the hub to the vertices.

Figure 3-7 is a portion of a circumferential mean velocity file. The file contains the circumferential mean velocities induced on the blade by the circulation distribution and by the thickness.

```
                TITLE ="Circumferential Mean Blade Velocity"
                VARIABLES = "X","Y","Z","VX","VY","VZ"
                ZONE T="VELOCITIES", I= 240
-0.16627        0.19145 -0.17308        0.11971 0.01132 -0.01241
-0.15747        0.19914 -0.16430        0.15086 0.01358 -0.02039
-0.14289        0.21042 -0.14933        0.17696 0.01462 -0.03066
-0.12291        0.22360 -0.12818        0.19689 0.01699 -0.04406
-0.09819        0.23685 -0.10119        0.21032 0.02295 -0.06017
-0.06963        0.24805 -0.06911        0.21752 0.03327 -0.07725
-0.03834        0.25520 -0.03319        0.21893 0.04772 -0.09347
-0.00556        0.25722 0.00464 0.21387 0.06523 -0.10738
0.02750 0.25389 0.04214 0.20134 0.08416 -0.11828
0.05973 0.24574 0.07704 0.18228 0.10291 -0.12651
0.08992 0.23411 0.10750 0.15785 0.12007 -0.13263
0.11675 0.22100 0.13256 0.12973 0.13351 -0.13566
```

Figure3-7. Sample PBD Circumferential Mean Blade Velocity File

The PBD FORTRAN executable prompts the user for name of the main administrative file. The program then reads the data in the administrative file and in the specified input files. Periodic status messages are printed to the monitor during the course of the hydrodynamic calculations. Program output is in the form of files formatted for plotting with a suitable graphics program. The files produced during a given run are a function of the mode selected for the run. The files are described below.

PBDOUT.CBD- a graphic of the centerbody, or hub.

PBDOUT.CMF- the circumferential mean forces on the blade.

PBDOUT.CMV- the circumferential mean velocities induced on the blade.

PBDOUT.GSP-	the bound circulation strength of each vortex segment versus radial and chordwise position (design modes only).
PBDOUT.SOL-	the bound circulation strength of each vortex segment versus radial and chordwise position (analysis modes only).
PBDOUT.IBG-	the input blade geometry as a Cartesian grid.
PBDOUT.KTQ-	a text file containing thrust and torque coefficients.
PBDOUT.VCP-	the velocities at the blade control points.
PBDOUT.OBG-	the output blade geometry for all blades on the propeller, plus the wake of the key blade and the image hub and duct lattices, if applicable.
PBDOUT.BSN-	the output B-spline control polygon.
PBDOUT.RDC-	the radial circulation distribution at the trailing edge (design modes only).
PBDOUT.SGR- modes	the radial circulation distribution at the trailing edge (analysis only).

Figure 3-8 shows the screen output for a sample PBD run.

PBD Propeller Blade Design and Analysis Code

Version no. 14.1.27
Release Date: Feb 01 1996

Enter PBD Master Input File Name... turb2.pbd
TURB2.PBD

turb2.ben
rotor2.vel

DESIGN MODE:

Iteration 1 Max radius error in fitting blade to hub= 0.0001
Iteration 1 Max radius error in fitting blade to tip= 0.0001
Time in BLINPT: 0 seconds
Time in BLADE: 0 seconds
Time in INPLOT: 0 seconds
Time in PBDTWK: 0 seconds
Time in ZEROHS: 0 seconds

Creating CMV horseshoes based on IMODE...
********* 1 out of 10
********* 2 out of 10
********* 3 out of 10
********* 4 out of 10
********* 5 out of 10
********* 6 out of 10
********* 7 out of 10
********* 8 out of 10
********* 9 out of 10
********* 10 out of 10
Time in HSCMV: 0 seconds
Time in SIGNCH: 0 seconds
Time in BSHAPE: 0 seconds
Time in PBPLOT: 0 seconds
BFORCE - No Navier Stokes coupling
———CALCULATION OF THRUST AND TORQUE COEFFICIENTS———

CD	KT	10*KQ	E/(1-W)
0.0000	0.2012	0.2881	1.000
0.0085	0.1983	0.3134	0.826

Time in BFORCE: 0 seconds

Program completed successfully

PBD Version No. 14.1.27
Release Date: Feb 01 1996

Figure3-8. Sample PBD Screen Output

A detailed discussion of PBD, including the theory behind the code, the input to the program, running the program, and output from the program may be found in PBD-14.2: A Coupled Lifting-Surface Design/Analysis Code for Marine Propulsors by S.D. Black, D.E. Egnor, D.P. Keenan, J.E. Kerwin, and T.E. Taylor.[13]

3.3 The Integrated PLL/PBD Windows™ application.

The implementation of PLL as a Windows™ application and the subsequent integration of PBD into the application were performed as distinct steps. The result will be presented in the final form for the purposes of this thesis. The term PLL from this point forward when referring to the Windows™ application will imply the integrated PLL/PBD application.

The PLL Windows™ application is similar in appearance and operation to the applications described in sections 2.1 and 2.3. This is expected since one of the advantages of the Windows™ environment is that all applications are similar in appearance and operation. The operation of PLL is, however, much more complex than the first two applications. This also is expected, since the original FORTRAN versions differed significantly in complexity of operation.

Figure 3-9 shows the PLL application as it appears upon starting the program.

[13] Scott D. Black, Dianne E. Egnor, David P. Keenan, Justin E. Kerwin, and Todd E. Taylor, PBD-14.2: A Coupled Lifting-Surface Design/Analysis Code for Marine Propulsors (Cambridge, Massachusetts; Massachusetts Institute of Technology, 1996).

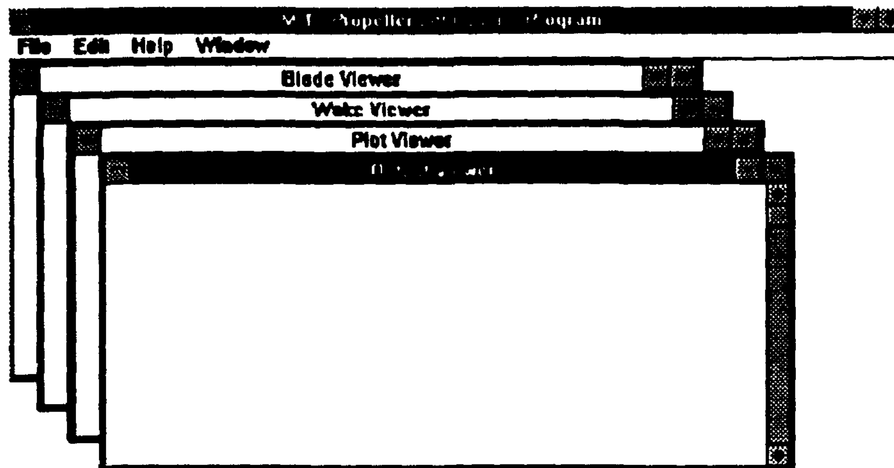

Figure 3-9. Windows™ PLL

Upon first inspection, three differences between PLL and the previous applications are immediately noticed. The PLL application has four windows displayed in the main window. This difference is due to the employment of the Multiple Document Interface (MDI) in PLL. In an MDI application, the main window is referred to as the frame window. The windows displayed inside the frame window are referred to as child windows or document windows. In the case of PLL, the document windows are the Blade, Wake, Plot, and Output Viewer windows. The purposes of these windows are as follows:

Blade Viewer-	to display the input blade file data, including ring data for ringed propulsors in a graphical format.
Wake Viewer-	to display the input wake data in a polar plot format.
Plot Viewer-	to display plotted output from the PLL and PBD FORTRAN executables.

Output Viewer- to display text file output from the PLL and PBD FORTRAN executables.

The second difference is the Window item on the main menu. This item is used to determine how the document windows will be displayed in the frame window. In PLL, unlike most MDI applications, the four document windows are created when program execution begins and remain in existence until program termination. Figure 3-9 shows the windows in a cascaded format. Figure 3-10 shows the windows in a tiled format with the focus set to the Output Viewer window and figure 3-11 shows the windows in the iconified state with the Window pull down menu activated and the focus set to the Wake Viewer window.

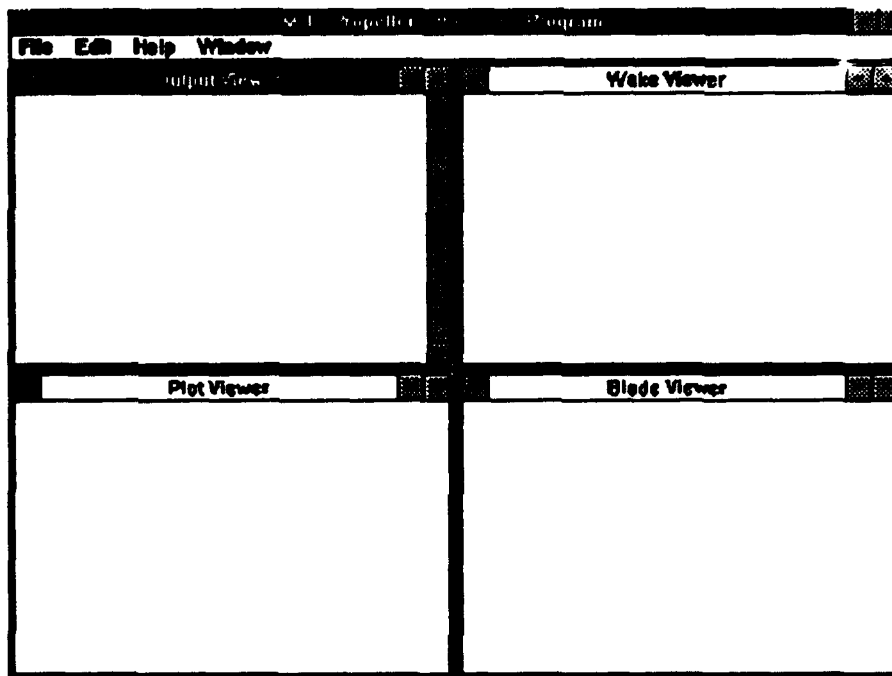

Figure 3-10. Windows™ PLL with Tiled Child Windows

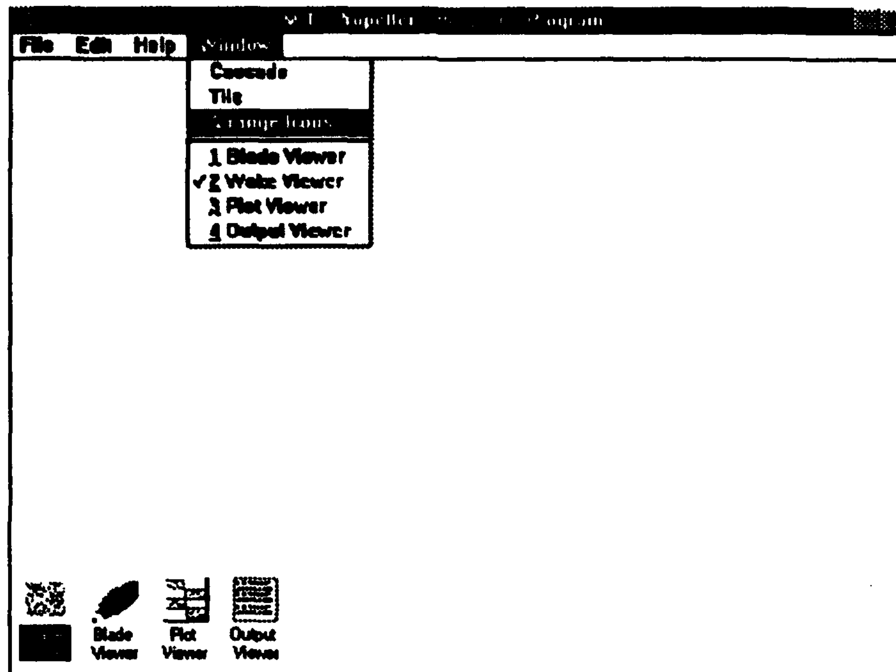

Figure 3-11. Windows™ PLL with Iconified Child Windows

The Window pull down menu can be used to display the child windows in cascaded or tiled formats. When one or more of the windows are iconified, it may be used to arrange the icon(s) in the frame window. The Window pull down menu can also be used to set the focus on a specific window.

The third difference that is noticed immediately is the vertical scroll bar in the Output Viewer window. The text files displayed in the Output Viewer window frequently exceed the vertical range of the window. The scroll bar allows the user to view the entire file, a portion at a time, by scrolling down the page. The user can also perform the scrolling function by using the Page Up, Page Down, Up Arrow, and Down Arrow keys on the keyboard.

3.3.1 The Blade and Wake Viewer Windows.

The next step the user must take if he or she wishes to perform a propulsor design is to open a project file. This is accomplished by selecting File|Open Project on the main

menu. The user specifies a project file using the Open dialog box. The program then reads overall input, blade input, and wake input files identical to those used by the original version of PLL. The Windows™ application is designed to read pre-existing PLL data files so that the user need not perform data manipulation in order to run old projects with the new software.

It is important to note here that project files are not used in the FORTRAN version of PLL. The project file replaces the initial terminal interactive input performed by user for the FORTRAN version, and also contains the information necessary to make settings analogous to the current settings for the FORTRAN version.

When the file has been opened, the blade input and wake data may be viewed using the Blade and Wake Viewer windows. Figure 3-12 shows the Blade Viewer window after a project is opened.

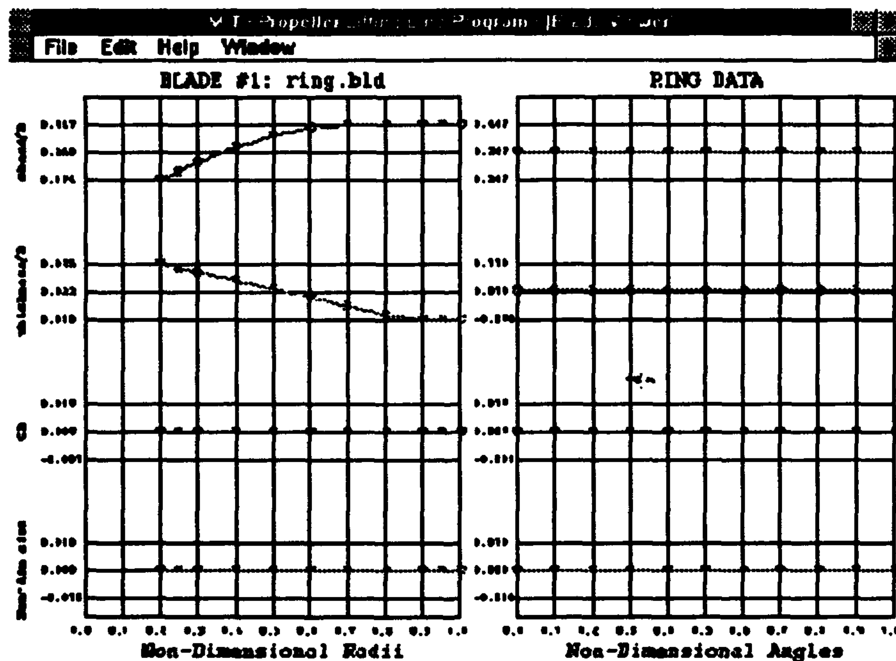

Figure 3-12. Windows™ PLL Blade Viewer

The data shown is for a ringed propeller. The plots are of non-dimensionalized chord and thickness distributions, viscous drag coefficient, and non-dimensionalized circulation distribution plotted versus non-dimensionalized radius in the case of the blade and non-dimensionalized angle in the case of the ring. Projects with a single non-ringed propeller display the blade information only. Projects with two components display the blade data for the first component on the left and the second component on the right.

Figure 3-13 shows the Wake Viewer window after a project is opened.

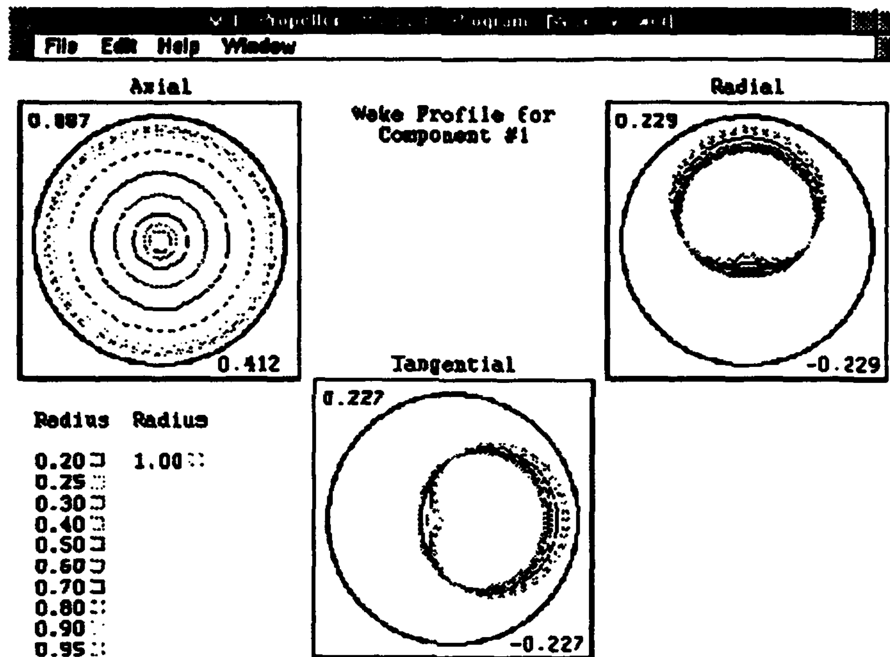

Figure 3-13. Windows™ PLL Wake Viewer

The Wake Viewer window displays polar plots of the axial, radial and tangential inflow wake velocity components for a range of radii. The values are non-dimensionalized with ship speed and are displayed such that port is left and starboard is right. The number displayed in the upper left corner of the individual plots is the value that corresponds to the black circle that bounds the plot. The number displayed in the lower right corner of

the individual plots is the value that corresponds to the center of the black circle. A legend is displayed in the lower left corner of the window. In the case of multiple component propulsors, the operator may switch between the wake plots for components one and two by double-clicking the left mouse button on the Wake Viewer window. This action has no effect if the open project is a single component project.

3.3.2 Edit Dialog Boxes.

The next step the user will want to perform in the propulsor design process is to review and possibly alter the current program settings. This is accomplished for the most part through a set of dialog boxes. The dialog boxes may be called using the Edit pull down menu on the main menu. The Project Settings dialog box is called by selecting Edit|Project Settings from the main menu. The Multiple Component Project Settings dialog box is shown in Figure 3-14.

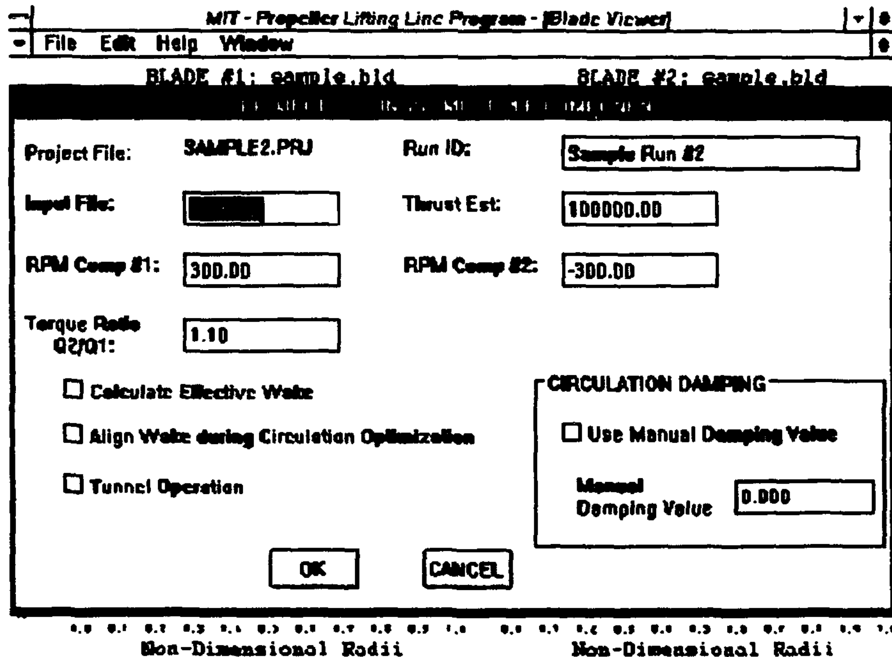

Figure 3-14. Windows™ PLL Multiple Component Project Settings Dialog Box

The user may use this dialog box to review and alter settings normally made as part of the terminal interactive input at the beginning of a PLL session. These settings include a run identifier, the name of the overall input file to be used, the RPM of each component, whether or not to compute the effective wake, the desired thrust, and the torque ratio between the two components. The user may also use this dialog box to align or not to align the wake during circulation optimization, to indicate that the propulsor is operating in a tunnel, and to manually specify a damping value.

The user may also review and alter settings with the Default Settings dialog box. The Default Settings dialog box is called by selecting Edit|Default Settings from the main menu. The Multiple Component Default Settings dialog box is shown in Figure 3-15.

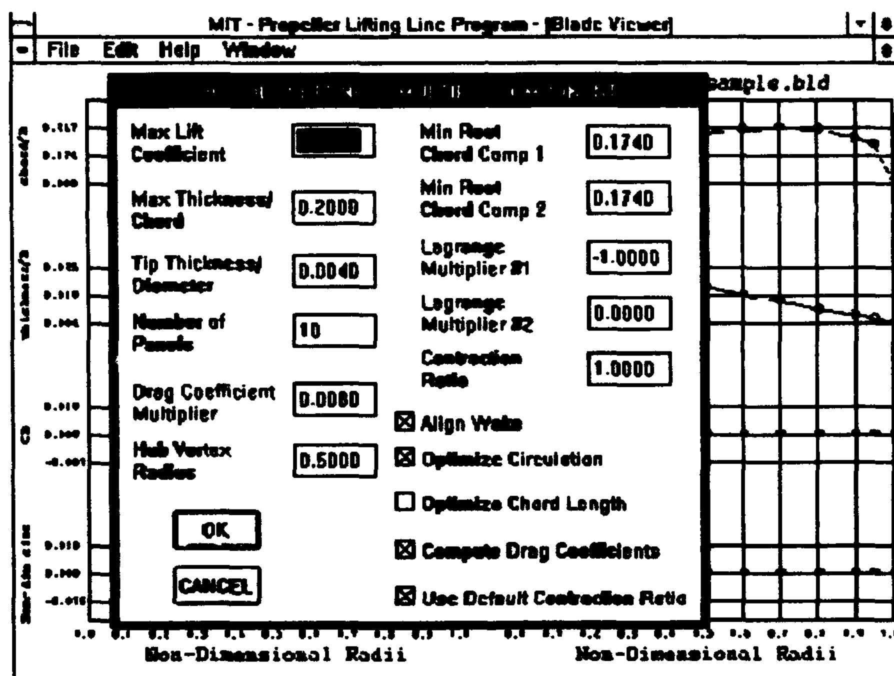

Figure 3-15. Windows™ PLL Multiple Component Default Settings Dialog Box

The Default Settings dialog box is roughly analogous to the Current Settings Menu from the original version of PLL. The user may review and alter the maximum lift coefficient,

the maximum thickness, the tip thickness the minimum root chord for each component, the Lagrange Multipliers used in solving for optimum load distributions, the number of panels, the drag coefficient multiplier, the hub vortex radius, and the wake contraction ratio. The user may elect to align or not to align the wake, to optimize or not to optimize the circulation distribution, to optimize or not to optimize the chord length distribution, to compute or not to compute the drag coefficients, and to use the default wake contraction ratio or to manually specify a contraction ratio.

The Duct Settings dialog box is called for projects with a duct by selecting Edit|Duct Settings from the main menu. The Duct Settings dialog box is shown in Figure 3-16.

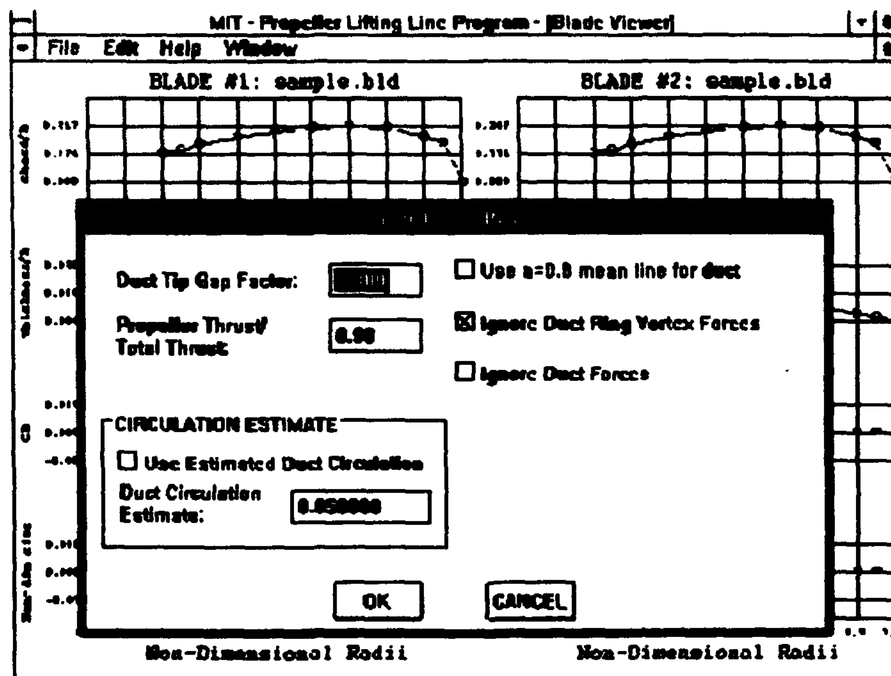

Figure 3-16. Windows™ PLL Duct Settings Dialog Box

The user may review and alter settings relating to duct calculations using the Duct Settings dialog box. The user may specify the duct tip gap factor and the ratio of propeller thrust to the sum of duct thrust and propeller thrust. The user may elect to use an a=0.8 mean line or a sinusoidal distribution of vorticity to specify duct circulation. The user may also elect to ignore duct ring vortex forces, or to ignore duct forces. The user may elect to manually specify a value for duct circulation.

The user may wish to review and alter the settings used for the ABS Rules strength calculation. The ABS Rules Strength Settings dialog box may be called by making the Edit|ABS Strength Settings selection on the main menu. The ABS Rules Strength Settings dialog box is shown in Figure 3-17.

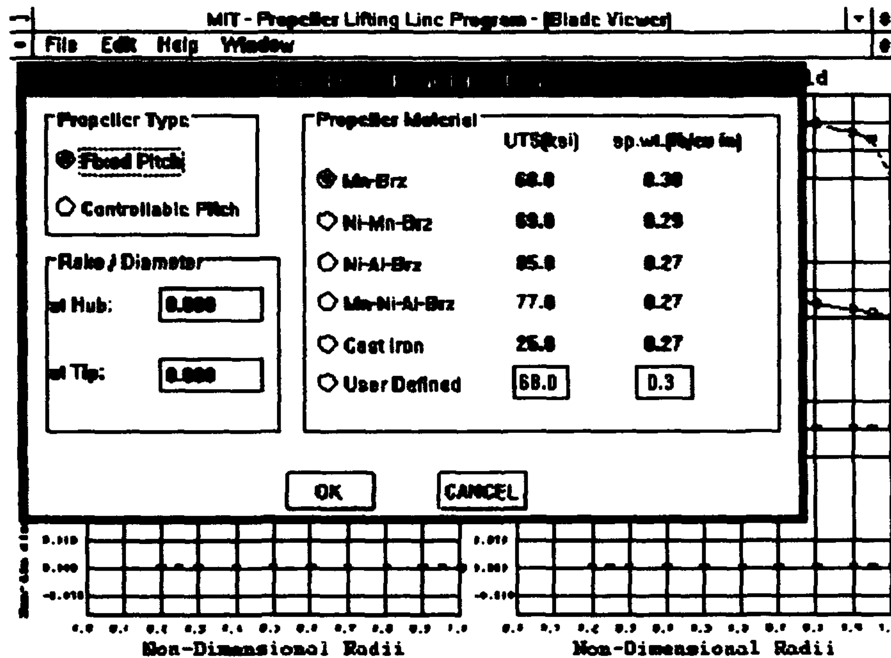

Figure 3-17. Windows™ PLL ABS Rules Strength Settings Dialog Box

The ABS Rules Strength Settings dialog box may be used to select a fixed or controllable pitch propeller, to select the propeller material properties including ultimate tensile strength and specific weight, and to specify the rake at the hub and the tip. The user may

select a user defined material by specifying an ultimate tensile strength and specific weight for a material other than the five pre-defined materials.

There are two dialog boxes that are used to specify settings that PLL uses to write input files for running the PBD portion of the program. The PBD Settings dialog box is used to make selections for parameters included in the PBD main administrative file. The PBD Skew/Rake Settings is used to specify the skew and rake values to be used when creating the B-spline input file. Figure 3-18 shows the PBD Settings dialog box.

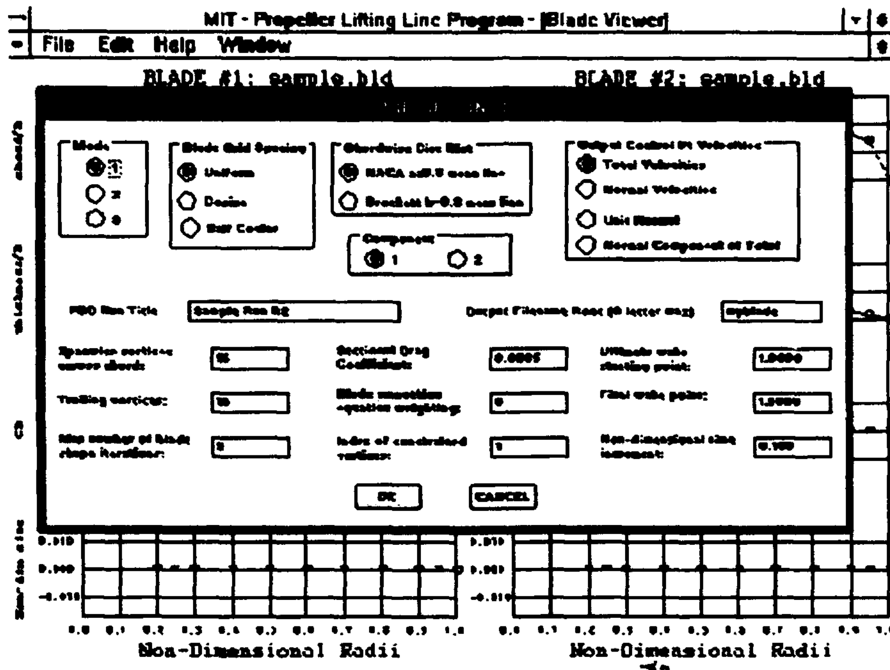

Figure 3-18. Windows™ PLL PBD Settings Dialog Box

The PBD Settings dialog box may be used to select the mode in which PBD will be run, the blade grid spacing, the type of chordwise circulation distribution, the velocities that will be output in the PBDOUT.VCP file, the component for which the files will be written, a run title, an output filename root, the number of spanwise vortices across the chord, the number of trailing vortices, the maximum number of blade shape iterations, the sectional drag coefficient, the weighting for the blade smoothing equations, the index of the

constrained vertices, the ultimate wake starting point, the final wake point, and the non-dimensional time increment.

The PBD Skew/Rake settings dialog box for the first component is shown in

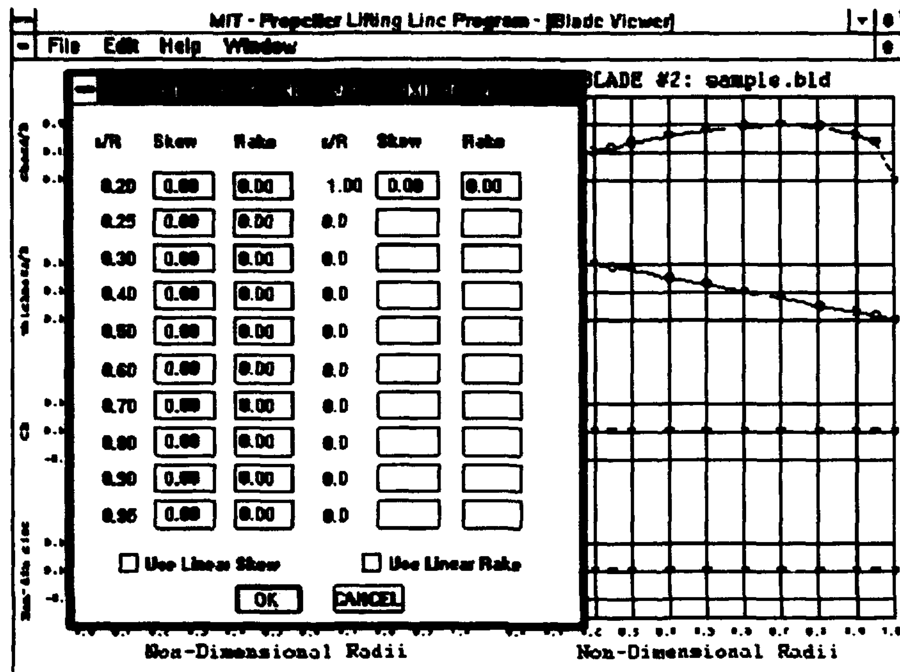

Figure 3-19. Windows™ PLL PBD Skew/Rake Settings Dialog Box

The PBD Skew/Rake settings dialog box is initialized with the current values of skew and rake at each of the radii used for blade input data. The default value is zero. The user may specify a value for each radii, or may specify a value for the smallest and largest radii and select a linear skew and/or rake distribution. The distribution is calculated after the dialog box is terminated. There are two separate PBD Skew/Rake Settings dialog boxes, one for the first component and one for the second component.

When the user is satisfied with the PLL settings, he or she may save the project as a project file. This is done by selecting File|Save Project from the main menu and using the Save As dialog box. The current project file may be replaced, or the revised project may be saved under a new or previous project file name.

3.3.3 Running PLL.

When the user has opened a project and made the desired settings using the edit dialog boxes, the user may then run the project by making the File|Run selection from the main menu. The program then allows the user to make additional settings using the Runtime dialog box. The Runtime dialog box is shown in Figure 3-20.

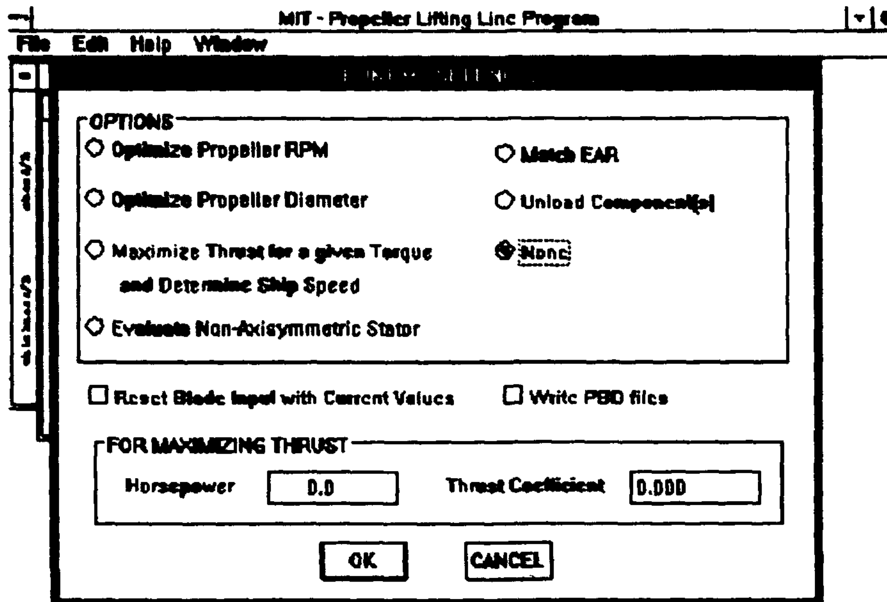

Figure 3-20. Windows™ PLL Runtime Settings Dialog Box

The user may select one of seven mutually exclusive settings from the OPTIONS area of the Runtime Settings dialog box. The options include optimizing propeller RPM, optimizing propeller diameter, maximizing thrust for a given torque and determining ship speed, evaluating a non-axisymmetric stator design, matching a value for expanded area ratio, unloading components, or none of the above options. If the user chooses to maximize thrust for a given torque and determine ship speed, horsepower and thrust

coefficient must also be specified. A brief description of the runtime options is provided below.

Optimize propeller RPM-after performing the hydrodynamics calculations for the "None" option, the program performs an iterative procedure to determine the optimum propeller RPM. The result is reported in a message box after termination of the FORTRAN executable. This optimization is not available for ducted or ringed propulsors. Figure 3-21 shows the Optimization Data dialog box. The Optimization Data dialog box is used for selecting the component to be optimized and for supplying a required thrust value. In the case of a contra-rotating propulsor, the dialog box is also used for supplying a torque ratio.

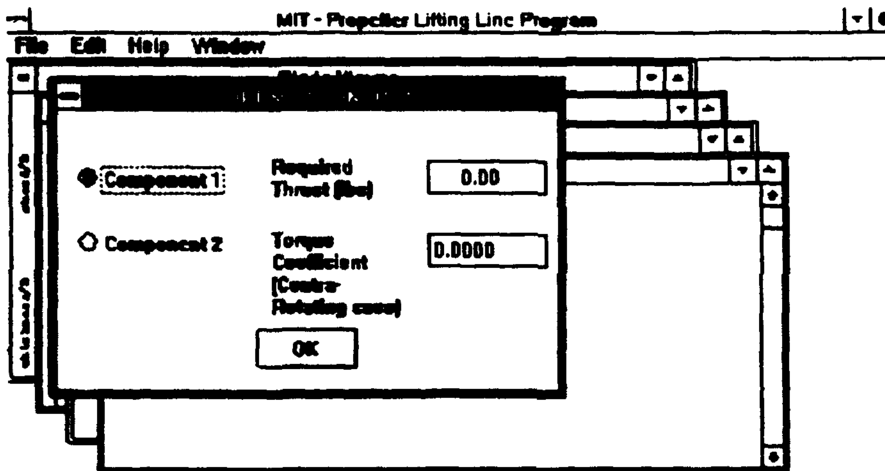

Figure 3-21. Windows™ PLL Optimization Data Dialog Box

Optimize propeller diameter-after performing the hydrodynamics calculations for the "None" option, the program performs an iterative procedure to determine the optimum propeller diameter. The result is reported in a message box after termination of the

FORTRAN executable. This optimization is not available for ducted or ringed propulsors. The Optimization Data dialog box is also used for this option.

Maximize thrust for a given torque and determine ship speed-after performing the hydrodynamics calculations for the "None" option, the program iterates to determine ship speed for a specified horsepower and thrust coefficient.

Evaluate a non-axisymmetric stator design-this option allows the user to select a non-axisymmetric data file using the Select Stator File dialog box. The program performs the normal hydrodynamic calculations for the currently open pre-swirl stator project, then reperforms the calculations using the selected non-axisymmetric stator file. This causes additional text output data to be displayed with the usual output files.

Match EAR-the match EAR option allows the user to specify an expanded area ratio to be matched using the Expanded Area Ratio dialog box. The single component Expanded Area Ratio dialog box is shown in figure 3-22.

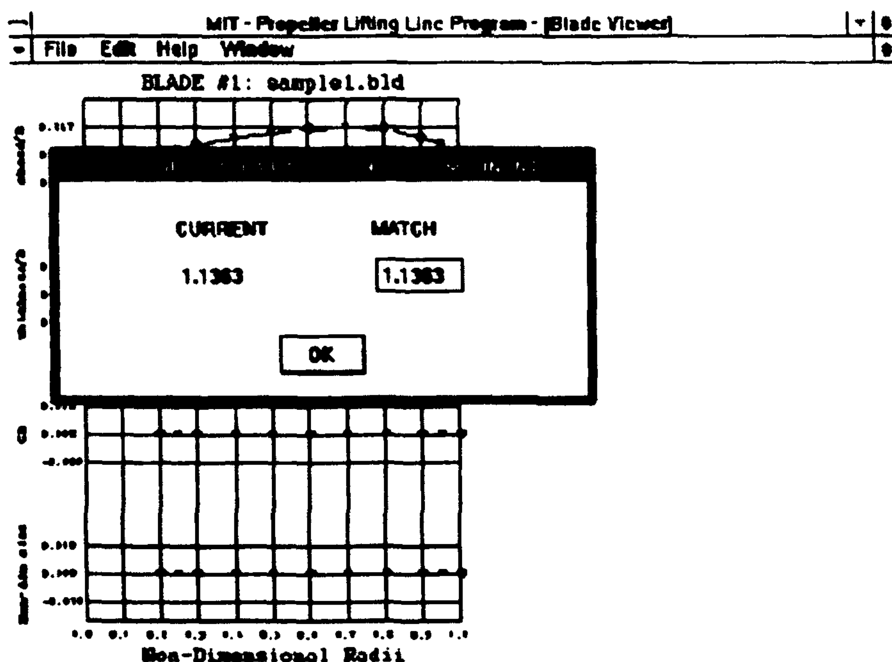

Figure 3-22. Windows™ PLL Expanded Area Ratio Dialog Box

PLL writes the expanded area ratio calculated on the most recent run of the current project and allows the user to specify a different value. PLL then performs the normal hydrodynamic calculations, scales the chord distribution to match the specified expanded area ratio, and reperforms the hydrodynamic calculations.

Unload Components-if the component is hubless, ringless, and does not have a zero gap duct, this option allows the user to specify unloading by modifying the sine series coefficients that describe the blade circulation distribution. This is accomplished using the Glauert Coefficients dialog box. The single component Glauert Coefficients dialog box is shown below in figure 3-23.

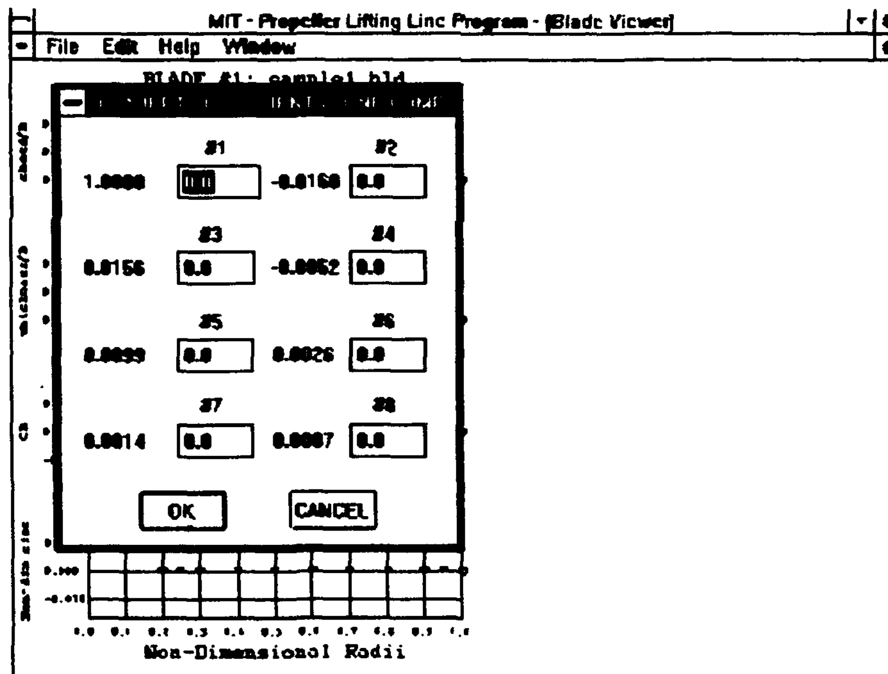

Figure 3-23. Windows™ PLL Glauert Coefficients Dialog Box

PLL initializes the dialog box with the sine series coefficients for the component circulation distribution for the most recent run of the current project. The user may specify changes to the coefficients as a fraction of the first coefficient. After the dialog box

is terminated PLL performs the normal hydrodynamic calculations, alters the circulation distribution as specified, and reperforms the hydrodynamic calculations.

If there is an image hub, a ring, or a zero gap duct, the Steepness dialog box is initialized with hub and tip control point radii and circulation values. The user may select the exponent to be used to unload the hub and tip. Figure 3-24 shows the multiple component Steepness dialog box.

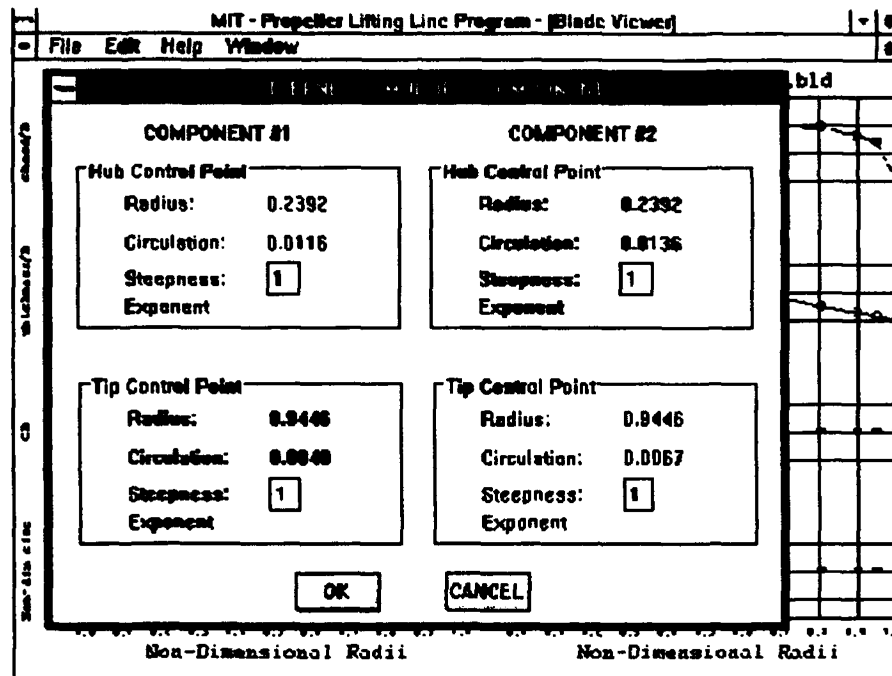

Figure 3-24. Windows™ PLL Steepness Dialog Box

After the Steepness dialog box terminates, PLL calculates and displays, using the Unload Coefficients dialog box, the percent unloading that may be accomplished with the specified steepness exponent. The user may input the size of the coefficient to control the amount of unloading. The multiple component Unload Coefficients dialog box is shown in figure 3-25.

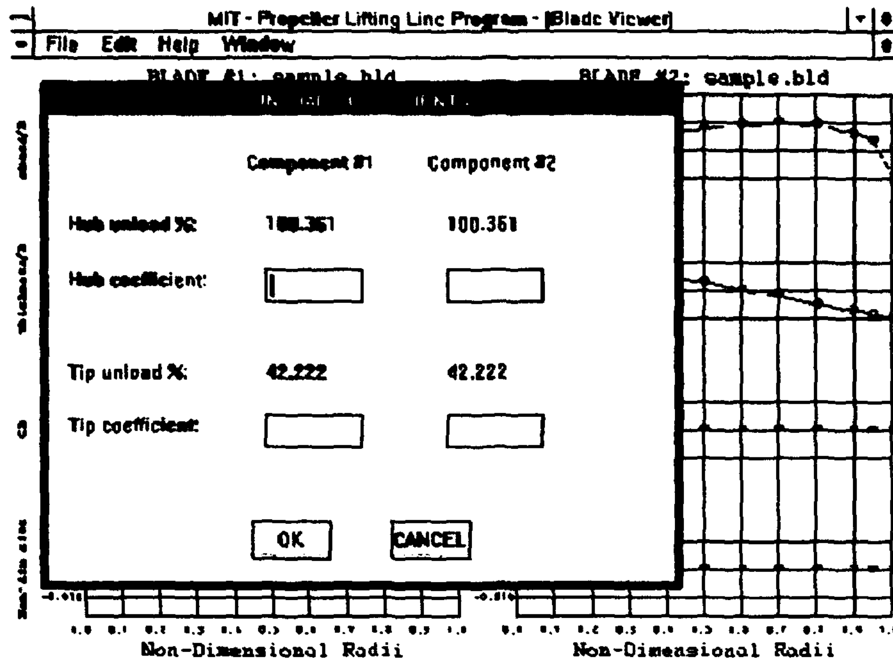

Figure 3-25. Windows™ PLL Unload Coefficients Dialog Box

The final two options available at run time are not mutually exclusive of each other or the options described above. The user may elect to have PLL write PBD B-spline input files in preparation for running the project using the PBD portion of the PLL Windows™ application. The user may also elect to reset the blade input values with current values determined by the previous PLL run.

3.3.4 The Output and Plot Viewer Windows.

The Windows™ PLL application uses the PLL FORTRAN executable to generate the same text output files that are created by the original version of PLL. In order to provide the user with an improved interface, PLL draws the output files to screen in the Output Viewer window. Figure 3-26 shows the Output Viewer window with a summary report displayed.

Figure 3-26. Windows™ PLL Output Viewer

The Output Viewer window may be used to view all of the text reports generated by PLL. The reports available depend on the type of project, and may include a summary report, detailed reports for each component, the results of the blade stress and ABS Rules strength calculation, a duct geometry file, a file describing the velocities far downstream of the propulsor, and non-axisymmetric stator output files describing the circulation on each blade, the forces on each blade, the velocity harmonics, and a comparison of axisymmetric and non-axisymmetric results.

The user may page through the results in a pre-defined order by double clicking the left mouse button while the cursor is on the Output Viewer window. A vertical scroll bar is provided since some files are greater than one page in length. The user may also choose the text display color from four choices (blue, green, red, and black) by double clicking the right mouse button while the cursor is on the Output Viewer window.

The Windows™ PLL application also uses the PLL FORTRAN executable to generate a data file used to provide the same plots available from the original version of PLL. In order to provide further improvements in the user interface, PLL plots the output parameters versus non-dimensional radius in a series of four screens in the Plot Viewer window. Multiple component propulsor parameters may be displayed one component at a time or the two components may be displayed together. Figure 3-27 shows the Plot Viewer window with two components plotted together.

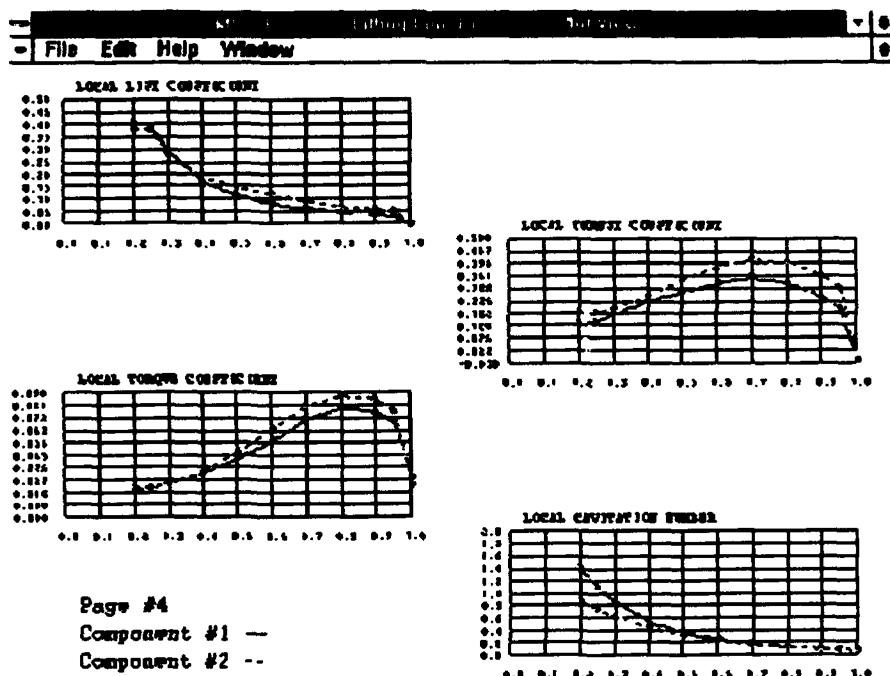

Figure 3-27. Windows™ PLL Plot Viewer

The Plot viewer provides plots of a total of sixteen parameters. They are organized into four screens, or pages, as indicated below.

Page 1- Chord Distribution Input, Chord Distribution Calculated, Undisturbed Pitch Angle, Induced Pitch Angle

Page 2- Effective Axial Inflow Velocity, Induced Axial Velocity, Tangential Inflow Velocity, Induced Tangential Velocity

Page 3- Thickness Distribution Input, Drag Coefficient, Circulation Input, Circulation Calculated

Page 4- Local Lift Coefficient, Local Torque Coefficient, Local Thrust Coefficient, Local Cavitation Number

The user may page through the four screens in the pre-defined order by double clicking the left mouse button while the cursor is on the Plot Viewer window. The user may also shift between the first component plot, second component plot, and combined plot by double clicking the right mouse button while the cursor is on the Plot Viewer window.

3.3.5 Additional Capabilities.

The Windows™ PLL application provides a few capabilities in addition to those described above. Figure 3-28 shows the File pull down menu.

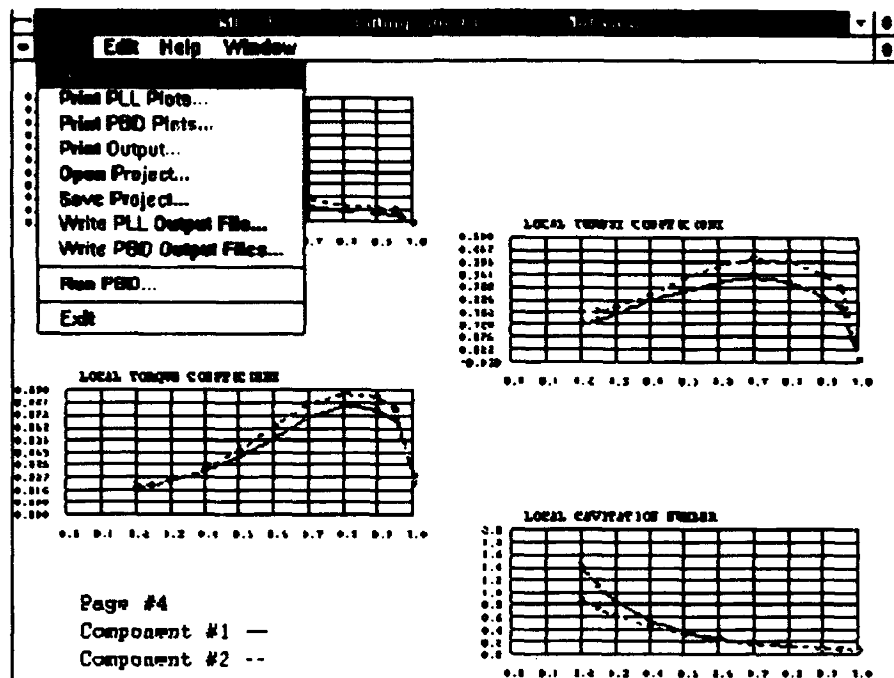

Figure 3-28. Windows™ PLL File Pull Down Menu

In addition to the selections described previously, the user may also choose the File|Print PLL Plots, File|Print Output, or File|Write PLL Output File selections.

The File|Print PLL Plots selection calls the Print dialog box to allow the user to select the plot screens to print and the number of copies. In the case of multiple component propulsors, all three available plots will be printed for each selected page. The File|Print Output selection calls the Print dialog box to allow the user to select the text output pages to print and the number of copies. The File|Write PLL Output File calls the Save As dialog box to allow the user to choose an output file name. After the dialog box terminates, the program writes all of the output text files viewable in the Output Viewer into a single data file with the name selected by the user.

3.3.6 The MIT-PLL Help Program.

The MIT-PLL Help program is a stand alone Windows™ application designed specifically to provide extensive on-line assistance to the PLL user. The program provides

help on a wide range of topics. Pull down menus are provided for the following general areas:

PLL User's Manual-the PLL user's manual tailored to fit the PLL Windows™ application provides information on the theory and operation of the FORTRAN executable. Figure 3-29 shows the MIT-PLL help program with the focus set to the PLL User's Manual|Chapter 3: Optimum Load Distributions|Multi-Component Propellers|Contra-Rotating Propellers selection.

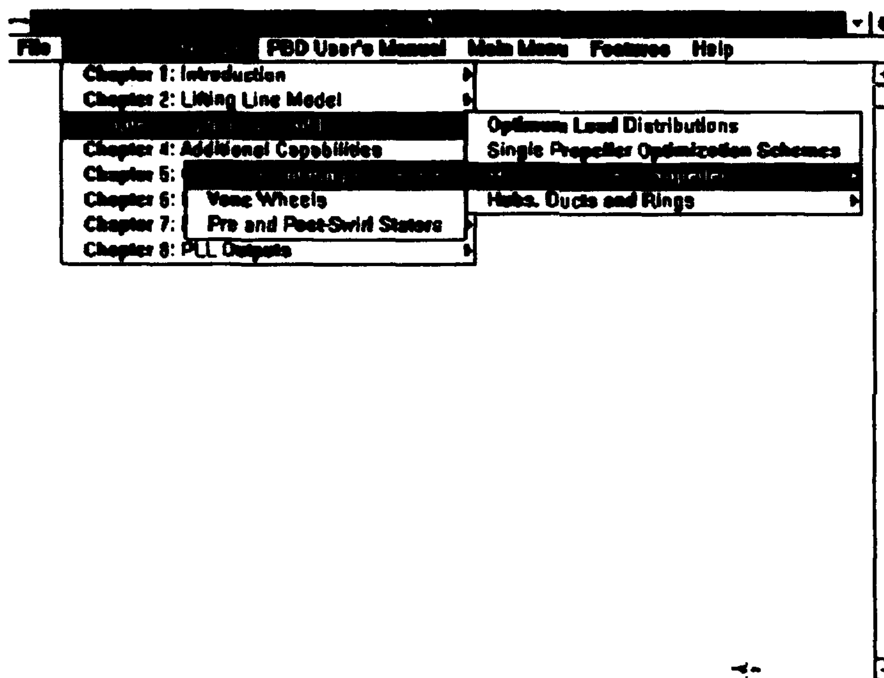

Figure 3-29. Windows™ MIT-PLL Help Program

PBD User's Manual-the PBD user's manual tailored to fit the PLL Windows™ application is also provided in an on-line format. The sub-headings provide information on the theory and operation of the FORTRAN executable.

Main Menu-the selections from this pull down menu provide information on the operation of the PLL main menu selections.

Features-the selections from this pull down menu provide information on the operation of the PLL viewer windows as well as general information on running PLL.

Help-the selections from this pull down menu provide information about the operation of the help program.

The MIT-PLL File menu allows the user to print the currently displayed topic or to exit the program. Figure 3-30 shows the MIT-PLL Help program with the Features|Wake Viewer selection displayed.

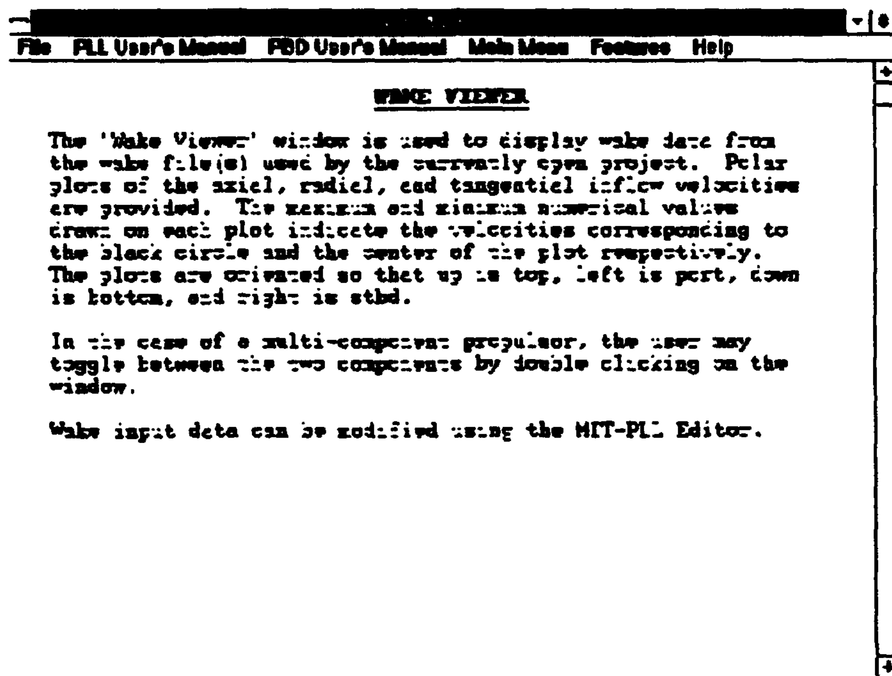

Figure 3-30. Windows™ MIT-PLL Help Program with Help Displayed

3.3.7 The MIT-PLL Editor Program.

The MIT-PLL Editor program is a stand alone Windows™ application that is used to edit PLL blade, wake, overall input, and non-axisymmetric stator files. The program is started by selecting Edit|Blade/Wake from the PLL main menu. The user may open a PLL file for editing by selecting one of the four file types from the Open pull down menu.

Figure 3-31 shows the MIT-PLL Editor program with the focus set to the Open|Blade selection and an open blade file.

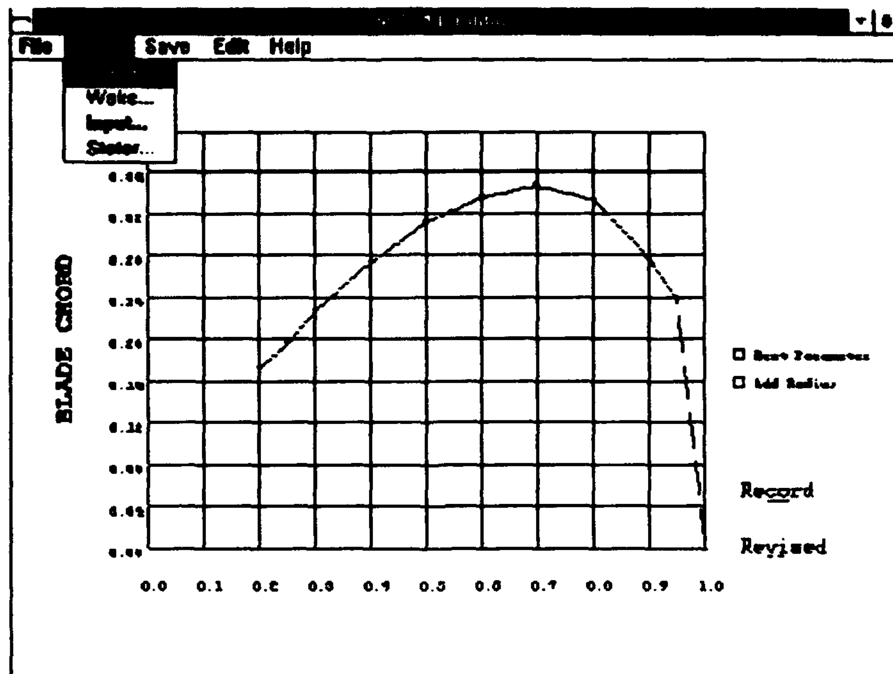

Figure 3-31. MIT-PLL Editor

PLL blade input files are displayed as a series of plots of parameters versus non-dimensional radius or angle, as appropriate. The user shifts between parameters by double clicking the left mouse button on the "Next Parameter" box on the screen. The user may alter parameter values by clicking the right mouse button on the graph at the desired value. The program then draws the data point with the nearest non-dimensional radius as a revised point at the indicated location. The user may add a new radius by double clicking the left mouse button on the "Add Radius" box. Figure 3-32 shows a blade chord plot with the record plot and a revised plot with reduced chord length. The Add Radius dialog box is shown with a new radius value entered.

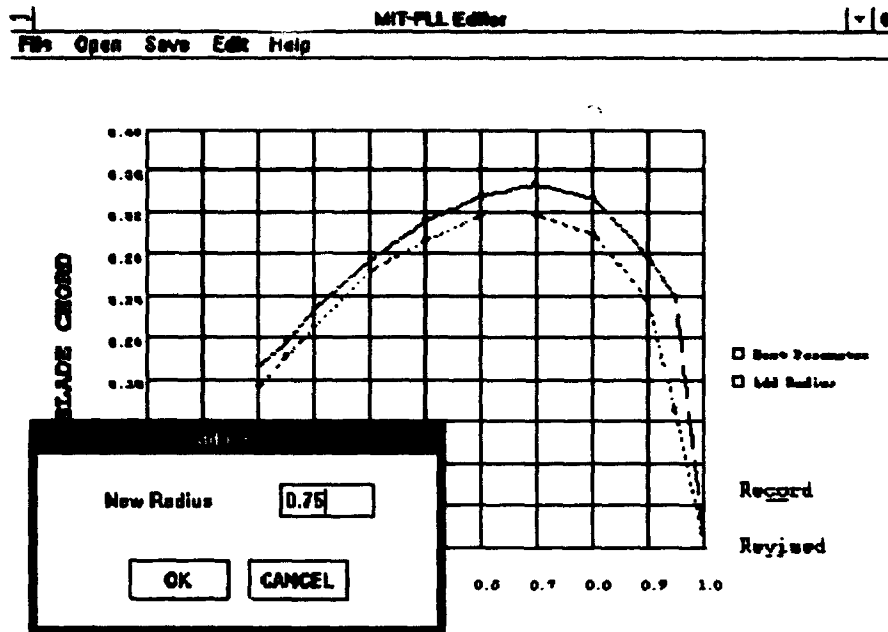

Figure 3-32. MIT-PLL Edit Process

When the user adds a new radius, it is added to the revised curve with a value interpolated between adjacent point values. When the user is satisfied with the revised curve, he or she may update the data by selecting File|Update Data from the main menu. If the user wishes to discard the current revised curve and return to the record data, he or she selects File|Reset Data from the main menu.

The final step in the edit process is saving the revised file. The Save pull down menu offers the option of saving blade, wake, overall input, or non-axisymmetric stator files. These selections allow the user to overwrite the original file that was edited or to save the current data under a new filename. The MIT-PLL Editor program then writes a standard format PLL file, readable by either the Windows™ PLL application or the original version.

The edit process for wake files is similar to that for blade files. Figure 3-33 shows the edit process in progress for a wake file.

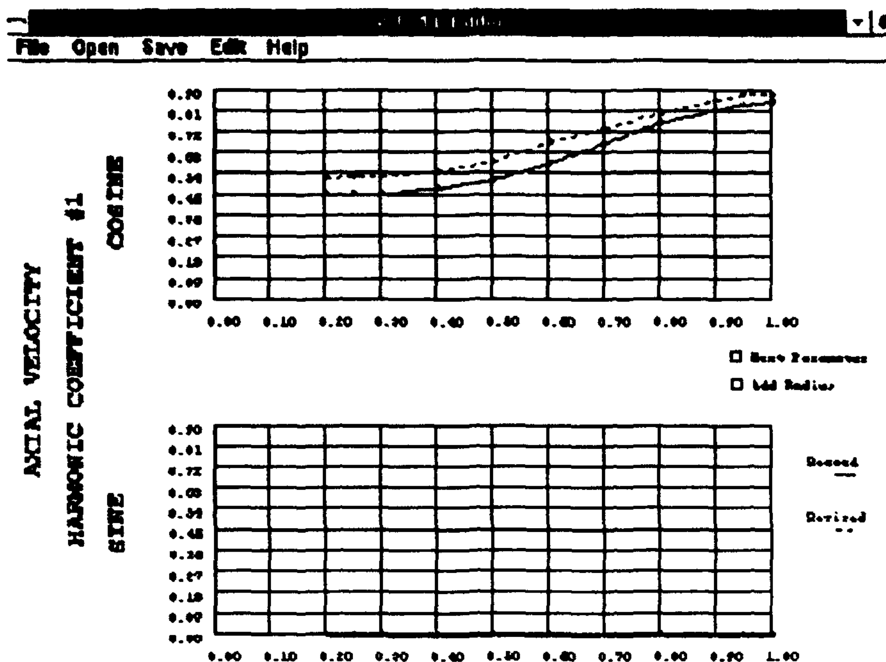

Figure 3-33. MIT-PLL Wake File Edit Process

PLL wake input files are displayed as a series of plots of sine and cosine harmonic coefficients versus non-dimensional radius for axial, radial, and tangential velocities. Editing is performed as described above.

Non-axisymmetric stator files are displayed and edited differently than blade and wake files. Figure 3-34 shows a non-axisymmetric stator file in the edit process.

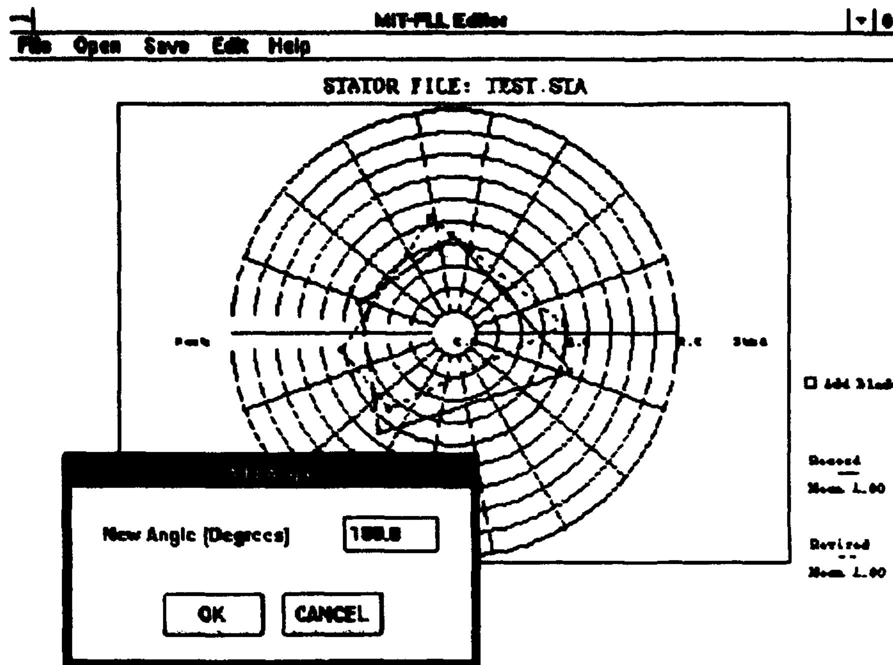

Figure 3-34. MIT-PLL Stator File Edit Process

Non-axisymmetric stator files are displayed in a polar plot format with the plot angle being the blade angle, zero at the top and proceeding counterclockwise. The magnitude of the point indicates the fraction of mean load for each blade. In order to change the location and/or loading of a blade, the user clicks and drags the point to the desired angle and loading using the right mouse button. The user may call a dialog box to add a new blade angle by double clicking the left mouse button on the "Add Blade" box. New blades are added at a load of 1.0. The mean values of the blade loadings for the revised and record plots are calculated and displayed in the plot legend. The process of updating, resetting, and writing revised stator files is the same as described above for blade files.

Overall input files are displayed and edited differently than blade, wake, and stator files. Figure 3-25 shows the MIT-PLL editor program with an open overall input file.

```
File  Open  Save  Edit  Help

     PROPELLER LIFTING LINE RUN:        4/8/1998
      OVERALL INPUT FILE:               DUCT.INP
50.500000 . . . . . . . . . . .Ship speed (ft/sec)
1.991000 . . . . . . . . . . .Fluid Density
10.000000 . . . . . . . . . . .Shaft centerline depth (ft)
2 . . . . . . . . . . .Number of components
Y . . . . . . . . . . .Image hub to be used
Y . . . . . . . . . . .Image duct to be used
0.500000 . . . . . . . . . . .(Duct chord length)/(Component #1 diameter)
0.006500 . . . . . . . . . . .Drag coefficient for the duct
0.050000 . . . . . . . . . . .(Duct thickness)/(Component #1 diameter)
10.100000 . . . . . . . . . . .Duct diameter (ft)
0.000000 . . . . . . . . . . .Axial location of duct mid-chord (ft)
-1.250000 . . . . . . . . . . .Axial location of component 1 (ft)
5 . . . . . . . . . . .Number of blades on component 1
10.000000 . . . . . . . . . . .Diameter of component 1 (ft)
sample.bld                      File containing blade inputs for comp. 1
10.000000 . . . . . . . . . . .Diameter of wake for component 1 (ft)
sample.wak                      File containing wake inputs for comp. 1
1.250000 . . . . . . . . . . .Axial location of component 2 (ft)
4 . . . . . . . . . . .Number of blades on component 2
10.000000 . . . . . . . . . . .Diameter of component 2 (ft)
sample.bld                      File containing blade inputs for comp. 2
10.000000 . . . . . . . . . . .Diameter of wake for component 2 (ft)
sample.wak                      File containing wake inputs for comp. 2
```

Figure 3-35. MIT-PLL Input File Edit Process

Overall input files are displayed in text format on the screen. Changes are made by making the Edit|Input Data selection from the main menu and using the dialog box provided. Figure 3-36 shows the Two Component - Ducted Input dialog box.

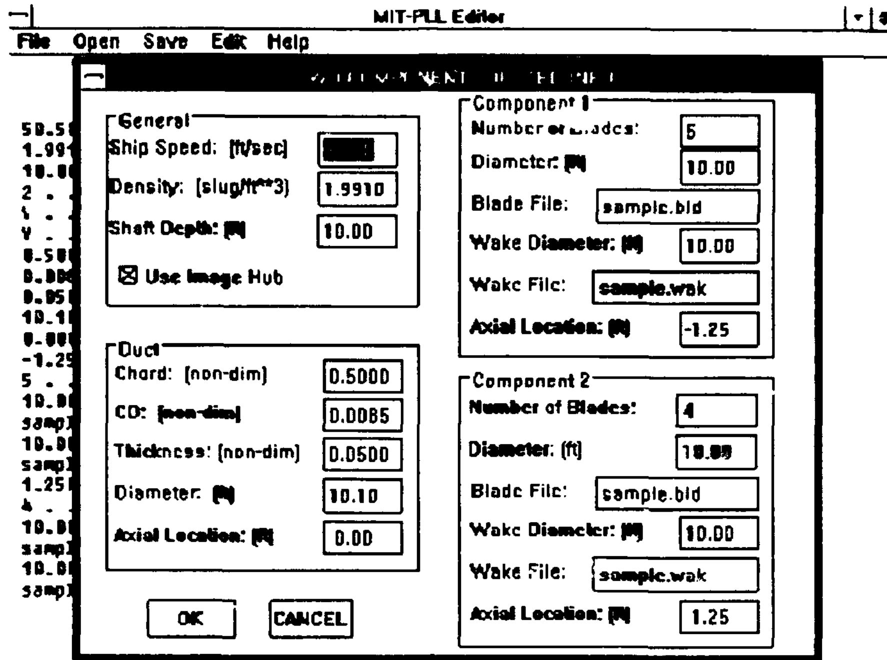

Figure 3-36. MIT-PLL Two Component - Ducted Input Dialog Box

Revised overall input file data is saved by using the Save|Input selection from the main menu and using the Save As dialog box to replace the original file or to create a new file.

The MIT-PLL Editor program Help pull down menu includes information on the program, presented in the form of message boxes. The File|Print selection may be used to make a hard copy of the current file.

3.3.8 Running PBD.

The user may elect to run the PBD portion of the Windows™ PLL application in two different ways. The first way is to cause the necessary B-spline file to be written by running the current project with the Write PBD files option selected in the PLL Runtime dialog box, and then selecting File|Run PBD from the main menu. This will allow the user to select the CURRPBD.PBD file, which is written by PLL with the settings in the PBD

Settings dialog box, using the Select PBD Admin File dialog box. The program then calls the PBD FORTRAN executable.

The second way to run PBD is to select File|Run PBD from the main menu and then use the Select PBD Admin File dialog box to run a previously prepared project by selecting the appropriate main administrative file. The program is designed to be compatible with files written for the original FORTRAN version of PBD. This may be done without a PLL project being open or without first running the open project.

Running PBD has no effect on the Blade and Wake Viewer windows, but PBD output is added to the data displayed in the Output and Plot Viewer windows. The data displayed in the Output Viewer window changes only by the addition of a screen with the PBDOUT.KTQ file. Figure 3-37 shows the Output Viewer window with the PBDOUT.KTQ file displayed.

File Edit Help Window

First table is total forces, second is CRP

--------CALCULATION OF THRUST AND TORQUE COEFFICIENTS--------

[illegible]	KT	10*KQ	E/(1-W)
[illegible]	[illegible]	[illegible]	[illegible]
[illegible]	[illegible]	[illegible]	[illegible]
[illegible]	0.4420	[illegible]	[illegible]
[illegible]	[illegible]	[illegible]	[illegible]
[illegible]	0.4406	[illegible]	[illegible]
[illegible]	[illegible]	[illegible]	[illegible]
[illegible]	[illegible]	[illegible]	[illegible]
[illegible]	[illegible]	[illegible]	[illegible]
[illegible]	[illegible]	[illegible]	[illegible]
[illegible]	0.4371	[illegible]	[illegible]

Figure 3-37. MIT-PLL Output Viewer with PBD Output

After a PBD run, the Plot Viewer window displays a number of additional pages. The first is a diagram of the input blade B-spline control net and the resultant blade in the form of a wireframe diagram. The second additional page is a wireframe diagram of the output blade grid for each blade on the propulsor, the centerbody, the transition wake, and hub and duct images as applicable. The third page is a plot of the velocities at the blade control points. The next is a contour plot of the bound circulation strength. The fifth additional plot is a plot of the radial circulation distribution. The final additional page is a Circumferential Mean Velocity Plot. Figures 3-38 through 3-43 show each of the additional pages.

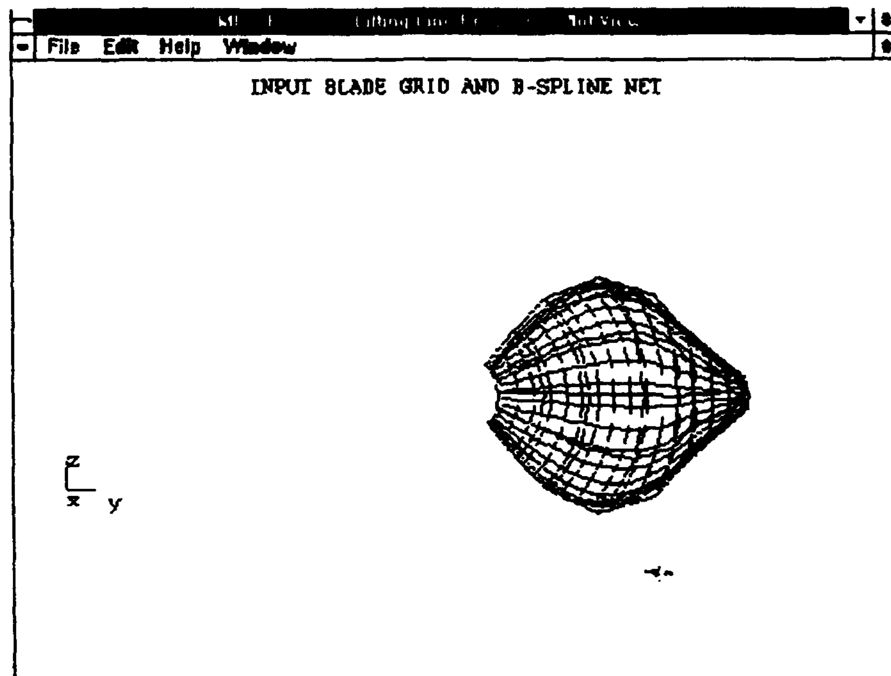

Figure 3-38. MIT-PLL Plot Viewer with PBD Input Blade

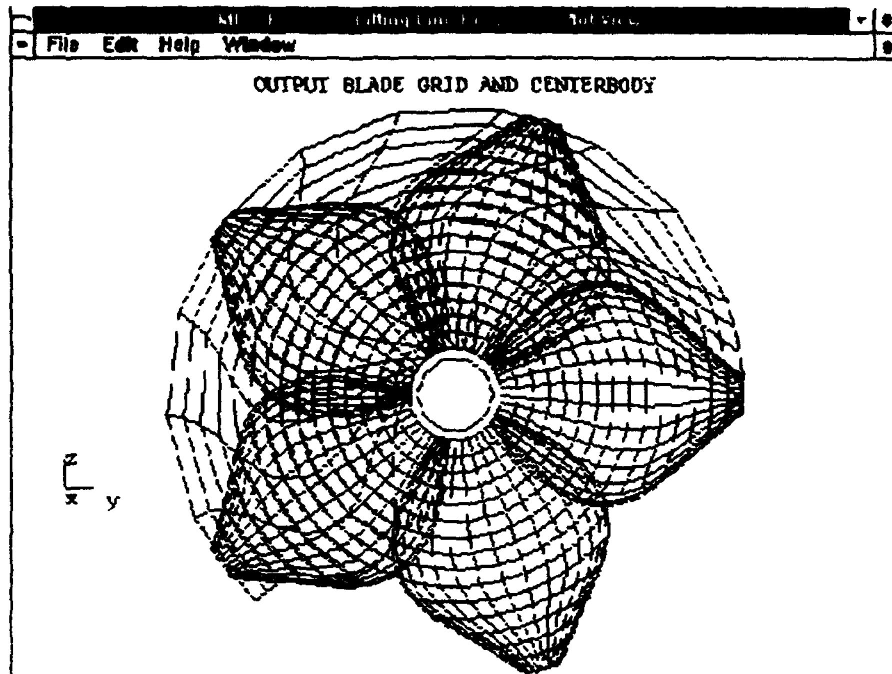

Figure 3-39. MIT-PLL Plot Viewer with PBD Output Blade and Centerbody

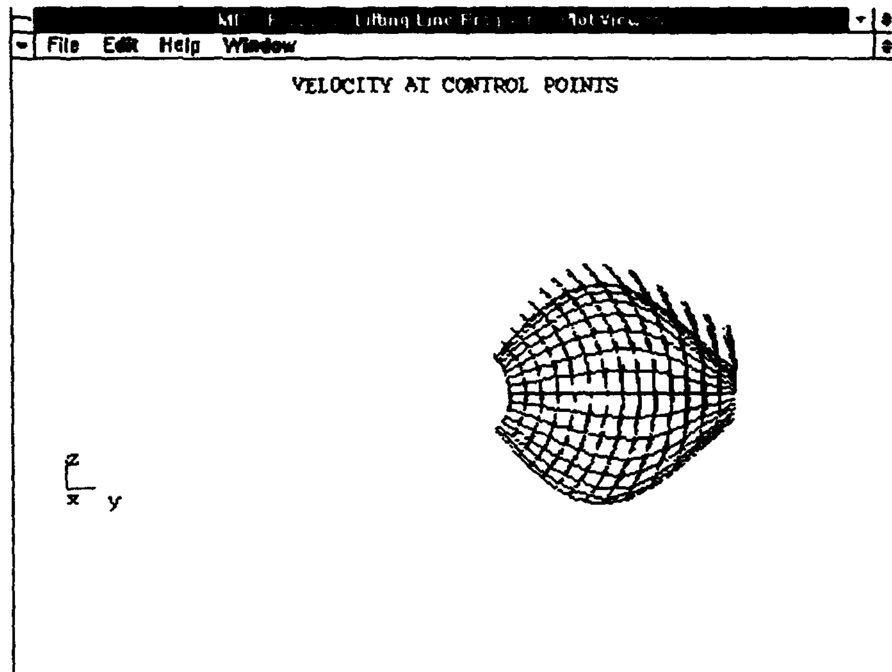

Figure 3-40. MIT-PLL Plot Viewer with PBD Control Point Velocity Plot

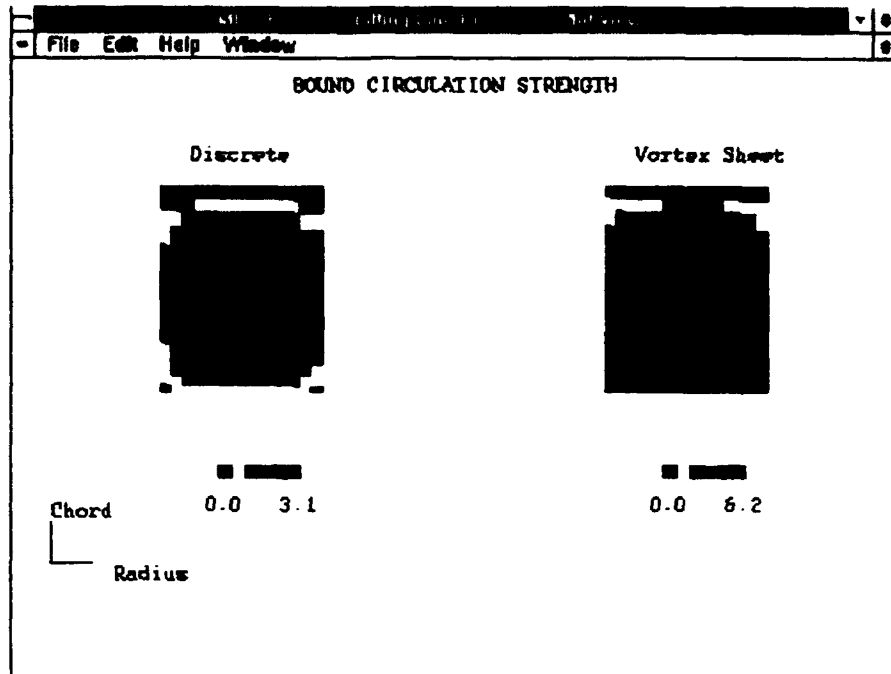

Figure 3-41. MIT-PLL Plot Viewer with PBD Bound Circulation Contour Plot

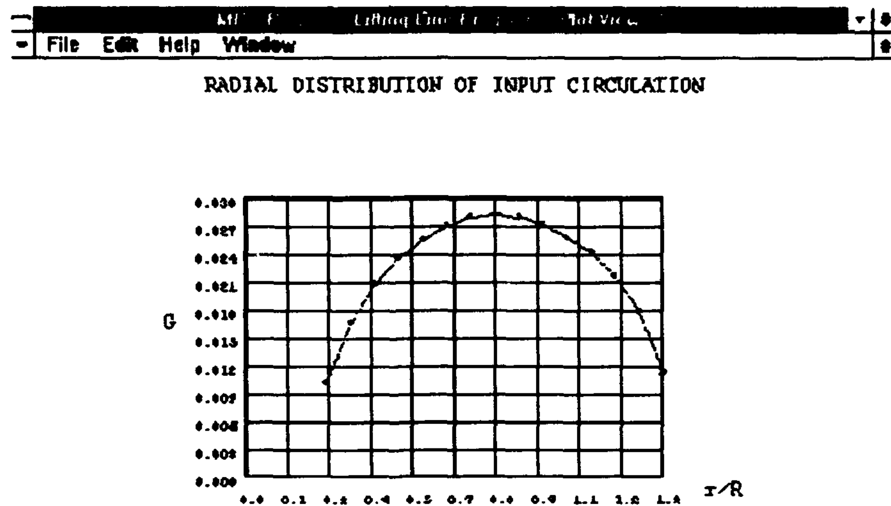

Figure 3-42. MIT-PLL Plot Viewer with PBD Radial Circulation Distribution Plot

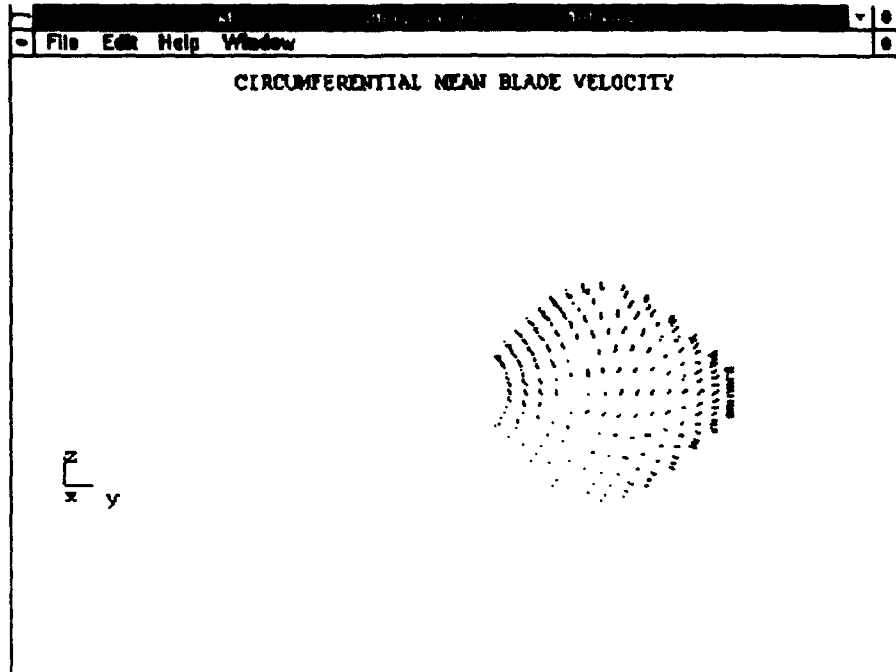

Figure 3-43. MIT-PLL Plot Viewer with Circumferential Mean Velocity Plot

The user may elect to view the PBD output in the Plot Viewer from a different orientation and/or in a different scale. This is accomplished by double clicking the right mouse button on the Plot Viewer window when a PBD plot is being displayed. Figure 3-44 shows the PBD Plot Geometry dialog box.

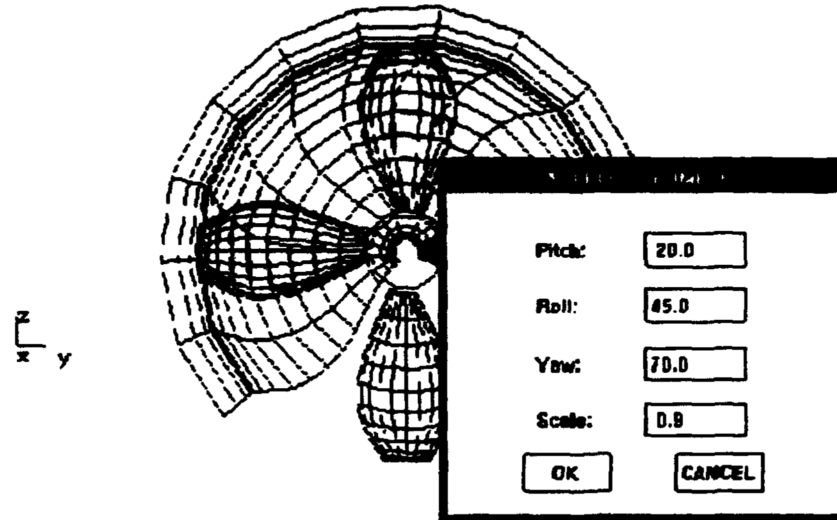

Figure 3-44. MIT-PLL PBD Plot Geometry Dialog Box

Figure 3-45 shows the result of altering the orientation and scale for the plot shown behind the dialog box in Figure 3-44 above.

File Edit Help Window

OUTPUT BLADE GRID AND CENTERBODY

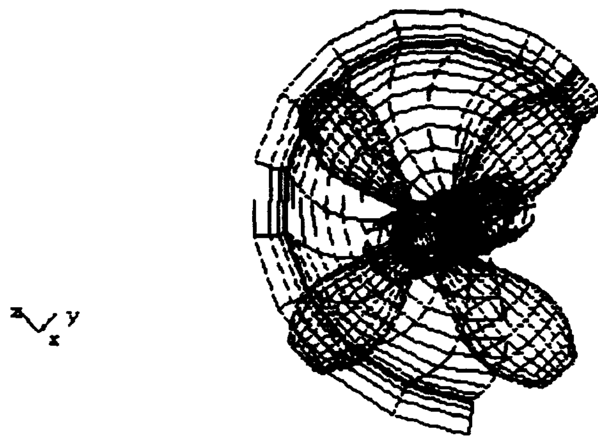

Figure 3-45. MIT-PLL PBD Plot with Altered Orientation and Scale

4. CONCLUSIONS AND FURTHER WORK

4.1 Conclusions.

The stated purpose of this thesis was to demonstrate the feasibility and desirability of the employment of personal computers in hydrofoil and propeller design. The approach was incremental in nature, focusing first on relatively simple FORTRAN codes from the MIT Hydrofoils and Propellers course. The process proceeded through the design and implementation of an integrated application that provides a seamless link between PLL and PBD.

The resulting applications are considered to have achieved the goal of demonstrating the feasibility and desirability of the employment of personal computers in hydrofoil and propeller design. The applications provide enhancements in the user interface, in terms of input, output, on-line help and portability as well as a reduction in the total time required in the design process.

4.2 Further Work.

Further work in this area can be grouped in three distinct areas. The first area is expansion of the PLL Windows™ application to provide the user with a more complete range of propeller design tools. The application could be expanded to provide seamless links to codes that analyze cavitating propellers, that perform steady and unsteady analyses, and that produce the inputs necessary for the computer aided manufacturing and inspection processes.

The second area for further work involves improvements to the existing code without alteration to the appearance or operation of the program. The program as it exists is the product of an evolutionary development. Initial versions of the program did not include all of the capabilities of the final version. As a result, there are inconsistencies in the appearance of the code depending on the point in the process at which it was

written. Given unlimited time, it would be a straightforward task to revise the code in order to take advantage of the learning curve and make the code more uniform in its design and faster in its execution. This would result in improvements that are only cosmetic in nature and, as previously stated, would do little in terms of improving the usefulness of the program.

The third and final area for further work includes improvements to the PLL Windows™ application produced as a part of this thesis. Some of the possible improvements are listed below.

-Incorporate graphical output specific to duct geometry and ring geometry into the plots available in the Plot Viewer window.

-Incorporate graphical output for non-axisymmetric stator blade forces, wake velocities, and circulation distribution into the plots available in the Plot Viewer window.

-Add the capability to display pre-existing PBD output files in the Plot Viewer window or a separate window that may be created and closed by the user during program execution.

-Incorporate the MIT-PLL editor program into a window in the PLL program to allow the user to make blade, wake, stator, and overall input file changes more rapidly during the design process.

-Incorporate a "tool bar" or "tool pallete" comprised of speed buttons to allow the user to quickly make common selections by clicking on a button displayed on the screen instead of using the main menu.

-Redesign the MIT-PLL Help program as a standard Windows™ Help program.

-Incorporate a capability for the user to input circulation distributions directly as Glauert coefficients.

-Redesign the dialog boxes in order to provide a more intuitive user interface.

-Implement the application for the UNIX operating system.

The implementation of any of these recommendations would provide tangible improvements to the software system presented in this thesis.

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APPENDIX A

Hydrofoil Vortex Lattice Lifting Line Program Code.

APPENDIX A.1

The VLL WinMain function.

A.1 The VLL WinMain function.

The WinMain function is the main entry point for an application. The WinMain function for VLL is shown below. For the purposes of this thesis, code will be depicted in a smaller font to distinguish it from main body text. Note that all text that falls between an occurrence of "/*" and the next occurrence of "*/" is interpreted by the compiler as a comment. Also note that the text following an occurrence of "//" on a given line is also interpreted by the compiler as a comment.

```
/*****************************************************************
* the WinMain function creates the main window                   *
*****************************************************************/
int PASCAL WinMain(HINSTANCE hInstance, HINSTANCE hPrevInstance,
        LPSTR lpCmdParam, int nCmdShow)
{
/*****************************************************************
* variable declarations                                          *
*****************************************************************/
    char    ProgName[ ] = "Hydrofoil Vortex Lifting Line";    //program name

    HWND  hWnd;                                              //handle to the main window

    MSG     msg;                                             //a Windows message structure

//define and register the window class, if an instance of this application
// is not already running

    if(!hPrevInstance){

    WNDCLASS  wndclass;

    wndclass.lpszClassName        =    ProgName;
    wndclass.lpfnWndProc          =    (WNDPROC) MainWndProc;
    wndclass.cbClsExtra           =    0;
    wndclass.cbWndExtra           =    0;
    wndclass.hInstance            =    hInstance;
    wndclass.hIcon                =    LoadIcon(hInstance,"NEWICON");
    wndclass.hCursor              =    LoadCursor(NULL, IDC_ARROW);
    wndclass.hbrBackground        =    (HBRUSH) (COLOR_WINDOW + 1);
    wndclass.lpszMenuName         =    "Main_Menu";
    wndclass.style                =    CS_VREDRAW | CS_HREDRAW;

    if(!RegisterClass(&wndclass))exit(0);;
    }

    ghInstance = hInstance;
```

```
//create and display window of the wndclass

        hWnd = CreateWindow(ProgName,"Hydrofoil Vortex Lifting Line",
                WS_OVERLAPPEDWINDOW,
                CW_USEDEFAULT, CW_USEDEFAULT,
                CW_USEDEFAULT, CW_USEDEFAULT,
                NULL, NULL, hInstance, NULL);

        ShowWindow(hWnd, nCmdShow);
        UpdateWindow(hWnd);

//while the window exists, receive and process Windows messages

        while (GetMessage(&msg, NULL, 0, 0))
        {
                TranslateMessage(&msg);
                DispatchMessage(&msg);
        }
        return msg.wParam;
}
```

When viewed for the first time, and particularly without the benefit of experience with the C programming language, the logic and operation of a WinMain function is not intuitively obvious. For that reason an extensive explanation of this particular WinMain function is provided here.

The function prototype for the WinMain function, shown here, indicates that the function returns an integer value and that the PASCAL calling convention is used.

```
int PASCAL WinMain(HINSTANCE hInstance, HINSTANCE hPrevInstance,
        LPSTR lpCmdParam, int nCmdShow)
```

The integer returned is msg.wParam, which consists of information regarding the message processed by the WinMain function. The value returned, however, is not currently used by Windows™. The PASCAL calling convention is employed because of its efficiency in passing variables between functions.

The WinMain function receives four parameters from Windows™. The first is the HINSTANCE hInstance. This is a 16 bit handle to this instance of VLL. The hPrevInstance parameter is a handle to the most recent instance of VLL that is still

running. It will be NULL or 0 if there are no other instances running. The third parameter is a LPSTR, which is a 32 bit pointer to a character string. A pointer is a variable used to store a memory address. The nCmdShow parameter is an integer value that indicates how the program will be initially displayed.

The first three lines of code in the WinMain function are declarations of automatic variables. An automatic variable is declared inside a function and is therefore private to that function. The variable only exists for the duration of the function call, and memory allocated for the variable is freed when the function returns.

```
char    ProgName[ ] = "Hydrofoil Vortex Lifting Line";    //program name
HWND hWnd;                                               //handle to the main window
MSG    msg;                                              //a windows message structure
```

The variables declared in this WinMain function are of three types. The first is an array of character (char) type data known as a string. The name of the variable is ProgName. As ProgName is declared it is also initialized with the value, Hydrofoil Vortex Lifting Line\0. The "\0" is NULL string terminator. The compiler automatically determines the size of the array necessary to store the characters, including the string terminator.

The second variable declared is of the HWND type. A HWND is a 16 bit handle to a window. The handle is used by Windows™ to identify the window created by this particular WinMain function.

The third variable is a Windows™ message structure. The concept of object-oriented programming is that "objects" exist in the form of data structures and are operated on by various functions[14]. A message structure includes six separate pieces of information. The details of the message structure can best be seen by analyzing the declaration of the structure, shown here.

---

[14]Charles Petzold,Programming Windows™ (Redmond, Washington: Microsoft Press, 1988)p.17.

```
typedef struct tagMSG {     /* msg */
    HWND            hwnd;
    UINT            message;
    WPARAM          wParam;
    LPARAM          lParam;
    DWORD           time;
    POINT           pt;
} MSG;
```

The typedef keyword assigns MSG as the name of the structure defined in the statement. The window handle, hwnd, is the handle of the window that receives the message. The unsigned integer, message, is message number. The WPARAM , wParam, is a 16 bit signed parameter passed with the message. The LPARAM, lParam is a 32 bit signed parameter passed with the message. The DWORD, time is a 32 bit unsigned integer which specifies the time when the message was posted. The POINT, pt, is a point data structure that contains the integer position in screen coordinates of the cursor at the time the message was posted.

The next step in initializing the program is to register a window class. If there is no previous instance of VLL running, then a window class is defined and registered. The window class is defined by filling in a WNDCLASS structure. The details of the window class structure are shown below.

```
typedef struct tagWNDCLASS {     /* wc */
    UINT            style;
    WNDPROC         lpfnWndProc;
    int             cbClsExtra;
    int             cbWndExtra;
    HINSTANCE       hInstance;
    HICON           hIcon;
    HCURSOR         hCursor;
    HBRUSH          hbrBackground;
    LPCSTR          lpszMenuName;
    LPCSTR          lpszClassName;
} WNDCLASS;
```

The style is an unsigned integer that tells the Windows™ environment how to handle windows of this class. The lpfnWndProc parameter is a 32 bit pointer to the

address of a function that will handle messages passed to the program. The cbClsExtra and cbWndExtra integers are amounts of extra bytes allocated for use by the programmer.

The hInstance handle informs Windows™ which instance of the program owns the window class. The handles, hIcon, hCursor, and hbrBackground specify the specify the program icon, cursor, and client area background color of the windows created using this class.

The lpszMenuName is a 32 bit pointer to a character string that indicates the name of the main menu to be used by the program. The lpszClassName is a pointer to a string that specifies the name of the class.

The code below checks to see if there is a previous instance of VLL running using the if(!hPrevInstance) statement. If there is no previous instance, then the steps within the braces are executed. First, a WNDCLASS structure variable, wndclass is declared and initialized. It should be noted that a variable naming convention called Hungarian notation is used for the data contained in structures. This convention consists of using a relatively short prefix, the variable name, and a longer descriptive suffix to indicate the specific parameter of the structure.

```
if(!hPrevInstance){

WNDCLASS  wndclass;

wndclass.lpszClassName       =    ProgName;
wndclass.lpfnWndProc         =    (WNDPROC) MainWndProc;
wndclass.cbClsExtra          =    0;
wndclass.cbWndExtra          =    0;
wndclass.hInstance           =    hInstance;
wndclass.hIcon               =    LoadIcon(hInstance,"NEWICON");
wndclass.hCursor             =    LoadCursor(NULL, IDC_ARROW);
wndclass.hbrBackground       =    (HBRUSH) (COLOR_WINDOW + 1);
wndclass.lpszMenuName        =    "Main_Menu";
wndclass.style               =    CS_VREDRAW | CS_HREDRAW;

if(!RegisterClass(&wndclass))exit(0);;
}
```

The parameters of the window class are initialized with the values that follow:

lpszClassName	address of the character array, Progname
lpfnWndProc	address of the function MainWndProc
cbClsExtra	0 extra bytes
cbWndExtra	0 extra bytes
hInstance	a handle to this instance of VLL
hIcon	the handle of the icon loaded by the LoadIcon statement
hCursor	the handle of the cursor loaded by the LoadCursor statement
hbrBackground	the handle to the brush currently set in the Windows™ Control Panel program
lpszMenuName	the name of the top level menu to be used
style	CS_VREDRAW | CS_HREDRAW are two window class styles, combined by the C logical "or" operator, that control the way WindowsTM redraws the application window

After the window class structure is filled in the program registers the class using the RegisterClass function. The RegisterClass function receives a pointer to a WNDCLASS structure and returns an atom that uniquely identifies the class. An atom is a 16 bit integer handle that identifies a character string. If the RegisterClass function fails, the program is terminated by the exit statement.

The ghInstance = hInstance; statement saves a copy of the handle to this instance of VLL in the global HINSTANCE variable, ghInstance. The global variable will be used later in the program to create temporary windows called dialog boxes.

The following code is used to create and display the window:

```
hWnd = CreateWindow(ProgName,"Hydrofoil Vortex Lifting Line",
        WS_OVERLAPPEDWINDOW,
        CW_USEDEFAULT, CW_USEDEFAULT,
        CW_USEDEFAULT, CW_USEDEFAULT,
        NULL, NULL, hInstance, NULL);
```

```
ShowWindow(hWnd, nCmdShow);
UpdateWindow(hWnd);
```

The CreateWindow function takes 11 parameters and returns a handle to the window created. A description of the 11 parameters follows:

LPCSTR	lpszClassName	pointer to the registered class name
LPCSTR	lpszWindowName	pointer to the window text
DWORD	dwStyle	window style
int	x	horizontal position of window
int	y	vertical position of window
int	nWidth	window width
int	nHeight	window height
HWND	hwndParent	handle of parent window
HMENU	hmenu	handle of menu or child-window identifier
HINSTANCE	hinst	handle of application instance
void FAR	*lpvParam	pointer to window-creation data

The ShowWindow function receives two parameters, the handle of the window to be shown and the integer nCmdShow which defines how the window should initially be displayed. The function causes the specified window to be displayed on the screen in the specified manner. The UpdateWindow function takes the handle to the window and sends a WM_PAINT message to cause the window client area to be painted.

The last statements of the WinMain function are the message loop. The message loop receives messages from Windows™, translates them, and sends them to the window procedure for processing.

```
while (GetMessage(&msg, NULL, 0, 0))
{
        TranslateMessage(&msg);
        DispatchMessage(&msg);
}
return msg.wParam;
```

The GetMessage function receives messages from the application message queue and fills in the MSG structure. The function returns "0" upon receipt of a WM_QUIT message. The loop is then terminated and the program ends.

Virtual key messages are translated by the TranslateMessage function. The DispatchMessage function sends messages to the window indicated by the msg.hwnd window handle.

It is important to note here that the GetMessage, TranslateMessage, and DispatchMessage functions do not receive the message structure itself, but the address of the message structure, &msg. The ampersand is the address operator. When followed by a variable name, it indicates the address of the variable. In the C programming language, functions may not operate on the arguments that are passed to them. Since the purposes of these functions include operating on the data contained in the message structure, the address of the structure must be passed.

APPENDIX A.2

The VLL MainWndProc function.

A.2 The VLL MainWndProc function.

The MainWndProc function is referred to as the window procedure. It is actually a callback function that uses a switch in processing and responding to Windows™ messages. The MainWndProc for VLL is shown below.

```
/*****************************************************************
* the MainWndProc function handles input and window management messages          *
*****************************************************************/
LRESULT CALLBACK _export MainWndProc(HWND hWnd, UINT message,
                    WPARAM wParam, LPARAM lParam)
{

  switch (message)
  {
    case WM_COMMAND :
    {

//this case refers menu selections to the WMCommand_Handler function

        return HANDLE_WM_COMMAND(hWnd, wParam, lParam, WMCommand_Handler);

    }

    case WM_CREATE :
    {

//this case initializes two global variables upon creation of the
// main window

        HDC    tempDC;                              //handle to a temporary device
                                                    // context

//get a handle to the screen device context

        tempDC = GetDC(hWnd);

//determine the width of the display in pixels and the height of the display
// in raster lines and cast them as floats

        width  = (float)GetDeviceCaps (tempDC, HORZRES);
        height = (float)GetDeviceCaps (tempDC, VERTRES);

//since the normal display aspect ratio is 4 to 3, ensure that the graphical
// output made by the program is in that aspect ratio

        if((width/height)>(4.0/3.0))
            width = height*(4.0/3.0);
        else
            height = width*(3.0/4.0);
```

```
//release the handle to the device context

        ReleaseDC(hWnd,tempDC);

        return 0;

        }

    case WM_PAINT : {

//this case handles painting the screen

        HDC     PaintDC;                         //handle to a device
                                                 // context

        PAINTSTRUCT ps;                          //paint structure

//prepare hWnd for painting and fill the paint structure, ps

        PaintDC = BeginPaint(hWnd, &ps);

//paint the data box whenever the screen is repainted

        paint_data_box(PaintDC );

//paint the graphs if vortex has been run and the variable data has not
// changed since vortex was run

        if(run_flag)

                    paint_graphs(PaintDC);

//mark the end of painting hWnd and return 0

        EndPaint(hWnd, &ps);

        return 0;

                    }

    case WM_DESTROY : {

//this case handles requests to exit the program made by methods other than
// the main menu

//delete the temporary plot data file if it was created

        if(access("plotdat.tmp", 0) == 0)

            unlink("plotdat.tmp");

        PostQuitMessage(0);
```

```
        return 0;
            }
    }
        return DefWindowProc (hWnd, message, wParam, lParam);
}
```

The function prototype for the MainWndProc function is shown below. LRESULT CALLBACK _export is the return type of the function. It tells the compiler to add the code required to allow the Windows™ operating environment to call the function. The four parameters passed to the window procedure are the same as the first four parameters of a message structure. This is not surprising since the purpose of the MainWndProc function is to respond to messages. The window handle is passed because any given program can use a number of different windows. The unsigned integer specifies the type of message being passed. The information passed in wParam and lParam varies with the message type.

```
LRESULT CALLBACK _export MainWndProc(HWND hWnd, UINT message,
                        WPARAM wParam, LPARAM lParam)
```

The next code encountered in the MainWndProc function is a switch. In C, a switch first evaluates the expression contained in the parentheses for an integral value. The program then branches to the case corresponding to the value of the expression and continues execution until a break statement or the end of the switch is encountered. A default case may also be specified. Any value of the expression not corresponding to one of the other cases causes the default case to be executed. In the case where there is no default and no case is matched, the cases are skipped and execution continues with the code after the switch.

In the case of the MainWndProc function, the expression evaluated is simply the unsigned integer indicating the message type.

```
switch (message)
```

This switch responds to four cases, WM_COMMAND, WM_CREATE, WM_PAINT, and WM_DESTROY. These cases are messages sent to the MainWndProc by the Windows™ environment.

The WM_COMMAND message is sent when the user makes a menu selection using the mouse or an accelerator key. It can also be sent by a control in a dialog box owned by the main window. When the WM_COMMAND message is received by the MainWndProc function, it refers the message to the WMCommand_Handler function by calling the HANDLE_WM_COMMAND macro. The HANDLE_WM_COMMAND macro breaks messages down into a form that can be used by the WMCommand_Handler function. The MainWndProc function also returns the value returned by the HANDLE_WM_COMMAND macro, indicating to the Windows™ environment if the message was handled.

```
case WM_COMMAND :
{
//this case refers menu selections to the WMCommand_Handler function
        return HANDLE_WM_COMMAND(hWnd, wParam, lParam, WMCommand_Handler);
}
```

One of the most attractive features of the Windows™ environment is its device independence. In order to build device independence into the VLL application it is necessary to assess the capabilities of the output devices used by the program and tailor the output accordingly.

The WM_CREATE message is sent after a window is created but before it is displayed. The WM_CREATE case is used to initialize the global variables width and height, which are used to scale the output that is drawn on the monitor. Note that global variables are variables that are made available to all of the functions in the program by declaring them external to any function definition.

```
case WM_CREATE :
{

//this case initializes two global variables upon creation of the
// main window

        HDC     tempDC;                         //handle to a temporary device
                                                // context

//get a handle to the screen device context

        tempDC = GetDC(hWnd);

//determine the width of the display in pixels and the height of the display
// in raster lines and cast them as floats

        width  = (float)GetDeviceCaps (tempDC, HORZRES);
        height = (float)GetDeviceCaps (tempDC, VERTRES);

//since the normal display aspect ratio is 4 to 3, ensure that the graphical
// output made by the program is in that aspect ratio

        if((width/height)>(4.0/3.0))
                width = height*(4.0/3.0);
        else
                height = width*(3.0/4.0);

//release the handle to the device context

        ReleaseDC(hWnd,tempDC);

        return 0;

        }
```

The first thing done in the WM_CREATE case is to declare tempDC as a handle to a device context. A device context is the link between a Windows™ application, a device driver, and an output device such as a monitor. The next statement uses the GetDC function to assign the value of the handle of the main window device context to tempDC. Once this is done, the case uses the GetDeviceCaps function to retrieve the width of the monitor display area in pixels (HORZRES) and the height of the monitor display area in raster lines (VERTRES). The integer values returned are cast as floating

point values because the width and height variables are declared as global floating point variables.

Most but not all device contexts have a horizontal to vertical aspect ratio of 640/480, or 4/3. The screen and printer output functions written for VLL assume a display area size of 640 pixels horizontally and 480 raster lines vertically and use the width and height values to scale the output to fit the device context. This prevents the output from being distorted in aspect ratio or scale when drawn on a device with a different aspect ratio or a different display resolution. The values of width and height are forced to the appropriate ratio by evaluating the aspect ratio of the device context and constraining the value of width to 4/3 of height if the aspect ratio is greater than 4/3, and constraining the value of height to 3/4 of width if the aspect ratio is less than 4/3.

After using the device context, the program must release it so it may be used by other applications if necessary. This is accomplished by the ReleaseDC command. The final step of the case returns "0", indicating to the Windows™ environment that the message was handled by the MainWndProc function.

The WM_PAINT message is received when either the application or the Windows™ environment requests that all or part of the client area be redrawn. This could occur if the window were resized or if the data to be displayed changed.

```
    case WM_PAINT : {
//this case handles painting the screen
        HDC     PaintDC;                        //handle to a device
                                                // context
        PAINTSTRUCT ps;                         //paint structure
//prepare hWnd for painting and fill the paint structure, ps
        PaintDC = BeginPaint(hWnd, &ps);
//paint the data box whenever the screen is repainted
        paint_data_box(PaintDC );
```

```
//paint the graphs if vortex has been run and the variable data has not
// changed since vortex was run

        if(run_flag)

                        paint_graphs(PaintDC);

//mark the end of painting hWnd and return 0

        EndPaint(hWnd, &ps);

        return 0;

                        }
```

The WM_PAINT case declares two variables. The first is a handle to a device context, PaintDC in this case. The second is a paint structure, ps. A Windows™ paint structure is declared as follows:

```
typedef struct tagPAINTSTRUCT {    /* ps */
  HDC  hdc;
  BOOL fErase;
  RECT rcPaint;
  BOOL fRestore;
  BOOL fIncUpdate;
  BYTE rgbReserved[16];
} PAINTSTRUCT;
```

The first parameter is a handle to a device context. The second parameter is a 16 bit boolean value indicating whether or not the background needs to be redrawn. The third parameter is a Windows™ rectangle structure that specifies the upper left and lower right corners of the rectangle to be painted. The remaining parameters of the PAINTSTRUCT are used internally by the Windows™ environment.

A Windows™ rectangle structure is declared as follows:

```
typedef struct tagRECT {    /* rc */
  int left;
  int top;
  int right;
  int bottom;
```

} RECT;

The purpose of the left and top parameters is to specify the Cartesian coordinates of the upper left corner of the rectangle. The right and bottom parameters specify the coordinates of the lower right corner.

The WM_PAINT case uses the BeginPaint function to prepare the main window for painting and to fill the paint structure with the data necessary for painting the window. The BeginPaint function receives the handle of the window to be painted and the address of the paint structure to be used and returns the handle of the device context. Once this is complete the case calls paint_data_box, a function written specifically for the VLL application to paint the current data selections on the screen. If the current data set has been processed by the part of the program that performs the actual hydrodynamic calculations, as indicated by the state of the integer variable run_flag, the case also causes the graphs to be drawn. This is done by calling the paint_graphs function, another function written specifically for the VLL application.

After the painting is complete, the EndPaint function is called to mark the end of the painting process. The case then returns "0" to indicate that the message was processed by the MainWndProc function.

The final case in the switch is WM_DESTROY, which is shown below. This case handles requests to terminate the program made by methods other than the main menu File|Exit selection. The access function is used to determine if the temporary plot data file, plotdat.tmp exists and deletes the file if it does exist.

The access function receives a file name and an access code. The access code "0" causes the function to check for file existence and return "0" if the file does exist. The unlink function deletes the specified file.

```
case WM_DESTROY : {

//this case handles requests to exit the program made by methods other than
// the main menu
```

```
//delete the temporary plot data file if it was created
        if(access("plotdat.tmp", 0) == 0)
                unlink("plotdat.tmp");
        PostQuitMessage(0);
        return 0;
                }
```

The WM_DESTROY case then posts a message to the Windows™ environment requesting to terminate execution and returns "0", indicating that the message was handled by the MainWndProc function.

The last statement in the MainWndProc, shown below, refers messages not processed by one of the four cases in the switch to the default window procedure. The DefWindowProc function processes the message and returns a value which is then returned to the Windows™ environment.

```
return DefWindowProc (hWnd, message, wParam, lParam);
```

APPENDIX A.3

The VLL WMCommand_Handler function.

A.3 The VLL WMCommand_Handler function.

The WMCommand_Handler function provides the functionality of a main menu to a Windows™ program. The WMCommand_Handler function used by VLL is shown below.

```
void WMCommand_Handler(HWND hWnd, int id, HWND hwndCtl, UINT codeNotify)
{

        DLGPROC dlgProc;                                        //pointer to a dialog procedure

//this switch handles the various main menu selections

        switch (id)
        {
        case IDM_RUN : {

        RECT    temp_rect;                                      //temporary rectangle structure
                                                                // for specifying portion of
                                                                        // screen to redraw

//if the user selects "Run", run the vortex program
                vortex(w_nm);
//set the run flag to 1 since vortex has been run
                run_flag = 1;
//cause appropriate sections of the screen to be repainted
                temp_rect.top    = (int)(left_rect.top*height/480.0);
                temp_rect.bottom = (int)(left_rect.bottom*height/480.0);
                temp_rect.left   = (int)(left_rect.left*width/640.0);
                temp_rect.right  = (int)(left_rect.right*width/640.0);
                InvalidateRect(hWnd, &temp_rect, TRUE);

                temp_rect.top    = (int)(right_rect.top*height/480.0);
                temp_rect.bottom = (int)(right_rect.bottom*height/480.0);
                temp_rect.left   = (int)(right_rect.left*width/640.0);
                temp_rect.right  = (int)(right_rect.right*width/640.0);
                InvalidateRect(hWnd, &temp_rect, TRUE);

                break;
                        }

        case IDM_PRINT : {

//this case calls the print dialog box

        PRINTDLG pd;                                            //print dialog structure
        DOCINFO di;                                             //document information structure
        int       j;                                                    //page counter

//if a print request is made using the main menu and vortex has not been run,
```

```
// print a warning and deny the request
                if (!run_flag)

                {
                    MessageBeep(MB_ICONEXCLAMATION);
                    MessageBox(hWnd, "Must run program prior to printing.",
            "WARNING!", MB_ICONSTOP | MB_OK | MB_TASKMODAL);
                break;
                }

//otherwise, process the request
//set all structure members to zero.

                memset(&pd, 0, sizeof(PRINTDLG));

                        di.cbSize = sizeof(DOCINFO);
                        di.lpszDocName = "VLL";
                        di.lpszOutput = NULL;

//initialize the necessary PRINTDLG structure members.
                pd.lStructSize = sizeof(PRINTDLG);
                pd.hwndOwner = hWnd;
                pd.Flags = PD_RETURNDC|PD_HIDEPRINTTOFILE|PD_NOSELECTION;
                pd.nFromPage = 1;
                pd.nToPage = 1;
                pd.nMinPage = 1;
                pd.nMaxPage = 1;

                if (PrintDlg(&pd) != 0) {

                        StartDoc(pd.hDC,&di);

                        for(j=0; j<pd.nCopies; j++){

                                StartPage(pd.hDC);
                                paint_data_box(pd.hDC );
                                paint_graphs(pd.hDC);
                                EndPage(pd.hDC);     }

                        EndDoc(pd.hDC);
                        DeleteDC(pd.hDC);

                                        }
                        if (pd.hDevMode != NULL)
                                GlobalFree(pd.hDevMode);
                        if (pd.hDevNames != NULL)
                                GlobalFree(pd.hDevNames);
                break;
                        }


        case IDM_GEOMETRY : {
//initialize temp_elements
                temp_elements = NUMBER_ELEMENTS;
```

```
//this case calls the geometry dialog box
                    dlgProc = (DLGPROC)MakeProcInstance((FARPROC)DlgProc,
                            ghInstance);
                    DialogBox(ghInstance, "GEOMETRY", hWnd, dlgProc);
                    FreeProcInstance((FARPROC)dlgProc);

//if the number of elements input by the user is outside the allowable,
// print a warning, cause the screen to be repainted, and terminate the case

                    if(temp_elements>40||temp_elements<2) {
                MessageBeep(MB_ICONEXCLAMATION);
                MessageBox(hWnd, "Number of Elements must be between 2 and 40",
                "WARNING!", MB_ICONSTOP | MB_OK | MB_TASKMODAL);
                InvalidateRect(hWnd, NULL, TRUE);
                break;
                                                    }
//if the number of elements input by the user is inside the allowable,
// use the value in temp_elements
                NUMBER_ELEMENTS = temp_elements;
//if constant vortex spacing is used, call the tip vortex dialog box
                    if(spacing_flag) {
                    Again_Tip_Vortex:
                    dlgProc = (DLGPROC)MakeProcInstance((FARPROC)TIPDlgProc,
                                    ghInstance);
                    DialogBox(ghInstance, "TIPVORTEX", hWnd, dlgProc);
                    FreeProcInstance((FARPROC)dlgProc);
//if the tip vortex supplied by the user is close to the zero, print a
// warning and reinitiate the dialog box
                    if(tip_vortex_inset<0.000001){
                    MessageBeep(MB_ICONEXCLAMATION);
                    MessageBox(hWnd, "Tip Vortex Inset/Panel Width must be > zero",
                    "WARNING!", MB_ICONSTOP | MB_OK | MB_TASKMODAL);
                    goto Again_Tip_Vortex;
                                        }
                                }

//cause the screen to be repainted if the dialog box was not canceled
                    if(!run_flag)

                            InvalidateRect(hWnd, NULL, TRUE);
                    break;
                                }

    case IDM_COEFFICIENTS : {

//this case calls the coefficients dialog box
            float     sum = 0.0;                          //used to sum the coefficients
            int       q;                                          //loop counter

                    Again_Coefficients:
                    dlgProc = (DLGPROC)MakeProcInstance((FARPROC)NextDlgProc,
                            ghInstance);
                    DialogBox(ghInstance, "COEFFICIENTS", hWnd, dlgProc);
                    FreeProcInstance((FARPROC)dlgProc);
```

```
//sum up the absolute values of the glauert coefficients input by the user
                for(q=0;q<5;q++)
                        sum += fabs(coefficients[q]);

//if the sum is close to zero, print a warning and reinitiate the dialog box
                if(sum<0.0000001) {
                MessageBox(hWnd, "At least one coefficient must be non-zero",
                 "WARNING!", MB_ICONSTOP | MB_OK | MB_TASKMODAL);
                goto Again_Coefficients;
                                        }

//cause the screen to be repainted if the dialog box was not canceled
                if(!run_flag)
                        InvalidateRect(hWnd, NULL, TRUE);
        break;
                                }
        case IDM_EXIT : {

//this case deletes the temporary file and terminates the program

                if(access("plotdat.tmp", 0) == 0)
                        unlink("plotdat.tmp");
                PostQuitMessage(0);
        break;
                        }

    case IDM_ABOUT : {

//this case calls the About dialog box
        dlgProc = (DLGPROC)MakeProcInstance((FARPROC)ABOUTDlgProc,
                        ghInstance);
        DialogBox(ghInstance, "ABOUT", hWnd, dlgProc);
        FreeProcInstance((FARPROC)dlgProc);
        break;
                        }

//the next several cases respond to the help section of the main menu
    case IDM_HELPGENERAL :
    {  MessageBox(hWnd, "The Hydrofoil Vortex Lifting Line Program \
applies a vortex lattice method to the straight line lifting problem.\n\n\
It calculates and displays both the exact and numerical solutions for \
induced downwash velocity, total lift, and total induced drag for a \
circulation distribution described by up to 5 Glauert coefficients.\n\n\
It then solves the 'analysis' problem by calculating and displaying \
the numerical approximation for the circulation distribution based on \
the exact downwash velocity solution.",
          "HELP", MB_ICONINFORMATION | MB_OK );
         break;
    }

        case IDM_HELPRUN :
    {  MessageBox(hWnd, "When 'File|Run' is selected from the main \
menu, the program uses the Current Variable Data to calculate and display \
```

```
numerical and exact solutions for downwash velocity and non-dimensional \
circulation.\n\n\
The lift, drag, and drag/lift squared coefficients are also calculated \
and a table of the error in the calculations is displayed.\n\n\
This selection also causes an ascii text file, 'output.dat', to be written \
to the directory where the program is resident.",
            "HELP", MB_ICONINFORMATION | MB_OK );
         break;
   }

            case IDM_HELPPRINT :
   {  MessageBox(hWnd, "When 'File|Print' is selected from the main \
menu, the program invokes standard Windows Print and Print Setup Dialog \
boxes to allow the user to print the data that appears on the screen.",
            "HELP", MB_ICONINFORMATION | MB_OK );
         break;
   }

            case IDM_HELPEXIT :
   {  MessageBox(hWnd, "When 'File|Exit' is selected from the main \
menu, the program is terminated.",
            "HELP", MB_ICONINFORMATION | MB_OK );
         break;
   }

            case IDM_HELPELEMENTS :
   {  MessageBox(hWnd, "When 'Options|Geometry' is selected from the \
main menu, the user may select a Number of Elements to use.\n\n\
The Number of Elements, M, must be between 2 and 40, inclusive.  For M \
elements there will be M+1 free vortices.\n\n\
The default value for M is 40.",
            "HELP", MB_ICONINFORMATION | MB_OK );
         break;
   }

            case IDM_HELPVORTEXSPACING :
   {  MessageBox(hWnd, "When 'Options|Geometry' is selected from the \
main menu, the user may select either cosine or constant lattice spacing \
for the free vortices.\n\n\
Cosine spacing uses a transformation of the spanwise coordinate, \
y = -(s/2)*cos(y~).  It is the default spacing and also in general produces \
more accurate results.\n\n\
Constant spacing results in singularities at the tips and therefore \
requires the use of a non-zero tip vortex inset.  The user is automatically \
prompted for a value for the ratio of tip vortex inset to panel width if \
the constant spacing option is selected.",
            "HELP", MB_ICONINFORMATION | MB_OK );
         break;
   }

            case IDM_HELPCONTROLPTSPACING :
   {  MessageBox(hWnd, "When 'Options|Geometry' is selected from the \
main menu, the user may select either cosine or midpoint spacing for the \
for the control points.\n\nMidpoint spacing interpolates between the \
```

```
vortices and Cosine spacing uses a transformation of the spanwise \
coordinate, y = -(s/2)*cos(y~). Cosine spacing is the default spacing and \
also in general produces more accurate results.",
            "HELP", MB_ICONINFORMATION | MB_OK );
          break;
    }

            case IDM_HELPTIPVORTEXINSET :
    {  MessageBox(hWnd, "When Constant control point spacing is selected \
in the Geometry Dialog Box, the user is automatically prompted for a value \
for the ratio of tip vortex inset to panel width.\n\n\
A positive, non-zero value is required.  The default value is 0.25.",
            "HELP", MB_ICONINFORMATION | MB_OK );
          break;
    }

            case IDM_HELPCOEFFICIENTS :
    {  MessageBox(hWnd, "When 'Options|Coefficients' is selected from \
the main menu, the user may select values for the first 5 Glauert \
coefficients to describe the spanwise circulation distribution.\n\n\
At least one of the coefficients must be non-zero.  The default values are \
0.0 for all except a1, for which 1.00 is the default value.",
            "HELP", MB_ICONINFORMATION | MB_OK );
          break;
    }

  }
}
```

The function prototype for the WMCommand_Handler function is shown below. The return type, void, indicates that no value is returned by the function. The first two parameters passed to the WMCommand_Handler function are the handle of the main window and an integer variable, id, that describes the particular message being handled. The integer is used as the argument for the switch that refers the message to a number of different cases for processing. The information passed in the other two parameters is not used in this program.

```
void WMCommand_Handler(HWND hWnd, int id, HWND hwndCtl, UINT codeNotify)
```

Before the switch is employed, a 32 bit pointer to a dialog procedure (DLGPROC), dlgProc, is declared. It is used in the three switch cases that call dialog box procedures.

The first case in the switch is the IDM_RUN case. The purpose of the IDM_RUN case is to cause the current input data to be processed by the functions that perform the hydrodynamic calculations and to cause the results to be written to the screen. IDM_RUN is an unsigned integer value that corresponds to the File|Run selection on the VLL main menu. The main menu is defined in a Windows™ resource file, pll.rc. The definitions of identifiers such as IDM_RUN are contained in a header file, pll.h. Both of these files are listed in Appendix A.6.

```
case IDM_RUN : {

RECT   temp_rect;                          //temporary rectangle structure
                                           // for specifying portion of
                                                // screen to redraw

//if the user selects "Run", run the vortex program
        vortex(w_nm);
//set the run flag to 1 since vortex has been run
        run_flag = 1;
//cause appropriate sections of the screen to be repainted
        temp_rect.top    = (int)(left_rect.top*height/480.0);
        temp_rect.bottom = (int)(left_rect.bottom*height/480.0);
        temp_rect.left   = (int)(left_rect.left*width/540.0);
        temp_rect.right  = (int)(left_rect.right*width/640.0);
        InvalidateRect(hWnd, &temp_rect, TRUE);

        temp_rect.top    = (int)(right_rect.top*height/480.0);
        temp_rect.bottom = (int)(right_rect.bottom*height/480.0);
        temp_rect.left   = (int)(right_rect.left*width/640.0);
        temp_rect.right  = (int)(right_rect.right*width/640.0);
        InvalidateRect(hWnd, &temp_rect, TRUE);

        break;
            }
```

The IDM_RUN case declares a rectangle structure for use in specifying the sections of the screen to be repainted. It then processes the input data by calling the vortex function. The vortex function is basically a translation of the FORTRAN VLL code into C. It is included in Appendix A.6.

The case then sets the run flag, indicating that the current set of input data has been processed. The rectangle structure, temp_rect, is then set to values corresponding to

rectangles surrounding first the screen graphical output and then the prediction error table. The InvalideRect function receives the handle of the window to be repainted, the address of a rectangle indicating the portion of the screen to be redrawn, and a boolean value that indicates if the background is to be erased during repainting. This causes a WM_PAINT message to be sent to the MainWndProc which causes the screen to be redrawn with the data calculated during the run.

The next case handled in the switch is the IDM_PRINT case. This case uses a Windows™ common dialog box to handle print requests made using the main menu. The IDM_PRINT case is shown below.

```
        case IDM_PRINT : {
//this case calls the print dialog box

        PRINTDLG pd;                                  //print dialog structure
        DOCINFO di;                                   //document information structure
        int        j;                                      //page counter

//if a print request is made using the main menu and vortex has not been run,
// print a warning and deny the request
                if (!run_flag)
                {
                    MessageBeep(MB_ICONEXCLAMATION);
                    MessageBox(hWnd, "Must run program prior to printing.",
            "WARNING!", MB_ICONSTOP | MB_OK | MB_TASKMODAL);
                break;
                }

//otherwise, process the request
//set all structure members to zero.

                memset(&pd, 0, sizeof(PRINTDLG));

                        di.cbSize = sizeof(DOCINFO);
                        di.lpszDocName = "VLL";
                        di.lpszOutput = NULL;

//initialize the necessary PRINTDLG structure members.
                pd.lStructSize = sizeof(PRINTDLG);
                pd.hwndOwner = hWnd;
                pd.Flags = PD_RETURNDC|PD_HIDEPRINTTOFILE|PD_NOSELECTION;
                pd.nFromPage = 1;
                pd.nToPage = 1;
                pd.nMinPage = 1;
```

```
pd.nMaxPage = 1;

if (PrintDlg(&pd) != 0) {

        StartDoc(pd.hDC,&di);

        for(j=0; j<pd.nCopies; j++){

                StartPage(pd.hDC);
                paint_data_box(pd.hDC );
                paint_graphs(pd.hDC);
                EndPage(pd.hDC);    }

        EndDoc(pd.hDC);
        DeleteDC(pd.hDC);

                        }
        if (pd.hDevMode != NULL)
                GlobalFree(pd.hDevMode);
        if (pd.hDevNames != NULL)
                GlobalFree(pd.hDevNames);
break;
          }
```

Three local variables are declared in the IDM_PRINT case. The first is print dialog structure, pd. The print dialog structure is defined as follows:

```
typedef struct tagPD {  /* pd */
   DWORD              lStructSize;
   HWND               hwndOwner;
   HGLOBAL            hDevMode;
   HGLOBAL            hDevNames;
   HDC                hDC;
   DWORD              Flags;
   UINT               nFromPage;
   UINT               nToPage;
   UINT               nMinPage;
   UINT               nMaxPage;
   UINT               nCopies;
   HINSTANCE          hInstance;
   LPARAM             lCustData;
   UINT               (CALLBACK* lpfnPrintHook)(HWND, UINT, WPARAM, LPARAM);
   UINT               (CALLBACK* lpfnSetupHook)(HWND, UINT, WPARAM, LPARAM);
   LPCSTR             lpPrintTemplateName;
   LPCSTR             lpSetupTemplateName;
   HGLOBAL            hPrintTemplate;
   HGLOBAL            hSetupTemplate;
} PRINTDLG;
```

The print dialog structure is used to initialize the common Print dialog box. After the OK button on the dialog box is selected, information regarding user selections is returned in the structure.

The second local variable is a document information structure, di. The document information structure is declared as follows:

```
typedef struct {    /* di */
    int                 cbSize;
    LPCSTR              lpszDocName;
    LPCSTR              lpszOutput;
} DOCINFO;
```

The document information structure is used to pass file name information to the StartDoc function. The cbSize parameter is the size of the structure itself in bytes. The lpszDocName is a pointer to a null-terminated string specifying the document name, in this case "VLL". The lpszOutput parameter points to a null-terminated string used to specify a file to which the output is redirected. Using the NULL value causes the output to go to the printer. The "print to file" capability is not implemented in VLL. The third local variable is an integer used as a counter for producing multiple copies of the output.

The next block of code in the case checks the run flag. If the flag is not set, which indicates that the current set of input data has not been run, the user receives an audible and printed warning and the switch is terminated by the break statement. The warning is implemented using two functions. The first is the MessageBeep function, which receives an unsigned integer specifying a particular sound and then causes the sound to be played. The MessageBox function receives the handle to the parent window, a pointer to a null-terminated string that is printed as the warning, a pointer to a null-terminated string that is printed as the title of the box, and an unsigned integer indicating the style of the box. The style can consist of any number of compatible styles combined by C logical "or" operators. In this case the function uses three styles:

MB_ICONSTOP	a stop sign appears in the box
MB_OK	the box contains one push button, labeled OK
MB_TASKMODAL	the user must respond to the box before continuing work in the parent window

Figure A-1 shows the message displayed by this code.

```
if (!run_flag)
{
    MessageBeep(MB_ICONEXCLAMATION);
    MessageBox(hWnd, "Must run program prior to printing.",
"WARNING!", MB_ICONSTOP | MB_OK | MB_TASKMODAL);
    break;
}
```

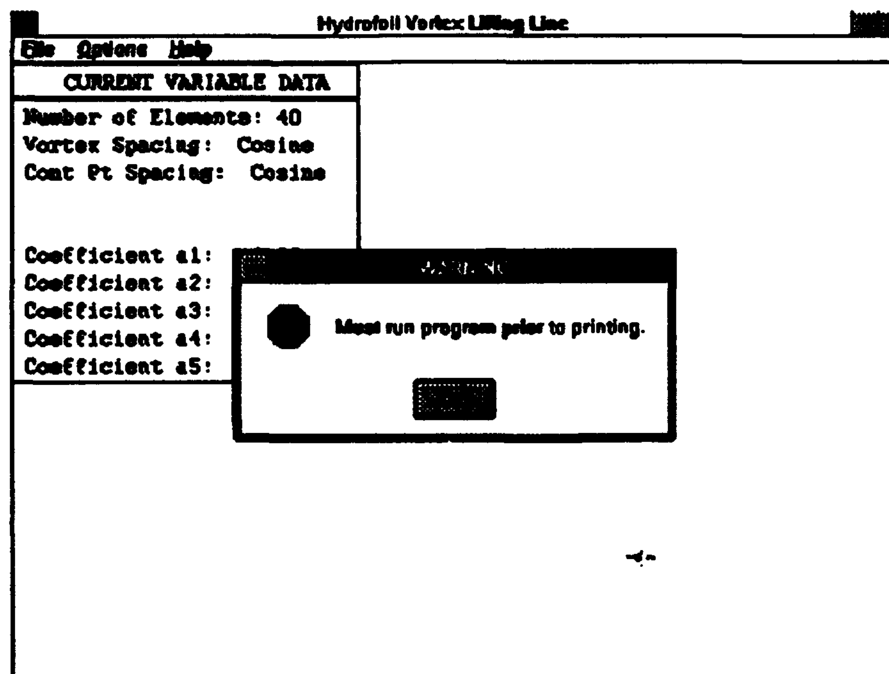

Figure A-1. Windows™ VLL with Error Warning Displayed

After it has been determined that the current data set has been run, the print dialog and document information structures are initialized. The memset function sets all of the items in the print dialog structure, pd, to zero. The sizeof function receives an expression or

type and returns the size in bytes. The next three statements initialize the document information structure as described above.

```
memset(&pd, 0, sizeof(PRINTDLG));

        di.cbSize = sizeof(DOCINFO);
        di.lpszDocName = "VLL";
        di.lpszOutput = NULL;

//initialize the necessary PRINTDLG structure members.
    pd.lStructSize = sizeof(PRINTDLG);
    pd.hwndOwner = hWnd;
    pd.Flags = PD_RETURNDC|PD_HIDEPRINTTOFILE|PD_NOSELECTION;
    pd.nFromPage = 1;
    pd.nToPage = 1;
    pd.nMinPage = 1;
    pd.nMaxPage = 1;
```

The last seven statements initialize the required parameters in the print dialog structure. The pd.Flags parameter specifies the way the common print dialog box is initialized. Any number of compatible flags may be used. In this case, the following are used:

PD_RETURNDC causes the PrintDlg function to return a handle to an appropriate device context in the pd.hDC field

PD_HIDEPRINTTOFILE hides and disables the Print to File check box in the common print dialog box

PD_NOSELECTION disables the Selection radio button

The other six statements are self-explanatory.

The program is then ready to call the PrintDlg function. The PrintDlg function receives the address of a print dialog structure and returns a nonzero value if the function successfully configures the system printer and zero otherwise. In VLL, if the PrintDlg function is successful, the StartDoc function is used to start a print job using the printer device context and the address of the document information structure.

```
if (PrintDlg(&pd) != 0) {

        StartDoc(pd.hDC,&di);

        for(j=0; j<pd.nCopies; j++){
```

```
                StartPage(pd.hDC);
                paint_data_box(pd.hDC );
                paint_graphs(pd.hDC);
                EndPage(pd.hDC);    }

        EndDoc(pd.hDC);
        DeleteDC(pd.hDC);

                    }
        if (pd.hDevMode != NULL)
                GlobalFree(pd.hDevMode);
        if (pd.hDevNames != NULL)
                GlobalFree(pd.hDevNames);
break;
          }
```

The IDM_PRINT case then uses a for loop to print the number of copies returned in the print dialog structure. In C, a for statement consists of three expressions enclosed in a set of parentheses, followed by a statement to be executed. The first expression, in this case j=0, is executed before the first iteration. The statement, in this case four statements enclosed in braces, is executed until the second expression becomes false. The third expression is executed after each iteration and is usually used to increment a counter. Note that in C, j++ increments j by the integer value 1.

The StartPage and EndPage functions receive a handle to the printer device context and mark the start and end of each page. The VLL program uses the print_data_box and print_graphs functions to draw the text and graphical data to the printer device context. The print_data_box and print_graphs functions are described in Appendix A.5.3 and included in Appendix A.6.

After the pages are drawn, the document is ended using the EndDoc function and the printer device context is deleted. The global memory objects, pd.hDevMode and pd.hDevNames, are then freed and the case is terminated.

The third case is the IDM_GEOMETRY case. This case calls the Geometry dialog box function for the purpose of receiving user input regarding the panelization of the lifting line and the spacing of the control points and the vortices.

The first thing done by the case is to initialize the value of a temporary storage location, temp_elements, with the current value of NUMBER_ELEMENTS, the number of elements into which the lifting line is discretized. The next step is to make an instance of the Geometry dialog box procedure. This essentially places the function at a specific location in memory, and allows the function access to the data in the application. The procedure instance is made with the MakeProcInstance function, which receives the address of a function and the handle to the application and returns the address of the function. The next step is to call the DialogBox function. The DialogBox function receives the handle of the application instance, the address of the dialog box template name, the handle of the owner window, and the address of the dialog procedure and creates a dialog box. The Geometry dialog box was is shown in Figure 2-4. Control is not returned to the application until the dialog box is terminated. Once the dialog box is terminated, the FreeProcInstance function is called to free the dialog box procedure.

```
        case IDM_GEOMETRY : {
//initialize temp_elements
                temp_elements = NUMBER_ELEMENTS;
//this case calls the geometry dialog box
                dlgProc = (DLGPROC)MakeProcInstance((FARPROC)DlgProc,
                        ghInstance);
                DialogBox(ghInstance, "GEOMETRY", hWnd, dlgProc);
                FreeProcInstance((FARPROC)dlgProc);
```

The case now checks the value input by the user, now located in temp_elements, to make sure it is within the limits imposed by the program. If the value is outside the range from two to 40 inclusive, a warning is printed and the screen is redrawn. Note that the value NULL is passed instead of the address of a rectangle structure in the call to InvalidateRect. This causes the entire window to be redrawn.

```
//if the number of elements input by the user is outside the allowable,
// print a warning, cause the screen to be repainted, and terminate the case

        if(temp_elements>40||temp_elements<2) {
    MessageBeep(MB_ICONEXCLAMATION);
    MessageBox(hWnd, "Number of Elements must be between 2 and 40",
    "WARNING!", MB_ICONSTOP | MB_OK | MB_TASKMODAL);
    InvalidateRect(hWnd, NULL, TRUE);
    break;
                                        }
```

If the number of elements input by the user with the dialog box is within the allowable range, then the case uses the value.

```
//if the number of elements input by the user is inside the allowable,
// use the value in temp_elements
    NUMBER_ELEMENTS = temp_elements;
```

The case then checks the type of vortex spacing specified by the user. If constant spacing is employed, the Tip Vortex dialog box procedure is called. This sequence is completely analogous with the sequence for the Geometry dialog box, with the exception of the label, Again_Tip_Vortex. This label is used to cause the Tip Vortex dialog box procedure to be called again if the user input is not acceptable.

```
//if constant vortex spacing is used, call the tip vortex dialog box
        if(spacing_flag) {
        Again_Tip_Vortex:
        dlgProc = (DLGPROC)MakeProcInstance((FARPROC)TIPDlgProc,
                    ghInstance);
        DialogBox(ghInstance, "TIPVORTEX", hWnd, dlgProc);
        FreeProcInstance((FARPROC)dlgProc);

//if the tip vortex supplied by the user is close to the zero, print a
// warning and reinitiate the dialog box
        if(tip_vortex_inset<0.000001){
        MessageBeep(MB_ICONEXCLAMATION);
        MessageBox(hWnd, "Tip Vortex Inset/Panel Width must be > zero",
        "WARNING!", MB_ICONSTOP | MB_OK | MB_TASKMODAL);
        goto Again_Tip_Vortex;
                    }
            }

//cause the screen to be repainted if the dialog box was not canceled
        if(!run_flag)
```

```
                InvalidateRect(hWnd, NULL, TRUE);
        break;
                }
```

After the dialog box procedure returns and the procedure instance is freed, the tip vortex inset is checked. If the value is less than a very small positive number, a warning message is printed and the Tip Vortex dialog box procedure is called again. The screen is then repainted if the run flag was cleared in the Geometry dialog procedure. This effectively causes the screen, with the exception of the current variable data, to be cleared indicating that the current data has not been run.

The next case is the IDM_COEFFICIENTS case. This case calls the Coefficients dialog procedure and inspects the input in a manner similar to the previous case. The IDM_COEFFICIENTS case declares two variables. The float variable, sum, is initialized to 0.0. It is used to sum the absolute values of the Glauert coefficients input by the user, in order to ensure that the at least one of the coefficients is non-zero. The integer, q, is used as a loop counter for this purpose.

```
    case IDM_COEFFICIENTS : {

//this case calls the coefficients dialog box
        float   sum = 0.0;                          //used to sum the coefficients
        int     q;                                  //loop counter

                Again_Coefficients:
                dlgProc = (DLGPROC)MakeProcInstance((FARPROC)NextDlgProc,
                        ghInstance);
                DialogBox(ghInstance, "COEFFICIENTS", hWnd, dlgProc);
                FreeProcInstance((FARPROC)dlgProc);

//sum up the absolute values of the glauert coefficients input by the user
                for(q=0;q<5;q++)
                        sum += fabs(coefficients[q]);

//if the sum is close to zero, print a warning and reinitiate the dialog box
                if(sum<0.0000001) {
                MessageBox(hWnd, "At least one coefficient must be non-zero",
                 "WARNING!", MB_ICONSTOP | MB_OK | MB_TASKMODAL);
                goto Again_Coefficients;
                                }

//cause the screen to be repainted if the dialog box was not canceled
```

```
		if(!run_flag)
			InvalidateRect(hWnd, NULL, TRUE);
	break;
				}
```

The Coefficients dialog procedure is provided with a label and called similarly to the Tip Vortex dialog procedure. After the dialog procedure returns, a for loop is used to sum the absolute values of the coefficients. The "+=" operator in the C programming language causes the value of the expression following the operator to be added to the value of the variable preceding the operator and the result to be stored in the variable preceding the operator. The "-=", "*=", and "/=" operators function similarly. If the sum of the absolute values of the coefficients indicates the case where all of the coefficients are zero, a warning is printed and the dialog procedure is called again. As in the case of the Geometry dialog box, if the run flag was cleared in the Coefficients dialog procedure, the screen is repainted.

The IDM_EXIT case handles request to terminate the program made by the main menu File|Exit selection. It uses essentially the same code described in Appendix A.2 in the WM_DESTROY case of the MainWndProc function.

```
	case IDM_EXIT : {

//this case deletes the temporary file and terminates the program

		if(access("plotdat.tmp", 0) == 0)
			unlink("plotdat.tmp");
		PostQuitMessage(0);
	break;
			}
```

The IDM_ABOUT case calls the About dialog box procedure. This dialog procedure differs from those described previously in that it is not used to receive user input data. Figure A-2 shows the VLL About dialog box.

```
case IDM_ABOUT : {
```

```
//this case calls the About dialog box
        dlgProc = (DLGPROC)MakeProcInstance((FARPROC)ABOUTDlgProc,
                        ghInstance);
        DialogBox(ghInstance, "ABOUT", hWnd, dlgProc);
        FreeProcInstance((FARPROC)dlgProc);
        break;
                }
```

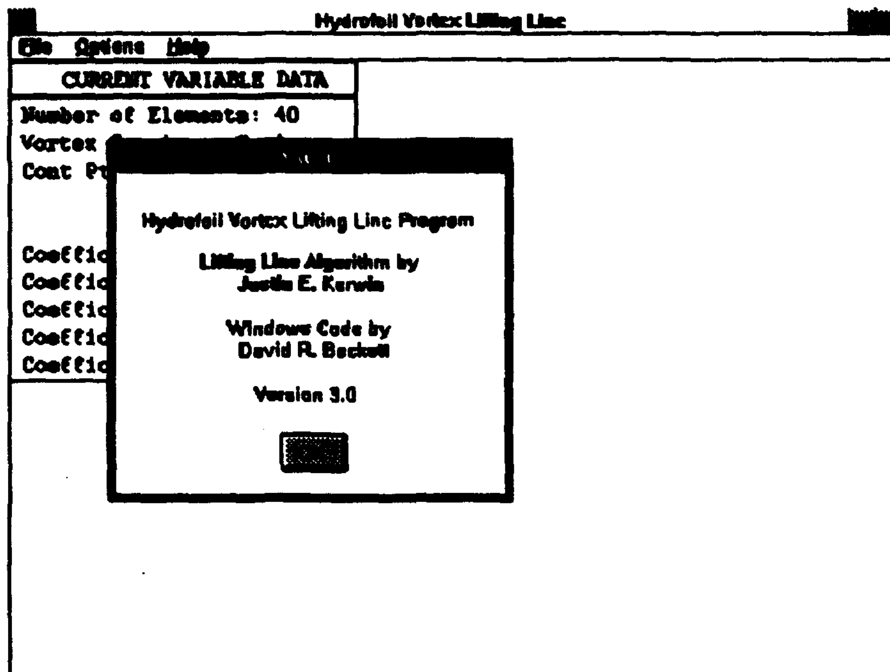

Figure A-2. Windows™ VLL with About Dialog Box Displayed

The next nine cases provide the on-line Help feature included with VLL. The nine cases are a series of MessageBox function calls that write descriptions of the operation of the main menu and the theory behind the vortex lattice method employed. The IDM_HELPGENERAL case is shown below as an example.

```
    case IDM_HELPGENERAL :
    {  MessageBox(hWnd, "The Hydrofoil Vortex Lifting Line Program \
applies a vortex lattice method to the straight line lifting problem.\n\n\
It calculates and displays both the exact and numerical solutions for \
induced downwash velocity, total lift, and total induced drag for a \
circulation distribution described by up to 5 Glauert coefficients.\n\n\
It then solves the 'analysis' problem by calculating and displaying \
the numerical approximation for the circulation distribution based on \
```

```
the exact downwash velocity solution.",
            "HELP", MB_ICONINFORMATION | MB_OK );
        break;
    }
```

APPENDIX A.4

VLL Dialog functions.

A.4 VLL Dialog functions.

Dialog boxes are a convenient means for allowing the application user to provide input to the program. The use of a single dialog box requires that two functions be added to the functions described above. The first is a callback function, similar to the MainWndProc. In the case of the Geometry dialog box in VLL, this function is declared as follows:

```
BOOL    CALLBACK _export DlgProc(HWND hDlg, UINT message, WPARAM wParam,
                                 LPARAM lParam);
```

The purpose of the function is to initialize the data displayed in the dialog box when it is created, and to refer messages received by the dialog box to the second function.

The second function is similar to the WMCommand_Handler function, and for the VLL Geometry dialog box is declared as follows:

```
void    WMDlgCommand_Handler(HWND hDlg, int id, HWND hwndCtl, UINT codeNotify);
```

The purpose of this function is to handle messages received by the dialog box, specifically messages from the "OK" or "CANCEL" buttons. The functions used in VLL for the Geometry dialog box will be described here. The functions used for the Coefficients, Tip Vortex Inset, and About dialog boxes are extremely similar and should be self-explanatory when the two functions described here are understood.

The callback function is listed below:

```
BOOL CALLBACK _export DlgProc(HWND hDlg, UINT message, WPARAM wParam,
                              LPARAM lParam)

{

        char    input[10] = "";                         //character string for writing output

        switch(message)
        {

        case WM_INITDIALOG : {

//initialize numerical and state dialog controls
```

```
		if(spacing_flag)

			CheckRadioButton (hDlg, IDM_COSINE, IDM_CONSTANT,
							IDM_CONSTANT);

		else

			CheckRadioButton (hDlg, IDM_COSINE, IDM_CONSTANT,
						IDM_COSINE);

		if(controlpt_flag)

			CheckRadioButton (hDlg,IDM_COSINECONTROL ,
						IDM_MIDPOINT, IDM_MIDPOINT);
		else

			CheckRadioButton (hDlg,IDM_COSINECONTROL ,
						IDM_MIDPOINT, IDM_COSINECONTROL);

		itoa(NUMBER_ELEMENTS,input,10);
		SetDlgItemText(hDlg,IDM_NUMOFELEMENTS,input);

		return TRUE;

			}

	case WM_COMMAND : {

		return (BOOL)HANDLE_WM_COMMAND(hDlg, wParam, lParam,
						WMDlgCommand_Handler);

			}

	}

	return FALSE;

}
```

A cursory inspection of the callback function reveals that the function consists essentially of a switch that handles two cases. Prior to the switch a character array, input, is declared for the purpose of writing text data to the dialog controls. There are ten types of dialog controls, only two of which are dealt with by the DlgProc function.

A dialog box may have up to 255 controls, selected from the below listed types:

Pushbuttons the type used for "OK" and "CANCEL" buttons

Radio Buttons	used to select an option from a group of mutually exclusive options
Check Boxes	used to select or deselect options which can be toggled on and off
Static Text Fields	used to provide labels or instructions
Group Boxes	allows grouping of a set of other controls
Listboxes	used for selecting an option, such as a file name from a list
Edit Boxes	allow the user to input text
Scroll Bars	used to input a linear value
Icons	used to provide visual input
Combination Boxes	a combination of an edit box and a list box

The VLL program makes use of the pushbutton, radio button, group box, static text field, and edit box types.

Controls that are used to display variable data and to receive user input are assigned identifiers in order to make the program code more easily understood. The appearance and operation of the dialog box is defined in a resource file that is part of the application. The four dialog resource templates and the main menu used in VLL are defined in the vll.rc file. The block of code used to define the VLL Geometry dialog box is shown below. The entire vll.rc file is contained in Appendix A.6.

```
GEOMETRY DIALOG 11, 35, 175, 137
STYLE DS_MODALFRAME | WS_POPUP | WS_CAPTION
CAPTION "Geometry"
BEGIN
	CONTROL "", IDM_NUMOFELEMENTS, "EDIT", ES_LEFT | WS_CHILD | WS_VISIBLE |
WS_BORDER | WS_TABSTOP, 66, 87, 34, 15
	CONTROL "Cosine", IDM_COSINE, "BUTTON", BS_AUTORADIOBUTTON | WS_CHILD |
WS_VISIBLE | WS_GROUP | WS_TABSTOP, 10, 20, 38, 13
	CONTROL "Constant", IDM_CONSTANT, "BUTTON", BS_AUTORADIOBUTTON |
WS_CHILD | WS_VISIBLE | WS_TABSTOP, 10, 39, 40, 14
	CONTROL "Cosine", IDM_COSINECONTROL, "BUTTON", BS_AUTORADIOBUTTON |
WS_CHILD | WS_VISIBLE | WS_GROUP | WS_TABSTOP, 95, 20, 38, 13
	CONTROL "Mid-Point", IDM_MIDPOINT, "BUTTON", BS_AUTORADIOBUTTON |
WS_CHILD | WS_VISIBLE | WS_TABSTOP, 95, 39, 45, 14
	PUSHBUTTON "OK", IDM_OKGEOM, 31, 109, 36, 15, WS_CHILD | WS_VISIBLE |
WS_TABSTOP
	PUSHBUTTON "CANCEL", IDM_CANCELGEOM, 100, 109, 36, 15, WS_CHILD |
WS_VISIBLE | WS_TABSTOP
```

```
        CONTROL "Lattice Spacing", -1, "STATIC", SS_LEFT | WS_CHILD | WS_VISIBLE, 10, 7, 61,
9
        LTEXT "Number of elements        40 Max", -1, 52, 63, 67, 17
        CONTROL "Control Point Spacing", -1, "STATIC", SS_LEFT | WS_CHILD | WS_VISIBLE,
95, 7, 71, 9
        CONTROL "", -1, "static", SS_BLACKFRAME | WS_CHILD | WS_VISIBLE, 5, 4, 61, 51
        CONTROL "", -1, "static", SS_BLACKFRAME | WS_CHILD | WS_VISIBLE, 91, 4, 77, 51
        CONTROL "", -1, "static", SS_BLACKFRAME | WS_CHILD | WS_VISIBLE, 44, 60, 83, 45
END
```

The first line of code defines the name, size, and screen position of the dialog resource. The second line describes the style of the dialog box and third line defines the caption displayed on the title bar.

After the BEGIN statement, the individual controls are defined. The edit box that displays and allows the user to alter the number of elements used in the program, for example, is the first control described. It is defined as a dialog control of the edit box type. The pair of double quotes indicates that there is no automatic initialization of the value of the box. IDM_NUMOFELEMENTS is an identifier used to refer to the control in order to make the source code more readable. The flags that are joined together with the logical "or" operators indicate how the control is to be drawn and processed by the Windows™ environment. The last four numbers describe the location of the control in the dialog box.

Dialog boxes may be constructed using a standard text editor, or using a graphical development environment such as the BORLAND® Resource Workshop™. Figure A-3 shows the VLL Geometry dialog box in the BORLAND® Resource Workshop™ graphical development environment. The point and click capability of a graphical environment makes the design and testing of dialog boxes fast and easy compared to the alternative of defining them using a text editor and recompiling the application for each test.

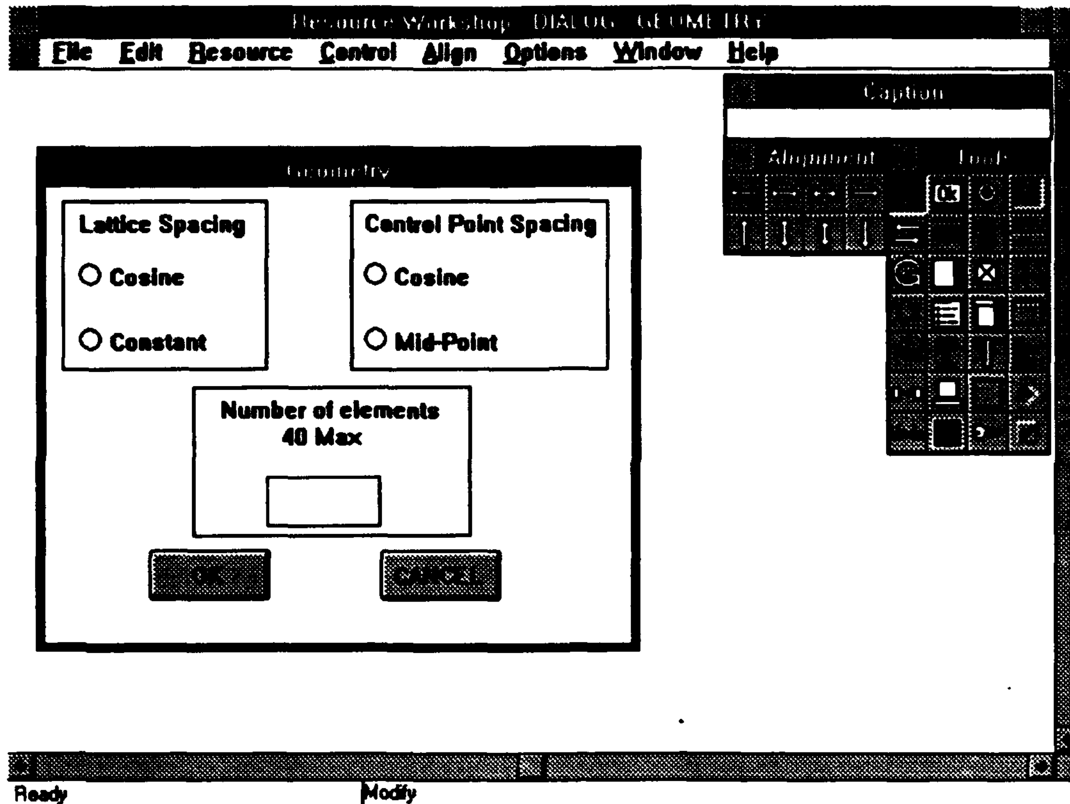

Figure A-3. VLL Geometry Dialog Box in BORLAND® Resource Workshop™

The WM_INITDIALOG case in this function evaluates the spacing flag and the control point flag and checks the appropriate radio button using the CheckRadioButton function. The CheckRadioButton function receives the handle of the dialog box, the identifier of the first and last button in the group, and the identifier of the button that is to be checked. It checks the button indicated and removes the check from the other buttons in the group. The CheckRadioButton function does not return a value.

The WM_INITDIALOG case also initializes the edit control that indicates the number of elements into which the lifting line is discretized. This is done in two steps. First the current value of NUMBER_ELEMENTS is written as a character string into the input variable array using the itoa function. The itoa function receives an integer value, the address of a character array, and the base to be used in converting the integer, and writes the integer value into the character string. In the second step, the SetDlgItemText

function is used to write the character string in the input array into the edit control indicated by IDM_NUMOFELEMENTS and contained in the dialog box indicated by hDlg. The case then returns the boolean value TRUE because the message was handled by the function.

The WM_COMMAND case refers messages to the WMDlgCommand_Handler using the HANDLE_WM_COMMAND macro and returns the value returned by the macro, indicating if the message was handled. If the message received by the callback command does not correspond to either case in the switch, then the boolean value FALSE is returned.

The second function used to handle the VLL Geometry dialog box, the WMCommand_Handler function, is shown below:

```
void WMDlgCommand_Handler(HWND hDlg, int id, HWND hwndCtl, UINT codeNotify)
{

        char      input[10] = "";                               //character string for receiving
input

        switch(id)
        {

        case IDM_OKGEOM : {

        HWND          hCtrl;                                    //handle to a dialog control
        DWORD         result;                                   //result of an interrogation of
                                                                // a dialog button

//get the state of the radio buttons and set the spacing and control point flags accordingly

                hCtrl  = GetDlgItem(hDlg, IDM_CONSTANT);
                result = SendMessage(hCtrl, BM_GETCHECK, 0, 0L);

                if (result)             spacing_flag = 1;
                else                    spacing_flag = 0;


                hCtrl  = GetDlgItem(hDlg, IDM_MIDPOINT);
                result = SendMessage(hCtrl, BM_GETCHECK, 0, 0L);

                if (result)             controlpt_flag = 1;
                else                    controlpt_flag = 0;
```

```
//get the number of elements input and store it in a temporary location

                GetDlgItemText(hDlg, IDM_NUMOFELEMENTS, input, 10);
                temp_elements = atoi(input);

//clear the run-flag to indicate that the user input data has changed

                run_flag = 0;

//drop through to the processing for the CANCEL case

                        }

        case IDM_CANCELGEOM : {

//end the dialog

                EndDialog(hDlg, 0);

                break;
                            }

  }
}
```

The WMDlgCommand_Handler function, like the DlgProc function, is essentially a switch that handles two cases. Also like the DlgProc function, prior to the switch a character array, input, is declared. In this procedure the array is used for the purpose of retrieving information from the dialog controls.

The IDM_OKGEOM case responds to the message sent when the user selects the "OK" button in the dialog box. A handle to a window, hCtrl and a DWORD, result are declared as local variables in this case. The case first uses the GetDlgItem function to get a handle first to the Constant Vortex spacing radio button. It then uses the SendMessage function to check the state of that button.

The GetDlgItem function receives a handle to a dialog box and the identifier of a control in that box and returns a handle to the control. The SendMessage function receives a handle to a dialog box control, a message identifier, and two additional message dependent items. In this case the message that is sent is a BM_GETCHECK message, the

two additional items are not used. The return values for the function when the message is BM_GETCHECK are the integer 1 if the button is checked and 0 if it is not checked.

The case sets the value of the spacing flag and then repeats the process for the control point spacing flag. The IDM_OKGEOM case then uses the GetDlgItemText function to copy the value in the Number of Elements edit box control into the input character array. The atoi function converts the ascii string pointed to by its argument to an integer value and returns that value.

The next statement clears the run flag on the assumption that some or all of the data handled by the Geometry has changed. Since there is no break statement in the IDM_OKGEOM case, program execution continues into the IDM_CANCELGEOM case and the dialog box is terminated by the EndDialog function. If the user selects the "CANCEL" button on the dialog box, the IDM_CANCELGEOM case is executed and the dialog box is terminated without changing either of the spacing flags, the number of elements, or the run flag.

Functions for initializing and retrieving the data from the Coefficients, Tip Vortex Inset, and About dialog boxes are completely analagous to the functions described above. The functions are part of the VLL program in the vll.c file, and listings can be found in Appendix A.6.

APPENDIX A.5

The VLL Output functions.

A.5 The VLL Output functions.

The VLL program uses four separate functions to provide output. Two provide output to the monitor and two provide output to the system printer. Each pair consists of a function that draws the current variable data and a function that draws the graphs and table. The functions are described below.

A.5.1 The VLL paint_data_box function.

The VLL paint_data_box function receives a handle to the monitor device context and draws the current variable data to the screen. A device context can be thought of as a structure that contains information about the output device and how text, lines, or regions are drawn on the output device. Output to a particular device is accomplished by a series of GDI function calls. The best way to gain an understanding of the GDI and device contexts is to closely inspect the functions that perform the output for VLL. The paint_data_box function will be the first to be considered, and is shown below.

```
/*********************************************************************
* the paint_data_box function draws current variable data to the passed device context   *
*********************************************************************/
 void paint_data_box(HDC PaintDC)
 {
/*********************************************************************
* declare variables that are defined in the vll.c file and that  will be used in this function  *
*********************************************************************/
extern   int        controlpt_flag, spacing_flag, NUMBER_ELEMENTS;

extern   float      tip_vortex_inset, coefficients[], width, height;

/*********************************************************************
*  Variable declarations                                                                  *
*********************************************************************/

        char            buffer[120];                    //buffer for character output

        int             i,                                      //loop counter
                        length;                         //length of character output

        HFONT           hFont,                          //handle to the default font
                        hOldFont;                       //handle to the original font
```

```
//get a handle to the device default font

        hFont = GetStockFont(DEVICE_DEFAULT_FONT);

//select the device default font

        hOldFont = SelectFont(PaintDC, hFont);

//enclose the current variable data box in a pair of rectangles

        Rectangle(PaintDC,(int)(1.0*width/640.0),(int)(0.0*height/480.0),
                (int)(250.0*width/640.0),(int)(25.0*height/480.0));

        Rectangle(PaintDC,(int)(1.0*width/640.0),(int)(25.0*height/480.0),
                (int)(250.0*width/640.0),(int)(230.0*height/480.0));

//label the box

        length = sprintf(buffer, "CURRENT VARIABLE DATA");

                TextOut(PaintDC,(int)(39.0*width/640.0) ,
                                (int)(5.0*height/480.0),
                                buffer, length);

//write the variable data

        length = sprintf(buffer, "Number of Elements: %d",NUMBER_ELEMENTS);

                TextOut(PaintDC, (int)(10.0*width/640.0),
                                (int)(30.0*height/480.0),
                                buffer, length);

//write the tip vortex inset if applicable

        if(spacing_flag) {

                length = sprintf(buffer, "Tip vortex inset/ ");

                        TextOut(PaintDC, (int)(10.0*width/640.0),
                                        (int)(90.0*height/480.0),
                                        buffer, length);

                length = sprintf(buffer, "  panel width: %5.4f",
                                tip_vortex_inset);

                        TextOut(PaintDC, (int)(10.0*width/640.0),
                                        (int)(110.0*height/480.0),
                                        buffer, length);

                length = sprintf(buffer,"Vortex Spacing:  Constant");

                        }
        else
                length = sprintf(buffer, "Vortex Spacing:  Cosine");
```

```
                        TextOut(PaintDC, (int)(10.0*width/640.0),
                                        (int)(50.0*height/480.0),
                                        buffer, length);

//write the control point spacing selection

        if(controlpt_flag)
                length = sprintf(buffer, "Cont Pt Spacing:  Midpoint");
        else
                length = sprintf(buffer, "Cont Pt Spacing:  Cosine");

                        TextOut(PaintDC, (int)(10.0*width/640.0),
                                        (int)(70.0*height/480.0),
                                        buffer, length);

//write out the Glauert coefficients

        for(i=0;i<5;i++){

                length=sprintf(buffer,"Coefficient a%d:  %+5.2f",i+1,
                            coefficients[i]);

                        TextOut(PaintDC,(int)(10.0*width/640.0),
                                       (int)((float)(130+i*20)*height/480.0),
                                       buffer,length);

                        }

//select the original font and delete the one created for this function

        SelectFont(PaintDC,hOldFont);

     DeleteObject(hFont);
}
```

After the function is declared, a declaration of the global variables that will be used in the paint_data_box function is made. The extern keyword tells the compiler that the original declarations of the variables that follow it are made in a separate source code file.

Five new variables are declared locally to the paint_data_box function. The character array, buffer, is used to store the text strings that will be written to the screen. The integer i is a loop counter and the integer length is used to indicate the length of the string written into buffer. The last two variables declared are HFONT variables. An

HFONT is a handle to a font that is used to draw the text output. In this case two are defined, a handle to the device default font, and a handle to the font originally specified upon creation of the device context.

The paint_data_box function uses the GetStockFont function to get a handle to the monitor device default font, the font preferred by the monitor. The GetStockFont function receives an unsigned integer and returns a handle to the specified font. The device default font is then selected into the device context using the SelectFont function. The SelectFont function receives the handle to the device context and the handle of a font, selects the font into the specified device context and returns a handle to the font that was replaced. The handle to the font originally in the device context is retained in hOldFont so that it may be selected back into the device context at the end of the function and hFont may be deleted. This is done to free the memory allocated to the font referred to by hFont.

Next the rectangles that enclose the current variable data are drawn using the Rectangle function.

```
Rectangle(PaintDC,(int)(1.0*width/640.0),(int)(0.0*height/480.0),
        (int)(250.0*width/640.0),(int)(25.0*height/480.0));
```

The Rectangle function receives the handle to the device context and the Cartesian coordinates of the upper left and lower right corners of the rectangle to be drawn. The coordinate system used on the screen is determined by the mapping mode of the device context. The default mapping mode is MM_TEXT. This means there is a one to one correspondence between logical units and pixels, and that the upper left corner of the client window is (0,0) with the positive x axis to the right and the positive y axis down the screen.

In order to provide for device independent output to monitors of different horizontal and vertical resolution, the logical coordinates are scaled by a factor of

width/640.0 or height/480.0 as appropriate. The result is then cast as an integer. The GDI recognizes integral coordinates since the finest resolution possible is one pixel.

After the rectangles are drawn, the data box is labeled.

```
length = sprintf(buffer, "CURRENT VARIABLE DATA");

        TextOut(PaintDC,(int)(39.0*width/640.0),
                        (int)(5.0*height/480.0),
                        buffer, length);
```

The sprintf function writes formatted character output to a character array and returns the number of bytes written, minus the null terminating character. The TextOut function is the most basic of the text drawing functions. It receives the handle to the device context where the text is to be drawn, an integral client area coordinate where the text is to be drawn, a pointer to the string to be drawn, and the length of the string to be drawn, in bytes.

The sprintf function is used in further, slightly more complicated statements, to write output strings that include variable data to the character array. In the statement shown here the current integer value of NUMBER_ELEMENTS is included in the output string. This is accomplished by using the %d format specifier to indicate where in the string the integer value will be printed, and then including the variable name in the list of output variables in the the sprinf statement.

```
length = sprintf(buffer, "Number of Elements: %d",NUMBER_ELEMENTS);
```

The paint_data_box function continues to test the vortex and control point spacing flags and provide appropriate output. A for loop is used to print each of the Glauert coefficients. The format specifier, %+5.4f, is used in the statement that writes Glauert coefficients to the buffer array. This indicates that a floating point number will be written, showing four decimal places, and including the sign even if it is positive.

```
        length=sprintf(buffer,"Coefficient a%d:  %+5.2f",i+1,
```

```
                    coefficients[i]);

            TextOut(PaintDC,(int)(10.0*width/640.0),
                        (int)((float)(130+i*20)*height/480.0),
                        buffer,length);
```

The y coordinate in the TextOut function in this case is calculated using the index of the coefficient.

The last two statements in this function use the SelectFont function to select the original font back into the device context and the DeleteObject function to free the memory associated with the font used to draw the text output. Since it is not permissible to delete a font, or any other object currently selected into the device context, the original font must first be restored. The memory is freed since if it were not, the memory would be effectively consumed and would not be released until termination of the current Windows™ session.

A.5.2 The VLL paint_graphs function.

The second function used by VLL to draw output to the screen is the paint_graphs function. It is shown below.

```
/*********************************************************************
* the paint_graphs function draws the graphs and percent error data          *
* on the passed device context                                               *
*********************************************************************/
void paint_graphs(HDC PaintDC)
{
/*********************************************************************
* declare variables that are defined in the vll.c file and that will be used in this function  *
*********************************************************************/

extern  float    width, height;

/*********************************************************************
*  Variable declarations                                                      *
*********************************************************************/

        HFONT         hFont,                          //handle to the default font
                      hSmallFont,                     //handle to a small font
```

```
            hFontVert,              //handle to a vertically
                                    // oriented font
            hOldFont;               //handle for default font

LOGFONT     lFont;                  //logical font structure for
                                    //   creating the fonts

HPEN        hPen[2],                //pens for drawing the data pts
            hThickPen,              //pen for drawing axes
            hOldPen;                //handle for default pen

HBRUSH      hBrush[2],              //brushes for drawing the data
                                    //   points
            hWhiteBrush,            //white brush
            hOldBrush;              //handle for old brush

char        buffer[120];            //buffer for character output

int         i,                      //loop counter
            length,                 //length of character output
            NUM_ELEMENTS;           //number of elements
                                    // (discretization)

float       m,                      //power of ten used in finding
                                    // max value of w or circ

            pzw,                    //percent error in lift, drag,
            pxw,                    // and lift/drag*drag given w
            prw,                    // and given circ
            pzg,
            pxg,
            prg,

            max_w=0,                //maximum and minimum values
            min_w=0,                // for w and circ for scaling plots
            max_circ=0,
            min_circ=0;

float       * w_ex,                 //pointers to arrays of floats
            * w_num,                // for storing plot data
            * circ,
            * y_cont,
            * gam ;

FILE        *plot;                  //pointer to a file structure

POINT       point,                  //point structure used for
                                    //   plotting data points
            origin,                 //origin of the current plot
            orig[2]={{460,100},     //origins of the velocity and
                     {460,320}};    // and circulation plots
```

```
//allocate memory for the vectors

        w_ex  = (float *) malloc((MAX_NUMBER_ELEMENTS+1)*sizeof (float));
        w_num = (float *) malloc((MAX_NUMBER_ELEMENTS+1)*sizeof (float));
        circ  = (float *) malloc((MAX_NUMBER_ELEMENTS+1)*sizeof (float));
        y_cont = (float *) malloc((MAX_NUMBER_ELEMENTS+1)*sizeof (float));
        gam   = (float *) malloc((MAX_NUMBER_ELEMENTS+1)*sizeof (float));

//create red and blue pens and brushes to draw the graphs

        hBrush[0] = CreateSolidBrush (RGB(255,0,0));
        hPen[0] = CreatePen (PS_SOLID, 1, RGB(255,0,0));

        hBrush[1] = CreateSolidBrush (RGB(0,0,255));
        hPen[1] = CreatePen (PS_SOLID, 1, RGB(0,0,255));

        hThickPen = CreatePen(PS_SOLID, 3, RGB(0,0,0));
        hWhiteBrush = GetStockObject(WHITE_BRUSH);

//use the device default font to fill a logical font structure

        GetObject(GetStockFont(DEVICE_DEFAULT_FONT),sizeof(LOGFONT),&lFont);

//get a handle to the device default font

        hFont = CreateFontIndirect(&lFont);

//alter the font size and create a small font for the axis labels

                lFont.lfHeight = 10;

        hSmallFont = CreateFontIndirect(&lFont);

//alter the font size and orientation and create a vertically oriented font

                lFont.lfEscapement = 900;
                lFont.lfHeight = 14;

        hFontVert = CreateFontIndirect(&lFont);

// set the background mode to transparent so the text doesn't overwrite data

        SetBkMode(PaintDC, TRANSPARENT);

//open and read the temporary data file

        plot = fopen("plotdat.tmp", "r");

//read the number of elements

        fscanf(plot,"%d",&NUM_ELEMENTS);

//read in the spanwise position of the control points, the exact circulation
// and downwash velocity, and the numerical downwash velocity and circulation
```

```
for (i=1;i<=NUM_ELEMENTS;i++)

        fscanf(plot,"%f %f %f %f %f", &y_cont[i], &gam[i], &w_ex[i],
               &w_num[i], &circ[i]);

//read in the percent error values

    fscanf(plot,"%f %f %f %f %f %f",&pzw,&pxw,&prw,&pzg,&pxg,&prg);

//close the plot file

    fclose (plot);

//Calculate the minimum and maximum values for w and circ

    for(i=1;i<=NUM_ELEMENTS;i++)  {

        max_circ = max(gam[i],max(max_circ,circ[i]));
        min_circ = min(gam[i],min(min_circ,circ[i]));

        max_w    = max(w_num[i],max(max_w,w_ex[i]));
        min_w    = min(w_num[i],min(min_w,w_ex[i]));

                                }

//ensure that max_circ and max_w are equal to the largest magnitude
// circulation and velocity

    max_circ = max(fabs(ceil(max_circ)),fabs(floor(min_circ)));
    max_w = max(fabs(ceil(max_w)),fabs(floor(min_w)));

//initialize m and multiply it by 10 until m*10 is greater than max_circ,
// then increase m by factors of 2 until m is greater than max_circ by no
// more than a factor of 2

    m= 0.001;

    while (m*10.0 < max_circ)        m = m * 10.0;

    while (m < max_circ)             m = m * 2.0;

//set max_circ equal to m so the plot will be properly scaled

    max_circ = m;

    m= 0.001;

    while (m*10.0 < max_w)           m = m * 10.0;

    while (m < max_w)                m = m * 2.0;

    max_w = m;
```

```
//set the min values equal to the negative of the max values

        min_circ = -max_circ;

        min_w = -max_w;


//Draw and label graphs

//set the origin for the downwash plot

        origin.x = orig[downwash].x;
        origin.y = orig[downwash].y;

//draw a box for the graph and use a box for the axes

        Rectangle(PaintDC,(int)((origin.x-190)*width/640.0),
                          (int)((origin.y-100)*height/480.0),
                          (int)((origin.x+170)*width/640.0),
                          (int)((origin.y+110)*height/480.0));

        Rectangle(PaintDC,(int)((origin.x-130)*width/640.0),
                          (int)((origin.y-75)*height/480.0),
                          (int)((origin.x+131)*width/640.0),
                          (int)((origin.y+76)*height/480.0));

// select a thick pen and draw the axes

        hOldPen = SelectPen(PaintDC,hThickPen);

        MoveTo(PaintDC,(int)((origin.x-130)*width/640.0),
                   (int)(origin.y*height/480.0));

        LineTo(PaintDC,(int)((origin.x+130)*width/640.0),
                   (int)(origin.y*height/480.0));

        MoveTo(PaintDC,(int)(origin.x*width/640.0),
                   (int)((origin.y-75)*height/480.0));

        LineTo(PaintDC,(int)(origin.x*width/640.0),
                   (int)((origin.y+75)*height/480.0));

//plot the numerical solution for downwash velocity

//select the red pen and brush

        SelectPen(PaintDC,hPen[0]);

        hOldBrush = SelectObject(PaintDC,hBrush[0]);

//loop through all of the control points

        for(i=1;i<=NUM_ELEMENTS;i++) {
```

```
//calculate the x and y coordinates corresponding to each point

        point.x=(int)(((((y_cont[i]/0.5)*130.0)+origin.x)*width)/640.0);
        point.y=(int)(((((-w_num[i]/max_w)*75.0)+origin.y)*height)/480.0);

//draw a rectangle for the numerical points

        Rectangle(PaintDC,point.x-3,point.y-3,point.x+3,point.y+3);

                                    }

//print sample rectangle (numerical point)

        point.x = 125*width/640.0;
        point.y = 290*height/480.0;

        Rectangle(PaintDC,point.x-3,point.y-3,point.x+3,point.y+3);

//select the blue pen and brush

        SelectPen(PaintDC,hPen[1]);

        SelectObject(PaintDC,hBrush[1]);

//Plot the exact solution for downwash velocity

//loop through all of the control points

        for(i=1;i<=NUM_ELEMENTS;i++) {

//calculate the x and y coordinates corresponding to each point

        point.x=(int)(((((y_cont[i]/0.5)*130.0)+origin.x)*width)/640.0);
        point.y=(int)(((((-w_ex[i]/max_w)*75.0)+origin.y)*height)/480.0);

//draw an ellipse for the exact points

        Ellipse(PaintDC,point.x-2,point.y-2,point.x+2,point.y+2);

                                    }

// print sample Ellipse (exact point)

        point.x = 125*width/640.0;
        point.y = 270*height/480.0;

        Ellipse(PaintDC,point.x-2,point.y-2,point.x+2,point.y+2);


//select the solid, thin, black pen, the white brush, and the small font

        SelectPen(PaintDC,hOldPen);

        SelectObject(PaintDC, hWhiteBrush);
```

```
        hOldFont = SelectFont(PaintDC,hSmallFont);

//align the text output to right adjusted and label the y axis

        SetTextAlign(PaintDC,TA_RIGHT);


//draw the horizontal lines for the graph

        for(i=-5;i<6;i++) {

                MoveTo(PaintDC,(int)((origin.x-132)*width/640.0),
                        (int)((origin.y-i*15)*height/480.0));

                LineTo(PaintDC,(int)((origin.x+130)*width/640.0),
                        (int)((origin.y-i*15)*height/480.0));


//label each horizontal line, the number of decimals displayed depending
// on the magnitude of the maximum value


        if(max_w < 10.0) {

                length = sprintf(buffer, "%4.2f",(max_w/5.0) * i);

                        TextOut(PaintDC,(int)((origin.x-140)*width/640.0),
                                (int)((origin.y-i*15-3)*height/480.0),
                                buffer, length);
                        }

        else {

                length = sprintf(buffer, "%4.1f",(max_w/5.0) * i);


                        TextOut(PaintDC,(int)((origin.x-140)*width/640.0),
                                (int)((origin.y-i*15-3)*height/480.0),
                                buffer, length);

                }

                        }

//restore the text alignment to left adjusted and label the x axis

        SetTextAlign(PaintDC,TA_LEFT);

        for(i=-5;i<6;i++) {

                MoveTo(PaintDC,(int)((origin.x+i*26)*width/640.0),
                        (int)(((origin.y+77)*height/480.0)));
```

```
                LineTo(PaintDC,(int)((origin.x+i*26)*width/640.0),
                        (int)(((origin.y-75)*height/480.0)));

                length = sprintf(buffer, "%2.1f",0.1*i);

                        TextOut(PaintDC,(int)((origin.x-8+i*26)*width/640.0),
                                (int)((origin.y+80)*height/480.0),
                                buffer, length);
                    }

//repeat the process for the circulation graph

        origin.x = orig[circu].x;
        origin.y = orig[circu].y;

        Rectangle(PaintDC,(int)((origin.x-190)*width/640.0),
                  (int)((origin.y-100)*height/480.0),
                  (int)((origin.x+170)*width/640.0),
                  (int)((origin.y+110)*height/480.0));

        Rectangle(PaintDC,(int)((origin.x-130)*width/640.0),
                  (int)((origin.y-75)*height/480.0),
                  (int)((origin.x+131)*width/640.0),
                  (int)((origin.y+76)*height/480.0));

        SelectPen(PaintDC,hThickPen);

        MoveTo(PaintDC,(int)((origin.x-130)*width/640.0),
               (int)(origin.y*height/480.0));

        LineTo(PaintDC,(int)((origin.x+130)*width/640.0),
               (int)(origin.y*height/480.0));

        MoveTo(PaintDC,(int)(origin.x*width/640.0),
               (int)((origin.y-75)*height/480.0));

    LineTo(PaintDC,(int)(origin.x*width/640.0),
               (int)((origin.y+75)*height/480.0));


        SelectPen(PaintDC,hPen[0]);

        SelectObject(PaintDC,hBrush[0]);

        for(i=1;i<=NUM_ELEMENTS;i++) {

        point.x=(int)(((((y_cont[i]/0.5)*130.0)+origin.x)*width)/640.0);
        point.y=(int)(((((-gam[i]/max_circ)*75.0)+origin.y)*height)/480.0);

        Rectangle(PaintDC,point.x-3,point.y-3,point.x+3,point.y+3);

                            }

        SelectPen(PaintDC,hPen[1]);
```

```
SelectObject(PaintDC,hBrush[1]);

for(i=1;i<=NUM_ELEMENTS;i++) {

point.x=(int)(((((y_cont[i]/0.5)*130.0)+origin.x)*width)/640.0);
point.y=(int)(((((-circ[i]/max_circ)*75.0)+origin.y)*height)/480.0);

Ellipse(PaintDC,point.x-2,point.y-2,point.x+2,point.y+2);

                                }

SelectPen(PaintDC,hOldPen);

SelectObject(PaintDC, hWhiteBrush);

SetTextAlign(PaintDC,TA_RIGHT);

for(i=-5;i<6;i++) {

        MoveTo(PaintDC,(int)((origin.x-132)*width/640.0),
                (int)((origin.y-i*15)*height/480.0));

        LineTo(PaintDC,(int)((origin.x+130)*width/640.0),
                (int)((origin.y-i*15)*height/480.0));

        if(max_w < 10.0) {

        length = sprintf(buffer, "%4.2f",(max_circ/5.0) * i);

                TextOut(PaintDC,(int)((origin.x-140)*width/640.0),
                                (int)((origin.y-i*15-3)*height/480.0),
                                buffer, length);

                        }

        else {

        length = sprintf(buffer, "%4.1f",(max_circ/5.0) * i);

                TextOut(PaintDC,(int)((origin.x-140)*width/640.0),
                                (int)((origin.y-i*15-3)*height/480.0),
                                buffer, length);

            }

                    }

SetTextAlign(PaintDC,TA_LEFT);

for(i=-5;i<6;i++) {

        MoveTo(PaintDC,(int)((origin.x+i*26)*width/640.0),
                (int)(((origin.y+77)*height/480.0)));
```

```
                LineTo(PaintDC,(int)((origin.x+i*26)*width/640.0),
                        (int)(((origin.y-75)*height/480.0)));

                length = sprintf(buffer, "%2.1f",0.1*i);

                        TextOut(PaintDC,(int)((origin.x-8+i*26)*width/640.0),
                                (int)((origin.y+80)*height/480.0),
                                buffer, length);

                    }

//select the vertical font and label the y axes

        SelectFont(PaintDC,hFontVert);

        length = sprintf(buffer, "W/U");

                TextOut(PaintDC, (int)(275.0*width/640.0),
                        (int)(120.0*height/480.0),
                        buffer, length);

        length = sprintf(buffer, "NON-DIM CIRC");

        TextOut(PaintDC, (int)(275.0*width/640.0),
                (int)(350.0*height/480.0),
                buffer, length);

//select the device default font back into the device context, label the
// x axes and the sample ellipse and rectangle

        SelectFont(PaintDC,hFont);

        length = sprintf(buffer, "SPANWISE POSITION Y/S");

                TextOut(PaintDC, (int)(370.0*width/640.0),
                        (int)(190.0*height/480.0),
                        buffer, length);

                TextOut(PaintDC, (int)(370.0*width/640.0),
                        (int)(410.0*height/480.0),
                        buffer, length);

        length = sprintf(buffer, "Exact:");

                TextOut(PaintDC, (int)(55.0*width/640.0),
                        (int)(260.0*height/480.0),
                        buffer, length);

        length = sprintf(buffer, "Approx:");

                TextOut(PaintDC, (int)(55.0*width/640.0),
                        (int)(280.0*height/480.0),
                        buffer, length);
```

```
//draw the percent error box and fill in the values

        Rectangle(PaintDC,(int)(1.0*width/640.0),(int)(300.0*height/480.0),
                          (int)(230.0*width/640.0),(int)(340.0*height/480.0));

        Rectangle(PaintDC,(int)(1.0*width/640.0),(int)(340.0*height/480.0),
                          (int)(230.0*width/640.0),(int)(360.0*height/480.0));

        length = sprintf(buffer, "Error in Predictions");

                TextOut(PaintDC, (int)(28.0*width/640.0),
                                 (int)(305.0*height/480.0),
                                 buffer, length);

        length = sprintf(buffer, "for Fz, Fx, Fx/(Fz)**2");

                TextOut(PaintDC, (int)(25.0*width/640.0),
                                 (int)(320.0*height/480.0),
                                 buffer, length);

        length = sprintf(buffer, "Given Gamma(y)");

                TextOut(PaintDC, (int)(54.0*width/640.0),
                                 (int)(342.0*height/480.0),
                                 buffer, length);

        Rectangle(PaintDC,(int)(1.0*width/640.0),(int)(360.0*height/480.0),
                          (int)(77.0*width/640.0),(int)(380.0*height/480.0));

        Rectangle(PaintDC,(int)(78.0*width/640.0),(int)(360.0*height/480.0),
                          (int)(153.0*width/640.0),(int)(380.0*height/480.0));

        Rectangle(PaintDC,(int)(154.0*width/640.0),(int)(360.0*height/480.0),
                          (int)(230.0*width/640.0),(int)(380.0*height/480.0));

        Rectangle(PaintDC,(int)(1.0*width/640.0),(int)(380.0*height/480.0),
                          (int)(230.0*width/640.0),(int)(400.0*height/480.0));

        Rectangle(PaintDC,(int)(1.0*width/640.0),(int)(400.0*height/480.0),
                          (int)(77.0*width/640.0),(int)(420.0*height/480.0));

        Rectangle(PaintDC,(int)(78.0*width/640.0),(int)(400.0*height/480.0),
                          (int)(153.0*width/640.0),(int)(420.0*height/480.0));

        Rectangle(PaintDC,(int)(154.0*width/640.0),(int)(400.0*height/480.0),
                          (int)(230.0*width/640.0),(int)(420.0*height/480.0));

        length = sprintf(buffer, "Given w*(y)");

                TextOut(PaintDC, (int)(70.0*width/640.0),
                                 (int)(382.0*height/480.0),
                                 buffer, length);
```

```
length = sprintf(buffer, "%3.1f%",pzg);

        TextOut(PaintDC, (int)(25.0*width/640.0),
                         (int)(402.0*height/480.0),
                         buffer, length);

length = sprintf(buffer, "%3.1f%",pxg);

        TextOut(PaintDC, (int)(102.0*width/640.0),
                         (int)(402.0*height/480.0),
                         buffer, length);

length = sprintf(buffer, "%3.1f%",prg);

        TextOut(PaintDC, (int)(178.0*width/640.0),
                         (int)(402.0*height/480.0),
                         buffer, length);

length = sprintf(buffer, "%3.1f%",pzw);

        TextOut(PaintDC, (int)(25.0*width/640.0),
                         (int)(362.0*height/480.0),
                         buffer, length);

length = sprintf(buffer, "%3.1f%",pxw);

        TextOut(PaintDC, (int)(102.0*width/640.0),
                         (int)(362.0*height/480.0),
                         buffer, length);

length = sprintf(buffer, "%3.1f%",prw);

        TextOut(PaintDC, (int)(178.0*width/640.0),
                         (int)(362.0*height/480.0),
                         buffer, length);


//select the original font, pen, and brush

    SelectObject(PaintDC, hOldBrush);
    SelectObject(PaintDC, hOldPen);
    SelectFont(PaintDC, hOldFont);

//delete the objects created for this function

    DeleteObject(hPen[0]);
    DeleteObject(hPen[1]);
    DeleteObject(hThickPen);

    DeleteObject(hBrush[0]);
    DeleteObject(hBrush[1]);
    DeleteObject(hWhiteBrush);

    DeleteObject(hFont);
```

```
        DeleteObject(hSmallFont);
        DeleteObject(hFontVert);

//free the allocated memory

        free( w_ex  );
        free( w_sum );
        free( circ  );
        free( y_cont);
        free( gam   );

}
```

As in the paint_data_box, a declaration of the global variables that will be used in the function is made after the function declaration . Several new variables are also declared locally to the function. Instead of describing them at this point, they will be explained along with the main body of the function.

This function uses the malloc function at run time to allocate memory for the data to be plotted. Its usage is illustrated below. The malloc function receives the number of bytes of memory heap to allocate and returns a pointer the allocated memory. In this case the pointer is then cast as a pointer to an array of floats and assigned to w_ex.

```
        w_ex  = (float *) malloc((MAX_NUMBER_ELEMENTS+1)*sizeof (float));
```

This is repeated for all of the dynamically allocated variables in the paint_graphs function.

A pair of brushes and pens are then created. The hBrush variable is an array of two brushes, a red brush and a blue brush. The brush selected in a device context controls how shapes such as rectangles and ellipses will be drawn. Specifically, the brush controls how the internal region will be drawn. The pen selected in a device context controls how lines or the borders of shapes such as rectangles and ellipses will be drawn. The paint_graphs function uses the CreateSolidBrush function to create the red and blue brushes. The function receives a color reference returned by the RGB macro and returns a handle to the new brush. The RGB macro receives an intensity between 0 and 255 for the red, green, and blue components and returns a color reference based on the specified

intensities and the capabilities of the output device. A solid white brush is also created, but instead of the CreateSolidBrush function, the GetStockObject function is used. The GDI has several predefined objects, including a white brush. The GetStockObject function receives an integer identifier and returns a handle to the stock object.

The CreatePen function is used to create the red and blue pens and a thick black pen. The function receives a line style, in this case solid, a line thickness in pixels, and a color reference. It returns a handle to the new pen.

The function then creates fonts that will be used to draw text output. The first step is to fill a logical font structure, lFont, using the attributes of the device default font. This is done by using the GetObject function. The GetObject function receives a handle to an object, the size of a buffer to receive data describing the object, and the address of the buffer. In this case the handle is the return value of the GetStockFont function, the address of the buffer is the address of the logical font structure, and the size of the buffer is the size of a LOGFONT structure. The LOGFONT structure is defined as follows:

```
typedef struct tagLOGFONT {     /* lf */
   int           lfHeight;
   int           lfWidth;
   int           lfEscapement;
   int           lfOrientation;
   int           lfWeight;
   BYTE          lfItalic;
   BYTE          lfUnderline;
   BYTE          lfStrikeOut;
   BYTE          lfCharSet;
   BYTE          lfOutPrecision;
   BYTE          lfClipPrecision;
   BYTE          lfQuality;
   BYTE          lfPitchAndFamily;
   BYTE          lfFaceName[LF_FACESIZE];
} LOGFONT;
```

The address of the logical font structure is then passed to the CreateFontIndirect function which creates a font with the attributes described in the structure and returns a handle to the new font. The attributes in the logical font structure are then modified and a small

font, hSmallFont, and a vertically oriented font, hFontVert are created. The lfHeight parameter of the LOGFONT structure specifies the cell height of the font in logical units. The lfEscapement parameter specifies the orientation of the text in tenths of a degree counterclockwise from the positive x axis.

VLL now sets the background mode for the device context using the SetBkMode function. The SetBkMode function can set the background mode to OPAQUE, which is the default, or TRANSPARENT. The OPAQUE mode causes the screen area under text that is printed to first be repainted with the background color. The TRANSPARENT mode causes the text to be printed directly over the pre-existing background.

```
SetBkMode(PaintDC, TRANSPARENT);
```

The paint_graphs function then reads the data to be plotted from a temporary plot file, plotdat.tmp, that was created at run time for the current data set. The file is opened using the fopen function. The fopen function receives a character constant file name string and a character constant mode, in this case "r" for read only, and returns a pointer to a stream. In this instance the value of the pointer is assigned to plot, a pointer to a file structure. A file structure is defined as follows:

```
typedef struct{
 short          level;
 unsigned       flags;
 char           fd;
 unsigned char  hold;
 short          bsize;
 unsigned char  *buffer, *curp;
 unsigned       istemp;
 short          token;
} FILE;
```

The paint_graphs function then uses the fscanf function to read the number of data points to be plotted, the values of spanwise control point position, circulation, and downwash velocity, both exact and numerical values, and the percent error values. The data file is

then closed using the fclose function, which receives a pointer to a file stream and returns 0 if successful and EOF if not successful. EOF is a constant that indicates that the end of a file has been reached.

```
//open and read the temporary data file

        plot = fopen("plotdat.tmp", "r");

//read the number of elements

        fscanf(plot,"%d",&NUM_ELEMENTS);

//read in the spanwise position of the control points, the exact circulation
// and downwash velocity, and the numerical downwash velocity and circulation

        for (i=1;i<=NUM_ELEMENTS;i++)

                fscanf(plot,"%f %f %f %f %f", &y_cont[i], &gam[i], &w_ex[i],
                        &w_num[i], &circ[i]);

//read in the percent error values

        fscanf(plot,"%f %f %f %f %f %f",&pzw,&pxw,&prw,&pzg,&pxg,&prg);

//close the plot file

        fclose (plot);
```

The paint_graphs function proceeds by finding the maximum and minimum values of circulation and downwash velocity that will be plotted. This is done by looping through all of the data and using nested max or min statements. For illustration purposes, the max_circ case is described.

The max macro compares two values of the same type and returns the larger of the two values. In the statement shown here, max_circ is compared with the numerical circulation value, circ[i], and the returned value is compared with the exact circulation value, gam[i]. The value returned from this comparison is assigned to the max_circ variable. This process is repeated over the range of control points so that the final value of max_circ is the largest circulation value that will be plotted.

```
//Calculate the minimum and maximum values for w and circ

        for(i=1;i<=NUM_ELEMENTS;i++) {

                max_circ = max(gam[i],max(max_circ,circ[i]));
                min_circ = min(gam[i],min(min_circ,circ[i]));

                max_w   = max(w_num[i],max(max_w,w_ex[i]));
                min_w   = min(w_num[i],min(min_w,w_ex[i]));

                                }
```

The values of max_circ and max_w are then adjusted to integral values just greater than or equal to the larger of the magnitudes of max and min values to be plotted. This is done using the floor and ceil functions, for the purpose of provide an integral range on the ordinates of the plots. The floor function returns the largest integer that is not greater than the argument and the ceiling function returns the smallest integer not less than the argument.

```
//ensure that max_circ and max_w are equal to the largest magnitude
// circulation and velocity

        max_circ = max(fabs(ceil(max_circ)),fabs(floor(min_circ)));
        max_w = max(fabs(ceil(max_w)),fabs(floor(min_w)));
```

The next ten lines of executable code adjust the maximum and minimum values to the y axes of the plots so that the x axis is in the middle of the plot and the vertical extent of the plotted data covers at least half of the vertical scale in either the positive or negative direction. This is done to give the plotted data a reasonable scale with respect to the plot area.

```
//initialize m and multiply it by 10 until m*10 is greater than max_circ,
// then increase m by factors of 2 until m is greater than max_circ by no
// more than a factor of 2

        m= 0.001;

        while (m*10.0 < max_circ)          m = m * 10.0;

        while (m < max_circ)               m = m * 2.0;

//set max_circ equal to m so the plot will be properly scaled
```

```
        max_circ = m;

        m= 0.001;

        while (m*10.0 < max_w)            m = m * 10.0;

        while (m < max_w)                 m = m * 2.0;

        max_w = m;

//set the min values equal to the negative of the max values

        min_circ = -max_circ;

        min_w = -max_w;
```

The origin is then set to the origin of the downwash velocity plot and the box outlines of the graph and the plot region are drawn using the Rectangle function.

```
//set the origin for the downwash plot

        origin.x = orig[downwash].x;
        origin.y = orig[downwash].y;

//draw a box for the graph and use a box for the axes

        Rectangle(PaintDC,(int)((origin.x-190)*width/640.0),
                        (int)((origin.y-100)*height/480.0),
                        (int)((origin.x+170)*width/640.0),
                        (int)((origin.y+110)*height/480.0));

        Rectangle(PaintDC,(int)((origin.x-130)*width/640.0),
                        (int)((origin.y-75)*height/480.0),
                        (int)((origin.x+131)*width/640.0),
                        (int)((origin.y+76)*height/480.0));
```

The x and y axes are then drawn using the thick pen. The MoveTo and LineTo functions are used for this purpose. The MoveTo function receives a handle to the device context and a Cartesian screen coordinate and moves the current position to the coordinate. The LineTo function also receives a handle to the device context and a Cartesian screen coordinate. The LineTo function causes a line to be drawn to the device context from the current position to the specified coordinate, using the pen selected in the device context.

```
// select a thick pen and draw the axes

        hOldPen = SelectPen(PaintDC,hThickPen);

        MoveTo(PaintDC,(int)((origin.x-130)*width/640.0),
                (int)(origin.y*height/480.0));

        LineTo(PaintDC,(int)((origin.x+130)*width/640.0),
                (int)(origin.y*height/480.0));

        MoveTo(PaintDC,(int)(origin.x*width/640.0),
                (int)((origin.y-75)*height/480.0));

        LineTo(PaintDC,(int)(origin.x*width/640.0),
                (int)((origin.y+75)*height/480.0));
```

The numerical solution for downwash velocity is then plotted using the red pen and brush. A for loop is used to index through each point and calculate the associated screen coordinate and draw a red rectangle centered at the screen coordinate.

```
        SelectPen(PaintDC,hPen[0]);

        hOldBrush = SelectObject(PaintDC,hBrush[0]);

//loop through all of the control points

        for(i=1;i<=NUM_ELEMENTS;i++) {

//calculate the x and y coordinates corresponding to each point

        point.x=(int)(((((y_cont[i]/0.5)*130.0)+origin.x)*width)/640.0);
        point.y=(int)(((((-w_num[i]/max_w)*75.0)+origin.y)*height)/480.0);

//draw a rectangle for the numerical points

        Rectangle(PaintDC,point.x-3,point.y-3,point.x+3,point.y+3);

                        }
```

A sample rectangle is then printed. It will be used as part of the plot legend.

```
//print sample rectangle (numerical point)

        point.x = 125*width/640.0;
        point.y = 290*height/480.0;

        Rectangle(PaintDC,point.x-3,point.y-3,point.x+3,point.y+3);
```

The process is repeated for the exact solution for downwash velocity, using blue circles instead of red rectangles. The code is shown above and is not repeated here.

The thin black pen, small font, and white brush are then selected into the device context for the purpose of labeling the graph and filling in the horizontal and vertical lines on the graph. The text alignment is set to right adjusted using the SetTextAlign function prior to printing . The SetTextAlign function receives a handle to the device context and a text alignment flag. The text alignment flag can be any of the following:

TA_CENTER	horizontally centered
TA_LEFT	aligned to the left
TA_RIGHT	aligned to the right

```
//select the solid, thin, black pen, the white brush, and the small font
        SelectPen(PaintDC,hOldPen);
        SelectObject(PaintDC, hWhiteBrush);
        hOldFont = SelectFont(PaintDC,hSmallFont);
//align the text output to right adjusted and label the y axis
        SetTextAlign(PaintDC,TA_RIGHT);
```

A for loop containing MoveTo, LineTo, sprintf, and TextOut function calls is then used to draw the horizontal lines and label the y axis. The number of decimal places drawn in the y axis labels is selected as one or two depending on the range of the graph.

```
//draw the horizontal lines for the graph
        for(i=-5;i<6;i++) {
                MoveTo(PaintDC,(int)((origin.x-132)*width/640.0),
                        (int)((origin.y-i*15)*height/480.0));
                LineTo(PaintDC,(int)((origin.x+130)*width/640.0),
                        (int)((origin.y-i*15)*height/480.0));
```

```
//label each horizontal line, the number of decimals displayed depending
// on the magnitude of the maximum value

        if(max_w < 10.0) {

                length = sprintf(buffer, "%4.2f",(max_w/5.0) * i);

                        TextOut(PaintDC,(int)((origin.x-140)*width/640.0),
                                (int)((origin.y-i*15-3)*height/480.0),
                                buffer, length);
                        }

        else {

                length = sprintf(buffer, "%4.1f",(max_w/5.0) * i);


                        TextOut(PaintDC,(int)((origin.x-140)*width/640.0),
                                (int)((origin.y-i*15-3)*height/480.0),
                                buffer, length);

                }

                        }
```

After restoring the text alignment to TA_LEFT, the default value, another for loop containing MoveTo, LineTo, sprintf, and TextOut function calls is used to draw the vertical lines and label the x axis.

```
//restore the text alignment to left adjusted and label the x axis

        SetTextAlign(PaintDC,TA_LEFT);

        for(i=-5;i<6;i++) {

                MoveTo(PaintDC,(int)((origin.x+i*26)*width/640.0),
                        (int)(((origin.y+77)*height/480.0)));

                LineTo(PaintDC,(int)((origin.x+i*26)*width/640.0),
                        (int)(((origin.y-75)*height/480.0)));

                length = sprintf(buffer, "%2.1f",0.1*i);

                        TextOut(PaintDC,(int)((origin.x-8+i*26)*width/640.0),
                                (int)((origin.y+80)*height/480.0),
                                buffer, length);
```

```
}
```

The origin is then reset to the circulation graph origin and the entire process, except for drawing the sample rectangle and ellipse, is repeated for the circulation graph. The code is shown above and is not repeated here. The vertical and device default fonts are then used in conjuction with sprintf and TextOut calls to label the graphs and the plot legend.

```
//select the vertical font and label the y axes

        SelectFont(PaintDC,hFontVert);

        length = sprintf(buffer, "W/U");

                TextOut(PaintDC, (int)(275.0*width/640.0),
                                (int)(120.0*height/480.0),
                                buffer, length);

        length = sprintf(buffer, "NON-DIM CIRC");

        TextOut(PaintDC, (int)(275.0*width/640.0),
                        (int)(350.0*height/480.0),
                        buffer, length);

//select the device default font back into the device context, label the
// x axes and the sample ellipse and rectangle

        SelectFont(PaintDC,hFont);

        length = sprintf(buffer, "SPANWISE POSITION Y/S");

                TextOut(PaintDC, (int)(370.0*width/640.0),
                                (int)(190.0*height/480.0),
                                buffer, length);

                TextOut(PaintDC, (int)(370.0*width/640.0),
                                (int)(410.0*height/480.0),
                                buffer, length);

        length = sprintf(buffer, "Exact:");

                TextOut(PaintDC, (int)(55.0*width/640.0),
                                (int)(260.0*height/480.0),
                                buffer, length);

        length = sprintf(buffer, "Approx:");

                TextOut(PaintDC, (int)(55.0*width/640.0),
```

```
                    (int)(280.0*height/480.0),
                    buffer, length);
```

The percent error data box is then drawn with a series of Rectangle function calls and filled in with sprintf and TextOut calls. The screen output is complete at that point. The original font, pen, and brush are selected back into the device context and the fonts, pens, and brushes created for the paint_graphs function are deleted. The memory allocated for the plot data is freed and the function terminates without a return statement. The code is shown above and not repeated here.

A.5.3 The VLL print_data_box and print_graphs functions.

VLL uses two functions to draw output to the system printer. The first is the print_data_box function. The print_data_box function is nearly identical to the paint_data_box function. The difference is that while the paint_data_box function uses the globally defined width and height variables that are initialized in the WM_CREATE case in the MainWndProc function, the print_data_box function declares local width and height float variables and calculates the horizontal and vertical display size internal to the function. These code segments are shown below.

```
/*******************************************************************
*  Variable declarations                                           *
*******************************************************************/

        float   width,                          //scale factors for ensuring the
                height;                         // graphical output is scaled to
                                                // a 640 by 480 window

//determine the width of the display in pixels and the height of the display
//  in raster lines and cast them as floats

        width  = (float)GetDeviceCaps (PaintDC, HORZRES);
        height = (float)GetDeviceCaps (PaintDC, VERTRES);

//since the normal display aspect ratio is 4 to 3, ensure that the graphical
// output made by the program is in that aspect ratio

        if((width/height)>(4.0/3.0))
                width = height*(4.0/3.0);
        else
                height = width*(3.0/4.0);
```

The second function used by VLL to draw output to the system printer is the print_graphs function. The print_graphs function, like the print_data_box function, is nearly identical to its screen painting counterpart. The difference between these two functions is also in the local declaration and calculation of the width and height variables. These code segments are shown below.

```
/*******************************************************************
*  Variable declarations                                           *
*******************************************************************/
float          width,                         //scale factors for ensuring the
               height;                        // graphical output is scaled to
                                              // a 640 by 480 window


//determine the width of the display in pixels and the height of the display
//  in raster lines and cast them as floats

        width  = (float)GetDeviceCaps (PaintDC, HORZRES);
        height = (float)GetDeviceCaps (PaintDC, VERTRES);

//since the normal display aspect ratio is 4 to 3, ensure that the graphical
// output made by the program is in that aspect ratio

        if((width/height)>(4.0/3.0))
                width = height*(4.0/3.0);
        else
                height = width*(3.0/4.0);
```

APPENDIX A.6

VLL program listings.

A.6 VLL program listings.

The VLL Windows™ application uses thirteen files. Listings for these files are included with this document as Appendix A.6 on a 3.5 inch, IBM PC formatted, double sided, high density floppy disk. The files are saved in an ASCII text format which can be read using a DOS text editor or any word processor capable of reading DOS text files. The complete files of this and the other programs in this thesis are not included in the written text of the thesis in the interest of limiting the size of the document. This page is included with the listings in a file named README.TXT.

The files included on the disk are described below.

VLL.C	-contains the WinMain, MainWndProc, WMCommand_Handler, and dialog box functions.
PRTGRA.C	-contains the print_graphs function.
NEWSOLVE.C	-contains the LUdecomposition and LUbacksubstitution functions.
PRTBOX.C	-contains the print_data_box function.
PNTBOX.C	-contains the paint_data_box function.
PRTGRA.C	-contains the paint_graphs function.
VLL.DEF	-the module definition file.
VLL.RC	-contains definitions of the resources used in the VLL program.
VORTEX.C	-contains the vortex function.
HEADER.H	-contains the #define and #include statements for the VLL program.
VLL.H	-contains the definitions of the Windows™ identifiers.
README.TXT	-contains a copy of this page.

The following files are not readable text files.

FOIL.ICO	-describes the icon used to represent the program in the Windows™ Program Manager.
VLL.PRJ	-the project file read by the compiler.

APPENDIX B

2D Vortex/Source Lattice with Lighthill Correction Program Code.

APPENDIX B.1

The VLMLE WinMain, MainWndProc, and WMCommand_Handler functions.

B.1 The VLMLE WinMain, MainWndProc, and WMCommand_Handler functions.

The WinMain, MainWndProc, and WMCommand_Handler functions in the VLMLE Windows™ application program are very similar to those of the VLL application. For this reason, the discussion of the functions will consist mainly of a comparison of the differences between the VLMLE functions and their VLL counterparts.

B.1.1 A comparison of the VLL and VLMLE WinMain functions.

The WinMain function for VLMLE differs from the WinMain function for VLL, essentially, only in the addition of the SetTimer function call shown below.

```
//create a timer
        SetTimer(hWnd,ID_TIMER,100,NULL);
```

The SetTimer function call is made immediately following the creation and display of the main window. The SetTimer function receives the handle to the window for which a timer is being set, a Windows™ identifier for the timer, the time-out duration in milliseconds, and the instance address of the timer procedure. In this case, the handle of the main window is specified as the window associated with the timer. IDM_TIMER is an identifier that is defined in the VLMLE header.h file. The NULL value for the instance address of the timer procedure and the 100 for the time-out value mean that the timer will cause a WM_TIMER message to be posted in the application message queue every tenth of a second. Since Windows™ provides only a limited number of timers, it is important to make judicious use of them and to properly terminate their use in order to return them to the operating environment for use by other applications. This will be taken care of in the MainWndProc function.

B.1.2 A comparison of the VLL and VLMLE MainWndProc functions.

The differences between the MainWndProc functions for the VLL and VLMLE functions are more extensive than those of the WinMain functions. The VLMLE MainWndProc function is shown below.

```
LRESULT CALLBACK _export MainWndProc(HWND hWnd, UINT message,
                    WPARAM wParam, LPARAM lParam)
{

  switch (message)
  {
//this case refers menu selections to the WMCommand_Handler function

    case WM_COMMAND :
    {
      return HANDLE_WM_COMMAND(hWnd, wParam, lParam, WMCommand_Handler);

    }

    case WM_PAINT :
    {
//this case handles painting the screen

        HDC     PaintDC;            //handle to a device context

        PAINTSTRUCT ps;              //paint structure

//prepare hWnd for painting and fill the paint structure, ps

      PaintDC = BeginPaint(hWnd, &ps);

//paint the data box whenever the screen is repainted

        paint_data_box(PaintDC );

//paint the graphs if the fortran executable has been run and the variable
// data has not changed since it was run

        if(run_flag)

            paint_graphs(PaintDC);

//mark the end of painting hWnd and return 0

        EndPaint(hWnd, &ps);

      return 0;

      }

    case WM_TIMER :
```

```
{

//this case is executed each timer interval.  it looks for the file that
// indicates the fortran executable is terminating and then repaints the
// screen and sets the run flag

        if(access("vlmle.dne", 0) == 0)  {

        RECT    temp_rect;              //temporary rectangle structure

        HDC     tempDC;                 //handle to a temporary device
                                              // context

        float   width,                  //scale factors for ensuring the
                height;                 // graphical output is scaled to
                                              [illegible] by 480 window

//get a handle to the screen device context

        tempDC = GetDC(hWnd);

//determine the width of the display in pixels and the height of the display
// in raster lines and cast them as floats

        width  = (float)GetDeviceCaps (tempDC, HORZRES);
        height = (float)GetDeviceCaps (tempDC, VERTRES);

//since the normal display aspect ratio is 4 to 3, ensure that the graphical
// output made by the program is in that aspect ratio

        if((width/height)>(4.0/3.0))
                width = height*(4.0/3.0);
        else
                height = width*(3.0/4.0);

//release the handle to the device context

        ReleaseDC(hWnd,tempDC);


                run_flag = 1;

//cause appropriate sections of the screen to be repainted

                temp_rect.top    = (int)(left_rect.top*height/480.0);
                temp_rect.bottom = (int)(left_rect.bottom*height/480.0);
                temp_rect.left   = (int)(left_rect.left*width/640.0);
                temp_rect.right  = (int)(left_rect.right*width/640.0);

                InvalidateRect(hWnd, &temp_rect, TRUE);

                temp_rect.top    = (int)(right_rect.top*height/480.0);
```

```
                    temp_rect.bottom = (int)(right_rect.bottom*height/480.0);
                    temp_rect.left  = (int)(right_rect.left*width/640.0);
                    temp_rect.right = (int)(right_rect.right*width/640.0);

                    InvalidateRect(hWnd, &temp_rect, TRUE);

                    unlink("vlmle.dne");

                                        }

            return 0;

    }

    case WM_DESTROY :
    {

//this case handles requests to exit the program made by methods other than
// the main menu

//delete the temporary files

        if(access("input.dat", 0) == 0) unlink("input.dat");

        if(access("output.dat", 0) == 0) unlink("output.dat");

//remove the timer and request that the program be terminated by the
// Windows environment

        KillTimer(hWnd,ID_TIMER);

      PostQuitMessage(0);

      return 0;
    }
  }
  return DefWindowProc (hWnd, message, wParam, lParam);
}
```

The MainWndProc for VLMLE has a function declaration identical to that of VLL. Like VLL, it also consists of a switch that handles four cases and passes messages not handled by the switch to the default window procedure. The WM_COMMAND case and the WM_PAINT case are identical to those of VLL.

A WM_CREATE case is not included in VLMLE as it was in VLL. In VLL the case was used to initialize global variables containing data regarding the horizontal and

vertical dimensions of the monitor display area. In VLMLE these calculations are performed in the output functions, paint_data_box and paint_graphs and locally in the cases which cause only portions of the monitor display to be redrawn. The advantage of performing the calculations in the output functions is that the output functions can be written to be independent of the output device. This means that the paint_data_box and paint_graphs functions write output both to the monitor and to the printer and no additional output functions are required. The disadvantage, which is extremely minor, is that the calculations must be repeated relatively frequently.

The VLMLE MainWndProc has a case, the WM_TIMER case, that is not included in the VLL function. The WM_TIMER case responds to WM_TIMER messages generated by the timer that is created in the WinMain function. Every tenth of a second, a WM_TIMER message is posted in the application message queue. In response to the messages, the access function is used to check for the existence of the vlmle.dne file. The vlmle.dne file is the dummy file that the VLMLE FORTRAN executable writes immediately prior to termination. If the file is found to exist, local variables are declared for the purpose of determining the size of the monitor display area. The size of the monitor display area is then calculated. The run flag is then set to indicate that the current set of variable data has been run and output created.

```
case WM_TIMER :
  {

//this case is executed each timer interval. it looks for the file that
// indicates the fortran executable is terminating and then repaints the
// screen and sets the run flag

        if(access("vlmle.dne", 0) == 0) {

        RECT   temp_rect;                         //temporary rectangle structure

        HDC    tempDC;                            //handle to a temporary device
                                                  // context
```

```
        float   width,                                          //scale factors for ensuring the
                height;                                         // graphical output is scaled to
                                                                // a 640 by 480 window

//get a handle to the screen device context

        tempDC = GetDC(hWnd);

//determine the width of the display in pixels and the height of the display
// in raster lines and cast them as floats

        width  = (float)GetDeviceCaps (tempDC, HORZRES);
        height = (float)GetDeviceCaps (tempDC, VERTRES);

//since the normal display aspect ratio is 4 to 3, ensure that the graphical
// output made by the program is in that aspect ratio

        if((width/height)>(4.0/3.0))
                width = height*(4.0/3.0);
        else
                height = width*(3.0/4.0);

//release the handle to the device context

        ReleaseDC(hWnd,tempDC);


                run_flag = 1;

//cause appropriate sections of the screen to be repainted

                temp_rect.top    = (int)(left_rect.top*height/480.0);
                temp_rect.bottom = (int)(left_rect.bottom*height/480.0);
                temp_rect.left   = (int)(left_rect.left*width/640.0);
                temp_rect.right  = (int)(left_rect.right*width/640.0);

                InvalidateRect(hWnd, &temp_rect, TRUE);

                temp_rect.top    = (int)(right_rect.top*height/480.0);
                temp_rect.bottom = (int)(right_rect.bottom*height/480.0);
                temp_rect.left   = (int)(right_rect.left*width/640.0);
                temp_rect.right  = (int)(right_rect.right*width/640.0);

                InvalidateRect(hWnd, &temp_rect, TRUE);

                unlink("vlmle.dne");

                                }

        return 0;

    }
```

The case then causes the area of the monitor exclusive of the Current Variable Data area to be erased and then repainted by calling the InvalidateRect function and specifying the appropriate rectangles. For this purpose the global rectangle structure variables left_rect and right_rect are scaled so that monitors with other than a 640 by 480 display area will be handled properly. The reason for not invalidating and redrawing the entire screen is to prevent screen flicker in the Current Variable Data area. The vlmle.dne file is then deleted using the unlink function and the case is terminated by returning a value of zero to indicate that the message was handled by the function.

The WM_DESTROY case is functionally identical to its VLL counterpart with the exception of the addition of a KillTimer function call.

```
KillTimer(hWnd,ID_TIMER);
```

The KillTimer function receives a handle to the window associated with the timer to be terminated, and the identifier of the timer and removes the timer. This is done due to the limited number of timers available in Windows™ so that the timer may be assigned to other applications.

B.1.3 A comparison of the VLL and VLMLE WMCommand_Handler functions.

The WMCommand_Handler function for VLMLE is very similar to the VLL WMCommand_Handler function in terms of functionality provided as well as structure. It is shown below in a series of segments, with a narrative discussion of the code interspersed throughout the segments.

The function consists mainly of a switch that handles requests made by the user with the main menu. At the start of the function a declaration of a pointer to a dialog procedure, dlgProc, is made. The pointer is used in three of the switch cases to process requests for interaction with dialog boxes.

```
void WMCommand_Handler(HWND hWnd, int id, HWND hwndCtl, UINT codeNotify)
```

```
{
    DLGPROC dlgProc;                              //pointer to a dialog procedure

    switch (id)
    {
```

The first case handled by the switch is the IDM_RUN case. This case responds to the main menu File|Run selection. The case first calculates the screen display area size in the same way used by the WM_TIMER case in section B.1.2.

```
    case IDM_RUN : {

    RECT   temp_rect;                             //temporary rectangle structure

    HDC    tempDC;                                //handle to a temporary device
                                                  // context

    float  width,                                 //scale factors for ensuring the
           height;                                // graphical output is scaled to
                                                  // a 640 by 480 window

//get a handle to the screen device context

    tempDC = GetDC(hWnd);

//determine the width of the display in pixels and the height of the display
// in raster lines and cast them as floats

    width  = (float)GetDeviceCaps (tempDC, HORZRES);
    height = (float)GetDeviceCaps (tempDC, VERTRES);

//since the normal display aspect ratio is 4 to 3, ensure that the graphical
// output made by the program is in that aspect ratio

    if((width/height)>(4.0/3.0))
           width = height*(4.0/3.0);
    else
           height = width*(3.0/4.0);

//release the handle to the device context

    ReleaseDC(hWnd,tempDC);
```

The case then clears the run flag in order to indicate that the current variable data has not yet been processed by the FORTRAN executable, and then clears the portion of the screen external to the Current Variable Data area. After this is accomplished, the

input data file, input.dat, that will be read by the FORTRAN executable is written. The number of panels to be used, the ideal lift coefficient, the angle of attack relative to the ideal angle of attack, and the thickness to chord ratio are included in the file.

```
//if the user selects "Run", write the input.dat file and run the
// vlmle fortran program

//clear the run flag and cause the screen, other than the data box, to
// be repainted

                run_flag = 0;

//cause appropriate sections of the screen to be repainted

                temp_rect.top    = (int)(left_rect.top*height/480.0);
                temp_rect.bottom = (int)(left_rect.bottom*height/480.0);
                temp_rect.left   = (int)(left_rect.left*width/640.0);
                temp_rect.right  = (int)(left_rect.right*width/640.0);

                InvalidateRect(hWnd, &temp_rect, TRUE);

                temp_rect.top    = (int)(right_rect.top*height/480.0);
                temp_rect.bottom = (int)(right_rect.bottom*height/480.0);
                temp_rect.left   = (int)(right_rect.left*width/640.0);
                temp_rect.right  = (int)(right_rect.right*width/640.0);

                InvalidateRect(hWnd, &temp_rect, TRUE);

                InvalidateRect(hWnd, &right_rect, TRUE);
                InvalidateRect(hWnd, &left_rect, TRUE);

//open the input.dat file and write the data used by the fortran executable

                in =fopen("INPUT.DAT", "w");

                        fprintf(in,"%d \n",NUMBER_PANELS);

                        fprintf(in,"%f \n",ideal_lift_coefficient);

                        fprintf(in,"%f \n",delta_alpha);

                        fprintf(in,"%f \n",thickness_chord_ratio);

                fclose (in);
```

The FORTRAN executable is then run by a call to the WinExec function. The WinExec function receives a pointer to the command line of the program to be run and the

window state in which the program will be displayed. In this case, a Windows™ Program Information File (.pif) which names the executable and describes how it is to be run is called by the WinExec function. This causes the FORTRAN program to be run in an iconified DOS window. The case is then terminated and execution of the FORTRAN executable continues in parallel with the Windows™ program.

```
//run the fortran executable in an inconified DOS window
                    WinExec("newvlmle.pif", SW_SHOWMINIMIZED);
    break;
                          }
```

The IDM_PRINT case is virtually identical to the VLL IDM_PRINT case, which is described in detail in section A.3.

```
        case IDM_PRINT : {
//this case calls the print dialog box
        PRINTDLG pd;                    //print dialog structure
        DOCINFO di;                     //document information structure
    int j;                  //page counter
//if a print request is made using the main menu and the case has not been run,
// print a warning and deny the request
                    if (!run_flag)
                    {
                        MessageBeep(MB_ICONEXCLAMATION);
                        MessageBox(hWnd, "Must run program prior to printing.",
            "WARNING!", MB_ICONSTOP | MB_OK | MB_TASKMODAL);
                    break;
                    }
//otherwise, process the request

//set all structure members to zero.
                    memset(&pd, 0, sizeof(PRINTDLG));
```

```
            di.cbSize = sizeof(DOCINFO);
            di.lpszDocName = "VLMLE";
            di.lpszOutput = NULL;

//initialize the necessary PRINTDLG structure members.

        pd.lStructSize = sizeof(PRINTDLG);
        pd.hwndOwner = hWnd;
        pd.Flags = PD_RETURNDC|PD_HIDEPRINTTOFILE|PD_NOSELECTION;
        pd.nFromPage = 1;
        pd.nToPage = 1;
        pd.nMinPage = 1;
        pd.nMaxPage = 1;


        if (PrintDlg(&pd) != 0) {


            StartDoc(pd.hDC,&di);

            for(j=0; j<pd.nCopies; j++){

                StartPage(pd.hDC);

                paint_data_box(pd.hDC );

                paint_graphs(pd.hDC);

                EndPage(pd.hDC);    }


            EndDoc(pd.hDC);

            DeleteDC(pd.hDC);


                        }

            if (pd.hDevMode != NULL)
                GlobalFree(pd.hDevMode);

            if (pd.hDevNames != NULL)
                GlobalFree(pd.hDevNames);

        break;

             }
```

The next case handles requests for the Geometry dialog box. As in the VLL WMCommandHandler function, the MakeProcInstance, DialogBox, and FreeProcInstance

functions are used to call and handle the dialog box. After the dialog box is terminated, the number of panels indicated by the user is tested. If the number falls outside the range of five to 100, a warning message is printed and the dialog session is repeated by using the SendMessage function to simulate a main menu request for the Geometry dialog box. The screen is then caused to be repainted using the InvalidateRect function. Since the run flag is cleared in the Geometry dialog procedure, this causes the Current Variable Data to be updated to reflect the new input data and the rest of the screen to be cleared.

```
    case IDM_GEOMETRY : {

//this case calls the geometry dialog box

                dlgProc = (DLGPROC)MakeProcInstance((FARPROC)DlgProc,
                        ghInstance);

                DialogBox(ghInstance, "GEOMETRY", hWnd, dlgProc);

                FreeProcInstance((FARPROC)dlgProc);

//if the number of elements input by the user is outside the allowable,
// print a warning, cause the dialog to be reinitiated

                if(NUMBER_PANELS>100||NUMBER_PANELS<5) {

        MessageBox(hWnd, "Number of Panels must be between 5 and 100",
            "WARNING!", MB_ICONSTOP | MB_OK | MB_TASKMODAL);

            SendMessage(hWnd,WM_COMMAND,IDM_GEOMETRY,MAKELONG(0,0));

                                                }
//otherwise, cause the screen to be repainted and terminate the case

                InvalidateRect(hWnd, NULL, TRUE);

                break;
                        }
```

The IDM_PARAMETERS case handles main menu requests for the Parameters dialog box. It calls the dialog box procedure and then causes the screen to be repainted with the same results as the IDM_GEOMETRY case.

```
    case IDM_PARAMETERS : {

//this case calls the geometry dialog box

                dlgProc = (DLGPROC)MakeProcInstance((FARPROC)NextDlgProc,
                        ghInstance);

                DialogBox(ghInstance, "PARAMETERS", hWnd, dlgProc);

                FreeProcInstance((FARPROC)dlgProc);

          InvalidateRect(hWnd, NULL, TRUE);

        break;

                        }
```

The IDM_EXIT case deletes the temporary data files, kills the timer, and requests that the Windows™ environment terminate the program. The IDM_ABOUT case and the help feature cases work in the same way as their counterparts in the VLL WMCommand_Handler function.

```
    case IDM_EXIT : {

//this case deletes the temporary files and terminates the program

                if(access("input.dat", 0) == 0) unlink("input.dat");

                if(access("output.dat", 0) == 0) unlink("output.dat");

//remove the timer and request that the program be terminated by the
// Windows environment

                KillTimer(hWnd,ID_TIMER);

                PostQuitMessage(0);

        break;
                        }

    case IDM_ABOUT : {

//this case calls the About dialog box

                dlgProc = (DLGPROC)MakeProcInstance((FARPROC)ABOUTDlgProc,
                        ghInstance);
```

```
                    DialogBox(ghInstance, "ABOUT", hWnd, dlgProc);

                    FreeProcInstance((FARPROC)dlgProc);

                    break;

                              }
//the next several cases respond to the help section of the main menu

          case IDM_HELPGENERAL :
    {  MessageBox(hWnd, "The 2-D Vortex/source Lattice Program \
applies a vortex lattice method with Lighthill correction.  It calculates \
and displays pressure coefficient on the upper and lower surfaces of a \
NACA 66 a=0.8 mean line foil with NACA 66 (Mod) thickness form.\n\n\
The user selects angle of attack relative to ideal angle of attack and \
ideal lift coefficient.",
 "HELP", MB_ICONINFORMATION | MB_OK );
        break;
    }

        case IDM_HELPRUN :
    {  MessageBox(hWnd, "When 'File|Run' is selected from the main \
menu, the program uses the Current Variable Data to calculate and display \
pressure coefficient on the upper and lower surfaces of the foil.\n\n\
The total lift coefficient is also calculated and displayed.\n\n\
This selection also causes a tecplot file, 'vlmle.tec', to be written \
to the directory where the program is resident.",
           "HELP", MB_ICONINFORMATION | MB_OK );
        break;
    }

          case IDM_HELPPRINT :
    {  MessageBox(hWnd, "When 'File|Print' is selected from the main \
menu, the program invokes standard Windows Print and Print Setup Dialog \
boxes to allow the user to print the data that appears on the screen.",
           "HELP", MB_ICONINFORMATION | MB_OK );
        break;
    }

          case IDM_HELPEXIT :
    {  MessageBox(hWnd, "When 'File|Exit' is selected from the main \
menu, the program is terminated.",
           "HELP", MB_ICONINFORMATION | MB_OK );
        break;
    }

          case IDM_HELPELEMENTS :
    {  MessageBox(hWnd, "When 'Options|Geometry' is selected from the main \
menu, the user may select a number of panels to use.\n\n\
The number of panels must be between 5 and 100, inclusive.  The default value \
for the number of panels is 40.",
           "HELP", MB_ICONINFORMATION | MB_OK );
        break;
    }
```

```
        case IDM_HELPTHICKCHORD :
    {  MessageBox(hWnd, "When 'Options|Geometry' is selected from the main \
menu, the user may select a value for the thickness to chord ratio.\n\n",
"HELP", MB_ICONINFORMATION | MB_OK );
        break;
    }

        case IDM_HELPPARAMETERS :
    {  MessageBox(hWnd, "When 'Options|Parameters' is selected from the \
main menu, the user may select values for ideal lift coefficient and the \
angle of attack relative to the ideal angle of attack.\n\n",
        "HELP", MB_ICONINFORMATION | MB_OK );
        break;
    }

  }
}
```

APPENDIX B.2

The VLMLE dialog and output functions.

B.2 The VLMLE dialog and output functions.

The dialog functions that initialize and handle input for the VLMLE dialog boxes are completely analogous to the VLL dialog functions described in section A.4. A complete listing of the VLMLE functions may be found in section B.4.

The paint_data_box function, shown below, fulfills the same roles as the VLL paint_data_box and print_data_box functions. This is made possible by calculating the scale factors for the width and height of the display internal to the function. The other significant difference between this function and the VLL functions is in the use of fonts. The VLL functions select the device default font into the device context and use it to draw the text output. VLMLE uses the system font.

```
void paint_data_box(HDC PaintDC)
{

/*********************************************************************
* declare variables that are defined in the vlmle.c file and that     *
* will be used in this function                                       *
*********************************************************************/


extern  int     NUMBER_PANELS;

extern  float   delta_alpha, ideal_lift_coefficient, thickness_chord_ratio;

/*********************************************************************
*  Variable declarations                                        *
*********************************************************************/

        char    buffer[120];                    //buffer for character output

        int     length;                         //length of character output

        float   width,                          //scale factors for ensuring the
                height;                         // graphical output is scaled to
                                                // a 640 by 480 window

//determine the width of the display in pixels and the height of the display
// in raster lines and cast them as floats

        width = (float)GetDeviceCaps (PaintDC, HORZRES);
        height = (float)GetDeviceCaps (PaintDC, VERTRES);

//since the normal display aspect ratio is 4 to 3, ensure that the graphical
// output made by the program is in that aspect ratio
```

```
		if((width/height)>(4.0/3.0))
			width = height*(4.0/3.0);
		else
			height = widt..*(3.0/4.0);

	//enclose the current variable data box in a pair of rectangles

		Rectangle(PaintDC,(int)(1*width/640.0),(int)(20*height/480.0),
			(int)(205*width/640.0),(int)(45*height/480.0));

		Rectangle(PaintDC,(int)(1.0*width/640.0),(int)(45*height/480.0),
			(int)(205*width/640.0),(int)(290*height/480.0));

	//label the box

		length = sprintf(buffer, "CURRENT VARIABLE DATA");

			TextOut(PaintDC,(int)(6*width/640.0) ,
					(int)(25*height/480.0),
					buffer, length);

		length = sprintf(buffer, "Thickness form:");

			TextOut(PaintDC,(int)(10*width/640.0),
					(int)(50*height/480.0),
					buffer, length);

		length = sprintf(buffer, "NACA-66(Mod)");

			TextOut(PaintDC,(int)(25*width/640.0),
					(int)(70*height/480.0),
					buffer, length);

		length = sprintf(buffer, "Camber:");

			TextOut(PaintDC,(int)(10*width/640.0),
					(int)(90*height/480.0),
					buffer, length);

		length = sprintf(buffer, "NACA a=0.8");

			TextOut(PaintDC,(int)(25*width/640.0),
					(int)(110*height/480.0),
					buffer, length);

		length = sprintf(buffer, "Number of Panels:");

			TextOut(PaintDC,(int)(10*width/640.0),
					(int)(130*height/480.0),
					buffer, length);

		length = sprintf(buffer, "%d",NUMBER_PANELS);
```

```
        TextOut(PaintDC,(int)(25*width/640.0),
                        (int)(150*height/480.0),
                        buffer, length);

    length = sprintf(buffer, "Ideal Lift Coeff:");

        TextOut(PaintDC,(int)(10*width/640.0),
                        (int)(170*height/480.0),
                        buffer, length);

    length = sprintf(buffer, "%5.3f",ideal_lift_coefficient);

        TextOut(PaintDC,(int)(25*width/640.0),
                        (int)(190*height/480.0),
                        buffer, length);

    length = sprintf(buffer, "Alpha-Alpha(ideal):");

        TextOut(PaintDC,(int)(10*width/640.0),
                        (int)(210*height/480.0),
                        buffer, length);

    length = sprintf(buffer, "%5.3f",delta_alpha);

        TextOut(PaintDC,(int)(25*width/640.0),
                        (int)(230*height/480.0),
                        buffer, length);

    length = sprintf(buffer, "Thick/Chord Ratio:");

        TextOut(PaintDC,(int)(10*width/640.0),
                        (int)(250*height/480.0),
                        buffer, length);

    length = sprintf(buffer, "%5.4f",thickness_chord_ratio);

        TextOut(PaintDC,(int)(25*width/640.0),
                        (int)(270*height/480.0),
                        buffer, length);
}
```

The paint_graphs function in VLMLE, like the paint_data_box function, fulfills the same roles as its VLL counterpart functions. This is accomplished in the same way as it is in the paint_data_box function. The VLMLE paint_graphs function also makes use of the system font rather than creating additional fonts. A complete listing of the paint_graphs function is contained in section B.4.

APPENDIX B.3

The VLMLE FORTRAN program.

B.3 The VLMLE FORTRAN program.

The Windows™ version of VLMLE relies upon a modified version of the original FORTRAN VLMLE program to perform the required hydrodynamic calculations. This is done in favor of converting the FORTRAN code to the C programming language. Although the conversion would be relatively simple in the case of VLMLE, this program is a proof of concept project that lays the groundwork for the use of more complicated programs, such as PLL, as stand alone FORTRAN executables. The modified version of VLMLE is shown below. The modifications appear in bold type.

```
      PROGRAM VLMLE
C---------------------------------------------------------
C    2-D Vortex/source lattice program with Lighthill's leading-edge
C    correction. Combines NACA-66(Mod) thickness form with NACA a=0.8
C    mean line at given angle of attack (measured relative to the
C    ideal angle of attack). The vortex lattice part of the computation
C    is identical to VLM2D. ---------------------------------
C    Written by: Justin E. Kerwin for 13.04   April 17, 1995----------
C
C    Modified by David R. Beckett 4/27/95
C    -to accomplish input by data file, input.dat
C    -removed screen output
C    -added statements to write output data to a data file, output.dat
C

      PARAMETER( MSD=100, MSD2=MSD+2, MCUB=4*(MSD-1), NCL=1,NCR=1 )
      PARAMETER( PI=3.141592653589793E00, HALF=0.5E00, RAD=PI/180.0 )
      PARAMETER( ZERO=0.0E00, ONE=1.0E00, TWO=2.0E00, ESL=0.0, ESR=0.0 )
      DIMENSION XV(MSD),XC(MSD),A(MSD,MSD),DX(MSD),B(MSD), GAMMA(MSD),
     *         WKAREA(MSD),IPIVOT(MSD),G(MSD),GEXACT(MSD),F(MSD),
     *         YT(MSD2),UT(MSD),CPU(MSD2),CPL(MSD2),CUBIC(MCUB)
C
C----Open the input data file as unit 2-----------------------
      OPEN(2,FILE='INPUT.DAT',STATUS='UNKNOWN',FORM='FORMATTED')
C

C----Compute vortex and control point positions and weight functions---
C
C----Comment out the request for the number of panels and associated read statement
C
C90   WRITE(*,'(" Enter number of panels (Max:",I4,")... ",$)') MSD
C     READ(*,*) MC
C
C-----Add a READ statement that reads the number of panels from the input.dat file
C
      READ(2,*) MC
```

```
C
C-----Comment out the test loop that checks the validity of the number of panels since
C        this is ensured in the C code
C
C     IF(MC.LT.5.OR.MC.GT.MSD) GO TO 90
      DELC=PI/FLOAT(MC)
      DO 100 N=1,MC
        XV(N)=HALF*(ONE-COS((N-HALF)*DELC))
        XC(N)=HALF*(ONE-COS(N*DELC))
        DX(N)=PI*SQRT(XV(N)*(ONE-XV(N)))/FLOAT(MC)
 100  CONTINUE

C-----Compute influence coefficient matrix A(N,M) and invert ---------
      TOP=ONE/(TWO*PI)
      DO 110 N=1,MC
        DO 120 M=1,MC
          A(N,M)=TOP/(XV(M)-XC(N))
 120    CONTINUE
 110  CONTINUE
      CALL FACTOR(A,IPIVOT,WKAREA,MC,MSD,IERR)

C-----Solve for GAMMA(X) FOR NACA A=.8 MEAN LINE ------------------
C
C-----Comment out the requests for the ideal lift coefficient and angle of attack and associated read
C       statements and read the values from the input.dat file
C
C     WRITE(*,'(A,$)') ' Enter ideal lift coefficient.... '
C     READ(*,*) CL
      READ(2,*) CL
C     WRITE(*,'(A,$)') ' Enter Alpha-Alpha(ideal) (deg)..... '
C     READ(*,*) ALPHA
      READ(2,*) ALPHA
     CALL AEIGHT(MC,XV,XC,B,F,GEXACT)
      DO 130 N=1,MC
        B(N)=CL*B(N)-ALPHA*RAD
        F(N)=CL*F(N)
 130  CONTINUE
      CALL SUBST(A,B,GAMMA,IPIVOT,MC,MSD)

C-----Sum circulation over chord and convert to vortex sheet strength---
      SUMG=ZERO
      DO 140 N=1,MC
        SUMG=SUMG+GAMMA(N)
        G(N)=GAMMA(N)/DX(N)
 140  CONTINUE
      CLNUM=TWO*SUMG
C
C-----Comment out the statement that writes the computed total lift coefficient to the screen
C
C    WRITE(*,'(" Computed total lift coefficient=",F8.4)') CLNUM
C
C-----open the output.dat file as unit 3, write the computed total lift coefficient and number of panels
C       to the file
C
```

```
      OPEN(3,FILE='OUTPUT.DAT',STATUS='UNKNOWN',FORM='FORMATTED')
      WRITE(3,'(F10.5)') CLNUM
      WRITE(3,'(I5)') MC

C----Velocity due to thickness--------------------------------
C
C----Comment out the request for thickness/chord ratio and associated read statement and read the
C     value from the input.dat file
C
C     WRITE(*,'(A,$)') ' Enter thickness/chord ratio... '
C     READ(*,*) TOC
      READ(2,*) TOC
    CALL NACA66(MC,TOC,RLE,XC,YT(2))
      YT(1)=ZERO
      DO 200 N=1,MC
        UT(N)=ZERO
        DO 210 M=1,MC
          UT(N)=UT(N)+TOP*(YT(M+1)-YT(M))/(XC(N)-XV(M))
 210    CONTINUE
 200  CONTINUE

C----Interpolate thickness velocity to vortex points----------------
      CALL UGLYDK(MC,NCL,NCR,XC,UT,ESL,ESR,CUBIC)
      CALL EVALDK(MC,MC,XC,XV,UT,CUBIC)

C----Compute surface velocities:First get value at leading edge--------
      QU=ALPHA*RAD*SQRT(TWO/RLE)
      CPU(1)=QU**2-ONE
      CPL(1)=CPU(1)
C----Next get remaining values over the chord----------------------
      DO 300 N=1,MC
        FLH=SQRT(XV(N)/(XV(N)+HALF*RLE))
        QU=(ONE+UT(N)+HALF*G(N))*FLH
        CPU(N+1)=QU**2-ONE
        QL=(ONE+UT(N)-HALF*G(N))*FLH
        CPL(N+1)=QL**2-ONE
 300  CONTINUE

C----Output the results in TECPLOT format------------------------
      OPEN(1,FILE='VLMLE.TEC',STATUS='UNKNOWN',FORM='FORMATTED')
      WRITE(1,'(A)') ' ZONE '
      WRITE(1,'(2F10.5)') ZERO,CPU(1)
      WRITE(1,'(2F10.5)') (XV(N),CPU(N+1),N=1,MC)
      WRITE(1,'(A)') ' ZONE '
      WRITE(1,'(2F10.5)') ZERO,CPL(1)
      WRITE(1,'(2F10.5)') (XV(N),CPL(N+1),N=1,MC)
      CLOSE(1)
C
C----write the pressure coefficient to the output.dat file
C
      WRITE(3,'(3F10.5)') ZERO,CPU(1),CPL(1)
      WRITE(3,'(3F10.5)') (XV(N),CPU(N+1),CPL(N+1),N=1,MC)
C
C----close the input.dat and output.dat files
```

```
C
      CLOSE(2)
      CLOSE(3)
C
C----write a dummy file, vlmle.dne, indicating that the FORTRAN executable has completed the
C      input/output functions and is ready to terminate execution
C
      OPEN(4,FILE='VLMLE.DNE',STATUS='UNKNOWN',FORM='FORMATTED')
      CLOSE(4)

      STOP
      END
```

The original VLMLE program was designed for the traditional terminal interactive input mode. The modified version substitutes file input for the terminal input. While the original version writes the computed total lift coefficient to the screen and generates a data file formatted for use with a graphics program, the modified version writes the output data to a file formatted for use by the Windows™ program. The modified version also retains the code that produces the formatted graphics file.

The VLMLE.FOR program calls subroutines that solve a system of linear equations, calculate the offsets of a NSRDC modified NACA 66 with a parabolic tail and a leading edge radius, and evaluate the camber, slope, and vortex sheet strength of an NACA a=0.8 mean line. These subroutines were not modified for the purpose of this thesis and are therefore not included in this appendix.

APPENDIX B.4

VLMLE program listings.

B.4 VLMLE program listings.

The VLMLE Windows™ application includes ten files. Listings for these files are included with this document as Appendix B.4 on a 3.5 inch, IBM PC formatted, double sided, high density floppy disk. The files are saved in an ASCII text format which can be read using a DOS text editor or any word processor capable of reading DOS text files. The complete files of this and the other programs in this thesis are not included in the written text of the thesis in the interest of limiting the size of the document. This page is included with the listings in a file named README.TXT.

The files included on the disk are described below.

VLMLE.C	-contains the WinMain, MainWndProc, WMCommand_Handler, and dialog box functions.
PAINTGRA.C	-contains the paint_graphs function.
PAINTBOX.C	-contains the paint_data_box function.
VLMLE.DEF	-the module definition file.
VLMLE.RC	-contains definitions of the resources used in the VLMLE program.
HEADER.H	-contains the #define and #include statements for the VLMLE program.
VLMLE.H	-contains the definitions of the Windows™ identifiers.
README.TXT	-contains a copy of this page.

The following files are not readable text files.

VLMLE.ICO	-describes the icon used to represent the program in the Windows™ Program Manager.
VLMLE.PRJ	-the project file read by the compiler.
NEWVLMLE.PIF	-a program information file used by the Windows™ environment to control how the FORTRAN executable is run.

APPENDIX C

PLL Program Code.

APPENDIX C.1

The PLL WinMain, FrameWndProc, and WMCommand_Handler functions.

C.1 The PLL WinMain, FrameWndProc, and WMCommand_Handler functions.

The PLL WinMain, FrameWndProc, and WMCommand_Handler functions are similar to the WinMain, MainWndProc, and WMCommand_Handler functions in the VLMLE Windows™ application program. They are different, however, due to the greater complexity of PLL and the application of the Multiple Document Interface. The discussion of these functions will focus on the new concepts necessary to understand the Windows™ PLL MDI application.

C.1.1 The PLL Winmain function.

The WinMain function is the main entry point for an for a MDI application, just as it is for non-MDI applications. The functions of the WinMain function for PLL are to register window classes for the frame window and the child windows, to create and display the frame and child windows, to initialize a timer for the frame window, to determine the size of the screen display area, and to initiate the main message loop. The WinMain function for PLL is shown below with discussion interspersed through the code.

```
int PASCAL WinMain(HINSTANCE hInstance, HINSTANCE hPrevInstance,
        LPSTR lpCmdParam, int nCmdShow)
{
```

The WinMain function is declared in the same way as the functions described in Appendix A and Appendix B. Additional character strings are declared here for the purpose of supplying different names for the four different child windows.

```
    char    ProgName[]           = "MIT - Propeller Lifting Line Program";
    char    BladeViewerName[]    = "Blade Viewer";
    char    WakeViewerName[]     = "Wake Viewer";
    char    OutputViewerName[]   = "Output Viewer";
    char    PlotViewerName[]     = "Plot Viewer";

    MDICREATESTRUCT   mcs;
    MSG               msg;
```

The MDICREATESTRUCT is declared as follows:

```
typedef struct tagMDICREATESTRUCT {
  LPCSTR    szClass;
  LPCSTR    szTitle;
  HINSTANCE hOwner;
  int       x;
  int       y;
  int       cx;
  int       cy;
  DWORD     style;
  LPARAM    lParam;
} MDICREATESTRUCT;
```

The MDICREATESTRUCT structure is used to provide information about the class, title, owner, location, and size of a MDI child window.

```
        ghInstance = hInstance;

        if (!hPrevInstance)
        {
        WNDCLASS wndclass;
```

The next several lines of code initialize the WNDCLASS structure with information about the frame window class and each of the child window classes, and register each of the classes using the RegisterClass function. This is done in the same way as described in Appendix A, except that the child windows are declared with the window class style CS_NOCLOSE. This prevents the child windows from being closed using the window system menu.

```
//set up class information for the frame window class

        wndclass.lpszClassName      = ProgName;
        wndclass.lpfnWndProc        = (WNDPROC) FrameWndProc;
        wndclass.cbClsExtra         = 0;
        wndclass.cbWndExtra         = 0;
        wndclass.hInstance          = hInstance;
        wndclass.hIcon              = LoadIcon(hInstance,"PLL_ICON");
        wndclass.hCursor            = LoadCursor(NULL,IDC_ARROW);
        wndclass.hbrBackground      = (HBRUSH) (COLOR_WINDOW + 1);
        wndclass.lpszMenuName               = "Main_Menu";
        wndclass.style              = CS_VREDRAW | CS_HREDRAW |CS_DBLCLKS;

//register frame class
        RegisterClass(&wndclass);

//set up class information for the blade window class

        wndclass.lpszClassName      = BladeViewerName;
```

```
        wndclass.lpfnWndProc          = (WNDPROC) MDIChildBladeWndProc;
        wndclass.cbClsExtra           = 0;
        wndclass.cbWndExtra           = sizeof(LOCALHANDLE);
        wndclass.hIcon                = LoadIcon(hInstance,"BLADE_ICON");
        wndclass.hCursor              = LoadCursor(NULL,IDC_ARROW);
        wndclass.hbrBackground        = (HBRUSH) (COLOR_WINDOW + 1);
        wndclass.lpszMenuName              = NULL;
        wndclass.style          CS_VREDRAW | CS_HREDRAW |CS_DBLCLKS |CS_NOCLOSE;

//register MDI blade child class
        RegisterClass(&wndclass);

//set up class information for the wake window class

        wndclass.lpszClassName        = WakeViewerName;
        wndclass.lpfnWndProc          = (WNDPROC) MDIChildWakeWndProc;
        wndclass.cbClsExtra           = 0;
        wndclass.cbWndExtra           = sizeof(LOCALHANDLE);
        wndclass.hIcon                = LoadIcon(hInstance,"WAKE_ICON");
        wndclass.hCursor              = LoadCursor(NULL,IDC_ARROW);
        wndclass.hbrBackground        = (HBRUSH) (COLOR_WINDOW + 1);
        wndclass.lpszMenuName          = NULL;
        wndclass.style          = CS_VREDRAW | CS_HREDRAW |CS_DBLCLKS|CS_NOCLOSE;

//register MDI wake child class
        RegisterClass(&wndclass);


//set up class information for the output window class

        wndclass.lpszClassName        = OutputViewerName;
        wndclass.lpfnWndProc          = (WNDPROC) MDIChildOutputWndProc;
        wndclass.cbClsExtra           = 0;
        wndclass.cbWndExtra           = sizeof(LOCALHANDLE);
        wndclass.hIcon                = LoadIcon(hInstance,"OUTPUT_ICON");
        wndclass.hCursor              = LoadCursor(NULL,IDC_ARROW);
        wndclass.hbrBackground        = (HBRUSH) (COLOR_WINDOW + 1);
        wndclass.lpszMenuName              = NULL;
        wndclass.style          = CS_VREDRAW | CS_HREDRAW |CS_DBLCLKS|CS_NOCLOSE;

//register MDI output window class
        RegisterClass(&wndclass);

//setup class information for the plot viewer class

        wndclass.lpszClassName        = PlotViewerName;
        wndclass.lpfnWndProc          = (WNDPROC) MDIChildPlotWndProc;
        wndclass.cbClsExtra           = 0;
        wndclass.cbWndExtra           = sizeof(LOCALHANDLE);
        wndclass.hIcon                = LoadIcon(hInstance,"PLOT_ICON");
        wndclass.hCursor              = LoadCursor(NULL,IDC_ARROW);
        wndclass.hbrBackground        = (HBRUSH) (COLOR_WINDOW + 1);
        wndclass.lpszMenuName              = NULL;
        wndclass.style          = CS_VREDRAW|CS_HREDRAW|CS_DBLCLKS|CS_NOCLOSE;
```

```
//register MDI plot viewer window class
        RegisterClass(&wndclass);
}
```

After the classes are registered, the frame window is created using the CreateWindow command. A timer is set such that a _TIMER message is sent to the window procedure for the frame window (FrameWndProc) every 500 milliseconds. This timer is used to periodically check for the termination of PLL and PBD FORTRAN executables.

```
//create frame window

        hFrameWnd = CreateWindow(ProgName,ProgName,
                                WS_OVERLAPPEDWINDOW|WS_CLIPCHILDREN,
                                CW_USEDEFAULT, CW_USEDEFAULT,
                                CW_USEDEFAULT, CW_USEDEFAULT,
                                NULL, NULL, hInstance, NULL);

//create a timer for determining how often to check for FORTRAN PLL run completion will

        SetTimer(hFrameWnd,ID_TIMER,500,NULL);

//create the child windows

        if(hFrameWnd && hMDIClientWnd)
        {

        RECT            current_rect;
        HDC             hDC;
        TEXTMETRIC      tm;
```

A TEXTMETRIC structure, tm, is declared here for use in determining the size of the screen display area in terms of the size of the text. A TEXTMETRIC structure is declared as follows:

```
typedef struct tagTEXTMETRIC {  /* tm */
   int  tmHeight;
   int  tmAscent;
   int  tmDescent;
   int  tmInternalLeading;
   int  tmExternalLeading;
   int  tmAveCharWidth;
   int  tmMaxCharWidth;
   int  tmWeight;
   BYTE tmItalic;
```

```
    BYTE tmUnderlined;
    BYTE tmStruckOut;
    BYTE tmFirstChar;
    BYTE tmLastChar;
    BYTE tmDefaultChar;
    BYTE tmBreakChar;
    BYTE tmPitchAndFamily;
    BYTE tmCharSet;
    int  tmOverhang;
    int  tmDigitizedAspectX;
    int  tmDigitizedAspectY;
} TEXTMETRIC;
```

A TEXTMETRIC structure contains information about the size and appearance of a font. If the program is successful to this point, the frame window is displayed and each of the child windows is created and displayed. The child windows are not created using the CreateWindow function, but rather are created by sending a WM_MDICREATE message along with a pointer to a properly initialized MDICREATESTRUCT structure to the client window. The client window is the window area inside the frame window. It is where the child windows are displayed, and it is controlled by the Windows™ operating environment.

All four child windows are created with the MDIS_ALLCHILDSTYLES style bits. The WS_VSCROLL style bit is specified for the Output Viewer window so that it is created with a vertical scroll bar.

```
ShowWindow(hFrameWnd, nCmdShow);
UpdateWindow(hFrameWnd);

mcs.szTitle      = BladeViewerName;
mcs.szClass      = BladeViewerName;
mcs.hOwner       = ghInstance;
mcs.x            = CW_USEDEFAULT;
mcs.y            = CW_USEDEFAULT;
mcs.cx           = CW_USEDEFAULT;
mcs.cy           = CW_USEDEFAULT;
mcs.style        = MDIS_ALLCHILDSTYLES;

hBladeWnd = (HWND)SendMessage(hMDIClientWnd,WM_MDICREATE,0,
                              (LONG)(LPMDICREATESTRUCT)&mcs);
```

```
ShowWindow(hBladeWnd, SW_SHOWNORMAL);

mcs.szTitle             = WakeViewerName;
mcs.szClass             = WakeViewerName;
mcs.hOwner              = ghInstance;
mcs.x                   = CW_USEDEFAULT;
mcs.y                   = CW_USEDEFAULT;
mcs.cx                  = CW_USEDEFAULT;
mcs.cy                  = CW_USEDEFAULT;
mcs.style               = MDIS_ALLCHILDSTYLES;

hWakeWnd = (HWND)SendMessage(hMDIClientWnd,WM_MDICREATE,0,
                              (LONG)(LPMDICREATESTRUCT)&mcs);

ShowWindow(hWakeWnd, SW_SHOWNORMAL);

mcs.szTitle             = PlotViewerName;
mcs.szClass             = PlotViewerName;
mcs.hOwner              = ghInstance;
mcs.x                   = CW_USEDEFAULT;
mcs.y                   = CW_USEDEFAULT;
mcs.cx                  = CW_USEDEFAULT;
mcs.cy                  = CW_USEDEFAULT;
mcs.style               = MDIS_ALLCHILDSTYLES;

hPlotWnd = (HWND)SendMessage(hMDIClientWnd,WM_MDICREATE,0,
                              (LONG)(LPMDICREATESTRUCT)&mcs);

ShowWindow(hPlotWnd, SW_SHOWNORMAL);

mcs.szTitle             = OutputViewerName;
mcs.szClass             = OutputViewerName;
mcs.hOwner              = ghInstance;
mcs.x                   = CW_USEDEFAULT;
mcs.y                   = CW_USEDEFAULT;
mcs.cx                  = CW_USEDEFAULT;
mcs.cy                  = CW_USEDEFAULT;
mcs.style               = MDIS_ALLCHILDSTYLES|WS_VSCROLL;

hOutputWnd = (HWND)SendMessage(hMDIClientWnd,WM_MDICREATE,0,
                              (LONG)(LPMDICREATESTRUCT)&mcs);

ShowWindow(hOutputWnd, SW_SHOWNORMAL);
```

The next six lines of code are used to determine how may lines of text fit into the Output Viewer child window. This is done in support of the operation of the vertical scroll bar associated with that window. The first line gets a handle to the device context for the window. The next line fills a TEXTMETRIC structure with information regarding the default font for the window. The height of an individual line of text is calculated by adding the tmHeight and tmExternalLeading values from the structure. The device context is released using the ReleaseDC command. The GetClientRect function is then used to fill the current_rect RECT structure with coordinates of the upper left and lower right corners of the Output Viewer window client area. The last line calculates the integral number of lines of text that can be displayed in the client area of the Output Viewer window.

```
hDC = GetDC(hOutputWnd);
GetTextMetrics(hDC,&tm);
LineHeight = tm.tmHeight + tm.tmExternalLeading;
ReleaseDC(hOutputWnd,hDC);

GetClientRect(hOutputWnd,&current_rect);
LinesInWindow=(int)((current_rect.bottom-current_rect.top)/LineHeight);

}
```

The main message loop for a MDI application is nearly identical to that of a non-MDI application. The difference is the use of the TranslateMDISysAccel function. The TranslateMDISysAccel function translates child window accelerator keystrokes and returns a non-zero value if the function is successful. In this case, if the function is unsuccessful the message is translated and dispatched as usual by the TranslateMessage and DispatchMessage commands.

```
while (GetMessage(&msg, NULL, 0, 0))
{
if(!TranslateMDISysAccel(hMDIClientWnd, &msg))

        TranslateMessage(&msg);
        DispatchMessage(&msg);
}
```

```
        return msg.wParam;
}
```

C.1.2 The PLL FrameWndProc function.

The PLL FrameWndProc is similar to the MainWndProc functions for the VLL and VLMLE programs. It consists of a switch that processes four different types messages and refers unprocessed messages to a default procedure, in this the Windows™ default frame window procedure. The PLL FrameWndProc function is shown below. As with the WinMain function above, discussion is interspersed through the code of the FrameWndProc function.

```
LRESULT CALLBACK _export FrameWndProc(HWND hWnd, UINT message,
                                WPARAM wParam, LPARAM lParam)

{
        switch(message)
        {
        case WM_CREATE : {
```

The first case is the WM_CREATE case. A *CLIENTCREATESTRUCT* structure contains a handle to the menu of a MDI client window and an unsigned integer identifier for the first child window. This case uses the GetMenu and GetSubMenu functions to initialize the hWindowMenu parameter and assigns the value 1000 as the identifier for the first child window. The GetMenu function receives a handle to a window and returns a handle to the menu of the specified window. The GetSubMenu function receives a handle to a menu with a pop up menu and an identifier for the pop up menu and returns a handle to the specified pop up menu. This is done here so that the names of the child windows will be added to the Window pull down menu on the main menu.

```
        CLIENTCREATESTRUCT ccs;                 //structure containing information
                                                // about a Multiple Document
                                                // Interface client window menu
                                                // and the window's first child
                                                // window

//intialize the structure
```

```
        ccs.hWindowMenu = GetSubMenu(GetMenu(hWnd), 3);
        ccs.idFirstChild = 1000;
```

The WM_CREATE case then creates the client window using the CreateWindow function, displays the window using the ShowWindow function, and returns zero to indicate that the message was handled by the function.

```
//create the MDI client window and save a handle to the window

        hMDIClientWnd = CreateWindow("MDICLIENT",NULL,
                        WS_CHILD|WS_CLIPCHILDREN|WS_VISIBLE,
                        0, 0, 0, 0, hWnd, 0,
                        ghInstance, (LPSTR)&ccs);

//display the window

        ShowWindow(hMDIClientWnd, SW_SHOW);

        return 0;

                    }
```

The WM_COMMAND case uses the HANDLE_WM_COMMAND macro to refer menu selections or dialog box messages to the WMCommand_Handler function.

```
    case WM_COMMAND : {

//this case refers menu selections to the WMCommand_Handler function

    return HANDLE_WM_COMMAND(hWnd, wParam, lParam, WMCommand_Handler);

                    }

    case WM_TIMER : {

    int     j;                                  //loop counter

    FILE    *in;                                //pointer to a file structure
```

The WM_TIMER case is processed every 500 milliseconds in response to a message sent by the timer associated with the frame window. The case first checks for the existence of a file written by the PLL FORTRAN executable to indicate that the FORTRAN executable was called and completed its calculations. If the file is found to exist, the case

deletes the file and looks for, reads, and deletes a series of files written by the FORTRAN executable.

```
//if the "all.dne" file exists, then the return value of access is 0 and the code in the braces is executed

        if(access("all.dne", 0) == 0)  {

//delete the all.dne file and read the files written by the fortran executable

                unlink("all.dne");

//plot1 and plot2.out contain the data to be plotted for components 1 & 2,
// glauert.coe contains the coefficients used for blade unloading if the
// loading is zero at the tip and hub, unload.dat contains the information
// used for blade unloading if the blade loading is non-zero at the hub
// or tip, ear.dat contains the data necessary for matching ear, duct.cir
// contains a value for duct circulation that is used to update the
// value proposed by the program in the duct settings dialog box

//if plot1.out exists, open it, read it, and then delete it and set the draw_plot_flag

                if(access("plot1.out", 0)==0) {

                        in = fopen("plot1.out", "r");

                        read_plot_file(in);

                        fclose(in);

                        unlink("plot1.out");

                        draw_plot_flag=1;

                                }
//repeat the process for plot2.out

                if(access("plot2.out", 0)==0) {

                        in = fopen("plot2.out", "r");

                read_plot_file(in);

                        fclose(in);

                        unlink("plot2.out");

                                }
```

The program looks for plot1.out and plot2.out, files containing data to be plotted on the Plot Viewer screen for the first and second components respectively. After the plot files have been read the InvalidateRect function is used to cause the Output and Plot Viewer windows to be drawn with the output from the current PLL run.

```
//cause the output and plot viewer windows to be painted

                InvalidateRect(hOutputWnd, NULL, TRUE);
                InvalidateRect(hPlotWnd, NULL, TRUE);
```

If the absrules.out file exists, the case declares two 16-bit file handles and uses them to append the ABS Rules calculation data in the absrule.out file to the stress calculation data in the stress.out file. The two files are temporary data files written by the PLL FORTRAN executable.

```
//if absrules.out exists, append the data to stress.out and delete the file

                if(access("absrules.out", 0)==0) {
        char    * buffer;                               //pointer to a character buffer
        int     num_bytes;                              //number of bytes read by _lread
        HFILE   in, out;                                //pointers to files

//allocate memory for reading the files into

        buffer  = (char *) malloc((max_buf_sz)*sizeof (char));
```

After allocating memory to store the absrule.out file data, the _lopen function is used to open the stress.out and absrule.out files. The _lopen function receives the address of the file to open and an access code and returns a file handle. In this case the stress.out file is opened with READ_WRITE access since data will be written to the file. The absrules.out file is opened with READ access. The _llseek function receives a file handle, a number of bytes to move, and a position in the file from which to move. The function moves the file pointer to the position specified, in this case the end of the stress.out file. The _lread function is then used to read in the data from the absrules.out file. The _lread function

receives a handle to a file, a buffer for receiving the data, and the length of the buffer. The function reads the file into the buffer and returns the total number of bytes that were read by the function. The _lwrite function is then used to append the data in the buffer to the stress.out file by writing it at the end of the file. The _lwrite function receives a handle to a file, a pointer to the data to be written, and the number of bytes to write. The _lclose function is then used to close both files.

```
out = _lopen("stress.out", READ_WRITE);
_llseek(out, 0L, 2);
in = _lopen("absrules.out", READ);
num_bytes= _lread(in, buffer, max_buf_sz);
_lwrite(out, buffer, num_bytes);
_lclose(in);
_lclose(out);
                    }
```

The program then reads and deletes a series of temporary data files written by the FORTRAN executable. Some of the files are read by functions written specifically for this application and the rest are read by opening the files with fopen function calls, reading the formatted data with fscanf function calls, and closing the files with fclose function calls. The glauert.coe file contains information about blades that are unloaded using alterations to the sine series coefficients that describe the circulation distribution. The unload.dat file contains data for the other cases. The ear.dat file contains the expanded area ratio for each component. The duct.cir file contains a value for duct circulation. The damp.val file contains a damping value used during the iterative process of calculating duct circulation.

```
//if glauert.coe exists, open it, read it, and then delete it
          if(access("glauert.coe", 0)==0) {
```

```
		in = fopen("glauert.coe", "r");
	read_glauert_file(in);
		fclose(in);
		unlink("glauert.coe");
				}
//if unload.dat exists, open it, read it, and then delete it
	if(access("unload.dat", 0)==0)  {
		in = fopen("unload.dat", "r");
		read_unload_dat_file(in);
		fclose(in);
		unlink("unload.dat");
				}
//if ear.dat exists, open it, read it, and then delete it
	if(access("ear.dat", 0)==0)  {
		in = fopen("ear.dat", "r");
//loop through the components and read the ear data
		for(j=0;j<LDEV;j++)
			fscanf(in,"%f ",&EAR[j]);
		fclose(in);
		unlink("ear.dat");
				}
//if duct.cir exists, open it, read it, and then delete it
	if(access("duct.cir", 0)==0) {
		in = fopen("duct.cir", "r");
		fscanf(in,"%f",&estimated_duct_circulation);
		fclose(in);
		unlink("duct.cir");
```

```
                }
//if damp.val exists, open it, read it, and then delete it
        if(access("damp.val", 0)==0) {
                in = fopen("damp.val", "r");
                fscanf(in,"%f",&damping);
                fclose(in);
                unlink("damp.val");
                }
```

If the optim.dat exists, the program opens the file and reads the data character by character into a local character array using the getc function. The data is then presented to the user in a message box. The getc function receives a pointer to a file structure and returns the next character from the stream converted into an integer value.

```
//check for the optim.dat file, which contains the optimization results for
// the optimize rpm or diameter case, print the results in a message box
// and delete the file
    if(access("optim.dat",0) == 0)  {
    char    string[240]="";                  //string for storing opt result
    int     nextchar=0,                      //integer for reading data
                                                 // character by character
            i=0;                             //character counter

//open the optim.dat file
                in = fopen("optim.dat", "r");
//read the string character by character until reaching end of file
                nextchar = getc(in);
                while(nextchar!=EOF){
                string[i]=nextchar;
                i++;
```

```
                    nextchar = getc(in); }
//put in a terminator at the end of the string
                    string[i]='\0';
//close and delete the optim.dat file
                    fclose(in);
                    unlink("optim.dat");
//print the results if a MessageBox
                    MessageBox(hWnd, string, "OPTIMIZATION RESULT",
                                   MB_ICONINFORMATION | MB_OK |
MB_TASKMODAL);
                              }
                         }
```

The case then checks for the existence of a file written by the PBD FORTRAN executable to indicate that a PBD run is complete. If the file is found to exist, the case deletes the file, sets a flag that indicates that PBD has been run, and if there is no PLL output, adjusts flags that control the data drawn on the Output and Plot Viewers so that the PBD data is displayed. The case then returns a zero value to indicate that the message was handled.

```
//if the "pbd.dne" file exists, delete it and check if there is pll data to
// plot, if there is not then set the plot_page to 4 so the pbd plots will
// be displayed on the plot viewer and set the output flag to pbdktq so the
// pbdout.ktq file will be displayed on the output viewer

        if(access("pbd.dne", 0) == 0)  {

//delete the pbd.dne file, adjust the draw plot and output flags and set the
//  pbd flag

                unlink("pbd.dne");

                if(!draw_plot_flag) plot_page=4;

                if(access("summary.out", 0) != 0) output_flag = pbdktq;

//set the pbd_flag to indicate that pbd has been run

                pbd_flag = 1;

                         }
```

```
return 0;

                    }
```

The WM_DESTROY case handles requests made to exit the program by methods other than the File|Exit selection on the main menu. It responds by sending a IDM_EXIT command to the WMCommandHandler function and returning zero to indicate that the message was handled.

```
        case WM_DESTROY : {

//this case handles requests to exit the program made by methods other than
// the main menu

            SendMessage(hWnd,WM_COMMAND,IDM_EXIT,MAKELONG(0,0));

        return 0;
                    }

        }

//refer messages not handle by this frame procedure to the Windows default
// frame procedure

        return DefFrameProc (hWnd, hMDIClientWnd, message, wParam, lParam);

}
```

C.1.3 The PLL WMCommand_Handler function.

The WMCommand_Handler function for PLL is very similar to the VLMLE and VLL WMCommand_Handler functions. It is shown below in a series of segments, with a narrative discussion of the code interspersed throughout the segments.

The function consists mainly of a switch that handles requests made by the user with the main menu.

```
void WMCommand_Handler(HWND hWnd, int id, HWND hwndCtl, UINT codeNotify)
{
```

```
switch (id)
{
case IDM_RUN_PBD : {
```

The IDM_RUN_PBD case uses the OPEN common dialog box. First, a series of character strings used to initialize the dialog box and return information such as the title of the file selected by the user and the complete path of the file are initialized. A destination file, PBDADMIN.NAM, is declared. The file returned by the dialog box is copied into this file. The PBD FORTRAN executable is coded to use this file title as the main administrative file.

```
//this case handles main menu requests to run MIT-PBD

        OPENFILENAME ofn;                          //openfilename structure used with
                                                   // GetOpenFileName function
        char    szFile[256]="\0",                  //name and location of the file
                                                   // to open
                szFileTitle[256],                  //name of file to open
                szFilter[]=                        //filter for list box
                "PBD Files (*.PBD)\0*.PBD\0",
                szDst[] = "PBDADMIN.NAM";          //file to copy selected file into
```

The case also declares two OFSTRUCT structures. An OFSTRUCT is used to return information regarding a file that has been opened by a call to the LZOpenFile function. In this instance a source and a destination structure are declared.

```
        OFSTRUCT     ofStrSrc,                         //source and destination
open file
                     ofStrDest;                    // structures

        HFILE  hfSrcFile,                          //source and destination file
handles
               hfDstFile;
```

The IDM_RUN_PBD case then deletes the previously existing CURRPBD.PBD and PBDADMIN.NAM files. The CURRPBD.PBD file is written by PLL using the current settings in the PBD Settings and PBD Skew/Rake Settings and the current PLL project and is made available to the user in the SELECT PBD ADMIN FILE dialog box. If a B-spline input file exists for the component indicated by the pbd_component variable

and a velocity file has been written for the current project, the write_pbd_admin_file function is called. This function writes the CURRPBD.PBD file.

```
//delete pre-existing currpbd.pbd, the pbd admin file written by PLL, and
// pbdadmin.nam, the file that the selected admin file is copied into for
// use by PBD

        unlink("CURRPBD.PBD");
        unlink("PBDADMIN.NAM");

//if a project is currently open and blade and velocity files are available,
// write a pbd admin file (currpbd.pbd)

        if(project_flag&&(access("currpbd1.bsn", 0) == 0)&&(pbd_component==0)&&
                (access("currpbd.vel", 0) == 0)) write_pbdadmin_file();

        if(project_flag&&(access("currpbd2.bsn", 0) == 0)&&(pbd_component==1)&&
                (access("currpbd.vel", 0) == 0)) write_pbdadmin_file();
```

The case then initializes the OPENFILENAME structure, ofn. The initialized variables include the size of the OPENFILENAME structure in bytes, the handle of the window that owns the dialog box, the address of the filter used for selecting files to display in the list box, the address of strings for receiving the file title and path and the size of those strings, the title of the dialog box, and flags that govern the operation of the dialog box. The OFN_FILEMUSTEXIST flag causes the dialog box to require that the selected file must exist. The OFN_HIDEREADONLY flag hides the read only check box.

```
//initialize the OPENFILENAME parameters

        memset(&ofn, 0, sizeof(OPENFILENAME));

                ofn.lStructSize         = sizeof(OPENFILENAME);
                ofn.hwndOwner           = hWnd;
                ofn.lpstrFilter         = szFilter;
                ofn.lpstrFile           = szFile;
                ofn.nMaxFile            = sizeof(szFile);
                ofn.lpstrFileTitle      = szFileTitle;
                ofn.lpstrTitle          = "SELECT PBD ADMIN FILE";
                ofn.nMaxFileTitle       = sizeof(szFileTitle);
                ofn.Flags               = OFN_FILEMUSTEXIST|OFN_HIDEREADONLY;
```

The GetOpenFileName function is then used to call the dialog box. If the dialog box terminates successfully, the LZOpenFile function is used to open the file returned by the

dialog box. The LZOpenFile function receives the address of the filename of the file to be opened, a pointer to a OFSTRUCT, and an unsigned integer which indicates the required action. The function opens for reading or creates and opens the file as indicated, fills the OFSTRUCT, and returns a handle to the file. The OFSTRUCT structure contains information including the length of the file in bytes and the path of the file.

```
//if the dialog is used successfully to choose a file, execute the code in the braces
        if (GetOpenFileName(&ofn)) {
//open the source file
                hfSrcFile =     LZOpenFile(ofn.lpstrFileTitle, &ofStrSrc, OF_READ);
//create the destination file
                hfDstFile =     LZOpenFile(szDst, &ofStrDest, OF_CREATE);
```

After the source and destination files are open, the LZCopy function is used to copy the file returned by the dialog box to PDDADMIN.NAM and the LZClose function is used to close both files. The LZCopy function receives handles to the source and destination files and returns the size of the destination file in bytes. The LZClose function receives the handle of the file to be closed and does not return a value.

```
//copy the source file to the destination file
                LZCopy(hfSrcFile, hfDstFile);
//close the files
                LZClose(hfSrcFile);
                LZClose(hfDstFile);
```

The IDM_RUN_PBD case then deletes previously existing PBD output files using the delete_files function and calls the PBD FORTRAN executable using the WinExec function. The PBD program information file, pbd.pif causes the pbdfort.exe program to be run in a window and the SW_SHOWMINIMIZED flag causes the window to be created and displayed in an iconified state. The case does not wait for the termination of

the FORTRAN executable, but rather uses the break statement to terminate the case allowing the user to continue to use the application while the FORTRAN executable runs in the background. The user may also elect to maximize the window in which the FORTRAN executable is running and observe the screen output provided. The screen output from the original version is left largely intact and will look very familiar to experienced PLL users.

```
//delete pre-existing pbd output files
                delete_files(pbd_files);

//run the pbdfort.exe fortran program in an iconified window
                WinExec("pbd.pif",SW_SHOWMINIMIZED );
                        }

        break;
                }
```

The IDM_MITPLLHELP case starts the Windows™ MIT-PLL Help program. The program is started using the WinExec function, and displayed in its default window size using the SW_SHOW window state. If the WinExec function is unsuccessful, it returns a value less than 32. The case checks the return value of the WinExec function and if the value is less than 32, changes to the \help subdirectory and attempts again to run the MIT-PLL Help program. If the WinExec function is again unsuccessful, an error message is printed. In either case the directory is changed back to the original directory using the chdir function. The chdir function changes the current working directory to the specifed path and returns negative one if unsuccessful and 0 if successful.

```
        case IDM_MITPLLHELP: {
//this case handles main menu request for the help program
//if the WinExec function is unsuccessful, change to the \help directory and
```

```
// try again

        if(WinExec("pllhelp.exe",SW_SHOW)<32){

                chdir("\help");

//if WinExec is again unsuccessful, print an error message and change back
// to the original directory

                if (WinExec("pllhelp.exe",SW_SHOW)<32) {

                        MessageBeep(MB_ICONEXCLAMATION);

                        MessageBox(hWnd, "An error occured when starting \
the MIT-PLL Help Program.","ERROR!", MB_ICONSTOP | MB_OK | MB_TASKMODAL);

                                                }
                        chdir("..");

                                        }

        break;

                        }
```

The IDM_OPENPROJECT allows the user to select and open a pre-existing PLL project file using the OPEN common dialog box. As in the IDM_RUN_PBD case, character strings and an OPENFILENAME structure are declared for use with the OPEN common dialog box. Additionally, a character string, buffer, a loop counter, M, and a pointer to a file structure, *in, are declared.

```
        case IDM_OPENPROJECT:{

        OPENFILENAME ofn;                               //openfilename structure used with
                                                        // GetOpenFileName function
        char    szFile[256]="\0",                       //name and location of the file
                                                        // to open
                szFileTitle[256],                       //name of file to open
                szFilter[]= "PRJ Files (*.PRJ)\0*.PRJ\0",  //filter for list box
                buffer[120];                            //buffer for writing output

        int     M;                                      //loop counter

        FILE    *in;                                    //pointer to a file structure

//initialize the OPENFILENAME parameters
```

```
memset(&ofn, 0, sizeof(OPENFILENAME));

        ofn.lStructSize =        sizeof(OPENFILENAME);
        ofn.hwndOwner =          hWnd;
        ofn.lpstrFilter =        szFilter;
        ofn.lpstrFile=           szFile;
        ofn.nMaxFile =           sizeof(szFile);
        ofn.lpstrFileTitle =     szFileTitle;
        ofn.nMaxFileTitle =      sizeof(szFileTitle);
        ofn.Flags=               OFN_FILEMUSTEXIST|OFN_HIDEREADONLY;

//if the dialog is used successfully to choose a file, execute the code in the braces

    if (GetOpenFileName(&ofn)) {
```

After the OPENFILENAME structure is initialized, the GetOpenFileName function is to call the Open dialog box. If the function does not return successfully, the bulk of code is skipped and the case is terminated. If the function does return successfully the initialize function is called and the project_flag variable is set to indicate that a project is open. The initialize function is used to reinitialize global variables that are initialized when the MIT-PLL program is started.

```
//run the initialize function to initialize the global variables

            initialize();

//set the project_flag to indicate that a project is now open

            project_flag = 1;
```

The case then opens the file returned in the OPENFILENAME structure, writes the filename to the PROJECTFILE character string variable, reads the project file by calling the read_project_file function and closes the project file.

```
//open the project file returned in the OPENFILENAME structure

            in = fopen(ofn.lpstrFileTitle,"r");

//write the file name into the PROJECTFILE variable

            sprintf(PROJECTFILE, "%s",ofn.lpstrFileTitle);

//read the project file, and close the file
```

```
read_project_file(in);

fclose (in);
```

The IDM_OPENPROJECT case then opens the input file specified in the project file. If the input file does not exist or for some other reason can not be opened, a warning is printed, the project_flag variable is cleared, and the case is terminated. Otherwise, the input file is read by calling the read_input_file function and closed using the fclose function.

```
//open and read the input file, print an error message if unable

        if ((in = fopen(INPUTFILE, "r"))== NULL) {

                MessageBeep(MB_ICONEXCLAMATION);

                MessageBox(hWnd, "Unable to open input file.",
                "ERROR!", MB_ICONSTOP | MB_OK | MB_TASKMODAL);

//clear the project_flag to indicate that a project is not open

                project_flag = 0;

                break;
                                        }

        read_input_file(in);

//close the input file

        fclose(in);
```

The case now uses a for statement to loop through the components, where LDEV is an integer variable equal to one for the single component case and two for the multiple component case, and read the blade and wake input files specified in the input file. If for some reason any of the input files can not be opened, a warning is displayed in a message box, the project_flag is cleared, and the case is terminated. The read_blade_file and read_wake_file functions are used to read the blade and wake input files. The minimum chord/diameter values for each component are set equal to the root chord/diameter values supplied in the blade files at the end of the loop.

```
//loop through the components and read the blade and wake files

		for(M=0;M<LDEV;M++){

			if ((in = fopen(BLDIN[M*21], "r"))== NULL) {

//print an error message if unable to open the blade file

				MessageBeep(MB_ICONEXCLAMATION);

				sprintf(buffer,"Unable to open blade file #%d.",M+1);

				MessageBox(hWnd, buffer,
				"ERROR!", MB_ICONSTOP | MB_OK | MB_TASKMODAL);

//clear the project_flag to indicate that a project is not open

				project_flag = 0;

		break;
								}

			read_blade_file(in,M);

			fclose(in);
			if ((in = fopen(WKIN[M*21], "r"))== NULL) {

//print an error message if unable to open the wake file

				MessageBeep(MB_ICONEXCLAMATION);

				sprintf(buffer,"Unable to open wake file #%d.",M+1);

				MessageBox(hWnd, buffer,
				"ERROR!", MB_ICONSTOP | MB_OK | MB_TASKMODAL);

//clear the project_flag to indicate that a project is not open

				project_flag = 0;

				break;
								}

			read_wake_file(in,M);

			fclose(in);

			HUBCHD[M] = XCHD[0][M];

				}
```

If the project has more than one component, the contraction ratio of the wake is set based on the same logic as is used in the original PLL version. This is done for the purpose of initializing the manual contraction ratio in the Default Settings dialog box with an appropriate value.

```
//if there is more than one component, set the contraction ratio
        if(LDEV>1) {
                if(image_duct=='Y')
                        CONRAT = 1.0;
                else{
                        if(fabs(RPM[2])<0.01){
                                if(XDLOC[0]>XDLOC[1])
                                        CONRAT = 1.0;
                                else
                                        CONRAT = 0.83;
                                }
                        else
                                CONRAT = 0.83;
                }
                }
```

Since a new project is now open, the pbd_flag variable is cleared to indicate that the current PLL project has not yet been run in PBD. The position of the vertical scroll bar is reset to the top by setting the Scroll_Pos integer value to zero and calling the SetScrollPos function. The SetScrollPos function receives the handle of the window with the scroll bar that is to be positioned, a flag that indicates in this case that the vertical scroll bar is the bar that is to be operated on, the position of the scroll box inside the scroll range, and a logical flag that indicates in this case that the scroll bar is to be repainted. The function causes the scroll box, also known as the thumb, to be moved to the indicated position and causes the scroll bar to be repainted.

```
//clear the pbd flag since the currently open project has not been run in PBD

        pbd_flag = 0;

//reset the vertical scroll bar position

        Scroll_Pos = 0;
        SetScrollPos(hOutputWnd, SB_VERT, Scroll_Pos, TRUE);
```

As a final action, the case uses the InvalidateRect function to cause the four child windows to be repainted. This causes the new blade and wake data to be displayed and causes the Output and Plot Viewer windows to be cleared. The case is then terminated.

```
//cause the screens to be repainted

        InvalidateRect(hBladeWnd, NULL, TRUE);
        InvalidateRect(hWakeWnd, NULL, TRUE);
        InvalidateRect(hOutputWnd, NULL, TRUE);
        InvalidateRect(hPlotWnd, NULL, TRUE);

                                    }

        break;

                            }
```

The IDM_EDITBLADEWAKE case is identical in function to the IDM_MITPLLHELP case. In this case the MIT-PLL Editor program is started in response to the Edit|Blade/Wake selection on the main menu.

```
        case IDM_EDITBLADEWAKE : {

//this case handles main menu request for the edit program

//if the WinExec function is unsuccessful, change to the \edit directory and try again

                if(WinExec("plledit.exe",SW_SHOW)<32){

                chdir("\edit");

//if WinExec is again unsuccessful, print an error message and change back
// to the original directory

                        if (WinExec("plledit.exe",SW_SHOW)<32) {

                                MessageBeep(MB_ICONEXCLAMATION);
```

```
                                MessageBox(hWnd, "An error occured when \
starting the MIT-PLL Editor Program.",
                                "ERROR!", MB_ICONSTOP | MB_OK | MB_TASKMODAL);

                                                    }
                                chdir("..");


                                }

        break;

                                }
```

The IDM_EDITPROJECT checks the project flag and prints a warning message if the user selects Edit|Project Settings from the main menu with no open project. If a project is open, the case tests LDEV and calls the appropriate dialog box based on the number of components in the project.

```
        case IDM_EDITPROJECT : {

        DLGPROC         DlgProc;                                    //pointer to a dialog
procedure

//if no project is open, print a warning message and terminate the case

                if(!project_flag){

                MessageBeep(MB_ICONEXCLAMATION);

                MessageBox(hWnd, "A project must be open in order to be edited.",
                "WARNING!", MB_ICONSTOP | MB_OK | MB_TASKMODAL);

                break;

                        }

//call the appropriate Project dialog box, depending on the number of components

                        if(LDEV <2){

                DlgProc = (DLGPROC)MakeProcInstance((FARPROC)Project1DlgProc, ghInstance);

                DialogBox(ghInstance, "PROJECT1", hWnd, DlgProc);

                                }

                        else {
```

```
DlgProc = (DLGPROC)MakeProcInstance((FARPROC)Project2DlgProc, ghInstance);
DialogBox(ghInstance, "PROJECT2", hWnd, DlgProc);
        }
FreeProcInstance((FARPROC)DlgProc);
break;
        }
```

The IDM_TILE, IDM_CASCADE, and IDM_ARRANGE cases respond to the Window|Tile, Window|Cascade, and Window|Arrange Icons selections on the main menu. They use the SendMessage function to send the appropriate message to the MDI Client Window to cause the child windows to be til·d or cascaded, or the iconified windows to be arranged.

```
case IDM_TILE : {
//send a message the the MDI client window to tile the child windows
        SendMessage(hMDIClientWnd, WM_MDITILE, 0, 0L);
break;
    }
case IDM_CASCADE : {
//send a message the the MDI client window to cascade the child windows
        SendMessage(hMDIClientWnd, WM_MDICASCADE, 0, 0L);
break;
    }
case IDM_ARRANGE : {
//send a message the the MDI client window to arrange the child window icons
        SendMessage(hMDIClientWnd, WM_MDIICONARRANGE, 0, 0L);
break;
    }
```

The IDM_RUN case responds to main menu File|Run requests. The OPENFILENAME, character, HFILE and OFSTRUCT declarations are made to support the use of the OPEN common dialog box in selecting a non-axisymmetric stator file if necessary. The DLGPROC variable is used for calling dialog boxes necessary for executing a variety of runtime options, in addition to calling the Runtime Settings dialog box. A pointer to a file structure is also declared, as well as a number of loop counters and a dummy variable for testing the value of the circulation distribution sine series coefficients.

```
        case IDM_RUN : {
//this case handles to run MIT-PLL

        DLGPROC         DlgProc;                                        //pointer to a dialog
procedure

        OPENFILENAME ofn;                               //openfilename structure used with
                                                        // GetOpenFileName function
        char    szFile[256]="\0",                       //name and location of the file
                                                        // to open
                szFileTitle[256],                       //name of file to open
                szFilter[]= "STA Files (*.STA)\0*.STA\0",       //filter for list box
                szDst[] = "STATOR.DAT";                 //file to copy selected file into

        OFSTRUCT        ofStrSrc,                               //source and destination
open file
                        ofStrDest;                      // structures

        HFILE   hfSrcFile,                              //source and destination file
handles
                hfDstFile;

        int     k, M, i,j,                              //loop counters
                circ_check=0;                           //dummy integer for checking for
                                                        // non-zero circ distribution

        FILE    *out;                                   //pointer to a file structure
```

The case first tests the project_flag. If no project is open a warning message is displayed and the case is terminated. If a project is open, the Runtime Settings dialog box is then called and the user is allowed to select from a variety of run time options.

```
if(!project_flag) {

MessageBeep(MB_ICONEXCLAMATION);

MessageBox(hWnd, "A project must be open in order to be run.",
        "WARNING!", MB_ICONSTOP | MB_OK | MB_TASKMODAL);

break; }


DlgProc = (DLGPROC)MakeProcInstance((FARPROC)RunTimeDlgProc, ghInstance);
DialogBox(ghInstance, "RUNTIME", hWnd, DlgProc);
FreeProcInstance((FARPROC)DlgProc);
```

When the Runtime Settings dialog box terminates, the case tests the run_ok_flag and terminates the case if the user selected the CANCEL button. If the OK button was selected, the delete_files and unlink functions are used to delete pre-existing temporary data files.

```
//if the cancel button is selected on the runtime dialog box, terminate the case

        if(run_ok_flag) break;

//delete pre-existing temporary data files

        delete_files(pll_files);

        unlink("currpbd.err");
        unlink("currpbd.ebs");
        unlink("optim.dat");
```

The case then sets variables that control the way data is displayed in the Wake, Output, and Plot Viewer windows. The Scroll_Pos variable was discussed previously. The component_flag variable determines which wake file is diplayed in the Wake Viewer window. The draw_plot_flag variable determines whether or not plots will be drawn in the Plot Viewer window. The output_flag variable determines which output page is displayed in the Output Viewer window. The plot_page flag variable determines which page will be plotted in the Plot Viewer window, and the plot_component_flag variable determines whether component one or two or both will be displayed.

```
//re-initialize the flags that control output and plot viewer plotting
```

```
// routines and cause the output and plot viewers to be redrawn

        Scroll_Pos = 0;
        component_flag=0;
        draw_plot_flag=0;
        output_flag=0;
        plot_page=0;
        plot_component_flag=0;
```

The scroll bar position is then reset and the Output Viewer and Plot Viewer windows are cleared since the data displayed there is no longer applicable.

```
        SetScrollPos(hWnd, SB_VERT, Scroll_Pos, TRUE);

        InvalidateRect(hOutputWnd, NULL, TRUE);
        InvalidateRect(hPlotWnd, NULL, TRUE);
```

The IDM_RUN case now tests the circulation_optimization_flag variable to determine if the user has chosen to optimize circulation. If not, the case uses a for loop to check the absolute values of the circulation distribution from the blade file(s) to ensure that a non-zero distribution has been supplied by the user. If the user supplied a zero circulation distribution then the circulation_optimization_flag is set by the program and a warning message is displayed.

```
//if the circulation optimization flag is not set, ensure that a non-zero
// circulation distribution has been input for both components, otherwise
// set the flag and print a warning

        if(!circulation_optimization_flag) {

//loop through the components

                for(M=0;M<LDEV;M++)

//loop through the radii for each component

                        for(k=0;k<MRPIN[M];k++)

//increment the circ_check variable

                                if(fabs(XG[k][M])>del)

                                        circ_check++;

        if(!circ_check){
```

```
circulation_optimization_flag = 1;

MessageBeep(MB_ICONEXCLAMATION);

MessageBox(hWnd, "Blade circulation input must be non-zero \
or Circulation Optimization must be selected. Circulation Optimization now \
selected.",
"WARNING!", MB_ICONSTOP | MB_OK | MB_TASKMODAL);

}
}
```

The case proceeds to check a variety of run time options and perform the necessary actions. The first is the option to use the current blade data as input data. If this option is selected, the program tests to see if the project is a ringed propeller. If it is, a warning message is printed since this option is not currently available for ringed propellers.

```
//if the reset blade data option is selected and the propulsor is ringed, print a warning

if(use_curr_blade){

if(ringed_propeller[0]=='Y'){

MessageBeep(MB_ICONEXCLAMATION);

MessageBox(hWnd, "The reset blade data option is not available for \
ringed propulsors. Continuing with normal run.",
"WARNING!", MB_ICONSTOP | MB_OK | MB_TASKMODAL);

}
}
```

The case then calls the write_misc_files function. This function writes a number of short data files based on the current project settings. The files are used to provide input to the PLL FORTRAN executable.

```
//write the misc output files that provide input to the fortran executable

write_misc_files();
```

If the user has elected to evaluate a non-axisymmetric stator, the STATOR.DAT file is deleted if it exists and the Select Stator File dialog box is called to allow the user to select a stator file.

```
//if the evaluate nonaxisymmetric stator selection is made on the runtime
// dialog box, allow the user to select a data file

        if(eval_nonaxi_stator) {

//delete the pre-existing data file

                unlink("STATOR.DAT");

//initialize the OPENFILENAME parameters

                memset(&ofn, 0, sizeof(OPENFILENAME));

                ofn.lStructSize         = sizeof(OPENFILENAME);
                ofn.hwndOwner           = hWnd;
                ofn.lpstrFilter         = szFilter;
                ofn.lpstrFile           = szFile;
                ofn.nMaxFile            = sizeof(szFile);
                ofn.lpstrFileTitle      = szFileTitle;
                ofn.lpstrTitle          = "SELECT STATOR FILE";
                ofn.nMaxFileTitle       = sizeof(szFileTitle);
                ofn.Flags               = OFN_FILEMUSTEXIST|OFN_HIDEREADONLY;
```

If the GetOpenFileName function returns successfully, the stator file selected by the user is copied into the STATOR.DAT file. The eval_nonaxi_stator variable is then cleared and the no_runtime_options flag is set so that there is no run time option selected the next time the Runtime Settings dialog box is called.

```
//if the dialog is used successfully to choose a file, execute the code in the braces

                if (GetOpenFileName(&ofn)) {

//open the source file

                hfSrcFile = LZOpenFile(ofn.lpstrFileTitle, &ofStrSrc, OF_READ);

//create the destination file

                hfDstFile = LZOpenFile(szDst, &ofStrDest, OF_CREATE);

//copy the source file to the destination file

                LZCopy(hfSrcFile, hfDstFile);
```

```
//close the files

                LZClose(hfSrcFile);
                LZClose(hfDstFile);

                                        }

//reset the run time options

                eval_nonaxi_stator = 0;
                no_runtime_options = 1;

                                }
```

The next runtime option handled is the Unload Component(s) option. If the unload_flag variable is set, the unload.set file is opened and written for use by the FORTRAN executable. A switch handles the two cases, single and multiple component propulsors.

```
//if the unload flag is set, call the appropriate dialog box and write a file with either the Glauert coefficient
// unload fractions or the hub and tip steepness exponents and coefficients

        if(unload_flag){

//open the unload settings flag

                out = fopen("unload.set", "w");

                switch(LDEV)
                {
        case 1 : {
```

If the current project has a single component, case 1 is executed. If there is no image hub and the component is not ringed and there is no zero gap duct, the GLAUERT1 dialog box is called. This allows the user to view the sine series coefficients that describe the current circulation distribution and to alter them in order to unload the blades. The data input by the user is then written to the unload.set file.

```
//if there is no image hub and the component is not ringed and there is no image duct, or there is an image
// duct and the gap is wide enough, then call the Glauert 1 dialog box and write the unload fractions

                if((image_hub!='Y') && (ringed_propeller[0]!='Y') &&
```

```
((image_duct!='Y') || ((image_duct=='Y') &&
        ((DDIAM-XDIAM[0]) >= 0.000002 ) ))) {

DlgProc = (DLGPROC)MakeProcInstance((FARPROC)Glauert1DlgProc, ghInstance);
DialogBox(ghInstance, "GLAUERT1", hWnd, DlgProc);
FreeProcInstance((FARPROC)DlgProc);

//write the file

        fprintf(out,"%d\n",NGC);

        for(i=0;i<NGC;i++)

                fprintf(out,"%f\n",GC_UNLOAD_FRAC[0][i]);

                                                }
```

If the above condition was not met, the Steep1 dialog box is called to allow the user to select steepness exponents with which to unload the hub and/or tip. The hub and tip unload percentages are then calculated using the same scheme as the original PLL version and the Coefficient1 dialog box is called in order to allow the user to select unload coefficients. The unload.set file is written with the user supplied exponents and coefficients.

```
//if the condition above is not met, then call the Steep 1 dialog box and then the Coefficient 1 dialog box
// and then write the file

        else {

        DlgProc = (DLGPROC)MakeProcInstance((FARPROC)Steep1DlgProc, ghInstance);
        DialogBox(ghInstance, "STEEP1", hWnd, DlgProc);
        FreeProcInstance((FARPROC)DlgProc);

//calculate the hub and tip unload percentages

        Q = ( hub_radius[0] - RZ[0] )/( 1.0 - RZ[0] );

        if(image_hub=='Y') {

                OMQSQ = 1.0 - Q*Q;
                GNHC[0] = 100.0*sqrt(OMQSQ)*pow(OMQSQ,(2*NHC[0]-2));
                        }
        else {
                P = 1.0 - Q;
                OMPSQ = 1.0 - P*P;
                GNHC[0] = 100.0*sqrt(OMPSQ)*pow(P,(2*NHC[0]-2));
        }
```

```
Q = ( tip_radius[0] - RZ[0] )/( 1.0 - RZ[0] );

if((ringed_propeller[0]=='Y')||
    ((image_duct=='Y')&&(( DDIAM - XDIAM[0])< 0.000002 ))){

        P = 1.0 - Q;
        OMPSQ = 1.0 - P*P;
        GNTC[0] = 100.0*sqrt(OMPSQ)*pow(OMPSQ,(2*NTC[0]-2));
                                                        }
else {
        OMQSQ = 1.0 - Q*Q;
        GNTC[0] = 100.0*sqrt(OMQSQ)*pow(Q,(2*NTC[0]-2));
        }
//call the COEFFICIENT1 dialog box

DlgProc = (DLGPROC)MakeProcInstance((FARPROC)Coefficient1DlgProc,
            ghInstance);
DialogBox(ghInstance, "COEFFICIENT1", hWnd, DlgProc);
FreeProcInstance((FARPROC)DlgProc);

//write the file

fprintf(out,"%d\n%f\n%d\n%f\n",hub_steepness[0],
hub_coefficient[0], tip_steepness[0], tip_coefficient[0]);

}

break;
        }
```

The multiple component case is analogous to the single component case. For loops are used for the calculations and writing the unload.set file.

```
case 2: {

//if there is no image hub and the components are not ringed and there is no image duct, or there is an
image
// duct and the gaps are wide enough, then call the Glauert 2 dialog box and write the unload fractions

        if((image_hub!='Y')&&(ringed_propeller[0]!='Y') &&
            (ringed_propeller[1]!='Y')&&((image_duct!='Y')||
            ((image_duct=='Y')&&
            (((DDIAM-XDIAM[0])>=0.000002)&&
            ((DDIAM-XDIAM[1])>=0.000002))))) {

DlgProc = (DLGPROC)MakeProcInstance((FARPROC)Glauert2DlgProc, ghInstance);
DialogBox(ghInstance, "GLAUERT2", hWnd, DlgProc);
FreeProcInstance((FARPROC)DlgProc);

fprintf(out,"%d\n",NGC);

//write the file
```

```
for(j=0;j<LDEV;j++){

        for(i=0;i<NGC;i++) {

                fprintf(out,"%f\n",GC_UNLOAD_FRAC[j][i]);

                        }
                }
                                        }

//if the condition above is not met, then call the Steep 2 dialog box and then the Coefficient 2 dialog box
// and then write the file

        else {

DlgProc = (DLGPROC)MakeProcInstance((FARPROC)Steep2DlgProc, ghInstance);
DialogBox(ghInstance, "STEEP2", hWnd, DlgProc);
FreeProcInstance((FARPROC)DlgProc);

//calculate the hub and tip unload percentages

for(i=0;i<LDEV;i++){

        Q = ( hub_radius[i] - RZ[i] )/( 1.0 - RZ[i] );

        if(image_hub=='Y') {

                OMQSQ = 1.0 - Q*Q;
                GNHC[i] = 100.0*sqrt(OMQSQ)*pow(OMQSQ,(2*NHC[i]-2));

                        }
        else {

                P = 1.0 - Q;
                OMPSQ = 1.0 - P*P;
                GNHC[i] = 100.0*sqrt(OMPSQ)*pow(P,(2*NHC[i]-2));
                }
        Q = ( tip_radius[i] - RZ[i] )/( 1.0 - RZ[i] );

        if((ringed_propeller[i]=='Y')||
                ((image_duct=='Y')&&
                (( DDIAM - XDIAM[i])< 0.000002 ))) {

                P = 1.0 - Q;
                OMPSQ = 1.0 - P*P;
                GNTC[i] = 100.0*sqrt(OMPSQ)*
                        pow(OMPSQ,(2*NTC[i]-2));

                                        }

        else {

                OMQSQ = 1.0 - Q*Q;
```

```
                GNTC[i] = 100.0*sqrt(OMQSQ)*
                        pow(Q,(2*NTC[i]-2));
                }

                }

        DlgProc = (DLGPROC)MakeProcInstance((FARPROC)Coefficient2DlgProc,
                ghInstance);
        DialogBox(ghInstance, "COEFFICIENT2", hWnd, DlgProc);
        FreeProcInstance((FARPROC)DlgProc);

        for(i=0;i<LDEV;i++)

                fprintf(out,"%d\n%f\n%d\n%f\n",hub_steepness[i],
        hub_coefficient[i], tip_steepness[i], tip_coefficient[i]);

                }
        break;

            }
    }
```

After the single and multiple component cases are handled, the case clears the unload_flag, sets the no_runtime_options flag, and closes the unload.set file.

```
//reset the run time options and close the unload settings file

        unload_flag = 0;
        no_runtime_options = 1;

        fclose(out);

            }
```

The option to match an expanded area ratio is the next option handled by the IDM_RUN case. If the match_EAR_flag is set, the single or multiple component EAR dialog box is called as appropriate. The ear.set file is then written and the match_EAR_flag is cleared.

```
//if the user selected the match EAR option, call the appropriate EAR dialog
// box and write the ear.set file

    if(match_EAR_flag){

        if(LDEV==1){

            DlgProc = (DLGPROC)MakeProcInstance((FARPROC)EAR1DlgProc,
```

```
                ghInstance);
            DialogBox(ghInstance, "EAR1", hWnd, DlgProc);

        }
        else{

            DlgProc = (DLGPROC)MakeProcInstance((FARPROC)EAR2DlgProc,
                ghInstance);
            DialogBox(ghInstance, "EAR2", hWnd, DlgProc);

        }

        FreeProcInstance((FARPROC)DlgProc);

        out = fopen("ear.set", "w");

        for(j=0;j<LDEV;j++)

            fprintf(out,"%f\n",EAR[j]);

//reset the run time options and close the setting file

        match_EAR_flag = 0;
        no_runtime_options = 1;

        fclose(out);

            }
```

If the option to maximize thrust for a given torque and determine ship speed option is selected, the maximize_thrust flag is cleared. If the project is a multiple component propulsor a warning message is printed since the option is not available for multiple component propulsors.

```
//if the maximize thrust for given torque and determine ship speed option is
// chosen, reset the runtime options and print a warning message if there is
// more than one component

    if(maximize_thrust){

        maximize_thrust = 0;
        no_runtime_options = 1;

    if(LDEV>1){

        MessageBeep(MB_ICONEXCLAMATION);

        MessageBox(hWnd, "The Maximize Thrust option is not available for \
multiple component propulsors.  Continuing with normal run.",
        "WARNING!", MB_ICONSTOP | MB_OK | MB_TASKMODAL);
```

```
        }
        }
```

If the user has elected to optimize RPM or diameter, a test is made to determine if the project is a ringed propeller or if the project has a duct. If the project is not a ringed propeller and has no duct, the Optimization Data dialog box is called and the user may select the component to optimize. The user must specify a required thrust to optimize for and in the case of a contra-rotating propulsor must specify a torque coefficient. The OPTIM.DAT file is then written to provide the user supplied data to the FORTRAN executable and the run time option is cleared.

```
//if the user selected the optimize RPM or diameter option, call the optimization
// dialog box

        if(optimize_rpm||optimize_diameter){

//the optimization procedures can not be used for ringed or ducted propulsors

            if(ringed_propeller[0]!='Y'&&image_duct!='Y'){


                DlgProc = (DLGPROC)MakeProcInstance((FARPROC)OPTIMIZATIONDlgProc,
                            ghInstance);
                DialogBox(ghInstance, "OPTIMIZATION", hWnd, DlgProc);

                FreeProcInstance((FARPROC)DlgProc);


                out = fopen("OPTIM.DAT", "w");

                    fprintf(out,"%d\n",opt_comp);
                    fprintf(out,"%f\n",thrust_req);
                    fprintf(out,"%f\n",torq_coeff);

//reset the run time options and close the data file

                    optimize_rpm = 0;
                    optimize_diameter = 0;
                    no_runtime_options = 1;

                    fclose(out);


                }
```

If the project is a ringed or ducted propulsor, a warning message is written into the OPTIM.DAT file for display after the run is complete and the run time option is cleared. Since the options.set file was previously written assuming that the RPM or diameter would be optimized, the file is rewritten with no runtime option.

```
        else{

                out = fopen("OPTIM.DAT", "w");

                        fprintf(out,"Optimization procedures can not be \
used for ringed or ducted propulsors");

                        fclose(out);

                        optimize_rpm = 0;
                        optimize_diameter = 0;
                        no_runtime_options = 1;

        out = fopen("options.set", "w");

                                fprintf(out,"99\n");
                                fprintf(out,"%f\n", horsepower);
                                fprintf(out,"%f\n", thrust_coefficient);

        fclose(out);


        }


                }
```

The final action of the IDM_RUN case is to use the WinExec function to cause the PLL FORTRAN executable to be run in an iconified window.

```
//run the fortran executable in an iconified window

                WinExec("pll.pif",SW_SHOWMINIMIZED );


        break;
                        }
```

The IDM_PRINTPLLPLOTS case is used to respond to the File|Print PLL Plots main menu selection. Two temporary integer variables are declared. They are used to retain information regarding the plot currently displayed in the Plot Viewer window since the plot_page and plot_component_flag variables are altered during the printing process. A loop counter is declared for the purpose of keeping track of the number of copies printed. PRINTDLG and DOCINFO structures are declared for use in calling the Print common dialog box and specifying the details of the document for the Windows™ Print Manager program. The PRINTDLG and DOCINFO structures and the printing process were described in Appendix A.3.

```
case IDM_PRINTPLLPLOTS : {

int     temp_plot_page,                         //copies of the plot_page and
        temp_plot_component_flag,               // plot_component_flag indices
        j;                                      //loop counter

PRINTDLG pd;                                    //print dialog structure

DOCINFO di;                                     //document information structure
```

The case first tests the draw_plot_flag to determine if any PLL plots are available for printing. If no plots are available, a warning message is displayed and the case is terminated.

```
//if there is are no PLL plots to print, print a warning and terminate the case

        if(!draw_plot_flag ){

                MessageBeep(MB_ICONEXCLAMATION);

                MessageBox(hWnd, "There are no PLL plots to print.",
                "WARNING!", MB_ICONSTOP | MB_OK | MB_TASKMODAL);

                break;

                        }
```

If PLL plots are available for printing, the plot_page and plot_component_flag values are saved in the temporary integer variables that were declared for that purpose.

This is done so that they can be restored after the printing process. The result of not restoring the values would be to possibly alter the plot displayed in the Plot Viewer window by processing a print request.

```
//otherwise, process the request

//save copies of the current plot_page and plot_component_flag indices since
// they will be altered during the printing process

        temp_plot_page = plot_page;

        temp_plot_component_flag = plot_component_flag;
```

The PRINTDLG and DOCINFO structures are initialized in the same way as described in Appendix A.3. The pd.nFromPage and pd.nMinPage are set to one and the pd.nToPage and pd.nMaxPage parameters are set to one and four respectively. This limits the range of page numbers available to the user through the Print common dialog box and initializes the values displayed in the box to one and four since PLL generates four plot pages.

```
//set all printdlg structure members to zero.

                memset(&pd, 0, sizeof(PRINTDLG));

//initialize the document information structure

                        di.cbSize        = sizeof(DOCINFO);
                        di.lpszDocName   = "MIT-PLL PLOTS";
                        di.lpszOutput    = NULL;

// Initialize the necessary PRINTDLG structure members.

        pd.lStructSize          = sizeof(PRINTDLG);
        pd.hwndOwner            = hWnd;
        pd.Flags                = PD_RETURNDC|PD_HIDEPRINTTOFILE|PD_NOSELECTION;
        pd.nFromPage            = 1;
        pd.nToPage              = 4;
        pd.nMinPage             = 1;
        pd.nMaxPage             = 4;

//if the PrintDlg function is successful, execute the code in the braces

        if (PrintDlg(&pd) != 0) {
```

If the PrintDlg function returns successfully, a document is started and a for loop is used to cause the number of copies requested by the user, pd.nCopies, to be printed. The case uses two additional for loops embedded in each other within the first for loop. The first causes all three available plots for each page in the case of a multiple component propulsor to be printed. The second causes each selected plot page to be printed.

```
//start the output document

                StartDoc(pd.hDC,&di);

//loop through the number of copies requested

                for(j=0; j<pd.nCopies; j++){

//# of plots per page, 1 for single component and 3 for multiple component propulsors
// calculated in the for loop by 1 + 2*(LDEV-1)

                        for(plot_component_flag=0;plot_component_flag<(1+2*(LDEV-1));
                                plot_component_flag++){

                                for(plot_page=pd.nFromPage-1;plot_page<pd.nToPage;
                                        plot_page++){

                                        StartPage(pd.hDC);

                                        printplot(pd.hDC);

                                        EndPage(pd.hDC);

                                                }

                        }

                                        }
```

The print process is terminated in the same way as described in Appendix A.3. The plot_page and plot_component_flag variables are restored to their original values and the case is terminated.

```
                EndDoc(pd.hDC);

                DeleteDC(pd.hDC);
                        }

        if (pd.hDevMode  != NULL) GlobalFree(pd.hDevMode);
```

```
        if (pd.hDevNames != NULL) GlobalFree(pd.hDevNames);
//restore the plot_page and plot_component_flag indices
        plot_page = temp_plot_page;
        plot_component_flag = temp_plot_component_flag;
        break;
                    }
```

The IDM_PRINTPBDPLOTS case is used to cause PBD plots to be printed. It is very similar to the IDM_PRINTPLLPLOTS case. The differences will be emphasized in this discussion.

```
case II      RINTPBDPLOTS : {

int     temp_plot_page,                    //copy of the plot_page index
        j;                                 //loop counter

PRINTDLG pd;                               //print dialog structure

DOCINFO di;                                //document information structure

FILE    *plot;                             //pointer to a file structure

POINT  origin={320,240};                   //origin of plot in screen
                                           // logical coordinates
```

The IDM_PRINTPBDPLOTS case declares a pointer to a FILE structure to be used in opening PBD output files that will be drawn to the printer device context. A POINT structure is declared and initialized. It is used to determine the point in the display area that will be used as the origin of the printed plots. As in the previous case, a temporary variable is declared to keep track of the plot page currently displayed in the Plot Viewer window. Only one temporary variable is required since the PBD plots do not have the option of presenting data for the first, second, or both components. Also as in the previous case, if there are no PBD plots to print, a warning message is printed and the case is terminated.

```
//if there is are no PBD plots to print, print a warning and terminate the case
```

```
if(!pbd_flag ){

        MessageBeep(MB_ICONEXCLAMATION);

        MessageBox(hWnd, "There are no PBD plots to print.",
        "WARNING!", MB_ICONSTOP | MB_OK | MB_TASKMODAL);

        break;

            }

//otherwise, process the request
```

After a copy of the plot_page value is saved the PRINTDLG and DOCINFO structures are initialized. In this case the page range is a function of the PBD run mode. The pd.nToPage is set to five since that is the minimum number of pages available. The value is incremented by one if the PBDOUT.CMV file is found to exist. The pd.nMaxPage value is then set equal to the pd.nToPage value.

```
//save a copy of the current plot_page index since it will be altered during
// the printing process

    temp_plot_page = plot_page;

//set all printdlg structure members to zero.

        memset(&pd, 0, sizeof(PRINTDLG));

//initialize the document information structure

            di.cbSize       = sizeof(DOCINFO);
            di.lpszDocName  = "MIT-PBD PLOTS";
            di.lpszOutput   = NULL;

// Initialize the necessary PRINTDLG structure members.

//if the pbdout.cmv file exists, set plot_page to 9 and plot that file

    pd.lStructSize  = sizeof(PRINTDLG);
    pd.hwndOwner    = hWnd;
    pd.Flags        = PD_RETURNDC|PD_HIDEPRINTTOFILE|PD_NOSELECTION;
    pd.nFromPage    = 1;
    pd.nMinPage     = 1;
    pd.nToPage      = 5;

//if the pbdout.cmv file does not exist, the maximum number of plots is 5,
```

```
// otherwise it is 6
        if(access("pbdout.cmv", 0) == 0) pd.nToPage++;
        pd.nMaxPage = pd.nToPage;
```

If the PrintDlg function returns successfully, the document is started and a for loop is again used to control the number of copies printed. Another for loop is used to loop through the pages to be plotted. The plot_page value in this case is incremented by three in this case in order to cause the four PLL plot pages to be skipped.

```
//if the PrintDlg function is successful, execute the code in the braces
        if (PrintDlg(&pd) != 0) {
//start the output document
                StartDoc(pd.hDC,&di);
//loop through the number of copies requested
                for(j=0; j<pd.nCopies; j++){
                        for(plot_page=pd.nFromPage+3;plot_page<=pd.nToPage+3;plot_page++){
                                StartPage(pd.hDC);
```

A switch is used to test the value of the plot_page variable and cause the appropriate files to be drawn to the printer device context, pd.hDC, that was returned by the PrintDlg function.

```
        switch(plot_page){
```

Case four corresponds to the plot of the input blade grid and control point net. The input blade grid is contained in the PBDOUT.IBG file and the B-spline net is contained in the PBDOUT.BSN file. The files are tested sequentially and if found to exist, they are opened with read access using the fopen function. The printer device context, the address or the origin, a pointer to the FILE structure, and a color value index are passed to the paint_graphs function to cause the plots to be drawn to the printer device context. The files are then closed.

```
case 4:{
//if the pbdout.ibg file exists, open it and plot it
        if(access("pbdout.ibg", 0) == 0) {
                plot = fopen("pbdout.ibg", "r");
                paint_graphs(pd.hDC, origin, plot, 0);
                fclose(plot);       }
        if(access("pbdout.ban", 0) == 0) {
                plot = fopen("pbdout.ban", "r");
                paint_graphs(pd.hDC, origin, plot, 1);
                fclose(plot);       }
        break;
        }
```

Cases five through nine are handled in a similar manner. Case five plots the drawing of the output blade grid, centerbody, transition wake, and hub and duct images. It uses the PBDOUT.HUB file with the paint_hub function, and the PBDOUT.HDI and PBDOUT.OBG files with the paint_graphs function.

```
case 5:{
        if(access("pbdout.hub", 0) == 0) {
                plot = fopen("pbdout.hub", "r");
                paint_hub(pd.hDC, origin, plot);
                fclose(plot);       }
        if(access("pbdout.hdi", 0) == 0) {
                plot = fopen("pbdout.hdi", "r");
                paint_graphs(pd.hDC, origin, plot, 1);
                fclose(plot);       }
```

```
            if(access("pbdout.obg", 0) == 0) {
                    plot = fopen("pbdout.obg", "r");
                    paint_graphs(pd.hDC, origin, plot, 0);
                    fclose(plot);        }
            break;
            }
```

Case six draws the control point velocity plot using the PBDOUT.VCP file and the paint_vcp function.

```
    case 6:{
            if(access("pbdout.vcp", 0) == 0) {
                    plot = fopen("pbdout.vcp", "r");
                    paint_vcp(pd.hDC, origin, plot);
                    fclose(plot);        }
            break;
            }
```

Case seven draws the circulation contour plot. It uses, depending on the run mode, either the PBDOUT.GSP or the PBDOUT.SOL function. The paint_gsp function is used in either case.

```
    case 7:{
//the circulation contour plot file may be either a .gsp or a .sol file
            if(access("pbdout.gsp", 0) == 0) {
                    plot = fopen("pbdout.gsp", "r");
                    paint_gsp(pd.hDC, origin, plot);
                    fclose(plot);        }
            else if(access("pbdout.sol", 0) == 0) {
                    plot = fopen("pbdout.sol", "r");
```

```
			paint_gsp(pd.hDC, origin, plot);
			fclose(plot);		}
		break;
		}
```

Case eight draws the radial circulation distribution plot. It uses, depending on the run mode, either the PBDOUT.RDC or the PBDOUT.SGR function. The paint_rdc function is used in either case.

```
	case 8:{
//the radial circulation distribution file may be either a .rdc or a .sgr  file
		if(access("pbdout.rdc", 0) == 0) {
			plot = fopen("pbdout.rdc", "r");
			paint_rdc(pd.hDC, plot);
			fclose(plot);			}
		else if(access("pbdout.sgr", 0) == 0) {
			plot = fopen("pbdout.sgr", "r");
			paint_rdc(pd.hDC, plot);
			fclose(plot);				}
		break;
		}
```

The final case, case nine, prints the circumferential mean velocity plot using the PBDOUT.CMV file and the paint_cmv function.

```
	case 9:{
		if(access("pbdout.cmv", 0) == 0) {
			plot = fopen("pbdout.cmv", "r");
			paint_cmv(pd.hDC, origin, plot);
```

```
                    fclose(plot);              }
                break;
                }
        }
                                        EndPage(pd.hDC);
                                                }
                                        }
```

The document is terminated in the manner described above, the plot_page value is restored, and the case is terminated.

```
                EndDoc(pd.hDC);
                DeleteDC(pd.hDC);
                            }
        if (pd.hDevMode  != NULL) GlobalFree(pd.hDevMode);
        if (pd.hDevNames != NULL) GlobalFree(pd.hDevNames);
//restore the plot_page index
        plot_page = temp_plot_page;
        break;
                            }
```

The IDM_PRINTOUTPUT case responds to main menu File|Print Output selections. The case declares a PRINTDLG structure and a DOCINFO structure as expected. Loop counters and a temporary variable for storing the value of output_flag are declared. The integer variable page is used in testing to determine if a particular page should be printed. The print_flag array is also used in determining if a particular page should be plotted.

```
        case IDM_PRINTOUTPUT : {
        int     temp_output_flag,                       //copy of the output_flag index
                i, j,                                   //loop counters
                page;                                   //page number
```

```
PRINTDLG pd;                                    //print dialog structure

DOCINFO di;                                     //document information structure

int     print_flag[11]={1,0,                    //integer array of flags that
                        0,0,                    // indicate if a particular
                        0,0,                    // file should be printed
                        0,0,
                        0,0,
                        0};
```

If there is no output to print, as indicated by the absence of the summary.out file, a warning message printed and the case is terminated.

```
//if no output is available, print an error message and terminate the case

    if(!project_flag||!(access("summary.out", 0) == 0)){

            MessageBeep(MB_ICONEXCLAMATION);

            MessageBox(hWnd, "A project must be open and output available in order to print.",
                    "WARNING!", MB_ICONSTOP | MB_OK | MB_TASKMODAL);

            break;                                  }
```

If there is output to print, the case proceeds by filling in the print_flag array. Two conditions must be met in order for an output file to be printed. The first is that the file must exist. The print_flag is filled in based on the existence of the output files corresponding to the position in the array. The 1th position in the array, for example, is incremented by one from its initialized value of zero if the detail1.out file is found to exist. The summary.out file is assumed to exist since the case was not immediately terminated based on the initial test, and the 0th value is initialized as one.

```
//otherwise, process the request

//set the print_flag for each output file that exists for this run

    if(access("detail1.out", 0) == 0)       print_flag[1] ++;
    if(access("detail2.out", 0) == 0)       print_flag[2] ++;
    if(access("stress.out",  0) == 0)       print_flag[3] ++;
    if(access("duct.geo",    0) == 0)       print_flag[4] ++;
    if(access("fards.out",   0) == 0)       print_flag[5] ++;
```

```
if(access("nonaxi.cir", 0) == 0)        print_flag[6] ++;
if(access("nonaxi.for", 0) == 0)        print_flag[7] ++;
if(access("nonaxi.cmp", 0) == 0)        print_flag[8] ++;
if(access("nonaxi.har", 0) == 0)        print_flag[9] ++;
if(access("pbdout.ktq", 0) == 0)        print_flag[10]++;
```

The case then saves a copy of the output_flag and initializes the PRINTDLG and DOCINFO structures. The output_flag is an index that indicates the file that is to be displayed in the Output Viewer window. The copy is saved so that the file displayed in the window will not be changed by the printing process.

```
//save a copy of the output flag since it will be altered during the printing process

    temp_output_flag = output_flag;

//set all of the printdlg structure members to zero

    memset(&pd, 0, sizeof(PRINTDLG));

//initialize the document information structure

        di.cbSize           = sizeof(DOCINFO);
        di.lpszDocName      = "MIT-PLL OUTPUT";
        di.lpszOutput       = NULL;

//initialize the necessary PRINTDLG structure members.

        pd.lStructSize   = sizeof(PRINTDLG);
        pd.hwndOwner     = hWnd;
        pd.Flags         = PD_RETURNDC|PD_HIDEPRINTTOFILE|PD_NOSELECTION;
        pd.nFromPage     = 1;
```

The sum of the values in the print_flag array is equal to the total number of files available for printing. A for loop is used to sum the values in the array into the pd.nToPage variable. The pd.nToPage value is then copied into the pd.nMaxpage variable to complete the initialization process for the PRINTDLG structure.

```
//sum the print_flag array to determine how many files are available to print

        for(i=0;i<11;i++) pd.nToPage+= print_flag[i];

        pd.nMinPage = 1;
        pd.nMaxPage = pd.nToPage;

//if the PrintDlg function is successful, execute the code in the braces
```

```
if (PrintDlg(&pd) != 0) {
//begin the document
        StartDoc(pd.hDC,&di);
//loop through the number of copies requested
        for(j=0; j<pd.nCopies; j++){
```

If the PrintDlg function returns successfully, a document is started and a for loop is used to print the number of copies requested by the user. The second condition that must be met in order for a file to be printed is that the user must specify that it be printed by including it in the print range. In this case, the from page and to page values selected by the user are interpreted as from file and to file values.

The temporary integer value, page, is set to zero. The value in page will be used to indicate the file number corresponding to a particular output file.

```
//set the current page number to zero
    page=0;
```

The case now uses a for loop to index through the print_flag array. If the value of the print_flag array indicates that the file exists, page is incremented so that the value in page corresponds to the page number, or file number, of the file corresponding to the print_flag index.

```
//loop through each of the ten possible output files
        for(i=0;i<10;i++){
//if the file exists, increment the page number
        if(print_flag[i]){
            page++;
```

The case then tests page to determine if it is within the range of files the user desires to print. If it is, then a page is started with the output_flag set so that the appropriate file will be printed. The printer device context is then passed to the printout function and the appropriate file is printed.

```
//if the page number is in the range requested by the user, print it
                    if((page>=pd.nFromPage)&&(page<=pd.nToPage)){
                         output_flag = i;
                         StartPage(pd.hDC);
                         printout(pd.hDC);
                         EndPage(pd.hDC);
                                                  }
                         }
                         }
                              }
```

After the appropriate number of copies of the requested files are printed, the case is terminated in the manner described above in the IDM_PRINTPLLPLOTS and IDM_PRINTPBDPLOTS cases.

```
//end the document
          EndDoc(pd.hDC);
          DeleteDC(pd.hDC);
                         }
          if (pd.hDevMode != NULL)  GlobalFree(pd.hDevMode);
          if (pd.hDevNames != NULL) GlobalFree(pd.hDevNames);
          output_flag = temp_output_flag;
     break;              }
```

The IDM_SAVEPROJECT case handles the File|Save Project main menu selection. If a project is currently open, it uses an OPENFILENAME structure and the GetSaveFileName function to call the Save common dialog box.

```
case IDM_SAVEPROJECT : {

	OPENFILENAME ofn;				//openfilename structure used with
							// GetOpenFileName function
	char	szFile[256],				//name and location of the file
							// to open
		szFileTitle[256],			//name of file to open
		szFilter[]= "PRJ Files (*.PRJ)\0*.PRJ\0";	//filter for list box

	FILE	*project;				//pointer to a file structure

//if there is no project open, print a warning and terminate the case

	if(!project_flag){

		MessageBeep(MB_ICONEXCLAMATION);

		MessageBox(hWnd, "A project must be open in order to be saved.",
			"WARNING!", MB_ICONSTOP | MB_OK | MB_TASKMODAL);

		break;		}

//otherwise, process the request
```

The case initializes the dialog box with the name of the currently open project in case the user wishes to overwrite the project file. Alternatively, the user may input any acceptable DOS filename.

```
//zero the openfilename structure

	memset(&ofn, 0, sizeof(OPENFILENAME));

//initialize the necessary OPENFILENAME structure parameters

		strcpy(szFile, PROJECTFILE);

		ofn.lStructSize		= sizeof(OPENFILENAME);
		ofn.hwndOwner		= hWnd;
		ofn.lpstrFilter		= szFilter;
		ofn.lpstrFile		= szFile;
		ofn.nMaxFile		= sizeof(szFile);
		ofn.lpstrFileTitle	= szFileTitle;
		ofn.nMaxFileTitle	= sizeof(szFileTitle);
		ofn.Flags		= OFN_OVERWRITEPROMPT|OFN_HIDEREADONLY;

//if the GetSaveFileName function is successful, execute the code in the braces
```

```
if (GetSaveFileName(&ofn)) {
```

If the GetSaveFileName function returns successfully, the file selected by the user is opened with write access, the filename is written to the PROJECTFILE global character array, and the new project file is written by calling the write_project_file function. The new project file is then closed and the case is terminated.

```
//open the file indicated by the user
            project = fopen(ofn.lpstrFileTitle,"w");
//copy the file title into the PROJECTFILE string
            sprintf(PROJECTFILE, "%s",ofn.lpstrFileTitle);
//write the project file by calling the write_project_file function
            write_project_file(project);
//close the file
            fclose (project);
            }
    break;                  }
```

The next five cases respond to the Edit|Default Settings, Edit|Duct Settings, Edit|ABS Strength Settings, Edit|PBD Settings, and Edit|PBD Skew/Rake Settings main menu selections. Each case declares a pointer to a dialog procedure, DlgProc.

```
    case IDM_DEFAULTSETTINGS : {
    DLGPROC     DlgProc;                        //pointer to a dialog
procedure
```

The IDM_DEFAULTSETTINGS case displays a warning message if there is no project open and terminates the case. If a project is open, the case calls the single or multiple component Default Settings dialog box based on a test of LDEV. The case terminates after the dialog box terminates.

```
//if no project is open, print a warning message and terminate the case
```

```
        if(!project_flag){

                MessageBeep(MB_ICONEXCLAMATION);

                MessageBox(hWnd, "A project must be open in order to be edit Default Settings.",
                        "WARNING!", MB_ICONSTOP | MB_OK | MB_TASKMODAL);

        break;          }

//call the appropriate Default Settings dialog box, depending on the number
// of components

        if(LDEV <2){

        DlgProc = (DLGPROC)MakeProcInstance((FARPROC)Default1SettingsDlgProc, ghInstance);
        DialogBox(ghInstance, "DEFAULT1SETTINGS", hWnd, DlgProc);

                        }

        else{

        DlgProc = (DLGPROC)MakeProcInstance((FARPROC)Default2SettingsDlgProc, ghInstance);
        DialogBox(ghInstance, "DEFAULT2SETTINGS", hWnd, DlgProc);
                }

        FreeProcInstance((FARPROC)DlgProc);

         break;                 }

        case IDM_DUCTSETTINGS : {

        DLGPROC         DlgProc;                                        //pointer to a dialog
procedure
```

The IDM_DUCTSETTINGS case displays a warning message if there is no project open or if there is no duct in the open project and terminates the case. If a ducted project is open, the case calls Duct Settings dialog box. The case terminates after the dialog box terminates.

```
//if no project is open or there is no duct, print a warning message and
// terminate the case

        if(!project_flag||(image_duct == 'N')||(image_duct == 'n')){

        MessageBeep(MB_ICONEXCLAMATION);

        MessageBox(hWnd, "A project with a duct must be open in order to edit the \
Duct Default Settings.",
        "WARNING!", MB_ICONSTOP | MB_OK | MB_TASKMODAL);
```

```
break;                                                  }

DlgProc = (DLGPROC)MakeProcInstance((FARPROC)DuctSettingsDlgProc, ghInstance);
DialogBox(ghInstance, "DUCTSETTINGS", hWnd, DlgProc);
FreeProcInstance((FARPROC)DlgProc);

break;                  }

case IDM_ABSRULES : {

DLGPROC       DlgProc;                                        //pointer to a dialog
procedure
```

The IDM_ABSRULES case displays a warning message if there is no project open and terminates the case. If a project is open, the case calls ABS Rules Strength Settings dialog box. The case terminates after the dialog box terminates.

```
if(!project_flag) {

MessageBeep(MB_ICONEXCLAMATION);

MessageBox(hWnd, "A project must be open in order to edit the ABS Rules \
Strength Calculation Settings.",
"WARNING!", MB_ICONSTOP | MB_OK | MB_TASKMODAL);

 break;          }

DlgProc = (DLGPROC)MakeProcInstance((FARPROC)ABSDlgProc, ghInstance);
DialogBox(ghInstance, "ABSRULES", hWnd, DlgProc);
FreeProcInstance((FARPROC)DlgProc);

break;          }
```

The IDM_EDITPBDSETTINGS case is analogous to the IDM_ABSRULES case.

```
case IDM_EDITPBDSETTINGS : {

DLGPROC       DlgProc;                                        //pointer to a dialog
procedure

if(!project_flag) {

        MessageBeep(MB_ICONEXCLAMATION);

        MessageBox(hWnd, "A project must be open in order to edit the PBD Settings.",
        "WARNING!", MB_ICONSTOP | MB_OK | MB_TASKMODAL);

break;          }
```

```
DlgProc = (DLGPROC)MakeProcInstance((FARPROC)PBDSettingsDlgProc, ghInstance);
DialogBox(ghInstance, "PBDSETTINGS", hWnd, DlgProc);
FreeProcInstance((FARPROC)DlgProc);

break;                          }
```

The IDM_EDITPBDSKEWRAKE case is analogous to the IDM_DEFAULTSETTINGS case.

```
case IDM_EDITPBDSKEWRAKE : {

DLGPROC      DlgProc;                                    //pointer to a dialog
procedure

if(!project_flag) {

        MessageBeep(MB_ICONEXCLAMATION);

MessageBox(hWnd, "A project must be open in order to edit the PBD Skew and Rake values.",
        "WARNING!", MB_ICONSTOP | MB_OK | MB_TASKMODAL);

break;          }

DlgProc = (DLGPROC)MakeProcInstance((FARPROC)SkewRake1DlgProc, ghInstance);
DialogBox(ghInstance, "SKEWRAKE1", hWnd, DlgProc);
FreeProcInstance((FARPROC)DlgProc);

if(LDEV>1){

DlgProc = (DLGPROC)MakeProcInstance((FARPROC)SkewRake2DlgProc, ghInstance);
DialogBox(ghInstance, "SKEWRAKE2", hWnd, DlgProc);
FreeProcInstance((FARPROC)DlgProc);
                    }

break;              }
```

The IDM_EDITPITCHROLLYAW case responds to a message sent by the MDIChildPlotWndProc in response to a right mouse button double click on the Plot Viewer window while a PBD plot is displayed. It calls the PBD Plot Geometry dialog box and terminates after the dialog box terminates. The MDIChildPlotWndProc function will be discussed in section C.2.3.

```
case IDM_EDITPITCHROLLYAW : {
```

```
        DLGPROC        DlgProc;                                         //pointer to a dialog
procedure

        DlgProc = (DLGPROC)MakeProcInstance((FARPROC)PBDPRYDlgProc, ghInstance);
        DialogBox(ghInstance, "PBDPRY", hWnd, DlgProc);
        FreeProcInstance((FARPROC)DlgProc);

        InvalidateRect(hPlotWnd, NULL, TRUE);

        break;
                              }
```

The IDM_WRITEOUTPUT case responds to the main menu File|Write PLL Output File selection. If there is an open project and output available, the case allows the user to select an output filename using the Save common dialog box.

```
        case IDM_WRITEOUTPUT : {

        OPENFILENAME ofn;                              //openfilename structure used with
                                                       // GetOpenFileName function
        char    szFile[256]="*.out\0",                 //name and location of the file
                                                       // to open
                szFileTitle[256],                      //name of file to open
                szFilter[]= "OUT Files (*.OUT)\0*.OUT\0";     //filter for list box

        HFILE  out;                                    //handle to a file

//if no project is open or there are no output files, print a warning
// and terminate the case

        if((!project_flag)||!(access("summary.out", 0) == 0)){

        MessageBeep(MB_ICONEXCLAMATION);

        MessageBox(hWnd, "A project must be open and output available to write an output file.",
                "WARNING!", MB_ICONSTOP | MB_OK | MB_TASKMODAL);

        break;                                  }

//initialize the OPENFILENAME parameters

        memset(&ofn, 0, sizeof(OPENFILENAME));

        // Initialize the OPENFILENAME members

                ofn.lStructSize         = sizeof(OPENFILENAME);
                ofn.hwndOwner           = hWnd;
                ofn.lpstrFilter         = szFilter;
                ofn.lpstrFile           = szFile;
```

```
		ofn.nMaxFile		= sizeof(szFile);
		ofn.lpstrFileTitle	= szFileTitle;
		ofn.nMaxFileTitle	= sizeof(szFileTitle);
		ofn.Flags		= OFN_OVERWRITEPROMPT|OFN_HIDEREADONLY;

	if (GetSaveFileName(&ofn)) {
```

Upon the successful return of the GetSaveFileName function, the case uses the _lcreat function to open or create the file selected by the user. The _lcreat function receives the address of the file title and a file attribute. In this case, if the file already exists it is opened for reading and writing and truncated to zero length. If the file does not exist, it is created with write access. The function returns a handle to the file.

```
//create an output file
		out = _lcreat(ofn.lpstrFileTitle, 0);
```

The case then writes all of the available PLL output files into the specified file by calling the write_output_file function, closes the file, and terminates the case.

```
//call the write_output_file fuction to write the output file
		write_output_file(out);
//close the overall output file
		_lclose(out);
				}
	break;			}
```

If there are PBD output files available as indicated by the pbd_flag variable, the IDM_WRITEPBDOUTPUT case responds to main menu File|Write PBD Output Files selections by calling the write_pbd_files function. Otherwise, a warning message is displayed and the case is terminated. The write_pbd_files function copies all of the available PBD output files into files having the root name specified in the PBD Settings dialog box and the appropriate extension.

```
	case IDM_WRITEPBDOUTPUT : {
```

```
if(pbd_flag)
        write_pbd_files();
else {
        MessageBeep(MB_ICONEXCLAMATION);

        MessageBox(hWnd, "No PBD files to write.",
                "WARNING!", MB_ICONSTOP | MB_OK | MB_TASKMODAL);
        }
break;                          }
```

The IDM_EXIT case responds to main menu File|Exit selections and to messages sent by the WM_DESTROY case in the FrameWndProc function. The function deletes temporary files by passing the pll_files and pbd_files flags to the delete_files function and by individually deleting the files not deleted by the delete_files function.

```
case IDM_EXIT : {
//delete the temporary files
                delete_files(pll_files);
                delete_files(pbd_files);

                unlink("curr1.bld");
                unlink("curr2.bld");
                unlink("aberules.set");
                unlink("ductforc.set");
                unlink("temp.def");
                unlink("temp.inp");
                unlink("temp.prj");
                unlink("thsttorq.set");
                unlink("wakecalc.set");
                unlink("wkalcirc.set");
                unlink("temp.out");
                unlink("options.set");
                unlink("damp.flg");
                unlink("optim.dat");
                unlink("time.dat");
                unlink("ear.dat");
                unlink("unload.dat");
                unlink("pbddef.dat");
                unlink("pbdadm1.dat");
                unlink("pbdadm2.dat");
                unlink("pbd.set");
                unlink("glauert.coe");
                unlink("d2xc1.inp");
                unlink("d2xc2.inp");
```

```
unlink("x2b1.inp");
unlink("x2b2.inp");
unlink("pbdadmin.nam");
unlink("currpbd.vel");
```

The IDM_EXIT case then frees the timer for use by other applications and sends a request to the Windows™ environment to terminate the program. The case is then terminated.

```
//delete the timer
        KillTimer(hWnd,ID_TIMER);

        PostQuitMessage(0);

        break;              }
```

The IDM_ABOUT case calls the About dialog box and terminates when the dialog box terminates.

```
        case IDM_ABOUT : {
// this handles the About dialog box

        DLGPROC DlgProc;

        DlgProc = (DLGPROC)MakeProcInstance((FARPROC)ABOUTDlgProc, ghInstance);
        DialogBox(ghInstance, "ABOUT", hWnd, DlgProc);
        FreeProcInstance((FARPROC)DlgProc);

        break;
                    }
```

Messages not handled by a prior case in the switch are referred to the default Windows™ frame procedure by calling the DefFrameProc function. The DefFrameProc function receives a handle to the frame window, a handle to the client window, and unsigned integer that specifies the message being sent, and 16 and 32 bit parameters with additional information that is a function of the message. The function processes the message and returns the processing result, which is also a function of the message that is sent.

```
default : {
DefFrameProc(hWnd, hMDIClientWnd, WM_COMMAND, id, 0L);
        }
    }
}
```

APPENDIX C.2

The PLL MDI Child Window Procedure functions.

C.2 The PLL MDI Child Window Procedure functions.

Child windows in a MDI application receive messages in the same way as their non-MDI application counterparts. The messages are not handled by the FrameWndProc but rather by individual child window procedures. Normally there is one child window procedure for each type of child window in a MDI application, and this is the case in PLL. The MDIChildBladeWndProc, MDIChildWakeWndProc, MDIChildOutputWndProc, and MDIChildPlotWndProc functions will be described in this appendix.

C.2.1 The PLL MDIChildBladeWndProc and MDIChildWakeWndProc functions.

The declarations of the MDIChildBladeWndProc and MDIChildWakeWndProc functions are the same as those of the MainWndProc functions described in Appendices A and B and of the FrameWndProc function described in section C.1.2. Their operation is also quite similar. Both of the child window procedures use switches to respond to messages passed by the Windows™ environment as a result of user action.

Both the MDIChildBladeWndProc function and the MDIChildWakeWndProc function respond to WM_PAINT commands. The MDIChildBladeWndProc function responds simply by calling the paintbld function and returning zero, indicating that the message was handled. The paintbld function receives the handle to the Blade Viewer window and draws the blade and ring parameter plots on the window. Messages other than WM_PAINT that are received by the Blade Viewer window are referred to the default MDI Child window procedure, DefMDIChildProc.

```
LRESULT CALLBACK _export MDIChildBladeWndProc(HWND hWnd, UINT message, WPARAM
wParam, LPARAM lParam)
{

        switch (message)
        {
        case WM_PAINT : {

//respond to WM_PAINT messages by calling the paintbld function
```

```
                paintbld(hWnd);

                return 0;

                        }
        }
//refer messages not handled above to the default windows MDI child window procedure

        return DefMDIChildProc(hWnd, message, wParam, lParam);
}
```

The response of the MDIChildWakeWndProc function to a WM_PAINT message is the same as the MDIChildBladeWndProc function except that the paint_wake function is called instead of the paint_bld function. The paint_wake function receives the handle to the Wake Viewer window and draws the project wake profile on the window. If the project has two components, the user may toggle between the wake profiles for the first and second components by double clicking the left mouse button while the cursor is on the Wake Viewer window. This action causes a WM_LBUTTONDBLCLK message to be sent to the MDIChildWakeWndProc function.

```
LRESULT CALLBACK _export MDIChildWakeWndProc(HWND hWnd, UINT message, WPARAM
wParam, LPARAM lParam)
{

        switch (message)
        {
        case WM_LBUTTONDBLCLK : {
```

Upon receipt of a WM_LBUTTONDBLCLK message, the case tests the LDEV integer variable to determine if the project is a single component project. If the current project has only one component the case is terminated immediately by returning zero, indicating to the Windows™ environment that the case was handled.

```
//if there is only one component terminate the case

                if(LDEV==1)  return 0;
```

If there is more than one component, a switch is used to toggle the component_flag integer variable from zero to one or one to zero depending on its initial state. The component_flag variable value controls the selection of the wake profile that will be drawn by the paint_wake function. After this is done, the InvalidateRect function is used to cause the Wake Viewer window to be redrawn since the data to be displayed on the screen has changed. A value of zero is then returned to indicate that the case has been handled.

```
//if there is more than one component, toggle the component_flag and repaint the screen

                    switch(component_flag)
                    {
                    case 0: { component_flag=1; break; }
                    case 1: { component_flag=0; break; }
                    }

                    InvalidateRect(hWnd, NULL, TRUE);

                    return 0;

                            }

        case WM_PAINT : {

//respond to WM_PAINT messages by calling the paintwake function

        paintwake(hWnd);

        return 0;
                        }

        }
```

As in the case of the MDIChildBladeWndProc function, if a message is not handled by the switch, it is referred to the default MDI Child window procedure.

```
//refer messages not handled above to the default windows MDI child window
// procedure

        return DefMDIChildProc(hWnd, message, wParam, lParam);
}
```

C.2.2 The PLL MDIChildOutputWndProc function.

The declaration and operation of the MDIChildOutputWndProc are similar to the declaration and operation of the functions described in section C.2.1 above. It is, however, a more complicated function due to the addition of three cases in the switch and the large number of different output files that may be selected for viewing.

```
LRESULT CALLBACK _export MDIChildOutputWndProc(HWND hWnd, UINT message, WPARAM
wParam, LPARAM lParam)
{
        switch (message)
        {
```

The first message handled in the MDIChildOutputWndProc function is the WM_LBUTTONDBLCLK message. Double clicking the left mouse button on the Output Viewer window causes the display to index to the next available file. If there are no output files to display, as indicated by the absence of the summary.out file, the case returns zero to indicate that the message was handled and takes no further action.

```
        case WM_LBUTTONDBLCLK : {

//if there is no summary.out file there is no reason to change the output_flag
// so just terminate the case

        if(access("summary.out", 0) != 0)

        return 0;
```

If there are output files to display, the case first resets the scroll bar position to the top of the page so that the next file in the sequence will be displayed starting at the top.

```
//set Scroll_Pos to zero so the new page will print at the top of the page
// and update the scroll bar position

                Scroll_Pos = 0;
                SetScrollPos(hWnd, SB_VERT, Scroll_Pos, TRUE);
```

Next, a switch is employed to determine which file is to be displayed based on which file is currently displayed. The existing files are displayed in the following order.

1. summary.out.
2. detail1.out.
3. detail2.out.
4. stress.out.
5. duct.geo.
6. fards.out.
7. nonaxi.cir.
8. nonaxi.for.
9. nonaxi.cmp.
10. nonaxi.har.
11. pbdout.ktq.

When the output_flag value has been indexed, the InvalidateRect function is used to cause the screen to be repainted and the case is terminated.

```
        switch(output_flag)
        {

        case summary: { output_flag = detailed1; break; }

//skip over detailed2 if there is only one component
        case detailed1: { if(LDEV==1)     output_flag = abs_rules_calc;
                          else            output_flag = detailed2;
                break; }

        case detailed2: { output_flag = abs_rules_calc; break; }

        case abs_rules_calc: {
//go to the duct geometry case if there is a duct.geo file
                if(access("duct.geo", 0) == 0)
                        output_flag = duct_geometry;
//go to the downstream velocities case if there is a fards.out file
                else
                        if(access("fards.out", 0) == 0)
                                output_flag = downstream_velocities;
//go to the non_axisym_cir case if there is a nonaxi.cir file
                        else
                                if(access("nonaxi.cir", 0) == 0)
                                        output_flag = non_axisym_cir;
                                else
//go to the pbdktq case if there is a pbdout.ktq file and the pbd_flag is set
                                        if((pbd_flag)&&
                                         access("pbdout.ktq", 0) == 0)
```

```
                                        output_flag = pbdktq;
//otherwise go back to the summary case
                                else
                                        output_flag = summary;

        break;}

        case duct_geometry: {
//go to the downstream velocities case if there is a fards.out file
                if(access("fards.out", 0) == 0)
                        output_flag = downstream_velocities;
//go to the non_axisym_cir case if there is a nonaxi.cir file
                else
                        if(access("nonaxi.cir", 0) == 0)
                                output_flag = non_axisym_cir;
                        else
//go to the pbdktq case if there is a pbdout.ktq file and the pbd_flag is set
                                if((pbd_flag)&&access("pbdout.ktq", 0) == 0)
                                        output_flag = pbdktq;
//otherwise go back to the summary case
                                else
                                        output_flag = summary;

        break;}

        case downstream_velocities:{
//go to the non_axisym_cir case if there is a nonaxi.cir file
                if(access("nonaxi.cir", 0) == 0)
                        output_flag = non_axisym_cir;
                else
//go to the pbdktq case if there is a pbdout.ktq file and the pbd_flag is set
                        if((pbd_flag)&&access("pbdout.ktq", 0) == 0)
                                output_flag = pbdktq;
//otherwise go back to the summary case
                        else
                                output_flag = summary;

        break;}

        case non_axisym_cir: { output_flag = non_axisym_for; break; }

        case non_axisym_for: { output_flag = non_axisym_cmp; break; }

        case non_axisym_cmp: { output_flag = non_axisym_har; break; }

        case non_axisym_har: {

//go to the pbdktq case if there is a pbdout.ktq file and the pbd_flag is set
                                if((pbd_flag)&&access("pbdout.ktq", 0) == 0)
                                        output_flag = pbdktq;
//otherwise go back to the summary case
                                else
                                        output_flag = summary;
```

```
break;}
case pbdktq: { output_flag = summary; break; }
}
InvalidateRect(hWnd, NULL, TRUE);
return 0;
                    }
```

The first additional case in the MDIChildOutputWndProc function is the WM_RBUTTONDBLCLK case. The WM_RBUTTONDBLCLK case responds to the user double clicking the right mouse button on the Output Viewer window. This causes the text_color flag to be indexed in a continuous loop from the default blue to green, to red, to black, and back to blue as the user continues to double click the right mouse button. It is accomplished with a switch similar to the one described in the WM_LBUTTONDBLCLK case above. After the text_color flag has been altered, the InvalidateRect function is used to cause the screen to be redrawn and the case is terminated by returning zero.

```
    case WM_RBUTTONDBLCLK: {

//if the right mouse button is double clicked, the text_color is indexed
// by one increment, starting with blue and progressing through green, red,
// and black then back to blue

            switch(text_color)
            {
            case blue:      { text_color = green; break; }
            case green:     { text_color = red;   break; }
            case red:       { text_color = black; break; }
            case black:     { text_color = blue;  break; }
            }

//cause the screen to be repainted once the text_color has been indexed

            InvalidateRect(hWnd, NULL, TRUE);

    return 0;
                    }
```

The other two new cases are the WM_VSCROLL and the WM_KEYDOWN cases. The first refers scroll bar messages to the WMVScroll_Handler function and the second refers messages to the WMKeydown_Handler function. These functions will be described later in this appendix.

```
        case WM_VSCROLL :
        {
        return HANDLE_WM_VSCROLL(hWnd, wParam, lParam, WMVScroll_Handler);
        }

         case WM_KEYDOWN :
        {
//this case handles keyboard entry

                return HANDLE_WM_KEYDOWN(hWnd,wParam,lParam,WMKeydown_Handler);

        }
```

The last case in the switch is the WM_PAINT case. This case passes the handle of the Output Viewer window to the paintout function. The paintout function draws the appropriate output file to the Output Viewer window device context.

```
        case WM_PAINT :
        {

                paintout(hWnd);

                return 0;

        }
        }
```

If a message is not handled by one of the cases in the switch, it is referred to the default MDI Child window procedure.

```
        return DefMDIChildProc(hWnd, message, wParam, lParam);
}
```

C.2.3 The PLL MDIChildPlotWndProc function.

The MDIChildPlotWndProc is similar to the MDIChildOutputWndProc function described in section C.2.2 above, but without the cases made necessary by the Output Viewer window scroll bar.

```
LRESULT CALLBACK _export MDIChildPlotWndProc(HWND hWnd, UINT message, WPARAM
wParam, LPARAM lParam)
{
        switch (message)
        {
```

The WM_LBUTTONDBLCLK case responds to the user double clicking the left mouse button on the Plot Viewer window. This action causes the plot displayed to index in a continuous loop through the available plots. This is more straightforward than the Output Viewer case because there is a lower degree of variability in the plots available.

```
        case WM_LBUTTONDBLCLK : {
//if there are no plots to draw and pbd has not been run, terminate the case
```

If there are no PLL and no PBD plots to draw, the case is terminated. Otherwise, a switch is used to alter the plot_page variable value based on the plot currently displayed and the plots available. The InvalidateRect function is then used to cause the screen to be redrawn and the case is terminated. The available plots are displayed in the following order:

1. PLL page 1.
2. PLL page 2.
3. PLL page 3.
4. PLL page 4.
5. PBD input blade B-spline control net and the resultant blade.
6. PBD output blade grid for each blade, centerbody, transition wake, and hub and duct images as applicable.
7. velocities at the blade control points.
8. contour plot of the bound circulation strength.
9. radial circulation distribution.
10. circumferential mean velocity plot.

```
                if(!draw_plot_flag && !pbd_flag)

                        return 0;

//if the left mouse button is double clicked on the plot page, index through the pages

                switch(plot_page)
                {
//plot_page values 0-3 cause pll plots to be drawn

                case 0:{ plot_page = 1; break; }
                case 1:{ plot_page = 2; break; }
                case 2:{ plot_page = 3; break; }

//if the pbd flag is set, index through the pbd plots

                case 3:{ if(pbd_flag) plot_page = 4;
                        else plot_page =0; break; }
                case 4:{ plot_page = 5; break; }
                case 5:{ plot_page = 6; break; }
                case 6:{ plot_page = 7; break; }
                case 7:{ plot_page = 8; break; }

//if the pbdout.cmv file exists, set plot_page to 9 and plot that file
// otherwise start over with case 0 if pll plots are to be drawn and case
// 4 if they are not to be drawn

                case 8:{ if(access("pbdout.cmv", 0) == 0)  plot_page = 9;
                            else if(draw_plot_flag)plot_page = 0;
                              else plot_page = 4;break; }

//start over with case 0 if pll plots are to be drawn and case 4 if they are
// not to be drawn

                case 9:{ if(draw_plot_flag)plot_page = 0;
                            else plot_page = 4; break; }
            }

                InvalidateRect(hWnd, NULL, TRUE);

            return 0;
            }
```

The user calls the PBD Plot Geometry dialog box by double clicking the right mouse button with the cursor on the Plot Viewer window while a PBD plot is displayed. If a multiple component PLL plot is displayed, the WM_RBUTTONDBLCLK message causes the plot displayed to index on a continuous loop between the component one plot, the component two plot, and the combined plot.

```
case WM_RBUTTONDBLCLK : {

//if the right mouse button is double clicked on the plot page and a pbd
// plot is displayed, send a message to the frame window to call the
// pbd pitch, roll, yaw dialog box
```

If the plot_page value is greater than three, then a PBD plot is being diplayed. The SendMessage function is used to send a IDM_EDITPITCHROLLYAW message to the FrameWndProc to cause the PBD Plot Geometry box to be called and the case is terminated.

```
if(plot_page>3){

        SendMessage(hFrameWnd,WM_COMMAND,IDM_EDITPITCHROLLYAW,
                        MAKELONG(0,0));

        return 0;
        }
```

If the plot_page value is not greater than three, then LDEV is tested. If the project is a single component project the case is terminated. If the project has two components, then the plot_component_flag is indexed on a continuous loop so that the component one, then the component two, and then the combined component plot will be displayed. The screen is then repainted and the case is terminated.

```
//if pll plots are being displayed and there is only one component, terminate the case

        if(LDEV==1)  return 0;

//for multiple components use the following switch to index through the cases
// where component 1 is plotted, component 2 is plotted, and both are plotted

        switch(plot_component_flag)
        {
        case 0: { plot_component_flag=1; break; }
        case 1: { plot_component_flag=2; break; }
        case 2: { plot_component_flag=0; break; }
        }

//cause the screen to be repainted

        InvalidateRect(hWnd, NULL, TRUE);

        return 0;
```

```
}
```

The WM_PAINT case is used to control the plots displayed on the Plot Viewer window. A PAINTSTRUCT structure, a handle to a device context, a pointer to a file structure, and a POINT structure are declared.

```
case WM_PAINT : {
PAINTSTRUCT ps;                          //paint structure
HDC     PlotPaintDC;                     //handle of the device context
FILE    *plot;                           //pointer to a file structure
POINT   origin={320,240};                //origin of plot in screen
                                         // logical coordinates
```

If a PLL plot page is to be displayed, the case passes the handle of the Plot Viewer window to the paint_plot function and terminates the case by returning zero.

```
//if a pll page is to be plotted, call the paintplot function and terminate the case
        if(plot_page<4){ paintplot(hWnd); return 0; }
```

If a PBD plot is to be drawn, the sine and cosine of the global pitch, roll, and yaw values are calculated. These values are used by the functions that draw the wireframe drawings using the PBD output files. The case then uses the BeginPaint function to prepare the Plot Viewer window for painting.

```
//calculate the cosine and sine of the roll, pitch, and yaw prior to painting a pbd page
        cos_roll        =cos(roll);
        sin_roll        =sin(roll);
        cos_yaw         =cos(yaw);
        sin_yaw         =sin(yaw);
        cos_pitch       =cos(pitch);
        sin_pitch       =sin(pitch);
// create the device context
        PlotPaintDC = BeginPaint(hWnd, &ps);
```

The WM_PAINT case then uses a switch to control the files and functions used to draw output to the Plot Viewer window. The switch is identical to the switch used in the IDM_PRINTPBDPLOTS case in the WMCommand_Handler function described in detail in section C.1.3.

```
//use a switch to determine which pbd output files are to be plotted and call the appropriate plot function

        switch(plot_page){

        case 4:{

//if the pbdout.ibg file exists, open it and plot it

                if(access("pbdout.ibg", 0) == 0) {

                        plot = fopen("pbdout.ibg", "r");

                        paint_graphs(PlotPaintDC, origin, plot, 0);

                        fclose(plot);       }

                if(access("pbdout.bsn", 0) == 0) {

                        plot = fopen("pbdout.bsn", "r");

                        paint_graphs(PlotPaintDC, origin, plot, 1);

                        fclose(plot);       }

                break;
                }

        case 5:{

                if(access("pbdout.hub", 0) == 0) {

                        plot = fopen("pbdout.hub", "r");

                        paint_hub(PlotPaintDC, origin, plot);

                        fclose(plot);       }

                if(access("pbdout.hdi", 0) == 0) {

                        plot = fopen("pbdout.hdi", "r");

                        paint_graphs(PlotPaintDC, origin, plot, 1);

                        fclose(plot);       }
```

```
			if(access("pbdout.obg", 0) == 0) {
				plot = fopen("pbdout.obg", "r");
				paint_graphs(PlotPaintDC, origin, plot, 0);
				fclose(plot);	}
			break;
			}
		case 6:{
			if(access("pbdout.vcp", 0) == 0) {
				plot = fopen("pbdout.vcp", "r");
				paint_vcp(PlotPaintDC, origin, plot);
				fclose(plot);	}
			break;
			}
		case 7:{
//the circulation contour plot file may be either a .gsp or a .sol file
			if(access("pbdout.gsp", 0) == 0) {
				plot = fopen("pbdout.gsp", "r");
				paint_gsp(PlotPaintDC, origin, plot);
				fclose(plot);	}
			else if(access("pbdout.sol", 0) == 0) {
				plot = fopen("pbdout.sol", "r");
				paint_gsp(PlotPaintDC, origin, plot);
				fclose(plot);	}
			break;
			}
		case 8:{
//the radial circulation distribution file may be either a .rdc or a .sgr file
			if(access("pbdout.rdc", 0) == 0) {
				plot = fopen("pbdout.rdc", "r");
```

```
                    paint_rdc(PlotPaintDC, plot);

                    fclose(plot);           }

            else if(access("pbdout.sgr", 0) == 0) {

                    plot = fopen("pbdout.sgr", "r");

                    paint_rdc(PlotPaintDC, plot);

                    fclose(plot);           }

            break;
            }

    case 9:{

            if(access("pbdout.cmv", 0) == 0) {

                    plot = fopen("pbdout.cmv", "r");

                    paint_cmv(PlotPaintDC, origin, plot);

                    fclose(plot);           }

            break;

            }
    }
```

The last action taken by the WM_PAINT case is to close out the paint command using the EndPaint function and to return zero to indicate that the case was handled.

```
//close out the paint command and terminate the case

                    EndPaint(hWnd, &ps);

                    return 0;
                    }
    }
```

Messages not handled by the switch are referred to the default MDI Child window procedure.

```
//refer messages not handled above to the default windows MDI child window procedure

    return DefMDIChildProc(hWnd, message, wParam, lParam);
}
```

APPENDIX C.3

The PLL dialog functions.

C.3 The PLL dialog functions.

The PLL Windows™ application makes extensive use of dialog boxes. Each dialog box requires two support functions. The dialog box functions used in PLL are very similar to those described in Appendices A.4 and B.2. The PLL dialog functions are listed below and are described briefly by text interspersed through the code.

C.3.1 The Run Time Settings dialog box functions.

The WMRunTimeDlgCommand_Handler and RunTimeDlgProc are used to initialize and then handle input from the Run Time Settings dialog box. The dialog box makes use of edit controls for receiving numerical input, check boxes for setting options, and auto-radio buttons for allowing the user to select from mutually exclusive options.

```
void WMRunTimeDlgCommand_Handler(HWND hDlg, int id, HWND hwndCtl, UINT codeNotify)
{
        char    input[20] = "";                                 //character string for i/o
        switch(id)
        {
        case IDM_OKRUNTIME : {

        HWND  hCtrl;                                            //handle to a dialog control

//read the data from the Run Time Settings dialog box

        GetDlgItemText(hDlg, IDM_HORSEPOWER, input, 20);
        horsepower = atof(input);

        GetDlgItemText(hDlg, IDM_THRUSTCOEFFICIENT, input, 20);
        thrust_coefficient = atof(input);
```

The procedure used to interrogate the auto-radio buttons and checkboxes is slightly different than the procedure used in the previous programs. The previous programs declared a DWORD variable and assigned the return value of the SendMessage function to the variable. The variable was then tested using an if statement and the flag value was set appropriately. In this case, the flags are set up so that a checked state indicates a value of one for the flag and an unchecked state indicates a zero value. The

return value from the SendMessage is cast as an integer value with the "(int)" that precedes the function call and the value is assigned directly to the flag. This eliminates the need to declare the DWORD and to perform the test using the if statement.

```
hCtrl = GetDlgItem(hDlg, IDM_OPTIMIZERPM);
optimize_rpm = (int)SendMessage(hCtrl, BM_GETCHECK, 0, 0L);

hCtrl = GetDlgItem(hDlg, IDM_OPTIMIZEDIAMETER);
optimize_diameter = (int)SendMessage(hCtrl, BM_GETCHECK, 0, 0L);

hCtrl = GetDlgItem(hDlg, IDM_MAXIMIZETHRUST);
maximize_thrust = (int)SendMessage(hCtrl, BM_GETCHECK, 0, 0L);

hCtrl = GetDlgItem(hDlg, IDM_NOOPTIONS);
no_runtime_options = (int)SendMessage(hCtrl, BM_GETCHECK, 0, 0L);

hCtrl = GetDlgItem(hDlg, IDM_UNLOAD);
unload_flag = (int)SendMessage(hCtrl, BM_GETCHECK, 0, 0L);

hCtrl = GetDlgItem(hDlg, IDM_MATCHEAR);
match_EAR_flag = (int)SendMessage(hCtrl, BM_GETCHECK, 0, 0L);

hCtrl = GetDlgItem(hDlg, IDM_USECURRBLD);
use_curr_blade = (int)SendMessage(hCtrl, BM_GETCHECK, 0, 0L);

hCtrl = GetDlgItem(hDlg, IDM_NONAXISYM);
eval_nonaxi_stator = (int)SendMessage(hCtrl, BM_GETCHECK, 0, 0L);

hCtrl = GetDlgItem(hDlg, IDM_WRITEPBDFILES);
pbd_file_flag = (int)SendMessage(hCtrl, BM_GETCHECK, 0, 0L);
```

The run_ok_flag variable is a global integer variable that is used to determine whether the user selected the "OK" button or the "CANCEL" button. This allows the program to terminate the File|Run case if the user changes his or her mind.

```
run_ok_flag = 0;

EndDialog(hDlg, 0);

break;
                        }

case IDM_CANCELRUNTIME : {

          run_ok_flag = 1;

          EndDialog(hDlg, 0);
```

```
				break;
					}
		}
}

BOOL CALLBACK _export RunTimeDlgProc(HWND hDlg, UINT message, WPARAM wParam,
LPARAM lParam)
{
	char	input[20] = "";				//character string for i/o
	switch(message)
	{
	case WM_INITDIALOG : {

//print the current values in the Run Time Settings dialog box

	sprintf(input,"%9.1f",horsepower);
	SetDlgItemText(hDlg,IDM_HORSEPOWER,input);

	sprintf(input,"%4.3f",thrust_coefficient);
	SetDlgItemText(hDlg,IDM_THRUSTCOEFFICIENT,input);
```

The functions in PLL make use of the CheckDlgButton function to initialize check boxes and auto-radio buttons. The CheckDlgButton function receives a handle to the dialog box, the identifier of the control, and an unsigned integer check state. The function then checks or clears the control as indicated by the state. In these cases the value of the flag is cast as an unsigned integer by using "(UINT)" preceding the variable. A value of one causes the associated button to be initialized in a checked state, and a zero value causes the button to be initialized in a cleared state.

```
	CheckDlgButton (hDlg, IDM_OPTIMIZERPM,		(UINT)optimize_rpm);
	CheckDlgButton (hDlg, IDM_OPTIMIZEDIAMETER,	(UINT)optimize_diameter);
	CheckDlgButton (hDlg, IDM_MAXIMIZETHRUST,		(UINT)maximize_thrust);
	CheckDlgButton (hDlg, IDM_NOOPTIONS,		(UINT)no_runtime_options);
	CheckDlgButton (hDlg, IDM_UNLOAD,		(UINT)unload_flag);
	CheckDlgButton (hDlg, IDM_MATCHEAR,		(UINT)match_EAR_flag);
	CheckDlgButton (hDlg, IDM_USECURRBLD,		(UINT)use_curr_blade);
	CheckDlgButton (hDlg, IDM_NONAXISYM,		(UINT)eval_nonaxi_stator);
	CheckDlgButton (hDlg, IDM_WRITEPBDFILES,	(UINT)pbd_file_flag);

	return TRUE;
				}

	case WM_COMMAND : {

		return (BOOL)HANDLE_WM_COMMAND(hDlg, wParam, lParam,
					WMRunTimeDlgCommand_Handler);
```

```
			}
		}
		return FALSE;
}
```

C.3.2 The Expanded Area Ratio dialog box functions.

The Expanded Area Ratio dialog box requires four separate functions. The WMEAR1DlgCommand_Handler, WMEAR2DlgCommand_Handler, EAR1DlgProc, and EAR2DlgProc functions are shown below. Four functions are required because single and multiple component boxes are provided. The identifiers used in the single component case for initializing the expanded area ratio value and receiving user input are also used for component one in the multiple component case. This reduces the total number of identifiers required and allows for reuse of some of the code.

```
void WMEAR1DlgCommand_Handler(HWND hDlg, int id, HWND hwndCtl, UINT codeNotify)
{
	char	input[20] = "";				//character string for i/o
	switch(id)
	{
	case IDM_OK1EAR : {

	GetDlgItemText(hDlg, IDM_1EAR, input, 20);
	EAR[0] = atof(input);

	EndDialog(hDlg, 0);

	break;
			}
	}
}

BOOL CALLBACK _export EAR1DlgProc(HWND hDlg, UINT message, WPARAM wParam,
	LPARAM lParam)
{
	char	input[20] = "";				//character string for i/o

	switch(message)
	{
	case WM_INITDIALOG : {


	sprintf(input,"%5.4f",EAR[0]);
	SetDlgItemText(hDlg,IDM_1EARDAT,input);
```

```
		sprintf(input,"%5.4f",EAR[0]);
		SetDlgItemText(hDlg,IDM_1EAR,input);

		return TRUE;
				}

		case WM_COMMAND : {

			return (BOOL)HANDLE_WM_COMMAND(hDlg, wParam, lParam,
						WMEAR1DlgCommand_Handler);
				}
		}
		return FALSE;
}

void WMEAR2DlgCommand_Handler(HWND hDlg, int id, HWND hwndCtl, UINT codeNotify)
{
		char	input[20] = "";					//character string for i/o
		switch(id)
		{
		case IDM_OK2EAR : {

		GetDlgItemText(hDlg, IDM_1EAR, input, 20);
		EAR[0] = atof(input);

		GetDlgItemText(hDlg, IDM_2EAR, input, 20);
		EAR[1] = atof(input);

		EndDialog(hDlg, 0);

		break;
				}
		}
}

BOOL CALLBACK _export EAR2DlgProc(HWND hDlg, UINT message, WPARAM wParam,
					LPARAM lParam)
{
		char	input[20] = "";					//character string for i/o
		switch(message)
		{
		case WM_INITDIALOG : {

		sprintf(input,"%5.4f",EAR[0]);
		SetDlgItemText(hDlg,IDM_1EARDAT,input);

		sprintf(input,"%5.4f",EAR[1]);
		SetDlgItemText(hDlg,IDM_2EARDAT,input);

		sprintf(input,"%5.4f",EAR[0]);
		SetDlgItemText(hDlg,IDM_1EAR,input);

		sprintf(input,"%5.4f",EAR[1]);
		SetDlgItemText(hDlg,IDM_2EAR,input);
```

```
return TRUE;
                        }

        case WM_COMMAND : {

                return (BOOL)HANDLE_WM_COMMAND(hDlg, wParam, lParam,
                                        WMEAR2DlgCommand_Handler);
                        }
        }
        return FALSE;
}
```

C.3.3 The Glauert Coefficients dialog box functions.

The Glauert Coefficients dialog boxes also require four functions to handle the single and multiple component cases. Since the coefficient values and the associated user input are handled as floating point arrays, the identifiers for the static text controls used to display the current values of the coefficients and the identifiers for the edit text controls used to receive the unload fractions are defined sequentially. This allows the controls to be initialized and read using for loops and thereby minimizing the amount of code needed and the size of the executable file.

```
void WMGlauert1DlgCommand_Handler(HWND hDlg, int id, HWND hwndCtl, UINT codeNotify)
{
        char    input[20] = "";                         //character string for i/o
        switch(id)
        {
        case IDM_OK1GLAUERT : {

        int k;                                          //loop counter

//loop through and read all of the Glauert coefficient unload fractions

        for(k=0; k<NGC;k++) {

                GetDlgItemText(hDlg, IDM_1GLAUERT1+k, input, 20);
                GC_UNLOAD_FRAC[0][k] = atof(input);

                        }
                                }

        case IDM_CANCEL1GLAUERT : {

        EndDialog(hDlg, 0);
```

```
                break;
                                        }
                }
        }

        BOOL CALLBACK _export Glauert1DlgProc(HWND hDlg, UINT message, WPARAM wParam,
                                        LPARAM lParam)
        {
                char    input[20] = "";                         //character string for i/o
                int     k;
                switch(message)
                {
                case WM_INITDIALOG : {

                for(k=0; k<NGC;k++) {

                        sprintf(input,"%5.4f",GC[0][k]);
                        SetDlgItemText(hDlg,IDM_1GC1+k,input);

                                }
                return TRUE;
                                        }

                case WM_COMMAND : {

                        return (BOOL)HANDLE_WM_COMMAND(hDlg, wParam, lParam,
                                        WMGlauert1DlgCommand_Handler);
                                }
                }

                return FALSE;
        }

        void WMGlauert2DlgCommand_Handler(HWND hDlg, int id, HWND hwndCtl, UINT codeNotify)
        {
                char    input[20] = "";                         //character string for i/o
                switch(id)
                {
                case IDM_OK2GLAUERT : {

                int     k;                                      //loop counter

        //loop through and read all of the Glauert coefficient unload fractions for both components

                for(k=0; k<NGC;k++) {

                GetDlgItemText(hDlg, IDM_1GLAUERT1+k, input, 20);
                GC_UNLOAD_FRAC[0][k] = atof(input);

                GetDlgItemText(hDlg, IDM_2GLAUERT1+k, input, 20);
                GC_UNLOAD_FRAC[1][k] = atof(input);

                                }
                                        }
```

```
        case IDM_CANCEL2GLAUERT : {

        EndDialog(hDlg, 0);

        break;
                                    }
        }
}

BOOL CALLBACK _export Glauert2DlgProc(HWND hDlg, UINT message, WPARAM wParam,
                                      LPARAM lParam)
{
        char    input[20] = "";                         //character string for i/o
        int     k;
        switch(message)
        {
        case WM_INITDIALOG : {

        for(k=0; k<NGC;k++) {

        sprintf(input,"%5.4f",GC[0][k]);
        SetDlgItemText(hDlg,IDM_1GC1+k,input);

        sprintf(input,"%5.4f",GC[1][k]);
        SetDlgItemText(hDlg,IDM_2GC1+k,input);

                }
        return TRUE;
                                    }

        case WM_COMMAND : {

                return (BOOL)HANDLE_WM_COMMAND(hDlg, wParam, lParam,
                                        WMGlauert2DlgCommand_Handler);
                        }
        }
        return FALSE;
}
```

C.3.4 The PBD Skew/Rake Settings dialog box functions.

The PBD Skew/Rake Settings dialog boxes also require four functions. In this case, however, the first two functions initialize and retrieve data from the component one box and the last two functions initialize and retrieve data from the component two box. These functions, like the Glauert Coefficients functions, make use of the sequential nature of the data by using for loops and sequentially defined identifiers. They are also coded to allow the user to cause the Command_Handler functions to calculate skew and/or rake

values for intermediate radii by supplying hub and tip skew and/or rake values and checking the appropriate box(es).

```
void WMSkewRake1DlgCommand_Handler(HWND hDlg, int id, HWND hwndCtl, UINT codeNotify)
{
        char     input[20] = "";                                          //character string for i/o
        HWND  hCtrl;                                                       //handle to a dialog
control
        switch(id)
        {
        case IDM_OK1SKEWRAKE : {
        int k;

//loop through and read all of the skew and rake inputs for component #1

        for(k=0; k<MRPIN[0];k++) {

        GetDlgItemText(hDlg, IDM_1SKEW1+k, input, 20);
        pbd_skew[k][0] = atof(input);

        GetDlgItemText(hDlg, IDM_1RAKE1+k, input, 20);
        pbd_rake[k][0] = atof(input);

                                }

        hCtrl = GetDlgItem(hDlg, IDM_LINEARSKEW1);
        linear_skew_flag[0] = (int)SendMessage(hCtrl, BM_GETCHECK, 0, 0L);

        hCtrl = GetDlgItem(hDlg, IDM_LINEARRAKE1);
        linear_rake_flag[0] = (int)SendMessage(hCtrl, BM_GETCHECK, 0, 0L);
```

If the linear_skew_flag was set by the user action of checking the "Use Linear Skew" check box, the program uses a for loop to calculate the skew value at each intermediate radius by interpolating between the hub and tip values.

```
//if the linear skew flag is set for component #1, calculate a linear skew distribution for component #1

        if(linear_skew_flag[0])

                for(k=1;k<MRPIN[0]-1;k++)

                        pbd_skew[k][0]=pbd_skew[0][0]+(pbd_skew[MRPIN[0]-1][0]-pbd_skew[0][0])
                                *(XRPIN[k][0]-XRPIN[0][0])/(XRPIN[MRPIN[0]-1][0]-
XRPIN[0][0]);
```

The same process is used for the rake settings.

```
//if the linear rake flag is set for component #1, calculate a linear rake distribution for component #1

        if(linear_rake_flag[0])

                for(k=1;k<MRPIN[0]-1;k++)

                        pbd_rake[k][0]=pbd_rake[0][0]+(pbd_rake[MRPIN[0]-1][0]-pbd_rake[0][0])
                                *(XRPIN[k][0]-XRPIN[0][0])/(XRPIN[MRPIN[0]-1][0]-
XRPIN[0][0]);


                                }

        case IDM_CANCEL1SKEWRAKE : {

        EndDialog(hDlg, 0);

        break;
                                }
        }
}

BOOL CALLBACK _export SkewRake1DlgProc(HWND hDlg, UINT message, WPARAM wParam,
                                LPARAM lParam)
{
        char    input[20] = "";                         //character string for i/o
        int     k;
        switch(message)
        {
        case WM_INITDIALOG : {

        for(k=0; k<MRPIN[0];k++) {

        sprintf(input,"%5.2f",XRPIN[k][0]);
        SetDlgItemText(hDlg,IDM_1RADIUS1+k,input);

        sprintf(input,"%5.2f",pbd_skew[k][0]);
        SetDlgItemText(hDlg,IDM_1SKEW1+k,input);

        sprintf(input,"%3.2f",pbd_rake[k][0]);
        SetDlgItemText(hDlg,IDM_1RAKE1+k,input);

                                }

        CheckDlgButton (hDlg, IDM_LINEARSKEW1, (UINT)linear_skew_flag[0]) ;
        CheckDlgButton (hDlg, IDM_LINEARRAKE1, (UINT)linear_rake_flag[0]) ;

        return TRUE;
                                }

        case WM_COMMAND : {
```

```
                        return (BOOL)HANDLE_WM_COMMAND(hDlg, wParam, lParam,
                                        WMSkewRake1DlgCommand_Handler);
                }
        }
        return FALSE;
}
```

The process is the same for the component two functions.

```
void WMSkewRake2DlgCommand_Handler(HWND hDlg, int id, HWND hwndCtl, UINT codeNotify)
{
        char input[20] = "";                              //character string for i/o
        HWND  hCtrl;
        switch(id)
        {
        case IDM_OK2SKEWRAKE : {

        int        k;

        for(k=0; k<MRPIN[1];k++) {

        GetDlgItemText(hDlg, IDM_2SKEW1+k, input, 20);
        pbd_skew[k][1] = atof(input);

        GetDlgItemText(hDlg, IDM_2RAKE1+k, input, 20);
        pbd_rake[k][1] = atof(input);

                        }


        hCtrl = GetDlgItem(hDlg, IDM_LINEARSKEW2);
        linear_skew_flag[1] = (int)SendMessage(hCtrl, BM_GETCHECK, 0, 0L);

        hCtrl = GetDlgItem(hDlg, IDM_LINEARRAKE2);
        linear_rake_flag[1] = (int)SendMessage(hCtrl, BM_GETCHECK, 0, 0L);


        if(linear_skew_flag[1])

                for(k=1;k<MRPIN[1]-1;k++)

                        pbd_skew[k][1]=pbd_skew[0][1]+(pbd_skew[MRPIN[1]-1][1]-pbd_skew[0][1])
                                *(XRPIN[k][1]-XRPIN[0][1])/(XRPIN[MRPIN[1]-1][1]-
XRPIN[0][1]);


        if(linear_rake_flag[1])

                for(k=1;k<MRPIN[1]-1;k++)

                        pbd_rake[k][1]=pbd_rake[0][1]+(pbd_rake[MRPIN[1]-1][1]-pbd_rake[0][1])
```

```
                                        *(XRPIN[k][1]-XRPIN[0][1])/(XRPIN[MRPIN[1]-1][1]-
XRPIN[0][1]);
                                        }

        case IDM_CANCEL2SKEWRAKE : {

        EndDialog(hDlg, 0);

        break;
                                        }
        }
}

BOOL CALLBACK _export SkewRake2DlgProc(HWND hDlg, UINT message, WPARAM wParam,
                                        LPARAM lParam)
{
        char    input[20] = "";                         //character string for i/o
        int     k;
        switch(message)
        {
        case WM_INITDIALOG : {

        for(k=0; k<MRPIN[1];k++) {

        sprintf(input,"%5.2f",XRPIN[k][1]);
        SetDlgItemText(hDlg,IDM_2RADIUS1+k,input);

        sprintf(input,"%5.2f",pbd_skew[k][1]);
        SetDlgItemText(hDlg,IDM_2SKEW1+k,input);

        sprintf(input,"%3.2f",pbd_rake[k][1]);
        SetDlgItemText(hDlg,IDM_2RAKE1+k,input);

                                        }

        CheckDlgButton (hDlg, IDM_LINEARSKEW2, (UINT)linear_skew_flag[1]) ;
        CheckDlgButton (hDlg, IDM_LINEARRAKE2, (UINT)linear_rake_flag[1]) ;

        return TRUE;
                                        }

        case WM_COMMAND : {

                return (BOOL)HANDLE_WM_COMMAND(hDlg, wParam, lParam,
                                        WMSkewRake2DlgCommand_Handler);
                        }
        }

        return FALSE;
}
```

C.3.5 The Steepness dialog box functions.

The single and multiple component Steepness dialog boxes also use four functions. The boxes are used to provide data to the user so that the exponents used to unload components may be selected. The data input using these dialog boxes is then used to calculate values used to initialize the Unload Coefficients dialog boxes.

```
void WMSteep1DlgCommand_Handler(HWND hDlg, int id, HWND hwndCtl, UINT codeNotify)
{
        char    input[20] = "";                                 //character string for i/o
        switch(id)
        {
        case IDM_OK1STEEP : {

        GetDlgItemText(hDlg, IDM_HUBSTEEPNESS1, input, 20);
        hub_steepness[0] = atoi(input);

        GetDlgItemText(hDlg, IDM_TIPSTEEPNESS1, input, 20);
        tip_steepness[0] = atoi(input);

                                }

        case IDM_CANCEL1STEEP : {

        EndDialog(hDlg, 0);

        break;
                                }
        }
}

BOOL CALLBACK _export Steep1DlgProc(HWND hDlg, UINT message, WPARAM wParam,
                                LPARAM lParam)
{
        char    input[20] = "";                                 //character string for i/o
        switch(message)
        {
        case WM_INITDIALOG : {

        sprintf(input,"%5.4f",hub_circ[0]);
        SetDlgItemText(hDlg,IDM_HUBCIRC1,input);

        sprintf(input,"%5.4f",hub_radius[0]);
        SetDlgItemText(hDlg,IDM_HUBRADIUS1,input);

        sprintf(input,"%5.4f",tip_circ[0]);
        SetDlgItemText(hDlg,IDM_TIPCIRC1,input);

        sprintf(input,"%5.4f",tip_radius[0]);
        SetDlgItemText(hDlg,IDM_TIPRADIUS1,input);

        return TRUE;
```

```
				}
	case WM_COMMAND : {

		return (BOOL)HANDLE_WM_COMMAND(hDlg, wParam, lParam,
					WMSteep1DlgCommand_Handler);
			}
	}
	return FALSE;
}

void WMSteep2DlgCommand_Handler(HWND hDlg, int id, HWND hwndCtl, UINT codeNotify)
{
	char	input[20] = "";				//character string for i/o
	switch(id)
	{
	case IDM_OK2STEEP : {

	 GetDlgItemText(hDlg, IDM_HUBSTEEPNESS1, input, 20);
	 hub_steepness[0] = atoi(input);

	 GetDlgItemText(hDlg, IDM_TIPSTEEPNESS1, input, 20);
	 tip_steepness[0] = atoi(input);

	 GetDlgItemText(hDlg, IDM_HUBSTEEPNESS2, input, 20);
	 hub_steepness[1] = atoi(input);

	 GetDlgItemText(hDlg, IDM_TIPSTEEPNESS2, input, 20);
	 tip_steepness[1] = atoi(input);

			}

	case IDM_CANCEL2STEEP : {

	EndDialog(hDlg, 0);

	break;
				}
	}
}

BOOL CALLBACK _export Steep2DlgProc(HWND hDlg, UINT message,WPARAM wParam,
				LPARAM lParam)
{
	char	input[20] = "";				//character string for i/o

	switch(message)
	{
	case WM_INITDIALOG : {

	sprintf(input,"%5.4f",hub_circ[0]);
	SetDlgItemText(hDlg,IDM_HUBCIRC1,input);

	sprintf(input,"%5.4f",hub_radius[0]);
```

```
        SetDlgItemText(hDlg,IDM_HUBRADIUS1,input);

        sprintf(input,"%5.4f",tip_circ[0]);
        SetDlgItemText(hDlg,IDM_TIPCIRC1,input);

        sprintf(input,"%5.4f",tip_radius[0]);
        SetDlgItemText(hDlg,IDM_TIPRADIUS1,input);

        sprintf(input,"%5.4f",hub_circ[1]);
        SetDlgItemText(hDlg,IDM_HUBCIRC2,input);

        sprintf(input,"%5.4f",hub_radius[1]);
        SetDlgItemText(hDlg,IDM_HUBRADIUS2,input);

        sprintf(input,"%5.4f",tip_circ[1]);
        SetDlgItemText(hDlg,IDM_TIPCIRC2,input);

        sprintf(input,"%5.4f",tip_radius[1]);
        SetDlgItemText(hDlg,IDM_TIPRADIUS2,input);

        return TRUE;
                            }

        case WM_COMMAND : {

                return (BOOL)HANDLE_WM_COMMAND(hDlg, wParam, lParam,
                                        WMSteep2DlgCommand_Handler);
                        }
        }
        return FALSE;
}
```

C.3.6 The Unload Coefficients dialog box functions.

The four functions that initialize and retrieve data from the Unload Coefficients dialog boxes are shown below.

```
void WMCoefficient1DlgCommand_Handler(HWND hDlg, int id, HWND hwndCtl, UINT codeNotify)
{
        char    input[20] = "";                         //character string for i/o
        switch(id)
        {
        case IDM_OK1COEFFICIENT : {


        GetDlgItemText(hDlg, IDM_HUBCOEFFICIENT1, input, 20);
        hub_coefficient[0] = atof(input);


        GetDlgItemText(hDlg, IDM_TIPCOEFFICIENT1, input, 20);
```

```
tip_coefficient[u] = atof(input);

                                  }

        case IDM_CANCEL1COEFFICIENT : {

        EndDialog(hDlg, 0);

        break;
                                             }
        }
}

BOOL CALLBACK _export Coefficient1DlgProc(HWND hDlg, UINT message, WPARAM wParam,
                                  LPARAM lParam)
{
        char      input[20] = "";                              //character string for i/o

        switch(message)
        {
        case WM_INITDIALOG : {


        sprintf(input,"%4.3f",GNHC[0]);
        SetDlgItemText(hDlg,IDM_HUBUNLOADPERCENT1,input);

        sprintf(input,"%4.3f",GNTC[0]);
        SetDlgItemText(hDlg,IDM_TIPUNLOADPERCENT1,input);

        return TRUE;
                                  }

        case WM_COMMAND : {

                return (BOOL)HANDLE_WM_COMMAND(hDlg, wParam, lParam,
                                  WMCoefficient1DlgCommand_Handler);
                         }
        }
        return FALSE;
}

void WMCoefficient2DlgCommand_Handler(HWND hDlg, int id, HWND hwndCtl, UINT codeNotify)
{
        char      input[20] = "";                              //character string for i/o
        switch(id)
        {
        case IDM_OK2COEFFICIENT : {

        GetDlgItemText(hDlg, IDM_HUBCOEFFICIENT1, input, 20);
        hub_coefficient[0] = atof(input);

        GetDlgItemText(hDlg, IDM_TIPCOEFFICIENT1, input, 20);
        tip_coefficient[0] = atof(input);
```

```
        GetDlgItemText(hDlg, IDM_HUBCOEFFICIENT2, input, 20);
        hub_coefficient[1] = atof(input);

        GetDlgItemText(hDlg, IDM_TIPCOEFFICIENT2, input, 20);
        tip_coefficient[1] = atof(input);

                                }

        case IDM_CANCEL2COEFFICIENT : {

        EndDialog(hDlg, 0);

        break;
                                        }
        }
}

BOOL CALLBACK _export Coefficient2DlgProc(HWND hDlg, UINT message, WPARAM wParam,
                                LPARAM lParam)
{
        char    input[20] = "";                                 //character string for i/o

        switch(message)
        {
        case WM_INITDIALOG : {

        sprintf(input,"%4.3f",GNHC[0]);
        SetDlgItemText(hDlg,IDM_HUBUNLOADPERCENT1,input);

        sprintf(input,"%4.3f",GNTC[0]);
        SetDlgItemText(hDlg,IDM_TIPUNLOADPERCENT1,input);

        sprintf(input,"%4.3f",GNHC[1]);
        SetDlgItemText(hDlg,IDM_HUBUNLOADPERCENT2,input);

        sprintf(input,"%4.3f",GNTC[1]);
        SetDlgItemText(hDlg,IDM_TIPUNLOADPERCENT2,input);

        return TRUE;
                                }

        case WM_COMMAND : {

                return (BOOL)HANDLE_WM_COMMAND(hDlg, wParam, lParam,
                                        WMCoefficient2DlgCommand_Handler);
                        }
        }
        return FALSE;
}
```

C.3.7 The Default Settings dialog box functions.

The four functions that initialize and retrieve data from the Default Settings dialog boxes are shown below.

```
void WMDefault1SettingsDlgCommand_Handler(HWND hDlg, int id, HWND hwndCtl,
                                    T codeNotify)
{
        char      input[2                                         //character string for i/o
        switch(id)
        {
        case IDM_OKDEFAULT1SETTINGS : {

        HWND              hCtrl;

        GetDlgItemText(hDlg, IDM_CLMAX, input, 20);
        CLMAX = atof(input);

        GetDlgItemText(hDlg, IDM_TCHDMAX, input, 20);
        TCHDMAX = atof(input);

        GetDlgItemText(hDlg, IDM_TTIP, input, 20);
        TTIP = atof(input);

        GetDlgItemText(hDlg, IDM_NPANEL, inpu
        NPANEL = atoi(input);

        GetDlgItemText(hDlg, IDM_CDCON, input, 20);
        CDCON = atof(input);

        GetDlgItemText(hDlg, IDM_RHVOR, input, 20);
        RHVOR = atof(input);

        GetDlgItemText(hDlg, IDM_HUBCHORD1, input, 20);
        HUBCHD[0] = atof(input);

        GetDlgItemText(hDlg, IDM_PL1, input, 20);
        PL1 = atof(input);

        hCtrl = GetDlgItem(hDlg, IDM_WAKEALIGNMENTFLAG);
        wake_alignment_flag = (int)SendMessage(hCtrl, BM_GETCHECK, 0, 0L);

        hCtrl = GetDlgItem(hDlg, IDM_CIRCOPTFLAG);
        circulation_optimization_flag = (int)SendMessage(hCtrl, BM_GETCHECK, 0, 0L);

        hCtrl = GetDlgItem(hDlg, IDM_CHORDCOPTFLAG);
        chord_optimization_flag = (int)SendMessage(hCtrl, BM_GETCHECK, 0, 0L);

        hCtrl = GetDlgItem(hDlg, IDM_EMPIRICALVCDFLAG);
        empirical_vcd_flag = (int)SendMessage(hCtrl, BM_GETCHECK, 0, 0L);

                                }
```

```
        case IDM_CANCELDEFAULT1SETTINGS : {

        EndDialog(hDlg, 0);

        break;
                                        }
        }
}

BOOL CALLBACK _export Default1SettingsDlgProc(HWND hDlg, UINT message, WPARAM wParam,
                                LPARAM lParam)
{
        char     input[20] = "";                              //character string for i/o
        switch(message)
        {
        case WM_INITDIALOG : {

        sprintf(input,"%5.4f",CLMAX);
        SetDlgItemText(hDlg,IDM_CLMAX,input);

        sprintf(input,"%5.4f",TCHDMAX);
        SetDlgItemText(hDlg,IDM_TCHDMAX,input);

        sprintf(input,"%5.4f",TTIP);
        SetDlgItemText(hDlg,IDM_TTIP,input);

        sprintf(input,"%d",NPANEL);
        SetDlgItemText(hDlg,IDM_NPANEL,input);

        sprintf(input,"%5.4f",CDCON);
        SetDlgItemText(hDlg,IDM_CDCON,input);

        sprintf(input,"%5.4f",RHVOR);
        SetDlgItemText(hDlg,IDM_RHVOR,input);

        sprintf(input,"%5.4f",HUBCHD[0]);
        SetDlgItemText(hDlg,IDM_HUBCHORD1,input);

        sprintf(input,"%5.4f",PL1);
        SetDlgItemText(hDlg,IDM_PL1,input);

        CheckDlgButton (hDlg, IDM_WAKEALIGNMENTFLAG, (UINT)wake_alignment_flag) ;
        CheckDlgButton (hDlg, IDM_CIRCOPTFLAG, (UINT)circulation_optimization_flag) ;
        CheckDlgButton (hDlg, IDM_CHORDCOPTFLAG, (UINT)chord_optimization_flag) ;
        CheckDlgButton (hDlg, IDM_EMPIRICALVCDFLAG, (UINT)empirical_vcd_flag) ;

        return TRUE;
                                }

        case WM_COMMAND : {

                return (BOOL)HANDLE_WM_COMMAND(hDlg, wParam, lParam,
                                WMDefault1SettingsDlgCommand_Handler);
                        }
```

```
	}
	return FALSE;
}

void WMDefault2SettingsDlgCommand_Handler(HWND hDlg, int id, HWND hwndCtl, UINT
codeNotify)
{
	char	input[20] = "";					//character string for i/o
	switch(id)
	{
	case IDM_OKDEFAULT2SETTINGS : {

	HWND		hCtrl;

	GetDlgItemText(hDlg, IDM_CLMAX, input, 20);
	CLMAX = atof(input);

	GetDlgItemText(hDlg, IDM_TCHDMAX, input, 20);
	TCHDMAX = atof(input);

	GetDlgItemText(hDlg, IDM_TTIP, input, 20);
	TTIP = atof(input);

	GetDlgItemText(hDlg, IDM_NPANEL, input, 20);
	NPANEL = atoi(input);

	GetDlgItemText(hDlg, IDM_CDCON, input, 20);
	CDCON = atof(input);

	GetDlgItemText(hDlg, IDM_RHVOR, input, 20);
	RHVOR = atof(input);

	GetDlgItemText(hDlg, IDM_HUBCHORD1, input, 20);
	HUBCHD[0] = atof(input);

	GetDlgItemText(hDlg, IDM_HUBCHORD2, input, 20);
	HUBCHD[1] = atof(input);

	GetDlgItemText(hDlg, IDM_PL1, input, 20);
	PL1 = atof(input);

	GetDlgItemText(hDlg, IDM_PL2, input, 20);
	PL2 = atof(input);

	hCtrl = GetDlgItem(hDlg, IDM_WAKEALIGNMENTFLAG);
	wake_alignment_flag = (int)SendMessage(hCtrl, BM_GETCHECK, 0, 0L);

	hCtrl = GetDlgItem(hDlg, IDM_CIRCOPTFLAG);
	circulation_optimization_flag = (int)SendMessage(hCtrl, BM_GETCHECK, 0, 0L);

	hCtrl = GetDlgItem(hDlg, IDM_CHORDCOPTFLAG);
	chord_optimization_flag = (int)SendMessage(hCtrl, BM_GETCHECK, 0, 0L);

	hCtrl = GetDlgItem(hDlg, IDM_EMPIRICALVCDFLAG);
```

```
empirical_vod_flag = (int)SendMessage(hCtrl, BM_GETCHECK, 0, 0L);

hCtrl = GetDlgItem(hDlg, IDM_CONRATFLAG);
contraction_ratio_flag = (int)SendMessage(hCtrl, BM_GETCHECK, 0, 0L);
```

If the contraction_ratio_flag is not set, then the contraction ratio is set to the value entered by the user. Otherwise, the default value is used.

```
if(!contraction_ratio_flag) {

        GetDlgItemText(hDlg, IDM_CONRAT, input, 20);
        CONRAT = atof(input);

                        }

                        }

case IDM_CANCELDEFAULT2SETTINGS : {

EndDialog(hDlg, 0);

break;
                                }
}
}

BOOL CALLBACK _export Default2SettingsDlgProc(HWND hDlg, UINT message, WPARAM wParam,
                        LPARAM lParam)
{
        char    input[20] = "";                         //character string for i/o
        switch(message)
        {
        case WM_INITDIALOG : {

        sprintf(input,"%5.4f",CLMAX);
        SetDlgItemText(hDlg,IDM_CLMAX,input);

        sprintf(input,"%5.4f",TCHDMAX);
        SetDlgItemText(hDlg,IDM_TCHDMAX,input);

        sprintf(input,"%5.4f",TTIP);
        SetDlgItemText(hDlg,IDM_TTIP,input);

        sprintf(input,"%d",NPANEL);
        SetDlgItemText(hDlg,IDM_NPANEL,input);

        sprintf(input,"%5.4f",CDCON);
        SetDlgItemText(hDlg,IDM_CDCON,input);

        sprintf(input,"%5.4f",RHVOR);
        SetDlgItemText(hDlg,IDM_RHVOR,input);
```

```
	sprintf(input,"%5.4f",HUBCHD[0]);
	SetDlgItemText(hDlg,IDM_HUBCHORD1,input);

	sprintf(input,"%5.4f",HUBCHD[1]);
	SetDlgItemText(hDlg,IDM_HUBCHORD2,input);

	sprintf(input,"%5.4f",PL1);
	SetDlgItemText(hDlg,IDM_PL1,input);

	sprintf(input,"%5.4f",PL2);
	SetDlgItemText(hDlg,IDM_PL2,input);

	sprintf(input,"%5.4f",CONRAT);
	SetDlgItemText(hDlg,IDM_CONRAT,input);

	CheckDlgButton (hDlg, IDM_WAKEALIGNMENTFLAG, (UINT)wake_alignment_flag);
	CheckDlgButton (hDlg, IDM_CIRCOPTFLAG, (UINT)circulation_optimization_flag);
	CheckDlgButton (hDlg, IDM_CHORDCOPTFLAG, (UINT)chord_optimization_flag);
	CheckDlgButton (hDlg, IDM_EMPIRICALVCDFLAG, (UINT)empirical_vcd_flag);
	CheckDlgButton (hDlg, IDM_CONRATFLAG, (UINT)contraction_ratio_flag);

	return TRUE;
			}

	case WM_COMMAND : {

		return (BOOL)HANDLE_WM_COMMAND(hDlg, wParam, lParam,
					WMDefault2SettingsDlgCommand_Handler);
			}
	}
	return FALSE;
}
```

C.3.8 The Duct Settings dialog box functions.

The Duct Settings dialog box is handled by the WMDuctSettingsDlgCommand_Handler and the DuctSettingsDlgProc functions shown below. No new concepts are used in these functions.

```
void WMDuctSettingsDlgCommand_Handler(HWND hDlg, int id, HWND hwndCtl, UINT codeNotify)
{
	char	input[20] = "";				//character string for i/o
	switch(id)
	{
	case IDM_OKDUCTSETTINGS : {

	HWND		hCtrl;

	hCtrl = GetDlgItem(hDlg, IDM_DUCTMEANLINEFLAG);
	duct_mean_line_flag = (int)SendMessage(hCtrl, BM_GETCHECK, 0, 0L);
```

```
hCtrl = GetDlgItem(hDlg, IDM_DUCTRINGVORTFORCESFLAG);
duct_ring_vortex_forces_flag = (int)SendMessage(hCtrl, BM_GETCHECK, 0, 0L);

hCtrl = GetDlgItem(hDlg, IDM_DUCTFORCESFLAG);
duct_forces_flag = (int)SendMessage(hCtrl, BM_GETCHECK, 0, 0L);

hCtrl = GetDlgItem(hDlg, IDM_ESTIMATEDUCTCIRCULATION);
estimate_duct_circulation_flag = (int)SendMessage(hCtrl, BM_GETCHECK, 0, 0L);

GetDlgItemText(hDlg, IDM_GAPFAC, input, 20);
GAPFAC = atof(input);

GetDlgItemText(hDlg, IDM_PROPDUCTTHRUSTRATIO, input, 20);
propeller_duct_thrust_ratio = atof(input);

GetDlgItemText(hDlg, IDM_DUCTCIRCULATION, input, 20);
estimated_duct_circulation = atof(input);

                        }

case IDM_CANCELDUCTSETTINGS : {

EndDialog(hDlg, 0);

break;
                              }
        }
}

BOOL CALLBACK _export DuctSettingsDlgProc(HWND hDlg, UINT message, WPARAM wParam,
                        LPARAM lParam)
{
        char    input[20] = "";                         //character string for i/o
        switch(message)
        {
        case WM_INITDIALOG : {

        sprintf(input,"%4.3f",GAPFAC);
        SetDlgItemText(hDlg,IDM_GAPFAC,input);

        CheckDlgButton(hDlg,IDM_DUCTMEANLINEFLAG,(UINT)duct_mean_line_flag);

        CheckDlgButton(hDlg,IDM_DUCTRINGVORTFORCESFLAG,
                        (UINT)duct_ring_vortex_forces_flag);

        CheckDlgButton (hDlg,IDM_DUCTFORCESFLAG,(UINT)duct_forces_flag);

        CheckDlgButton(hDlg,IDM_ESTIMATEDUCTCIRCULATION,
                        (UINT)estimate_duct_circulation_flag);

        sprintf(input,"%3.2f",propeller_duct_thrust_ratio);
        SetDlgItemText(hDlg,IDM_PROPDUCTTHRUSTRATIO,input);

        sprintf(input,"%7.6f",estimated_duct_circulation);
```

```
        SetDlgItemText(hDlg,IDM_DUCTCIRCULATION,input);

        return TRUE;
                            }

        case WM_COMMAND : {

                return (BOOL)HANDLE_WM_COMMAND(hDlg, wParam, lParam,
                                        WMDuctSettingsDlgCommand_Handler);
                }
        }
        return FALSE;
}
```

C.3.9 The PBD Settings dialog box functions.

The next two functions support the PBD Settings dialog box.

```
void WMPBDSettingsDlgCommand_Handler(HWND hDlg, int id, HWND hwndCtl, UINT codeNotify)
{
        char    input[81] = "";                                 //character string for i/o
        switch(id)
        {
        case IDM_OKPBDSETTINGS : {

        HWND            hCtrl;

        GetDlgItemText(hDlg, IDM_PBDRUNTITLE, input, 81);
        sprintf(pbd_run_title, input);

        GetDlgItemText(hDlg, IDM_PBDOUTPUTROOT, input, 9);
        sprintf(pbd_output_root, input);
```

The PBD Settings makes use of auto-radio buttons in receiving input regarding the blade grid spacing, the component for which to write files, the run mode, and the plot mode. Unlike previous cases, the effect of the input is not to cause a flag to be set or cleared. In these cases the choice of a particular selection causes a variable to have a specific value. This requires the use of the if statement to determine the state of the buttons and assign the values of the variables.

```
        hCtrl = GetDlgItem(hDlg, IDM_UNIFORM);
        if (SendMessage(hCtrl, BM_GETCHECK, 0, 0L))    ISPN = 0;

        hCtrl = GetDlgItem(hDlg, IDM_COSINE);
        if (SendMessage(hCtrl, BM_GETCHECK, 0, 0L))    ISPN = 1;

        hCtrl = GetDlgItem(hDlg, IDM_HALFCOSINE);
```

```
if (SendMessage(hCtrl, BM_GETCHECK, 0, 0L))    ISPN = 2;

hCtrl = GetDlgItem(hDlg, IDM_NACA08CIRC);
MLTYPE = (int)SendMessage(hCtrl, BM_GETCHECK, 0, 0L);

hCtrl = GetDlgItem(hDlg, IDM_PBDCOMP1);
if (SendMessage(hCtrl, BM_GETCHECK, 0, 0L))    pbd_component = 0;

hCtrl = GetDlgItem(hDlg, IDM_PBDCOMP2);
if (SendMessage(hCtrl, BM_GETCHECK, 0, 0L))    pbd_component = 1;

hCtrl = GetDlgItem(hDlg, IDM_IMODE1);
if (SendMessage(hCtrl, BM_GETCHECK, 0, 0L))    IMODE = 1;

hCtrl = GetDlgItem(hDlg, IDM_IMODE2);
if (SendMessage(hCtrl, BM_GETCHECK, 0, 0L))    IMODE = 2;

hCtrl = GetDlgItem(hDlg, IDM_IMODE3);
if (SendMessage(hCtrl, BM_GETCHECK, 0, 0L))    IMODE = 3;

hCtrl = GetDlgItem(hDlg, IDM_NPLOT1);
if (SendMessage(hCtrl, BM_GETCHECK, 0, 0L))    NPLOT = 1;

hCtrl = GetDlgItem(hDlg, IDM_NPLOT2);
if (SendMessage(hCtrl, BM_GETCHECK, 0, 0L))    NPLOT = 2;

hCtrl = GetDlgItem(hDlg, IDM_NPLOT3);
if (SendMessage(hCtrl, BM_GETCHECK, 0, 0L))    NPLOT = 3;

hCtrl = GetDlgItem(hDlg, IDM_NPLOT4);
if (SendMessage(hCtrl, BM_GETCHECK, 0, 0L))    NPLOT = 4;

GetDlgItemText(hDlg, IDM_NKEY, input, 20);
NKEY = atoi(input);

GetDlgItemText(hDlg, IDM_MKEY, input, 20);
MKEY = atoi(input);

GetDlgItemText(hDlg, IDM_NITER, input, 20);
NITER = atoi(input);

GetDlgItemText(hDlg, IDM_RADWGT, input, 20);
RADWGT = atoi(input);

GetDlgItemText(hDlg, IDM_NUFIX, input, 20);
NUFIX = atoi(input);

GetDlgItemText(hDlg, IDM_CDRAG, input, 20);
CDRAG = atof(input);

GetDlgItemText(hDlg, IDM_XULT, input, 20);
XULT = atof(input);

GetDlgItemText(hDlg, IDM_XFINAL, input, 20);
```

```
        XFINAL = atof(input);

        GetDlgItemText(hDlg, IDM_DTPROP, input, 20);
        DTPROP = atof(input);

                                  }

        case IDM_CANCELPBDSETTINGS : {

        EndDialog(hDlg, 0);

        break;
                                          }
        }
}
BOOL CALLBACK _export PBDSettingsDlgProc(HWND hDlg, UINT message, WPARAM wParam,
                          LPARAM lParam)
{
        char      input[82] = "";                          //character string for i/o
        switch(message)
        {
        case WM_INITDIALOG : {
```

The way in which auto-radio buttons are use in these two functions complicates the initialization of the dialog box as well. Switches are used to cause the appropriate buttons to be checked.

```
                switch (ISPN)
                {
                case 0:{
                CheckRadioButton (hDlg,IDM_UNIFORM,IDM_HALFCOSINE,IDM_UNIFORM);
                break; }

                case 1:{
                CheckRadioButton (hDlg,IDM_UNIFORM,IDM_HALFCOSINE,IDM_COSINE);
                break; }

                case 2:{
                CheckRadioButton
(hDlg,IDM_UNIFORM,IDM_HALFCOSINE,IDM_HALFCOSINE);
                break; }
                }

                switch (IMODE)
                {
                case 1:{
                CheckRadioButton (hDlg, IDM_IMODE1, IDM_IMODE3, IDM_IMODE1) ;
                break; }
                case 2:{
```

```
        CheckRadioButton (hDlg, IDM_IMODE1, IDM_IMODE3, IDM_IMODE2) ;
        break; }
        case 3:{
        CheckRadioButton (hDlg, IDM_IMODE1, IDM_IMODE3, IDM_IMODE3) ;
        break; }
        }

        switch (pbd_component)
        {
        case 0:{
        CheckRadioButton (hDlg, IDM_PBDCOMP1, IDM_PBDCOMP2, IDM_PBDCOMP1) ,
        break; }
        case 1:{
        CheckRadioButton (hDlg, IDM_PBDCOMP1, IDM_PBDCOMP2, IDM_PBDCOMP2) ;
        break; }
        }

        if(MLTYPE) CheckDlgButton (hDlg, IDM_BROCKETT08, (UINT)1);
        else     CheckDlgButton (hDlg, IDM_NACA08CIRC, (UINT)1);


        switch (NPLOT)
        {
        case 1:{
        CheckRadioButton (hDlg, IDM_NPLOT1, IDM_NPLOT4, IDM_NPLOT1) ;
        break; }
        case 2:{
        CheckRadioButton (hDlg, IDM_NPLOT1, IDM_NPLOT4, IDM_NPLOT2) ;
        break; }
        case 3:{
        CheckRadioButton (hDlg, IDM_NPLOT1, IDM_NPLOT4, IDM_NPLOT3) ;
        break; }
        case 4:{
        CheckRadioButton (hDlg, IDM_NPLOT1, IDM_NPLOT4, IDM_NPLOT4) ;
        break; }
        }

if(strlen(pbd_run_title)>2) sprintf(input,"%s",pbd_run_title);
else     sprintf(input,"%s",RUN_ID);
SetDlgItemText(hDlg,IDM_PBDRUNTITLE,input);

sprintf(input,"%s",pbd_output_root);
SetDlgItemText(hDlg,IDM_PBDOUTPUTROOT,input);

sprintf(input,"%d",NKEY);
SetDlgItemText(hDlg,IDM_NKEY,input);

sprintf(input,"%d",MKEY);
SetDlgItemText(hDlg,IDM_MKEY,input);

sprintf(input,"%d",NITER);
SetDlgItemText(hDlg,IDM_NITER,input);

sprintf(input,"%d",RADWGT);
```

```
		SetDlgItemText(hDlg,IDM_RADWGT,input);

		sprintf(input,"%d",NUFIX);
		SetDlgItemText(hDlg,IDM_NUFIX,input);

		sprintf(input,"%5.4f",CDRAG);
		SetDlgItemText(hDlg,IDM_CDRAG,input);

		sprintf(input,"%5.4f",XULT);
		SetDlgItemText(hDlg,IDM_XULT,input);

		sprintf(input,"%5.4f",XFINAL);
		SetDlgItemText(hDlg,IDM_XFINAL,input);

		sprintf(input,"%4.3f",DTPROP);
		SetDlgItemText(hDlg,IDM_DTPROP,input);

		return TRUE;
				}

		case WM_COMMAND : {

			return (BOOL)HANDLE_WM_COMMAND(hDlg, wParam, lParam,
						WMPBDSettingsDlgCommand_Handler);
				}
		}
		return FALSE;
}
```

C.3.10 The Project Settings dialog box functions.

The next four functions support the single and multiple component Project Settings dialog boxes. No new concepts are employed in these functions.

```
void WMProject1DlgCommand_Handler(HWND hDlg, int id, HWND hwndCtl, UINT codeNotify)
{
		char	input[21] = "";				//character string for i/o

		switch(id)
		{
		case IDM_OKPROJECT1 : {

		HWND  hCtrl;

		GetDlgItemText(hDlg, IDM_RUN_ID, input, 21);
		sprintf(RUN_ID, input);

		GetDlgItemText(hDlg, IDM_INPUTFILE, input, 20);
		sprintf(INPUTFILE, input);

		GetDlgItemText(hDlg, IDM_RPM1, input, 20);
		RPM[0] = atof(input);
```

```
		hCtrl = GetDlgItem(hDlg, IDM_EFFECTIVEWAKEFLAG);
		effective_wake_flag = (int)SendMessage(hCtrl, BM_GETCHECK, 0, 0L);

		GetDlgItemText(hDlg, IDM_THRUSTESTIMATE, input, 20);
		thrust_estimate = atof(input);

		hCtrl = GetDlgItem(hDlg, IDM_TUNNELOPERATIONFLAG);
		tunnel_operation_flag = (int)SendMessage(hCtrl, BM_GETCHECK, 0, 0L);

		GetDlgItemText(hDlg, IDM_PROPRINGTHRUSTRATIO, input, 20);
		propeller_ring_thrust_ratio = atof(input);

					}

		case IDM_CANCELPROJECT1 : {

		EndDialog(hDlg, 0);

		break;
					}
		}
}

BOOL CALLBACK _export Project1DlgProc(HWND hDlg, UINT message, WPARAM wParam,
				LPARAM lParam)
{
		char	input[21] = "";					//character string for i/o
		switch(message)
		{
		case WM_INITDIALOG : {

		sprintf(input,"%s",PROJECTFILE);
		SetDlgItemText(hDlg,IDM_PROJECTFILE,input);

		sprintf(input,"%s",RUN_ID);
		SetDlgItemText(hDlg,IDM_RUN_ID,input);

		sprintf(input,"%s",INPUTFILE);
		SetDlgItemText(hDlg,IDM_INPUTFILE,input);

		sprintf(input,"%6.2f",RPM[0]);
		SetDlgItemText(hDlg,IDM_RPM1,input);

		sprintf(input,"%6.2f",thrust_estimate);
		SetDlgItemText(hDlg,IDM_THRUSTESTIMATE,input);

		CheckDlgButton(hDlg,IDM_EFFECTIVEWAKEFLAG,(UINT)effective_wake_flag);
		CheckDlgButton(hDlg, IDM_TUNNELOPERATIONFLAG,(UINT)tunnel_operation_flag);

		sprintf(input,"%3.2f",propeller_ring_thrust_ratio);
		SetDlgItemText(hDlg,IDM_PROPRINGTHRUSTRATIO,input);

		return TRUE;
```

```
                    }
        case WM_COMMAND : {

                return (BOOL)HANDLE_WM_COMMAND(hDlg, wParam, lParam,
                                        WMProject1DlgCommand_Handler);
                }
        }
        return FALSE;
}

void WMProject2DlgCommand_Handler(HWND hDlg, int id, HWND hwndCtl, UINT codeNotify)
{
        char    input[21] = "";                         //character string for i/o
        switch(id)
        {
        case IDM_OKPROJECT2 : {

        HWND            hCtrl;

        GetDlgItemText(hDlg, IDM_RUN_ID, input, 21);
        sprintf(RUN_ID, input);

        GetDlgItemText(hDlg, IDM_INPUTFILE, input, 20);
        sprintf(INPUTFILE, input);

        GetDlgItemText(hDlg, IDM_RPM1, input, 20);
        RPM[0] = atof(input);

        GetDlgItemText(hDlg, IDM_RPM2, input, 20);
        RPM[1] = atof(input);

        hCtrl = GetDlgItem(hDlg, IDM_EFFECTIVEWAKEFLAG);
        effective_wake_flag = (int)SendMessage(hCtrl, BM_GETCHECK, 0, 0L);

        GetDlgItemText(hDlg, IDM_THRUSTESTIMATE, input, 20);
        thrust_estimate = atof(input);

        hCtrl = GetDlgItem(hDlg, IDM_TUNNELOPERATIONFLAG);
        tunnel_operation_flag = (int)SendMessage(hCtrl, BM_GETCHECK, 0, 0L);

        GetDlgItemText(hDlg, IDM_TORQUERATIO, input, 20);
        torque_ratio = atof(input);

        hCtrl = GetDlgItem(hDlg, IDM_CIRCOPTWAKEALGNFLAG);
        circ_opt_wake_alignment_flag = (int)SendMessage(hCtrl, BM_GETCHECK, 0, 0L);

        hCtrl = GetDlgItem(hDlg, IDM_USEMANUALDAMPING);
        estimate_damping_flag = (int)SendMessage(hCtrl, BM_GETCHECK, 0, 0L);

        GetDlgItemText(hDlg, IDM_MANUALDAMPING, input, 20);
        damping = atof(input);

                    }
```

```
        case IDM_CANCELPROJECT2 : {

        EndDialog(hDlg, 0);

        break;
                                }
        }
}

BOOL CALLBACK _export Project2DlgProc(HWND hDlg, UINT message, WPARAM wParam,
                        LPARAM lParam)
{
        char    input[21] = "";                                 //character string for i/o

        switch(message)
        {
        case WM_INITDIALOG : {

        sprintf(input,"%s",PROJECTFILE);
        SetDlgItemText(hDlg,IDM_PROJECTFILE,input);

        sprintf(input,"%s",RUN_ID);
        SetDlgItemText(hDlg,IDM_RUN_ID,input);

        sprintf(input,"%s",INPUTFILE);
        SetDlgItemText(hDlg,IDM_INPUTFILE,input);

        sprintf(input,"%6.2f",RPM[0]);
        SetDlgItemText(hDlg,IDM_RPM1,input);

        sprintf(input,"%6.2f",RPM[1]);
        SetDlgItemText(hDlg,IDM_RPM2,input);

        sprintf(input,"%6.2f",thrust_estimate);
        SetDlgItemText(hDlg,IDM_THRUSTESTIMATE,input);

        CheckDlgButton(hDlg,IDM_EFFECTIVEWAKEFLAG,(UINT)effective_wake_flag);
        CheckDlgButton(hDlg,IDM_TUNNELOPERATIONFLAG,(UINT)tunnel_operation_flag);
        CheckDlgButton(hDlg,IDM_CIRCOPTWAKEALGNFLAG,
                (UINT)circ_opt_wake_alignment_flag);
        CheckDlgButton(hDlg,IDM_USEMANUALDAMPING,(UINT)estimate_damping_flag);

        sprintf(input,"%4.3f",damping);
        SetDlgItemText(hDlg,IDM_MANUALDAMPING,input);

        sprintf(input,"%3.2f",torque_ratio);
        SetDlgItemText(hDlg,IDM_TORQUERATIO,input);

        return TRUE;
                        }

        case WM_COMMAND : {
```

```
                return (BOOL)HANDLE_WM_COMMAND(hDlg, wParam, lParam,
                                                WMProject2DlgCommand_Handler);
                        }
        }
        return FALSE;
}
```

C.3.11 The ABS Rules Strength Settings dialog box functions.

The WMABSDlgCommand_Handler and ABSDlgProc functions shown below initialize and retrieve data from the ABS Rules Strength Settings dialog box.

```
void WMABSDlgCommand_Handler(HWND hDlg, int id, HWND hwndCtl, UINT codeNotify)
{
        char    input[20] = "";                         //character string for i/o
        switch(id)
        {
        case IDM_OKABSRULES: {

        HWND            hCtrl;

        hCtrl = GetDlgItem(hDlg, IDM_FIXEDPITCH);
        propeller_type_flag = (int)SendMessage(hCtrl, BM_GETCHECK, 0, 0L);

        hCtrl = GetDlgItem(hDlg, IDM_MNBRZ);
        if (SendMessage(hCtrl, BM_GETCHECK, 0, 0L))
                propeller_material = manganese_bronze;

        hCtrl = GetDlgItem(hDlg, IDM_NIMNBRZ);
        if (SendMessage(hCtrl, BM_GETCHECK, 0, 0L))
                propeller_material = nickel_manganese_bronze;

        hCtrl = GetDlgItem(hDlg, IDM_NIALBRZ);
        if (SendMessage(hCtrl, BM_GETCHECK, 0, 0L))
                propeller_material = nickel_aluminum_bronze;

        hCtrl = GetDlgItem(hDlg, IDM_MNNIALBRZ);
        if (SendMessage(hCtrl, BM_GETCHECK, 0, 0L))
                propeller_material = manganese_nickel_aluminum_bronze;

        hCtrl = GetDlgItem(hDlg, IDM_CASTIRON);
        if (SendMessage(hCtrl, BM_GETCHECK, 0, 0L))
                propeller_material = cast_iron;

        hCtrl = GetDlgItem(hDlg, IDM_USERDEFINEDMATERIAL);
        if (SendMessage(hCtrl, BM_GETCHECK, 0, 0L))
                propeller_material = user_defined_material;

        GetDlgItemText(hDlg, IDM_HUBRAKE, input, 20);
        rake[0] = atof(input);
```

```
GetDlgItemText(hDlg, IDM_TIPRAKE, input, 20);
rake[1] = atof(input);

GetDlgItemText(hDlg, IDM_USERDEFINEDUTS, input, 20);
material_constant[user_defined_material][0] = atof(input);

GetDlgItemText(hDlg, IDM_USERDEFINEDSW, input, 20);
material_constant[user_defined_material][1] = atof(input);

                        }

case IDM_CANCELABSRULES : {

EndDialog(hDlg, 0);

break;
                        }
        }
}

BOOL CALLBACK _export ABSDlgProc(HWND hDlg, UINT message,
                WPARAM wParam, LPARAM lParam)
{
        char    input[20] = "";                         //character string for i/o

        switch(message)
        {
        case WM_INITDIALOG : {

        sprintf(input,"%4.3f",rake[0]);
        SetDlgItemText(hDlg,IDM_HUBRAKE,input);

        sprintf(input,"%4.3f",rake[1]);
        SetDlgItemText(hDlg,IDM_TIPRAKE,input);

        sprintf(input,"%4.1f",material_constant[propeller_material][0]);
        SetDlgItemText(hDlg,IDM_USERDEFINEDUTS,input);

        sprintf(input,"%4.1f",material_constant[propeller_material][1]);
        SetDlgItemText(hDlg,IDM_USERDEFINEDSW,input);

        switch (propeller_material)
        {
        case manganese_bronze:{
        CheckRadioButton(hDlg,IDM_MNBRZ,IDM_USERDEFINEDMATERIAL,
                        IDM_MNBRZ);
        break;}
        case nickel_manganese_bronze:{
        CheckRadioButton(hDlg,IDM_MNBRZ,IDM_USERDEFINEDMATERIAL,
                        IDM_NIMNBRZ);
        break;}
        case nickel_aluminum_bronze:{
        CheckRadioButton(hDlg,IDM_MNBRZ,IDM_USERDEFINEDMATERIAL,
                        IDM_NIALBRZ);
```

```
		break;}
		case manganese_nickel_aluminum_bronze:{
		CheckRadioButton(hDlg,IDM_MNBRZ,IDM_USERDEFINEDMATERIAL,
					IDM_MNNIALBRZ);
		break;}
		case cast_iron:{
		CheckRadioButton(hDlg,IDM_MNBRZ,IDM_USERDEFINEDMATERIAL,
					IDM_CASTIRON);
		break;}
		case user_defined_material:{
		CheckRadioButton(hDlg,IDM_MNBRZ,IDM_USERDEFINEDMATERIAL,
					IDM_USERDEFINEDMATERIAL);
		break;}
		}

		switch (propeller_type_flag)
		{
		case 1:{
		CheckRadioButton (hDlg, IDM_FIXEDPITCH, IDM_CONTROLLABLEPITCH,
					IDM_FIXEDPITCH);
		break; }
		case 0:{
		CheckRadioButton (hDlg, IDM_FIXEDPITCH, IDM_CONTROLLABLEPITCH,
					IDM_CONTROLLABLEPITCH) ;
		break; }
		}

		return TRUE;
					}

		case WM_COMMAND : {

			return (BOOL)HANDLE_WM_COMMAND(hDlg, wParam, lParam,
						WMABSDlgCommand_Handler);
				}
		}

		return FALSE;

}
```

C.3.12 The PBD Plot Geometry dialog box functions.

The PBD Plot Geometry dialog box is the only dialog box in PLL that is not called by a main menu selection either directly or indirectly. It is called by double clicking the right mouse button on a PBD plot in the Plot Viewer window.

```
void WMPBDPRYDlgCommand_Handler(HWND hDlg, int id, HWND hwndCtl, UINT codeNotify)
{
	char	input[20] = "";				//character string for i/o
```

```
        switch(id)
        {
        case IDM_OKPBDPRY: {
```

The pitch, roll, and yaw angles are stored in memory in the units of radians, but are displayed on the screen and input by the user in the units of degrees. The conversion is done in the assignment statements in the Command_Handler function and in the sprintf functions in the DlgProc function.

```
        GetDlgItemText(hDlg, IDM_PBDPITCH, input, 20);
        pitch = PI*atof(input)/180.0;

        GetDlgItemText(hDlg, IDM_PBDROLL, input, 20);
        roll = PI*atof(input)/180.0;

        GetDlgItemText(hDlg, IDM_PBDYAW, input, 20);
        yaw = PI*atof(input)/180.0;

        GetDlgItemText(hDlg, IDM_PBDSCALE, input, 20);
        scale_factor = atof(input);

                        }

        case IDM_CANCELPBDPRY : {

        EndDialog(hDlg, 0);

        break;
                                }
        }

}

BOOL CALLBACK _export PBDPRYDlgProc(HWND hDlg, UINT message, WPARAM wParam,
                        LPARAM lParam)
{
        char    input[20] = "";                         //character string for i/o
        switch(message)
        {
        case WM_INITDIALOG : {

        sprintf(input,"%4.1f",pitch*180.0/PI);
        SetDlgItemText(hDlg,IDM_PBDPITCH,input);

        sprintf(input,"%4.1f",roll*180.0/PI);
        SetDlgItemText(hDlg,IDM_PBDROLL,input);

        sprintf(input,"%4.1f",yaw*180.0/PI);
```

```
	SetDlgItemText(hDlg,IDM_PBDYAW,input);

	sprintf(input,"%4.1f",scale_factor);
	SetDlgItemText(hDlg,IDM_PBDSCALE,input);

	return TRUE;

			}

	case WM_COMMAND : {

		return (BOOL)HANDLE_WM_COMMAND(hDlg, wParam, lParam,
					WMPBDPRYDlgCommand_Handler);
			}
	}

	return FALSE;
}
```

C.3.13 The Optimization Data dialog box functions.

The Optimization Data dialog box is handled by the two functions shown below.

```
void WMOPTIMIZATIONDlgCommand_Handler(HWND hDlg, int id, HWND hwndCtl, UINT
codeNotify)
{
	char	input[20] = "";				//character string for i/o

	switch(id)
	{
	case IDM_OKOPTDATA: {

	HWND		hCtrl;
```

If there is only one component in the project, the opt_comp flag is set to one regardless of the user input. Otherwise, the flag is set in the usual manner.

```
	if(LDEV==1)opt_comp =1;

	else{

	hCtrl = GetDlgItem(hDlg, IDM_OPTCOMP1);
	if (SendMessage(hCtrl, BM_GETCHECK, 0, 0L))
		opt_comp = 1;

	hCtrl = GetDlgItem(hDlg, IDM_OPTCOMP2);
	if (SendMessage(hCtrl, BM_GETCHECK, 0, 0L))
		opt_comp = 2;

	}
```

```
        GetDlgItemText(hDlg, IDM_OPTREQTHRUST, input, 20);
        thrust_req = atof(input);

        GetDlgItemText(hDlg, IDM_OPTTORQCOEFF, input, 20);
        torq_coeff = atof(input);

        EndDialog(hDlg, 0);

        break;          }
        }
}

BOOL CALLBACK _export OPTIMIZATIONDlgProc(HWND hDlg, UINT message,WPARAM
wParam,
                LPARAM lParam)
{
        char    input[20] = "";                         //character string for i/o
        switch(message)
        {
        case WM_INITDIALOG : {
        switch (opt_comp)
        {
        case 1:{
        CheckRadioButton (hDlg, IDM_OPTCOMP1, IDM_OPTCOMP2, IDM_OPTCOMP1);
        break; }
        case 2:{
        CheckRadioButton (hDlg, IDM_OPTCOMP1, IDM_OPTCOMP2, IDM_OPTCOMP2) ;
        break; }
        }

        sprintf(input,"%9.2f",thrust_req);
        SetDlgItemText(hDlg,IDM_OPTREQTHRUST,input);

        sprintf(input,"%5.4f",torq_coeff);
        SetDlgItemText(hDlg,IDM_OPTTORQCOEFF,input);

        return TRUE;

                        }

        case WM_COMMAND :  {

                return (BOOL)HANDLE_WM_COMMAND(hDlg, wParam, lParam,
                                WMOPTIMIZATIONDlgCommand_Handler);
                        }
        }

        return FALSE;

}
```

C.3.14 The About dialog box functions.

The About dialog box is handled by the last two functions in this section.

```
void WMABOUTDlgCommand_Handler(HWND hDlg, int id, HWND hwndCtl, UINT codeNotify)
{
        switch(id)
        {
        case IDM_OKABOUT : {

        EndDialog(hDlg, 0);

        break;                  }
        }
}

BOOL CALLBACK _export ABOUTDlgProc(HWND hDlg, UINT message, WPARAM wParam,
                PARAM lParam)
{
        switch(message)
        {
        case WM_INITDIALOG : {

        return TRUE;            }

        case WM_COMMAND : {

                return (BOOL)HANDLE_WM_COMMAND(hDlg, wParam, lParam,
                                WMABOUTDlgCommand_Handler);
                        }
        }

        return FALSE;

}
```

APPENDIX C.4

The PLL output functions.

C.4 The PLL output functions.

The PLL Windows™ application uses twelve different functions to draw graphical output to the monitor and/or system printer. Four of the functions are used exclusively for PLL output. Six are used exclusively for PBD output and two provide PLL and PBD output. In addition to the functions that provide monitor and printer output, two functions provide output in the form of text files. The output function declarations are listed below in the order in which they will be presented.

```
//PLL output
void    paintbld(HWND hWnd);
void    paintwake(HWND hWnd);
void    paintplot(HWND hWnd);
void    printplot(HDC hDC);

//PLL and PBD output
void    paintout(HWND hWnd);
void    printout(HDC hDC);

//PBD output
void    paint_graphs(HDC PaintDC, POINT origin, FILE *plot, int color);
void    paint_hub(HDC PaintDC, POINT origin, FILE *plot);
void    paint_gsp(HDC PaintDC, POINT origin, FILE *plot);
void    paint_vcp(HDC PaintDC, POINT origin, FILE *plot);
void    paint_cmv(HDC PaintDC, POINT origin, FILE *plot);
void    paint_rdc(HDC PaintDC, FILE *plot);

//text file output
void    write_output_file(HFILE out);
void    write_pbd_files(void);
```

The output functions used in PLL are similar to those used in VLL and VLMLE. The explanations provided here will assume that the output file descriptions included in Appendices A and B are understood.

C.4.1 The paintbld function.

The paintbld function is used to draw blade data on the Blade Viewer window. It is not used to draw output to the system printer. It draws cartesian plots of non-dimensional chord, thickness, drag, and circulation of the blades for component(s) 1 (and 2) and for the ring in the case of ringed propellers. The handle of the Blade Viewer window is passed as the argument of the function.

```
void paintbld(HWND hWnd)
 {

/*******************************************************************
* declare variables that are defined in the pll.c file and that     *
* will be used in this function                                     *
*******************************************************************/
```

The paintbld function plots data contained in the global variables declared below. The plot data is not read from a data file.

```
extern char     BLDIN[max_comp][21],
                ringed_propeller[max_comp];

extern int      LDEV, project_flag, MRPIN[max_comp],
                MBIN[max_comp];

extern float    XRPIN[max_rad][max_comp],
                XCHD[max_rad][max_comp],
                XTHK[max_rad][max_comp],
                XCD[max_rad][max_comp],
                XG[max_rad][max_comp],
                BAR[max_comp],
                BANGIN[max_ang][max_comp],
                BCHDIN[max_ang][max_comp],
                BTHKIN[max_ang][max_comp],
                BCDIN[max_ang][max_comp],
                BCIRIN[max_ang][max_comp];

/*******************************************************************
*  Variable declarations                                            *
*******************************************************************/

        PAINTSTRUCT ps;                         //paint structure

        HDC     BladePaintDC;                   //handle of the device context

        HFONT hFont,                            //fonts for drawing alphanumerics
```

```
                hVertFont,
                hSmallFont,
                hOldFont;

        HPEN    hPlotPen[4][2],                         //pens for drawing plots
                hStandardPen,
                hOldPen;

        LOGFONT lFont;                                  //logical font structure for
                                                        // creating the fonts

        HBRUSH          hBrush,                         //brushes for drawing on the
                hOldBrush;                              // screen

        POINT   origin[2]={{35,5},                      //origins of the plots of
                        {345 5}},                       // components 1 and 2
                origin_graph,                           //temp storage of the origin
                                                        // of the graph being plotted
                point[max_rad];                         //point structures used to plot
                                                        // the parameters in the
                                                        // form of polylines

        int     delta_y = 100,                          //vertical graph spacing
                length,                                 //length of character strings
                M, j, i,                                //loop counters

                number_of_graphs;                               //the number of
components to
                        // be graphed

        float   max_chord, min_chord,                   //max and min values for the
                max_thick, min_thick,                           // four parameters
                max_drag, min_drag,
                max_circ, min_circ;

        float   width, height,                          //display size scaled to 640/480
                delta_chord,                            //differential between the max
                delta_thick,                            // and min values for the
                delta_drag,                             // parameters
                delta_circ;

        char    buffer[120];                            //character string used for
                                                        // text output
```

The painting process is started using the BeginPaint function. If a project is currently open, the appropriate data is plotted. Otherwise, the bulk of the code is skipped and the painting process is terminated.

```
//create the device context
```

```
		BladePaintDC = BeginPaint(hWnd, &ps);

// if a project is currently open, draw the blade data

		if(project_flag){
```

The size of the display area is calculated so that the output may be made independent of the specifications of the monitor.

```
//determine the width of the display in pixels and the height of the display
// in raster lines and cast them as floats

		width  = (float)GetDeviceCaps (BladePaintDC, HORZRES);
		height = (float)GetDeviceCaps (BladePaintDC, VERTRES);

//since the normal display aspect ratio is 4 to 3, ensure that the graphical
// output made by the program is in that aspect ratio

		if((width/height)>(4.0/3.0))
			width = height*(4.0/3.0);
		else
			height = width*(3.0/4.0);
```

Three fonts, eight pens, and a brush are created for the purpose of drawing the output.

```
//create fonts for drawing alphanumeric output

		hFont = GetStockFont(DEVICE_DEFAULT_FONT);

		GetObject(hFont,sizeof(LOGFONT),&lFont);

			lFont.lfHeight = -8;

		hSmallFont = CreateFontIndirect(&lFont);

		GetObject(hFont,sizeof(LOGFONT),&lFont);

			lFont.lfEscapement = 900;
			lFont.lfHeight     = -10;

		hVertFont = CreateFontIndirect(&lFont);

//create pens for drawing plots

		hPlotPen[0][0] = CreatePen(PS_SOLID, 1, RGB(255,0,0));
		hPlotPen[1][0] = CreatePen(PS_SOLID, 1, RGB(0,255,0));
		hPlotPen[2][0] = CreatePen(PS_SOLID, 1, RGB(0,0,255));
```

```
        hPlotPen[3][0] = CreatePen(PS_SOLID, 1, RGB(255,0,255));

        hPlotPen[0][1] = CreatePen(PS_DOT, 1, RGB(255,0,0));
        hPlotPen[1][1] = CreatePen(PS_DOT, 1, RGB(0,255,0));
        hPlotPen[2][1] = CreatePen(PS_DOT, 1, RGB(0,0,255));
        hPlotPen[3][1] = CreatePen(PS_DOT, 1, RGB(255,0,255));

        hStandardPen  = CreatePen(PS_SOLID, 1, RGB(0,0,0));

//create and select a hollow brush so that ellipses and rectangles will
//not overwrite pre-existing graphical output, also save a handle to the
//original brush

        hBrush   = GetStockObject(HOLLOW_BRUSH);
        hOldBrush = SelectObject(BladePaintDC,hBrush);
```

The y axes are labeled using the vertical font. The file names used in the project are printed at the top of the appropriate graph.

```
//select the vertical font and label the y-axes of the plots

        hOldFont = SelectFont(BladePaintDC,hVertFont);

//select the standard pen

        hOldPen = SelectPen(BladePaintDC,hStandardPen);

//align the text such that it is centered

        SetTextAlign(BladePaintDC,TA_CENTER);

  length = sprintf(buffer, "chord/D");

   TextOut(BladePaintDC,(int)((origin[0].x-30)*width/640.0),
                    (int)((origin[0].y+1*delta_y-40)*height/480.0),
                    buffer, length);

  length = sprintf(buffer, "thickness/D");

   TextOut(BladePaintDC,(int)((origin[0].x-30)*width/640.0),
                    (int)((origin[0].y+2*delta_y-40)*height/480.0),
                    buffer, length);

  length = sprintf(buffer, "CD");

   TextOut(BladePaintDC,(int)((origin[0].x-30)*width/640.0),
                    (int)((origin[0].y+3*delta_y-40)*height/480.0),
                    buffer, length);

  length = sprintf(buffer, "Non-dim circ");

   TextOut(BladePaintDC,(int)((origin[0].x-30)*width/640.0),
```

```
                (int)((origin[0].y+4*delta_y-40)*height/480.0),
                buffer, length);

//select the normal size font and draw the file names for both components
// at the top of the graphs

        SelectFont(BladePaintDC,hFont);

 for(M=0;M<LDEV;M++) {

        length = sprintf(buffer, "BLADE #%d: %s", M+1, BLDIN[M*21]);

         TextOut(BladePaintDC,(int)((origin[M].x+155)*width/640.0),
                        (int)((origin[M].y)*height/480.0),
                        buffer, length);

        length = sprintf(buffer, "Non-Dimensional Radii");

         TextOut(BladePaintDC,(int)((origin[M].x+155)*width/640.0),
                        (int)((origin[M].y+410)*height/480.0),
                        buffer, length);
                }

//for the ringed propeller case, label the graphs appropriately

 if((ringed_propeller[0]==(char)(89))||(ringed_propeller[1]==(char)(89)))

        {

        length = sprintf(buffer, "RING DATA");

         TextOut(BladePaintDC,(int)((origin[1].x+155)*width/640.0),
                        (int)((origin[1].y)*height/480.0),
                        buffer, length);

        length = sprintf(buffer, "Non-Dimensional Angles");

         TextOut(BladePaintDC,(int)((origin[1].x+155)*width/640.0),
                        (int)((origin[1].y+410)*height/480.0),
                        buffer, length);
        }


                SetTextAlign(BladePaintDC,TA_LEFT);

//select the small font for labeling the x-axes

        SelectFont(BladePaintDC,hSmallFont);
```

The appropriate number of graphs is drawn based on the number of components and if a single component project is a ringed propeller. The vertical lines for the graph are then drawn as a series of rectangles. The horizontal lines are drawn by using MoveTo and LineTo calls nested in two for loops. The x axes are then labeled.

```
//determine the number of graphs by considering LDEV and whether a
// single component is ringed

        number_of_graphs = LDEV;

        if((ringed_propeller[0]==(char)(89))||
                (ringed_propeller[1]==(char)(89)))

                        number_of_graphs++;

//draw the vertical lines of the graphs by drawing a series of rectangles

 for(M=0;M<number_of_graphs;M++){

        for(j=1;j<6;j++){

 Rectangle(BladePaintDC,(int)((origin[M].x+155-j*27)*width/640.0),
        (int)((origin[M].y+20)*height/480.0),
        (int)((origin[M].x+155+j*27)*width/640.0),
        (int)((origin[M].y+395)*height/480.0));

                }

//draw the horizontal lines for the graphs

        for(i=0;i<4;i++){

                for(j=1;j<4;j++){

                MoveTo(BladePaintDC,(int)((origin[M].x+20)*width/640.0),
                (int)((origin[M].y+20+(i*delta_y)+(j*20))*height/480.0));

                LineTo(BladePaintDC,(int)((origin[M].x+290)*width/640.0),
                (int)((origin[M].y+20+(i*delta_y)+(j*20))*height/480.0));

                                }
                        }

//complete the graphs by drawing a vertical line at the center of the graphs

 MoveTo(BladePaintDC,(int)((origin[M].x+155)*width/640.0),
                (int)((origin[M].y+20)*height/480.0));

 LineTo(BladePaintDC,(int)((origin[M].x+155)*width/640.0),
```

```
                    (int)((origin[M].y+395)*height/480.0));

//label the x-axes

 for(j=0;j<11;j++){

        length = sprintf(buffer, "%2.1f",j/10.0);

        TextOut(BladePaintDC,(int)((origin[M].x+10+j*27)*width/640.0),
                        (int)((origin[M].y+400)*height/480.0),
                        buffer, length);

                }
}
```

A for loop is used to perform the calculations and GDI calls to scale and draw the output for the graphs for each component.

```
//loop through both components

 for(M=0;M<LDEV;M++){
```

The maximum and minimum values for each of the parameters is calculated. If the values are the same, they are artificially separated. The difference between the maximum and minimum values is then calculated.

```
//initialize the maximum and minimum values for each parameter to be plotted

        max_chord=0.0;  min_chord=1.0;

        max_thick=0.0;  min_thick=1.0;

        max_drag= 0.0;  min_drag= 1.0;

        max_circ= 0.0;  min_circ= 1.0;

//for each radius, compare the parameter value to the previous maximum and
// value, and store the max/min

        for(j=0;j<MRPIN[M];j++){

                max_chord = max(max_chord,XCHD[j][M]);
                min_chord = min(min_chord,XCHD[j][M]);

                max_thick = max(max_thick,XTHK[j][M]);
                min_thick = min(min_thick,XTHK[j][M]);
```

```
max_drag = max(max_drag,XCD[j][M]);
min_drag = min(min_drag,XCD[j][M]);

max_circ = max(max_circ,XG[j][M]);
min_circ = min(min_circ,XG[j][M]);

                    }

//if the maximum and minimum values are close together, spread them apart

        if(max_chord - min_chord<del)
                {max_chord = max_chord+0.1;
                 min_chord = min_chord-0.1;}

        if(max_thick - min_thick<del)
                {max_thick = max_thick+0.1;
                 min_thick = min_thick-0.1;}

        if(max_drag - min_drag<del)
                {max_drag  = max_drag+0.01;
                 min_drag  = min_drag-0.01;}

        if(max_circ - min_circ<del)
                {max_circ  = max_circ+0.01;
                 min_circ  = min_circ-0.01;}

//find the differential between the min and max values for each parameter

        delta_chord = max_chord - min_chord;

        delta_thick = max_thick - min_thick;

        delta_drag  =  max_drag -  min_drag;

        delta_circ  =  max_circ -  min_circ;
```

The plots are then drawn using polylines of the appropriate color and the y axis value labels are written. The individual points are drawn as circles. This is done for the chord, thickness, drag coefficient, and circulation.

```
//plot the four parameters
 //start with the non-dimensionalized chord
  //select the appropriate colored pen

        SelectPen(BladePaintDC,hPlotPen[0][0]);

  //adjust the origin of the plot
```

```
	origin_graph.x = origin[M].x+20;
	origin_graph.y = origin[M].y+40;

//loop through all the radii, store the location of each point in an
//array of point structures, and draw an ellipse at each point

	for(j=0;j<MRPIN[M];j++){

		point[j].x = (int)((origin_graph.x+270*XRPIN[j][M])*
					width/640.0);
		point[j].y = (int)((origin_graph.y+((max_chord-XCHD[j][M])/
					delta_chord)*40)*height/480.0);

		Ellipse(BladePaintDC,point[j].x-3,point[j].y-3,
					point[j].x+3,point[j].y+3);

				}

//draw a polyline connecting all of the points

	Polyline(BladePaintDC,point,MRPIN[M]);

//label the y-axis

	for(j=0;j<3;j++){

	length = sprintf(buffer, "%4.3f",min_chord+(j*delta_chord/2.0));

	 TextOut(BladePaintDC,(int)((origin_graph.x-31)*width/640.0),
				(int)((origin_graph.y+37-j*20)*height/480.0),
				buffer, length);
			}

//plot the non-dimensionalized thickness

	SelectPen(BladePaintDC,hPlotPen[1][0]);

	origin_graph.y = origin_graph.y+delta_y;

	for(j=0;j<MRPIN[M];j++){

		point[j].x = (int)((origin_graph.x+270*XRPIN[j][M])*
					width/640.0);
		point[j].y = (int)((origin_graph.y+((max_thick-XTHK[j][M])/
					delta_thick)*40)*height/480.0);

		Ellipse(BladePaintDC,point[j].x-3,point[j].y-3,
					point[j].x+3,point[j].y+3);

				}

	Polyline(BladePaintDC,point,MRPIN[M]);

	for(j=0;j<3;j++){
```

```
        length = sprintf(buffer, "%4.3f",min_thick+(j*delta_thick/2.0));

         TextOut(BladePaintDC,(int)((origin_graph.x-31)*width/640.0),
                        (int)((origin_graph.y+37-j*20)*height/480.0),
                        buffer, length);
                }

//plot the viscous drag coefficient

        SelectPen(BladePaintDC,hPlotPen[2][0]);

        origin_graph.y = origin_graph.y+delta_y;


        for(j=0;j<MRPIN[M];j++){

                point[j].x = (int)((origin_graph.x+270*XRPIN[j][M])*
                                width/640.0);
                point[j].y = (int)((origin_graph.y+((max_drag-XCD[j][M])/
                                delta_drag)*40)*height/480.0);

                Ellipse(BladePaintDC,point[j].x-3,point[j].y-3,
                                point[j].x+3,point[j].y+3);

                                }

        Polyline(BladePaintDC,point,MRPIN[M]);

        for(j=0;j<3;j++){

        length = sprintf(buffer, "%4.3f",min_drag+(j*delta_drag/2.0));

         TextOut(BladePaintDC,(int)((origin_graph.x-31)*width/640.0),
                        (int)((origin_graph.y+37-j*20)*height/480.0),
                        buffer, length);
                }

//plot the non-dimensional circulation

        SelectPen(BladePaintDC,hPlotPen[3][0]);

        origin_graph.y = origin_graph.y+delta_y;

        for(j=0;j<MRPIN[M];j++){

                point[j].x = (int)((origin_graph.x+270*XRPIN[j][M])*
                                width/640.0);
                point[j].y = (int)((origin_graph.y+((max_circ-XG[j][M])/
                                delta_circ)*40)*height/480.0);

                Ellipse(BladePaintDC,point[j].x-3,point[j].y-3,
                                point[j].x+3,point[j].y+3);
```

```
                    }
        Polyline(BladePaintDC,point,MRPIN[M]);

        for(j=0;j<3;j++){

        length = sprintf(buffer, "%4.3f",min_circ+(j*delta_circ/2.0));

         TextOut(BladePaintDC,(int)((origin_graph.x-31)*width/640.0),
                        (int)((origin_graph.y+37-j*20)*height/480.0),
                        buffer, length);

                    }
 }
```

The process is repeated for the ring data in the case of a single component ringed propeller. In this case the values are plotted against a non-dimensionalized angle.

```
//if component #1 is a ringed propeller, plot the ring parameters in
//the location where component #2 is normally plotted

if((ringed_propeller[0]==(char)(89))||(ringed_propeller[1]==(char)(89)))

{
//initialize the maximum and minimum values for each parameter to be plotted

        max_chord=0.0;  min_chord=1.0;

        max_thick=0.0;  min_thick=1.0;

        max_drag= 0.0;  min_drag= 1.0;

        max_circ= 0.0;  min_circ= 1.0;

//for each angle, compare the parameter value to the previous maximum and
// value, and store the max/min

        for(j=0;j<MBIN[0];j++){

                max_chord = max(max_chord,BCHDIN[j][0]);
                min_chord = min(min_chord,BCHDIN[j][0]);

                max_thick = max(max_thick,BTHKIN[j][0]);
                min_thick = min(min_thick,BTHKIN[j][0]);

                max_drag  = max(max_drag,BCDIN[j][0]);
                min_drag  = min(min_drag,BCDIN[j][0]);

                max_circ  = max(max_circ,BCIRIN[j][0]);
                min_circ  = min(min_circ,BCIRIN[j][0]);
```

```
                }

//if the maximum and minimum values are close together, spread them apart

        if(max_chord - min_chord<del)
                {max_chord = max_chord+0.1;
                 min_chord = min_chord-0.1;}

        if(max_thick - min_thick<del)
                {max_thick = max_thick+0.1;
                 min_thick = min_thick-0.1;}

        if(max_drag - min_drag<del)
                {max_drag  = max_drag+0.01;
                 min_drag  = min_drag-0.01;}

        if(max_circ - min_circ<del)
                {max_circ  = max_circ+0.01;
                 min_circ  = min_circ-0.01;}

//find the differential between the min and max values for each parameter

        delta_chord = max_chord - min_chord;

        delta_thick = max_thick - min_thick;

        delta_drag  =  max_drag -  min_drag;

        delta_circ  =  max_circ -  min_circ;

//plot the four parameters

 //start with the non-dimensionalized chord

  //select the appropriate colored pen

        SelectPen(BladePaintDC,hPlotPen[0][0]);

  //adjust the origin of the plot

        origin_graph.x = origin[M].x+20;
        origin_graph.y = origin[M].y+40;

        for(j=0;j<MBIN[0];j++){

                point[j].x = (int)((origin_graph.x+270*BANGIN[j][0])*
                                width/640.0);
                point[j].y = (int)((origin_graph.y+((max_chord-BCHDIN[j][0])/
                                delta_chord)*40)*height/480.0);

                Ellipse(BladePaintDC,point[j].x-3,point[j].y-3,
                                point[j].x+3,point[j].y+3);

                }
```

```
Polyline(BladePaintDC,point,MBIN[0]);

for(j=0;j<3;j++){

length = sprintf(buffer, "%4.3f",min_chord+(j*delta_chord/2.0));

 TextOut(BladePaintDC,(int)((origin_graph.x-31)*width/640.0),
                      (int)((origin_graph.y+37-j*20)*height/480.0),
                      buffer, length);

                }

//plot the non-dimensionalized thickness

SelectPen(BladePaintDC,hPlotPen[1][0]);

origin_graph.y = origin_graph.y+delta_y;

for(j=0;j<MBIN[0];j++){

        point[j].x = (int)((origin_graph.x+270*BANGIN[j][0])*
                           width/640.0);
        point[j].y = (int)((origin_graph.y+((max_thick-BTHKIN[j][0])/
                           delta_thick)*40)*height/480.0);

        Ellipse(BladePaintDC,point[j].x-3,point[j].y-3,
                           point[j].x+3,point[j].y+3);

                           }

Polyline(BladePaintDC,point,MBIN[0]);

for(j=0;j<3;j++){

length = sprintf(buffer, "%4.3f",min_thick+(j*delta_thick/2.0));

 TextOut(BladePaintDC,(int)((origin_graph.x-31)*width/640.0),
                      (int)((origin_graph.y+37-j*20)*height/480.0),
                      buffer, length);

                }

//plot the viscous drag coefficient

SelectPen(BladePaintDC,hPlotPen[2][0]);

origin_graph.y = origin_graph.y+delta_y;

for(j=0;j<MBIN[0];j++){

        point[j].x = (int)((origin_graph.x+270*BANGIN[j][0])*
                           width/640.0);
```

```
                point[j].y = (int)((origin_graph.y+((max_drag-
BCDIN[j][0])/delta_drag)*40)*height/480.0);

                Ellipse(BladePaintDC,point[j].x-3,point[j].y-3,
                        point[j].x+3,point[j].y+3);

                        }

        Polyline(BladePaintDC,point,MBIN[0]);

        for(j=0;j<3;j++){

        length = sprintf(buffer, "%4.3f",min_drag+(j*delta_drag/2.0));

         TextOut(BladePaintDC,(int)((origin_graph.x-31)*width/640.0),
                        (int)((origin_graph.y+37-j*20)*height/480.0),
                        buffer, length);

                    }

//plot the non-dimensional circulation

        SelectPen(BladePaintDC,hPlotPen[3][0]);

        origin_graph.y = origin_graph.y+delta_y;

        for(j=0;j<MBIN[0];j++){

                point[j].x = (int)((origin_graph.x+270*BANGIN[j][0])*
                        width/640.0);
                point[j].y = (int)((origin_graph.y+((max_circ-BCIRIN[j][0])/
                        delta_circ)*40)*height/480.0);

        Ellipse(BladePaintDC,point[j].x-3,point[j].y-3,
                    point[j].x+3,point[j].y+3);

                }

        Polyline(BladePaintDC,point,MBIN[0]);

        for(j=0;j<3;j++){

        length = sprintf(buffer, "%4.3f",min_circ+(j*delta_circ/2.0));

         TextOut(BladePaintDC,(int)((origin_graph.x-31)*width/640.0),
                        (int)((origin_graph.y+37-j*20)*height/480.0),
                        buffer, length);

                    }
 }

}
```

After the plots are complete, the original pen, font, and brush are selected back into the device context and the pens, fonts, and brush created for this function are deleted. The paint process is then terminated using the EndPaint function.

```
//select the original brush, pen and font back into the device
// context and delete the fonts, pens, and brush created for this function

        SelectPen(BladePaintDC,hOldPen);
        SelectFont(BladePaintDC,hOldFont);
        SelectObject(BladePaintDC,hOldBrush);

        DeleteFont(hFont);
        DeleteFont(hSmallFont);
        DeleteFont(hVertFont);

        DeleteObject(hBrush);

        DeleteObject(hStandardPen);

        for(i=0;i<2;i++)
                for(j=0;j<4;j++)
                                DeleteObject(hPlotPen[j][i]);

//close out the paint command

        EndPaint(hWnd, &ps);
}
```

C.4.2 The paintwake function.

The paintwake function is used to draw polar plots of the axial, radial, and tangential wake profiles for the project component(s) to the Wake Viewer window on the monitor. It is not used to produce printed output. The function also writes the CURRPBD.VEL file that is used as input to the PBD FORTRAN executable. The paintwake function receives the handle to the Wake Viewer window as an argument.

```
void paintwake(HWND hWnd)
 {

/*******************************************************************
* declare variables that are defined in the pll.c file and that    *
* will be used in this function                            *
*******************************************************************/
```

```
extern int      LDEV, project_flag, component_flag,
                NRWIN[max_comp], NHARMA[max_comp],
                NHARMR[max_comp], NHARMT[max_comp];

extern float    XRWIN[max_wake_rad][max_comp],
                XVA[max_wake_rad][max_wake_har][2][max_comp],
                XVR[max_wake_rad][max_wake_har][2][max_comp],
                XVT[max_wake_rad][max_wake_har][2][max_comp],
                XFINAL;

extern char     WKIN[max_comp][21];


/*******************************************************************
* Variable declarations                                             *
*******************************************************************/

        HDC     WakePaintDC;                    //handle of the device context

        PAINTSTRUCT ps;                         //paint structure

        HPEN    hColorPen[max_rad],             //pens for drawing plots
                hThickPen,                      //pen for boxing plots
                hOldPen;                        //handle of original pen

        HFONT hFont,                            //font for text output
                hOldFont;                       //original font

        HBRUSH          hBrush,                 //brushes for drawing on the
                hOldBrush;                      //screen

        FILE    *out;                           //pointer to a file structure

        POINT   origin_graph[3]=                //points defined to locate the
                {{110,130},                     //origins of the polar plots
                 {530,130},                     //and the key on the screen
                 {320,330}},
                origin_key={20,235},
                points[31];                     //point structures used to plot
                                                //the velocity profiles in the
                                                //form of polylines

        int     length,                         //length of character strings
                i, j, k, m, n,                  //counters for loops
                ellipse_size=90,                //size of the polar plots
                J;                                      //number of axial
positions for
                                                // specifying velocities in
                                                // pbd .vel file


        float   max[3]={-2.0,                   //maximum and minimum values
                        -2.0,                   //of the axial, radial, and
                        -2.0},                  //tangential velocities, used
```

```
        min[3]={ 2.0,                       //to scale the polar plots
                 2.0,
                 2.0},

        width, height,                      //display size scaled to 640/480
        delta,                              //used to scale the polar plots

        theta[30],                          //discrete angles for
                                            //calculating and plotting
                                            //velocities

        velocity[3]                         //4-D array for storing the
        [max_comp]                          //calculated wake velocities
        [max_wake_rad]
        [30],

        ax_pos;                             //axial position for writing pbd
                                            // velocity file

char    buffer[120];                        //a buffer used for writing
                                            //text output
```

As in the paintbld function, the window is prepared for painting with the BeginPaint function. If a project is not open the bulk of the code is skipped and the painting process is terminated.

```
//create the device context

        WakePaintDC = BeginPaint(hWnd, &ps);

//only plot the profiles if a project is currently open

        if(project_flag){
```

Twenty different colored pens are created since as many as twenty different radii may be used for specifying the wake profile. A thick black pen is created for drawing frame rectangles around the plots.

```
//create solid pens

        hThickPen = CreatePen(PS_SOLID,2,RGB(0,0,0));

        hColorPen[0]=CreatePen(PS_SOLID, 1, RGB(255,0,0)); //red
        hColorPen[1]=CreatePen(PS_SOLID, 1, RGB(255,255,0));//yellow
        hColorPen[2]=CreatePen(PS_SOLID, 1, RGB(0,255,0)); //green
        hColorPen[3]=CreatePen(PS_SOLID, 1, RGB(0,255,255));//light blue
        hColorPen[4]=CreatePen(PS_SOLID, 1, RGB(0,0,255)); //bright blue
```

```
        hColorPen[5]=CreatePen(PS_SOLID, 1, RGB(255,0,255));//magenta
        hColorPen[6]=CreatePen(PS_SOLID, 1, RGB(0,64,128)); //dark blue

//create dotted pens

        hColorPen[7]=CreatePen(PS_DOT, 1, RGB(255,0,0));   //red
        hColorPen[8]=CreatePen(PS_DOT, 1, RGB(255,255,0)); //yellow
        hColorPen[9]=CreatePen(PS_DOT, 1, RGB(0,255,0));   //green
        hColorPen[10]=CreatePen(PS_DOT, 1, RGB(0,255,255)); //light blue
        hColorPen[11]=CreatePen(PS_DOT. 1, RGB(0,0,255));   //bright blue
        hColorPen[12]=CreatePen(PS_DOT, 1, RGB(255,0,255)); //magenta
        hColorPen[13]=CreatePen(PS_DOT, 1, RGB(0,64,128));  //dark blue

//create dashed pens

        hColorPen[14]=CreatePen(PS_DASH, 1, RGB(255,0,0)); //red
        hColorPen[15]=CreatePen(PS_DASH, 1, RGB(255,255,0));//yellow
        hColorPen[16]=CreatePen(PS_DASH, 1, RGB(0,255,0)); //green
        hColorPen[17]=CreatePen(PS_DASH, 1, RGB(0,255,255));//light blue
        hColorPen[18]=CreatePen(PS_DASH, 1, RGB(0,0,255)); //bright blue
        hColorPen[19]=CreatePen(PS_DASH, 1, RGB(255,0,255));//magenta
```

The size of the display area is calculated.

```
//determine the width of the display in pixels and the height of the display
// in raster lines and cast them as floats

        width  = (float)GetDeviceCaps (WakePaintDC, HORZRES);
        height = (float)GetDeviceCaps (WakePaintDC, VERTRES);

//since the normal display aspect ratio is 4 to 3, ensure that the graphical
// output made by the program is in that aspect ratio

        if((width/height)>(4.0/3.0))
                width = height*(4.0/3.0);
        else
                height = width*(3.0/4.0);
```

The device default font and a hollow brush are selected into the device context.

```
//create font for drawing alphanumeric output

        hFont = GetStockFont(DEVICE_DEFAULT_FONT);

//select a thick pen for drawing the polar plot outer ring and save a handle
// to the old pen

        hOldPen = SelectPen(WakePaintDC,hThickPen);

//create and select a hollow brush so that ellipses and rectangles will
// not overwrite pre-existing graphical output, also save a handle to the
```

```
// original brush

        hBrush = GetStockObject(HOLLOW_BRUSH);
        hOldBrush = SelectObject(WakePaintDC,hBrush);

//select the normal sized font and save a handle to the old font

        hOldFont = SelectFont(WakePaintDC,hFont);
```

Thirty evenly spaced angles are used for calculating and plotting the velocity profiles.

```
//calculate the discrete angles for which the velocities will be calculated

        for(i=0;i<30;i++)  theta[i]=i*pi/15.0;
```

The screen and the individual plots are labeled. The bounding rectangles are then drawn. A circle indicating the maximum velocity on the plot is also drawn.

```
//align the text such that it is centered and draw the main heading

        SetTextAlign(WakePaintDC,TA_CENTER);

        length = sprintf(buffer, "Wake Profile for");

        TextOut(WakePaintDC,(int)(320*width/640.0),
         (int)(30*height/480.0), buffer, length);

        length = sprintf(buffer, "Component #%d",component_flag+1);

        TextOut(WakePaintDC,(int)(320*width/640.0),
         (int)(45*height/480.0), buffer, length);

//label the three polar plots

        length = sprintf(buffer, "Axial");

        TextOut(WakePaintDC,(int)((origin_graph[axial].x)*width/640.0),
         (int)((origin_graph[axial].y-120)*height/480.0), buffer, length);

        length = sprintf(buffer, "Radial");

        TextOut(WakePaintDC,(int)((origin_graph[radial].x)*width/640.0),
         (int)((origin_graph[radial].y-120)*height/480.0), buffer, length);

        length = sprintf(buffer, "Tangential");

        TextOut(WakePaintDC,(int)((origin_graph[tangential].x)*width/640.0),
         (int)((origin_graph[tangential].y-120)*height/480.0), buffer, length);
```

```
        SetTextAlign(WakePaintDC,TA_LEFT);

//draw the rectangles that enclose the polar plots and the circles that
//indicate the maximum velocities

        for(j=axial;j<=tangential;j++) {

    Rectangle(WakePaintDC,(int)((origin_graph[j].x-100)*width/640.0),
        (int)((origin_graph[j].y-100)*width/640.0),
        (int)((origin_graph[j].x+100)*width/640.0),
        (int)((origin_graph[j].y+100)*width/640.0));

    Ellipse(WakePaintDC,(int)((origin_graph[j].x-ellipse_size)*width/640.0),
        (int)((origin_graph[j].y-ellipse_size)*width/640.0),
        (int)((origin_graph[j].x+ellipse_size)*width/640.0),
        (int)((origin_graph[j].y+ellipse_size)*width/640.0));

                                        }
```

The velocity components are calculated at each radius and angle using the velocity harmonics, which are stored in memory as global variables.

```
//calculate the axial, radial, and tangential velocities for each angle

//first, loop through the radii

        for(k=0;k<NRWIN[component_flag];k++){

//include the 0th order terms

                for(m=0;m<30;m++){

        velocity[0][component_flag][k][m]= XVA[k][0][0][component_flag];
        velocity[1][component_flag][k][m]= XVR[k][0][0][component_flag];
        velocity[2][component_flag][k][m]= XVT[k][0][0][component_flag];

//add the contributions of the higher order terms for the axial, radial,
//and tangential velocities

        for(n=1;n<NHARMA[component_flag];n++)           {

        velocity[0][component_flag][k][m]=velocity[0][component_flag][k][m]+
                XVA[k][n][0][component_flag]*cos((n)*theta[m]);

        velocity[0][component_flag][k][m]=velocity[0][component_flag][k][m]+
                XVA[k][n][1][component_flag]*sin((n)*theta[m]);

                                                        }
        for(n=1;n<NHARMR[component_flag];n++){
```

```
velocity[1][component_flag][k][m]=velocity[1][component_flag][k][m]+
        XVR[k][n][0][component_flag]*cos((n)*theta[m]);
velocity[1][component_flag][k][m]=velocity[1][component_flag][k][m]+
        XVR[k][n][1][component_flag]*sin((n)*theta[m]);

                                }
for(n=1;n<NHARMT[component_flag];n++){

velocity[2][component_flag][k][m]=velocity[2][component_flag][k][m]+
        XVT[k][n][0][component_flag]*cos((n)*theta[m]);
velocity[2][component_flag][k][m]=velocity[2][component_flag][k][m]+
        XVT[k][n][1][component_flag]*sin((n)*theta[m]);

                                }

                        }
                                }
```

The maximum and minimum values for the axial, radial, and tangential velocities are then calculated using three nested for loops.

```
//loop through the axial, radial, and tangential velocities for each radii
//and angle to find the maximum and minimum values

        for(k=0;k<NRWIN[component_flag];k++)
        {

                for(n= axial; n<= tangential; n++)
        {

                        for(m=0;m<30;m++)
                {

                max[n] = max(max[n],velocity[n][component_flag][k][m]);

                min[n] = min(min[n],velocity[n][component_flag][k][m]);

                        }

                }

        }
```

A velocity profile file formatted for use by PBD is then printed.

```
//open a file and write the wake velocities at a series of axial positions
// from upstream (x=-3.0) of the propeller to at least the XFINAL position
// specified in the PBD settings

//open the file, print a warning if unable to open the file
```

```
if ((out = fopen("currpbd.vel", "w")) == NULL) {

        MessageBeep(MB_ICONEXCLAMATION);

        MessageBox(hWnd, "Unable to open file 'currpbd.vel'.",
    "WARNING!", MB_ICONSTOP | MB_OK | MB_TASKMODAL);

                                        }
    else{

//calculate the number of axial positions to output data for

    J = (int)((XFINAL/1.5)+3);

//print the header line

    fprintf(out,"ZONE T="Inflow", I= %d, J= %d, F=POINT\n",J,NRWIN[0]);

//loop through radii at which the wake is specified

    for (i=0;i<NRWIN[0];i++)

//loop through each axial position

      for(ax_pos=-3.0; ax_pos<=XFINAL; ax_pos+=1.5)

//print the axial position, radius, axial velocity, radial velocity, and
// tangential position

            fprintf(out," %f %f %f %f %f\n", ax_pos, XRWIN[i][0],
             velocity[0][0][i][0], velocity[1][0][i][0], velocity[2][0][i][0]);

//close the file

    fclose(out);

      }
```

The difference between the maximum and minimum values to be plotted for each of the three plots is calculated and adjusted. The minimum and maximum values are labeled on the plots.

```
//loop through the axial, radial, and tangential plots, determine
// the maximum and minimum values that will be used on the plots,
// draw the values on the plots, then draw the polylines on the plots

    for(n= axial; n<= tangential; n++){

//calculate the differential between the maximum and minimum values
            delta = max[n]-min[n];
```

```
//if the differential is close to zero, set the differential to 0.1

                    if(delta<del) min[n] = min[n]-0.1;

//recalculate the differential and widen the range so that the max
// and min velocities do not plot exactly on the limits of the graphs

                    delta = max[n]-min[n];

                    max[n] = max[n] + 0.1*delta;

                    min[n] = min[n] - 0.1*delta;

//draw the min value on the plot

          length = sprintf(buffer,"%4.3f",min[n]);

          TextOut(WakePaintDC,(int)((origin_graph[n].x+40)*width/640.0),
                    (int)((origin_graph[n].y+80)*height/480.0), buffer, length);

//draw the max value on the plot

          length = sprintf(buffer,"%4.3f",max[n]);

          TextOut(WakePaintDC,(int)((origin_graph[n].x-95)*width/640.0),
                    (int)((origin_graph[n].y-95)*height/480.0), buffer, length);
```

The velocity profile for each plot is drawn as a series of polylines corresponding to the different radii. The angle corresponds to the angular position relative to the hub and the magnitude is the magnitude of the velocity component.

```
//loop through each of the radii

          for(k=0;k<NRWIN[component_flag];k++)
          {

//select the pen corresponding to the appropriate radius

                    SelectPen(WakePaintDC,hColorPen[k]);

//calculate the x and y value in screen coordinates for each angle
//and velocity and store in the points array

            for(m=0;m<30;m++)
            {

                    points[m].x= (int)((origin_graph[n].x+
                    (((velocity[n][component_flag][k][m]-min[n])*ellipse_size/
                    (max[n]-min[n]))*cos((pi/2.0)+theta[m])))*width/640.0);
```

```
points[m].y= (int)((origin_graph[n].y-
(((velocity[n][component_flag][k][m]-min[n])*ellipse_size/
(max[n]-min[n]))*sin((pi/2.0)+theta[m])))*height/480.0);

                }
//close the polyline by setting the final point equal to the first

        points[30].x=points[0].x;
        points[30].y=points[0].y;

//draw the polyline

        Polyline(WakePaintDC,points,31);

                }

        }
```

A key is drawn to indicate the correlation between the pen colors and styles and the radii.

```
//draw the key

//first, draw the heading

        length = sprintf(buffer, "Radius");

        TextOut(WakePaintDC,(int)(origin_key.x*width/640.0),
         (int)((origin_key.y+15)*height/480.0), buffer, length);

        TextOut(WakePaintDC,(int)((origin_key.x+70)*width/640.0),
         (int)((origin_key.y+15)*height/480.0), buffer, length);

//write each value of radius

  for(k=0;k<min(10,NRWIN[component_flag]);k++)
   {
        length = sprintf(buffer, "%3.2f",XRWIN[k][component_flag]);

        TextOut(WakePaintDC,(int)(origin_key.x*width/640.0),
         (int)((origin_key.y+45+k*15)*height/480.0), buffer, length);

//select the appropriate pen and draw a rectangle indicating the pen
//style and color

        SelectPen(WakePaintDC,hColorPen[k]);

        Rectangle(WakePaintDC,(int)((origin_key.x+40)*width/640.0),
        (int)((origin_key.y+48+k*15)*height/480.0),
        (int)((origin_key.x+50)*width/640.0),
```

```
                (int)((origin_key.y+57+k*15)*height/480.0));

    }

//if there are more than 10 radii, draw another column the same way

  if(10<NRWIN[component_flag])
  {

        length = sprintf(buffer, "Radius");

        TextOut(WakePaintDC,(int)((origin_key.x+70)*width/640.0),
         (int)((origin_key.y+15)*height/480.0), buffer, length);


  for(k=10;k<NRWIN[component_flag];k++)
   {
     length = sprintf(buffer, "%3.2f",XRWIN[k][component_flag]);

        TextOut(WakePaintDC,(int)((origin_key.x+70)*width/640.0),
         (int)((origin_key.y+45+(k-10)*15)*height/480.0), buffer, length);

        SelectPen(WakePaintDC,hColorPen[k]);

        Rectangle(WakePaintDC,(int)((origin_key.x+110)*width/640.0),
        (int)((origin_key.y+48+(k-10)*15)*height/480.0),
        (int)((origin_key.x+120)*width/640.0),
        (int)((origin_key.y+57+(k-10)*15)*height/480.0));

   }
  }
```

After the plots are complete, the original pen, font, and brush are selected back into the device context and the pens, fonts, and brush created for this function are deleted. The paint process is then terminated.

```
//select the standard pen and brush styles

        SelectFont(WakePaintDC,hOldFont);
        SelectPen(WakePaintDC,hOldPen);
        SelectObject(WakePaintDC,hOldBrush);

//delete objects that were created but are not currently selected into the
//device context

   for(i=0;i<20;i++) DeleteObject(hColorPen[i]);

   DeleteObject(hBrush);
   DeleteFont(hFont);
   DeleteObject(hThickPen);
```

```
        }
//close out the paint command

        EndPaint(hWnd, &ps);
}
```

C.4.3 The paintplot function.

The paintplot function uses the draw function to draw the PLL plots on the Plot Viewer window. The paintplot function does not provide printed output. The paintplot function receives the handle of the Plot Viewer window as an argument. It passes a screen location, a pointer to the data array to be plotted, the index of the plot name, and the handle of the screen device context to the draw function. Both functions are shown below.

```
void paintplot(HWND hWnd)
 {

/*********************************************************************
* declare variables that are defined in the pll.c file and that     *
* will be used in this function                             *
*********************************************************************/

extern  int        project_flag, plot_page, draw_plot_flag;

extern  float      CHORDINPUT[max_comp][max_rad],
                   PITCHANGLEUNDISTURBED[max_comp][max_rad],
                   CHORDCALC[max_comp][max_rad],
                   PITCHANGLEINDUCED[max_comp][max_rad],

                   UAINEFFECTIVE[max_comp][max_rad],
                   UTIN[max_comp][max_rad],
                   UAINDUCED[max_comp][max_rad],
                   UTINDUCED[max_comp][max_rad],

                   THICKNESS[max_comp][max_rad],
                   CIRCULATIONINPUT[max_comp][max_rad],
                   DRAG[max_comp][max_rad],
                   CIRCULATIONCALC[max_comp][max_rad],

                   LOCALCL[max_comp][max_rad],
                   LOCALCT[max_comp][max_rad],
                   LOCALCQ[max_comp][max_rad],
                   CAVITATIONNUMBER[max_comp][max_rad];
```

```
/*********************************************************************
* Variable declarations                                             *
*********************************************************************/

        HDC     PlotPaintDC;                            //handle of the device context

        PAINTSTRUCT ps;                                 //paint structure
```

The paintplot function prepares the Plot Viewer window for painting using the BeginPaint function. If there is no open project, or if the draw_plot_flag has not been set, the bulk of the code is skipped and the paint process is terminated.

```
//create the device context

        PlotPaintDC = BeginPaint(hWnd, &ps);

//only plot the parameters if a project is currently open and the draw flag has been set

        if((project_flag)&&(draw_plot_flag)){
```

The paintplot function evaluates the plot_page flag. This variable indicates which of the four PLL plot pages is to be drawn. Each of the four cases makes four calls to the draw function. The draw function receives an index that determines the location on the screen where the plot is to be drawn, the address of the first parameter value to be plotted, an index of the name of the plot, and the handle of the device context.

```
//plot the appropriate page of output by passing an index for the position of each graph, the address of the
// appropriate parameter, an index indicating the storage location of the plot name, and a handle to the
// device context, for each graph

        switch(plot_page)
        {
        case 0:   {

        draw(0,&CHORDINPUT[0][0],                       0,PlotPaintDC);
        draw(1,&PITCHANGLEUNDISTURBED[0][0],            9,PlotPaintDC);
        draw(2,&CHORDCALC[0][0],                        1,PlotPaintDC);
        draw(3,&PITCHANGLEINDUCED[0][0],                10,PlotPaintDC);

        break;
                  }

        case 1: {

        draw(0,&UAINEFFECTIVE[0][0],             6,PlotPaintDC);
```

```
draw(1,&UTIN[0][0],                          8,PlotPaintDC);
draw(2,&UAINDUCED[0][0],                     11,PlotPaintDC);
draw(3,&UTINDUCED[0][0],                     12,PlotPaintDC);

break;
        }

case 2: {

draw(0,&THICKNESS[0][0],                     2,PlotPaintDC);
draw(1,&CIRCULATIONINPUT[0][0],              3,PlotPaintDC);
draw(2,&DRAG[0][0],                          7,PlotPaintDC);
draw(3,&CIRCULATIONCALC[0][0],               4,PlotPaintDC);

break;
        }

case 3: {

draw(0,&LOCALCL[0][0],                       13,PlotPaintDC);
draw(1,&LOCALCT[0][0],                       14,PlotPaintDC);
draw(2,&LOCALCQ[0][0],                       15,PlotPaintDC);
draw(3,&CAVITATIONNUMBER[0][0],              16,PlotPaintDC);

break;
        }

}

                                }
```

After the plotting is complete, the paint process is terminated.

```
//close out the paint command

        EndPaint(hWnd, &ps);

}
```

The draw function draws cartesian plots of the PLL graphical output on four separate pages for each component, or with both components on the same plots. The plots are drawn on the screen. This function does not produce printed output.

```
void draw(int graph_origin_index, float *parameter, int plot_name_index, HDC PlotPaintDC)
{
/************************************************************************
* declare variables that are defined in the pll.c file and that     *
* will be used in this function                              *
************************************************************************/
```

```
extern int      plot_page, plot_component_flag, draw_plot_flag, LDEV;
extern int      number_radii[max_comp];

extern float    RADIUS[max_comp][max_rad];

/*****************************************************************
* Variable declarations                              *
*****************************************************************/

        HBRUSH      hBrush,                     //brushes for drawing on the
                    hOldBrush;                  //screen

        HPEN    hPlotPen[4][2],                 //pens for drawing plots
                hStandardPen,
                hOldPen;

        HFONT hFont,                            //fonts for drawing alphanumerics
                hMediumFont,
                hSmallFont,
                hOldFont;

        LOGFONT lFont;                          //logical font structure for
                                                // creating the fonts

        POINT   origin_graph[4]=                //points defined to locate the
                {{0,10},                        // origins of the plots
                 {320,110},
                 {0,220},
                 {320,320}},

                left={40,15},                   //points that define the extents
                right={290,105},                // of the plot rectangles

                point[max_rad];                 //point structures used to plot
                                                // the parameters in the
                                                // form of polylines

        int     decimal_places,                 //indicator of decimal places to
                                                // display for y-axis labels
                length,                         //length of character strings
                i=0, j,                         //counters
                shift=3;                        //number of pixels to shift
                                                // y-axis labels

        char    buffer[120];                    //character string used for
                                                // text output

        float   max_value=-10.0,                //max value of parameter
                min_value=10.0,                 //min value of parameter
                delta,                          //(max-min) for parameter
                width, height;                  //display size scaled to 640/480

        char    plot_name[17][40]={                     //plot labels
```

```
"CHORD DISTRIBUTION INPUT",
"CHORD DISTRIBUTION CALCULATED",
"THICKNESS DISTRIBUTION INPUT",
"CIRCULATION INPUT",
"CIRCULATION CALCULATED",
"AXIAL INFLOW VELOCITY, NOMINAL",
"AXIAL INFLOW VELOCITY, EFFECTIVE",
"DRAG COEFFICIENT",
"TANGENTIAL INFLOW VELOCITY",
"UNDISTURBED PITCH ANGLE",
"INDUCED PITCH ANGLE",
"INDUCED AXIAL VELOCITY",
"INDUCED TANGENTIAL VELOCITY",
"LOCAL LIFT COEFFICIENT",
"LOCAL THRUST COEFFICIENT",
"LOCAL TORQUE COEFFICIENT",
"LOCAL CAVITATION NUMBER"};
```

The size of the display area is calculated to ensure device independence. Small, medium, and normal size fonts, as well as a hollow brush and eight pens are created for the purpose of drawing the output.

```
//determine the width of the display in pixels and the height of the display
// in raster lines and cast them as floats

    width  = (float)GetDeviceCaps (PlotPaintDC, HORZRES);
    height = (float)GetDeviceCaps (PlotPaintDC, VERTRES);

//since the normal display aspect ratio is 4 to 3, ensure that the graphical
// output made by the program is in that aspect ratio

    if((width/height)>(4.0/3.0))
        width = height*(4.0/3.0);
    else
        height = width*(3.0/4.0);

//create fonts for drawing alphanumeric output

    hFont = GetStockFont(DEVICE_DEFAULT_FONT);

    GetObject(hFont,sizeof(LOGFONT),&lFont);

        lFont.lfHeight = -8;

    hSmallFont = CreateFontIndirect(&lFont);

     GetObject(hFont,sizeof(LOGFONT),&lFont);

        lFont.lfHeight = -10;
```

```
        hMediumFont = CreateFontIndirect(&lFont);

//create and select a hollow brush so that ellipses and rectangles will
// not overwrite pre-existing graphical output, also save a handle to the
// original brush

        hBrush    = GetStockObject(HOLLOW_BRUSH);
        hOldBrush = SelectObject(PlotPaintDC,hBrush);

//create pens for drawing plots

        hPlotPen[0][0] = CreatePen(PS_SOLID, 1, RGB(255,0,0));
        hPlotPen[1][0] = CreatePen(PS_SOLID, 1, RGB(0,255,0));
        hPlotPen[2][0] = CreatePen(PS_SOLID, 1, RGB(0,0,255));
        hPlotPen[3][0] = CreatePen(PS_SOLID, 1, RGB(255,0,255));

        hPlotPen[0][1] = CreatePen(PS_DOT, 1, RGB(255,0,0));
        hPlotPen[1][1] = CreatePen(PS_DOT, 1, RGB(0,255,0));
        hPlotPen[2][1] = CreatePen(PS_DOT, 1, RGB(0,0,255));
        hPlotPen[3][1] = CreatePen(PS_DOT, 1, RGB(255,0,255));

        hStandardPen   = CreatePen(PS_SOLID, 1, RGB(0,0,0));


//select the medium font for labeling the plot

        hOldFont = SelectFont(PlotPaintDC,hMediumFont);
```

The plot is labeled, and the graph is made by drawing a series of rectangles. The x axis is then labeled.

```
//read the plot name into the buffer and write the plot name

while(plot_name[plot_name_index][i]!=NULL){

        buffer[i] = plot_name[plot_name_index][i];

        i++;
                                        }

 TextOut(PlotPaintDC,(int)((origin_graph[graph_origin_index].x+50)*width/640.0),
        (int)((origin_graph[graph_origin_index].y)*height/480.0), buffer, i);


//select the standard pen and draw the graph for plotting the parameter by
//drawing a series of rectangles

        hOldPen = SelectPen(PlotPaintDC, hStandardPen);

        for(i=0;i<5;i++) {

 Rectangle(PlotPaintDC,
```

```
        (int)((origin_graph[graph_origin_index].x+left.x+i*25)*width/640.0),
        (int)((origin_graph[graph_origin_index].y+left.y)*height/480.0),
        (int)((origin_graph[graph_origin_index].x+right.x-i*25)*width/640.0),
        (int)((origin_graph[graph_origin_index].y+right.y)*height/480.0));


 Rectangle(PlotPaintDC,
        (int)((origin_graph[graph_origin_index].x+left.x)*width/640.0),
        (int)((origin_graph[graph_origin_index].y+left.y+i*9)*height/480.0),
        (int)((origin_graph[graph_origin_index].x+right.x)*width/640.0),
        (int)((origin_graph[graph_origin_index].y+right.y-i*9)*height/480.0));

                    }

 Rectangle(PlotPaintDC,
        (int)((origin_graph[graph_origin_index].x+left.x)*width/640.0),
        (int)((origin_graph[graph_origin_index].y+left.y)*height/480.0),
        (int)((origin_graph[graph_origin_index].x+left.x+125)*width/640.0),
        (int)((origin_graph[graph_origin_index].y+right.y)*height/480.0));

 Rectangle(PlotPaintDC,
        (int)((origin_graph[graph_origin_index].x+left.x)*width/640.0),
        (int)((origin_graph[graph_origin_index].y+left.y+45)*height/480.0),
        (int)((origin_graph[graph_origin_index].x+right.x)*width/640.0),
        (int)((origin_graph[graph_origin_index].y+right.y)*height/480.0));

//select the small font and label the x-axis of the plot

        SelectFont(PlotPaintDC,hSmallFont);

        for(i=0;i<11;i++){

        length = sprintf(buffer, "%2.1f",i/10.0);

        TextOut(PlotPaintDC,
        (int)((origin_graph[graph_origin_index].x+left.x-5+i*25)*width/640.0),
        (int)((origin_graph[graph_origin_index].y+right.y+10)*height/480.0),
        buffer, length);

                    }
```

A switch is used in calculating the maximum and minimum values to be plotted. If the plot_component_flag is zero or one, then only the first or second component is considered. Otherwise both components are considered since they will be plotted together.

```
//if the plot_component_flag is one or two, look at only that component to
//find the maximum and minimum values to plot, otherwise consider both

 switch(plot_component_flag<2)
 {
```

```
case false:
{

 for(j=0;j<2;j++) {
  for(i=0;i<number_radii[j];i++) {

 max_value =
        max(max_value,parameter[j*max_rad+i]);

 min_value =
        min(min_value,parameter[j*max_rad+i]);

                                    }
                        }
 break;}

case true:
{
        for(i=0;i<number_radii[plot_component_flag];i++){

        max_value =
          max(max_value,parameter[plot_component_flag*max_rad+i]);
        min_value =
          min(min_value,parameter[plot_component_flag*max_rad+i]);

                                                        }
 break;}
}
```

The maximum and minimum values are adjusted to a reasonable range for the plot and the y axis scale is plotted with the appropriate number of significant digits.

```
//adjust the maximum and minimum values such that the range of the plot
//is reasonable and the values are printed to the correct number of
//significant digits


//if the maximum value is greater than zero, use logs to establish the
//maximum value as a round number slightly higher than the maximum value,
//otherwise set the maximum value to 0.0


        if(max_value >= del)

          max_value = pow(10.0,floor(log10(max_value)))*

            (1.0+floor(max_value/(pow(10.0,floor(log10(max_value))))));


        else if(max_value <= -del)
```

```
        max_value = 0.0;

//if the minimum value is less than zero, use logs to establish the
//minimum value as a round number slightly lower than the minimum value,
//otherwise set the minimum value to 0.0


        if(min_value <= -del)

         min_value = -(pow(10.0,floor(log10(fabs(min_value))))*

           (1.0+floor(fabs(min_value)/(pow(10.0,floor(log10(fabs(min_value))))))));

        else if(min_value >= 0)

         min_value = 0.0;

//if the maximum and minimum values are very close together, spread them
//apart slightly

        if(max_value - min_value<del)

     {  max_value = max_value + 0.1;

                if((min_value - 0.1)> 0.0)

                        min_value = min_value - 0.1;
        }

//find the difference between the maximum and minimum values

        delta = max_value - min_value;

//initialize the decimal_places indicator

decimal_places = 2;

        if(fabs(max_value)>del)

                decimal_places =
                        min(floor(log10(fabs(max_value))),decimal_places);

        if(fabs(min_value)>del)

                decimal_places =
                        min(floor(log10(fabs(min_value))),decimal_places);

//label the y-axis based on the value of the decimal_places indicator

switch(decimal_places){

  case 2:
  {
```

```
 for(i=0;i<11;i++){

length = sprintf(buffer, "%d",(int)(max_value-((i*delta)/10.0)));

TextOut(PlotPaintDC,(int)((origin_graph[graph_origin_index].x+left.x+
                shift*4-40)*width/640.0),
        (int)((origin_graph[graph_origin_index].y+left.y-
                3+i*9)*height/480.0), buffer, length);

        }


  break;}

  case 1:
  {

 for(i=0;i<11;i++){

length = sprintf(buffer, "%5.0f",max_value-((i*delta)/10.0));

TextOut(PlotPaintDC,(int)((origin_graph[graph_origin_index].x+left.x+
                shift*3-40)*width/640.0),
        (int)((origin_graph[graph_origin_index].y+left.y-
                3+i*9)*height/480.0), buffer, length);

        }


  break;}

  case 0:
  {

 for(i=0;i<11;i++){

length = sprintf(buffer, "%5.1f",max_value-((i*delta)/10.0));

TextOut(PlotPaintDC,(int)((origin_graph[graph_origin_index].x+left.x+
                shift*3-40)*width/640.0),
        (int)((origin_graph[graph_origin_index].y+left.y-
                3+i*9)*height/480.0), buffer, length);

        }


  break;}

  case -1:
  {

 for(i=0;i<11;i++){

length = sprintf(buffer, "%5.2f",max_value-((i*delta)/10.0));
```

```
TextOut(PlotPaintDC,(int)((origin_graph[graph_origin_index].x+left.x+
                                shift*2-40)*width/640.0),
                        (int)((origin_graph[graph_origin_index].y+left.y-
                                3+i*9)*height/480.0), buffer, length);

                        }


  break;}

  case -2:
  {

 for(i=0;i<11;i++){

length = sprintf(buffer, "%5.3f",max_value-((i*delta)/10.0));

TextOut(PlotPaintDC,(int)((origin_graph[graph_origin_index].x+left.x+
                                shift*1-40)*width/640.0),
                        (int)((origin_graph[graph_origin_index].y+left.y-
                                3+i*9)*height/480.0), buffer, length);

                        }


  break;}

  default :
  {

 for(i=0;i<11;i++){

length = sprintf(buffer, "%5.4f",max_value-((i*delta)/10.0));

TextOut(PlotPaintDC,(int)((origin_graph[graph_origin_index].x+left.x-
                                40)*width/640.0),
                        (int)((origin_graph[graph_origin_index].y+left.y-
                                3+i*9)*height/480.0), buffer, length);

                        }


  break;}

}

//select the normal size font for plotting the key and page #

        SelectFont(PlotPaintDC,hFont);
```

The plot is drawn using a switch to determine if one or both of the components should be plotted. The plots are drawn with polylines, using circles to mark the individual points. The solid pens are used for the single component plots and for component one on the dual component plots. The dotted pens are used for component two on dual component plots.

```
//if the plot_component_flag is one or two, plot only the values for that component, otherwise plot both
// on the same graph

 switch(plot_component_flag<2)
 {

   case false:
   {

//loop through the two components for the case where both will be plotted together

for(j=0;j<2;j++){

//select the color pen for the appropriate graph

        SelectPen(PlotPaintDC,hPlotPen[graph_origin_index][0]);

//loop through the points to be plotted, and for each point calculate and store the x and y coordinates to
// be plotted also draw a circle using the solid pen to indicate the location of the point

        for(i=0;i<number_radii[j];i++) {

                point[i].x = (int)((origin_graph[graph_origin_index].x+
                        left.x+RADIUS[j][i]*250)*width/640.0);

                point[i].y = (int)((origin_graph[graph_origin_index].y+
                        left.y-((parameter[j*max_rad+i]-max_value)/
                        delta)*90)*height/480.0);

                Ellipse(PlotPaintDC,point[i].x-2,point[i].y-2,point[i].x+2,
                        point[i].y+2);
                                }

//select the style and color pen for the appropriate component and graph

        SelectPen(PlotPaintDC,hPlotPen[graph_origin_index][j]);

//plot the polyline

        Polyline(PlotPaintDC,point,number_radii[j]);
}

//plot the key for the page
```

```
for(j=0;j<2;j++){

//write the "Component #"

        length = sprintf(buffer, "Component #%d",j+1);

        TextOut(PlotPaintDC,(int)(50*width/640.0),
                (int)((400+j*20)*height/480.0), buffer, length);

//using the appropriate pen, draw a line that indicates which polyline
//is component #1 and which is component #2

        SelectPen(PlotPaintDC,hPlotPen[0][j]);

        MoveTo(PlotPaintDC,(int)(170*width/640.0),
                (int)((408+j*20)*height/480.0));

        LineTo(PlotPaintDC,(int)(185*width/640.0),
                (int)((408+j*20)*height/480.0));

                  }

   break;}

   case true:
   {

//select the color pen for the appropriate graph

        SelectPen(PlotPaintDC,hPlotPen[graph_origin_index][0]);

//loop through the points to be plotted, and for each point calculate and
//store the x and y coordinates to be plotted
//also draw a circle using the solid pen to indicate the location of the
//point

        for(i=0;i<number_radii[plot_component_flag];i++){

                point[i].x = (int)((origin_graph[graph_origin_index].x+
                left.x+RADIUS[plot_component_flag][i]*250)*width/640.0);

                point[i].y = (int)((origin_graph[graph_origin_index].y+
                left.y-((parameter[plot_component_flag*max_rad+i]-
                max_value)/delta)*90)*height/480.0);

                Ellipse(PlotPaintDC,point[i].x-2,point[i].y-2,point[i].x+2,point[i].y+2);

                                                  }
//select the color pen for the appropriate graph

        Polyline(PlotPaintDC,point,number_radii[plot_component_flag]);

//write the "Component #" and draw a line that indicates the pen style and
```

```
//color

        length = sprintf(buffer, "Component #%d",plot_component_flag+1);

        TextOut(PlotPaintDC,(int)(50*width/640.0),
                (int)(400*height/480.0), buffer, length);


    break;}
}
```

The page number is drawn to the screen. The original pen, brush, and font are selected back into the device context, and the fonts, pens, and brush created for this function are deleted.

```
//write the "Page #"

        length = sprintf(buffer, "Page #%d",plot_page+1);

        TextOut(PlotPaintDC,(int)(50*width/640.0),
                (int)((380)*height/480.0), buffer, length);

//restore the original brush, font, and pen

        SelectObject(PlotPaintDC,hOldBrush);

        SelectPen(PlotPaintDC,hOldPen);

        SelectFont(PlotPaintDC,hOldFont);

//delete the brushes, pens, and fonts

        DeleteObject(hBrush);
        DeleteObject(hFont);
        DeleteObject(hMediumFont);
        DeleteObject(hSmallFont);
        DeleteObject(hStandardPen);

        for(i=0;i<2;i++)
                for(j=0;j<4;j++)
                                DeleteObject(hPlotPen[j][i]);
}
```

C.4.4 The printplot function.

The printplot function is almost exactly the same as the paintplot function. The printplot function is used to draw the same output as the paintplot function, but it is drawn

to the printer instead of the monitor. The printplot function receives the handle to the printer device context after the printer device context has already been prepared for painting. The printplot function uses the drawprint function in the same way that the paintplot function uses the draw function. Since the functions are nearly exactly alike, the printplot and drawprint functions are not shown here and instead are listed in the final section of this appendix.

C.4.5 The paintout function.

The paintout function is used to draw text output files to the Output Viewer window on the monitor. The paintout function receives the handle to the Output Viewer window.

```
void paintout(HWND hWnd)
 {

/*******************************************************************
* declare variables that are defined in the pll.c file and that will be used in this function    *
*******************************************************************/

extern   int        project_flag, Scroll_Pos, LinesInWindow, Total_Lines,
                    output_flag, text_color, LineHeight;


/*******************************************************************
*  Variable declarations                              *
********************************************************************/

        HDC     OutPaintDC;                              //handle of the device context

        PAINTSTRUCT ps;                                  //paint structure

        RECT    rect;                                    //rectangle structure for
                                                         // defining the text region

        HFONT hFont,                                     //fonts for text output
                hSmallFont,
                hOldFont;                                //original font

        LOGFONT lFont;                                   //logical font structure for
                                                         // creating fonts

        char    OUTFILE[14];                             //a character string indicating
                                                         // the output file
```

```
char    * buffer;                    //pointer to a character buffer

int     num_bytes;                   //number of bytes read by _lread

float   width,                       //display size scaled to 640/480
        height;                      // used to scale the polar plots

HFILE   in;                          //file handle
```

The paintout function uses the BeginPaint function to prepare the window for painting. If the there are no PLL or PBD output files, the bulk of the code is skipped and the paint process is terminated. If there are output files to display, the malloc function is used to allocate enough memory to store a file of the size specified by max_buf_sz parameter. The max_buf_sz parameter is defined in the header.h file as 10000.

```
//create the device context

        OutPaintDC = BeginPaint(hWnd, &ps);

//only draw output if there is a project open and files to be drawn

        if((project_flag)&&((access("summary.out", 0) == 0)||(access("pbdout.ktq", 0) == 0))){

//allocate memory for reading the file into

                buffer = (char *) malloc((max_buf_sz)*sizeof (char));
```

The size of the display area is determined and scale factors are calculated for the purpose of making the output device independent.

```
//determine the width of the display in pixels and the height of the display
// in raster lines and cast them as floats

                width  = (float)GetDeviceCaps (OutPaintDC, HORZRES);
                height = (float)GetDeviceCaps (OutPaintDC, VERTRES);

//since the normal display aspect ratio is 4 to 3, ensure that the graphical
// output made by the program is in that aspect ratio

                if((width/height)>(4.0/3.0))
                        width = height*(4.0/3.0);
                else
                        height = width*(3.0/4.0);
```

A rectangle is initialized for use with the DrawText function, scaled to the dimensions of the device context display area. Small and normal sized fonts are then created for painting the text output.

```
//initialize the rectangle for displaying the file

        rect.left     =     (int)(20*width/640.0);
        rect.right    =         (int)(625*width/640.0);
        rect.top      =     (int)(15*height/480.0);
        rect.bottom   =     (int)(6000*height/480.0);

//get a handle to the device default font

    hFont = GetStockFont(DEVICE_DEFAULT_FONT);

//use the device default font to fill a logical font structure

    GetObject(hFont,sizeof(LOGFONT),&lFont);

//alter the font size and create a small font

        lFont.lfHeight = -11;

    hSmallFont = CreateFontIndirect(&lFont);
```

The global integer variable, text_color, is used in a switch to set the color of the text drawn to the screen. The blue, green, red, and black values are defined in the header.h file. The SetTextColor receives a handle to a device context and a RGB color value and sets the device context text color to the RGB value.

```
//this switch sets the text color based on the value of the text_color flag

    switch(text_color)
    {
     case blue:    {     SetTextColor(OutPaintDC,RGB(0,0,128));  break;  }
     case green:   {     SetTextColor(OutPaintDC,RGB(0,128,64)); break;  }
     case red:     {     SetTextColor(OutPaintDC,RGB(255,0,0));  break;  }
     case black:   {     SetTextColor(OutPaintDC,RGB(0,0,0));    break;  }
    }
```

The OUTFILE variable is a character array that is used with the _lopen function to open the appropriate output file. The content of the OUTFILE variable is determined by a switch that tests the output_flag variable to determine which file is to be printed.

//this switch writes the appropriate file name into the OUTFILE

```
switch(output_flag)
{
  case summary:               { strcpy(OUTFILE,"summary.out\0"); break;}
  case downstream_velocities: { strcpy(OUTFILE,"fards.out\0");  break;}
  case duct_geometry:         { strcpy(OUTFILE,"duct.geo\0");   break;}
  case abs_rules_calc:        { strcpy(OUTFILE,"stress.out\0"); break;}
  case detailed1:             { strcpy(OUTFILE,"detail1.out\0"); break;}
  case detailed2:             { strcpy(OUTFILE,"detail2.out\0"); break;}
  case non_axisym_cir:        { strcpy(OUTFILE,"nonaxi.cir\0");  break;}
  case non_axisym_for:        { strcpy(OUTFILE,"nonaxi.for\0");  break;}
  case non_axisym_cmp:        { strcpy(OUTFILE,"nonaxi.cmp\0");  break;}
  case non_axisym_har:        { strcpy(OUTFILE,"nonaxi.har\0");  break;}
  case pbdktq:                { strcpy(OUTFILE,"pbdout.ktq\0");  break;}
}
```

The appropriate output file is opened using the _lopen function and read using the _lread function. The file is then closed using the _lclose function.

```
//open, read into the buffer, and close the data file

        in = _lopen(OUTFILE, READ);

        num_bytes= _lread(in, buffer, max_buf_sz);

        _lclose(in);
```

The small font is selected into the device context prior to painting the output. The vertical extents of the rectangle structure that will be used with the DrawText function to paint the output are adjust based on the position of the scroll bar and the height of a line of text in the Output Viewer window.

```
//select the small font and save a handle to the original font

        hOldFont = SelectFont(OutPaintDC,hSmallFont);

//adjust the top and bottom of the temporary rectangle structure to account for the position of the vertical
// scroll bar position

        rect.top        = rect.top    - Scroll_Pos*LineHeight;

        rect.bottom     = rect.bottom - Scroll_Pos*LineHeight;
```

The next executable line of code uses the DrawText function to paint the output file onto the Output Viewer window. The DrawText function receives a handle to a device context, the address of the string to be drawn, the number of bytes to draw, the address of a rectangle structure that describes the region where the text is to be drawn, and flags that describe how the text is to be drawn. The function returns the height of the text that was drawn. This statement divides the return value by the height in pixels of a line of text to determine the total number of lines of text painted and assigns the value to the Total_Lines variable. The flags used are described below:

DT_LEFT-	causes the text to be left aligned.
DT_WORDBREAK-	causes lines to be broken between words if a word would extend past the edge of the display rectangle
DT_NOCLIP-	draws the text without clipping
DT_NOPREFIX-	turns off the processing of prefix characters

```
//draw the text file in the region defined by rect and calculate the total number of lines of text to draw

        Total_Lines=(int)(DrawText(OutPaintDC,buffer,num_bytes, &rect,
                          DT_LEFT|DT_WORDBREAK|DT_NOCLIP|DT_NOPREFIX)/LineHeight);
```

The scroll range is then set based on the total number of lines of text displayed in the Output Viewer window, using the SetScrollRange function. The SetScrollRange function receives a handle to the window associated with the scroll bar that is to have its range set, a scroll bar flag that specifies the bar to set, the minimum and maximum scroll bar settings in the range, and a redraw flag that specifies in this case that the scroll bar is to be redrawn.

```
//set the range of the scroll bar to the total number of lines so the range covers the entire text region

        SetScrollRange(hWnd, SB_VERT, 0, Total_Lines, TRUE);
```

The original font is selected back into the device context, the memory used to store the text is freed, and the fonts created for this function are then destroyed. The paint process is then terminated.

```
//select the original font back into the device context

        SelectFont(OutPaintDC,hOldFont);

//free the allocated memory

        free( buffer );

//delete the fonts created for this function

        DeleteFont(hFont);
        DeleteFont(hSmallFont);
                                        }

//close out the paint command

        EndPaint(hWnd, &ps);
}
```

C.4.6 The printout function.

The printout function is used to draw text output files to the system printer. The function is nearly identical to the paintout function in section C.4.5 above. The printout function receives the handle to the printer device context. The only other difference is that it does not use any of the variables associated with the scroll bar. The function is shown below.

```
void printout(HDC OutPaintDC)
 {

/*********************************************************************
* declare variables that are defined in the pll.c file and that     *
* will be used in this function                                     *
*********************************************************************/

extern   int        output_flag, text_color;

/*********************************************************************
*  Variable declarations                                            *
```

```
**********************************************************************/

        RECT    rect;                                   //rectangle structure for
                                                        // defining the text region

        HFONT hFont,                                    //font for text output
         hOldFont;                                      //original font

        char    OUTFILE[14];                            //a character string indicating
                                                        // the output file

        char    * buffer;                               //pointer to a character buffer

        int     num_bytes;                              //number of bytes read by _lread

        float   width,                                  //display size scaled to 640/480
                height;                                 //used to scale the polar plots

        HFILE   in;                                     //file handle

//allocate memory for reading the file into

                buffer = (char *) malloc((max_buf_sz)*sizeof (char));

//determine the width of the display in pixels and the height of the display in raster lines and cast
// them as floats

                width  = (float)GetDeviceCaps (OutPaintDC, HORZRES);
                height = (float)GetDeviceCaps (OutPaintDC, VERTRES);

//since the normal display aspect ratio is 4 to 3, ensure that the graphical
// output made by the program is in that aspect ratio

                if((width/height)>(4.0/3.0))
                        width = height*(4.0/3.0);
                else
                        height = width*(3.0/4.0);

//initialize the rectangle for displaying the file

                rect.left       = (int)(20*width/640.0);
                rect.right      = (int)(625*width/640.0);
                rect.top        = (int)(15*height/480.0);
                rect.bottom     = (int)(6000*height/480.0);

//select the device default font and save a handle to the original font

                hFont = GetStockFont(DEVICE_DEFAULT_FONT);

                hOldFont = SelectFont(OutPaintDC, hFont);

//this switch sets the text color based on the value of the text_color flag

        switch(text_color)
```

```
         {
          case blue:        {SetTextColor(OutPaintDC,RGB(0,0,128)); break; }
          case green:       {SetTextColor(OutPaintDC,RGB(0,128,64));break; }
         case red:          {SetTextColor(OutPaintDC,RGB(255,0,0)); break; }
         case black:        {SetTextColor(OutPaintDC,RGB(0,0,0));  break; }
         }

//this switch writes the appropriate file name into the OUTFILE

 switch(output_flag)
 {
   case summary:                    { strcpy(OUTFILE,"summary.out\0"); break;}
   case downstream_velocities:      { strcpy(OUTFILE,"fards.out\0");  break;}
   case duct_geometry:              { strcpy(OUTFILE,"duct.geo\0");   break;}
   case abs_rules_calc:             { strcpy(OUTFILE,"stress.out\0"); break;}
   case detailed1:                  { strcpy(OUTFILE,"detail1.out\0"); break;}
   case detailed2:                  { strcpy(OUTFILE,"detail2.out\0"); break;}
   case non_axisym_cir:             { strcpy(OUTFILE,"nonaxi.cir\0");  break;}
   case non_axisym_for:             { strcpy(OUTFILE,"nonaxi.for\0");  break;}
   case non_axisym_cmp:             { strcpy(OUTFILE,"nonaxi.cmp\0");  break;}
   case non_axisym_har:             { strcpy(OUTFILE,"nonaxi.har\0");  break;}
   case pbdktq:                     { strcpy(OUTFILE,"pbdout.ktq\0");  break;}
 }

//open, read into the buffer, and close the data file

         in = _lopen(OUTFILE, READ);

         num_bytes= _lread(in, buffer, max_buf_sz);

         _lclose(in);

//draw the text
                   DrawText(OutPaintDC,buffer,num_bytes,&rect,
                            DT_LEFT|DT_WORDBREAK|DT_NOCLIP|DT_NOPREFIX);
//free the allocated memory

                   free( buffer );

//select the original font back into the device context and delete the font created for this function

                   SelectFont(OutPaintDC, hOldFont);

                   DeleteFont(hFont);
}
```

C.4.7 The paint_graphs function.

The paint_graphs function is used to draw the input and output blade grids wireframe diagrams, the B-spline control net wireframe, and hub and duct images to the

passed device context, PaintDC. This allows the function to draw on the screen as well as the printer. The function receives the handle to the monitor or printer device context, a point structure that defines the location on the display where the plot origin will be, a pointer to the FILE structure that contains information about the PBD output file that will be plotted, and an index that determines the color that is used to plot the data.

The D7POINT structure is defined as a cartesian point in 7 space. It is defined external to the paint_graphs functions since it will be used in other functions used to read PBD output files and draw PBD output plots on the Plot Viewer window. It consists of seven floating point values organized in a structure.

```
        struct  D7POINT {  /* 7-D pt */
        float   x,y,z,r,u,v,w;
                        } D7POINT;
void paint_graphs(HDC PaintDC, POINT origin, FILE *plot, int color)
{

/*******************************************************************
* declare variables that are defined in the pll.c file and that     *
* will be used in this function                        *
*******************************************************************/

extern  int     plot_page;

extern  float   scale_factor;

/*******************************************************************
*  Variable declarations                               *
*******************************************************************/

        char    buffer[120];                    //character string for text output

        int     i=0, j,                         //loop counters
                nextchar=1,                     //used for reading input file
                                                // character by character

                points_per_line,                //dimensions of array of xyz
                lines,                          // points describing the wireframes
                length;                         //length of text output strings

        struct  D7POINT *points;                //pointer to 7d point array used
                                                // for reading and storing
```

```
                                                // description of the wireframes

float   width, height,                          //display size scaled to 640/480
        X, Y,                                   //3d point converted to screen
                                                // coordinates

        scale=15.0,                             //scale factor to fit plot on screen
        axis = 2.0;                             //scale factor for the axis plot

HPEN  hPen[2], hOldPen;                         //pens for drawing wireframes

POINT origin_axis;                              //origin for the axis plot

HFONT hFont, hOldFont;                          //fonts for writing text output
```

After variable declarations are made, the function creates a blue and a green pen for drawing output and gets a handle to the device default font. The size of the display area is calculated. A scale to be used to plot the data is calculated based on user input provided with the PBD Plot Geometry dialog box.

```
//create a blue and a green pen for drawing the control point grid and the velocity vectors

        hPen[0] = CreatePen(PS_SOLID, 1, RGB(0,0,255));

        hPen[1] = CreatePen(PS_SOLID, 1, RGB(0,128,64));

//get a handle to the device default font

        hFont = GetStockFont(DEVICE_DEFAULT_FONT);

//determine the width of the display in pixels and the height of the display
// in raster lines and cast them as floats

        width  = (float)GetDeviceCaps (PaintDC, HORZRES);
        height = (float)GetDeviceCaps (PaintDC, VERTRES);

//since the normal display aspect ratio is 4 to 3, ensure that the graphical
// output made by the program is in that aspect ratio

        if((width/height)>(4.0/3.0))
                width = height*(4.0/3.0);
        else
                height = width*(3.0/4.0);

//select the device default font and the pen indicated by the color index
// passed in the function call into the device context and save handles to
// the original font and pen

        hOldFont = SelectFont(PaintDC, hFont);
```

```
        hOldPen = SelectPen(PaintDC,hPen[color]);
//adjust the scale factor by an amount determined by the user
        scale = scale_factor * scale;
```

The function now reads in the data to be plotted. The output files written by the PBD FORTRAN executable are in a standard format for use by a graphics program. The first two lines are not used by this function and are therefore discarded. A while statement is used to read the data character by character using the getc function until a carriage return or linefeed statement is encountered.

```
//read in the data to be plotted
//scrap the first line
        while (nextchar!=13&&nextchar!=10)
                nextchar = getc(plot);
        nextchar = 1;
//scrap the second line
        while (nextchar!=13&&nextchar!=10)
                nextchar = getc(plot);
        nextchar =1;
```

The function then employs a while statement to check for the end of the data file. If the end of the data file is not found, the function reads the next zone of the data file. This is done in order to allow the function to handle data files with multiple zones, such as an output blade grid file which will have a separate zone for each blade and an additional zone for the transition wake.

```
//the purpose of this while statement is to allow the function to read and plot a series of wireframes from
// the same file, as in the case of a pbdout.obg file which contains zones for all of the blades as well as
// the transition wake
        while((nextchar=getc(plot))!=EOF){
```

The next five lines of executable code search the next line in the data file for the second "=" sign. The function then reads the first dimension of the data array into the points_per_line variable.

```
//extract the number of points_per_line and the number of lines

//read the third line, looking for the first equal sign

        while (nextchar!=61)
                nextchar = getc(plot);
        nextchar =1;

//continue reading the third line, looking for the second equal sign

        while (nextchar!=61)
                nextchar = getc(plot);

//read the points per line

        fscanf(plot,"%d",&points_per_line);

        nextchar=1;
```

The third "=" sign encountered keys the function to read the second dimension of the data array into the lines variable. The rest of the line is then discarded.

```
//continue reading the third line, looking for the third equal sign

        while (nextchar!=61)
                nextchar = getc(plot);

        fscanf(plot,"%d",&lines);

//scrap the rest of line

                while (nextchar!=13&&nextchar!=10)
                        nextchar = getc(plot);
```

Memory is then allocated for storage of the file data in the points array using the malloc and sizeof functions. The data is read into the points array using two for loops. The points array, although it contains a two dimensional array, is accessed as a one dimensional array. Note that the index of the array is indicated as "i*points_per_line+j". This index refers to the jth column in the ith row, where the column and row indices run from zero to "lines-1" and zero to "points_per_line-1" respectively.

```
//allocate memory for storing the points that describe the wireframe

        points = (struct D7POINT * ) malloc((lines*points_per_line)*sizeof (struct D7POINT));
```

```
//read and store the point data

        for (i=0; i<lines; i++) {

        for (j=0; j<points_per_line; j++) {

        fscanf(plot,"%f %f %f %f %f %f %f", &points[i*points_per_line+j].x,
                &points[i*points_per_line+j].y, &points[i*points_per_line+j].z,
                &points[i*points_per_line+j].r, &points[i*points_per_line+j].u,
                &points[i*points_per_line+j].v, &points[i*points_per_line+j].w);

                                }
                        }
```

The rest of the line is then discarded character by character until a carriage return or linefeed is encountered in order to prepare the file so that the next zone may be read.

```
//scrap the rest of line

                while (nextchar!=13&&nextchar!=10)
                        nextchar = getc(plot);
                nextchar = getc(plot);
```

The text alignment for the device context is set to center adjusted and the plot label is drawn at the top of the page using the TextOut function. The label drawn is a function of the plot_page variable value since the paint_graphs function is used for drawing the input blade grid and B-spline net as well as the output blade grid and transition wake.

The strlen function is used to provide the length of the text to be drawn. The strlen function receives a string or the address of a string and returns the length of the string minus the null terminating character.

```
//label the plot

        SetTextAlign(PaintDC,TA_CENTER);

//determine the label by testing the plot_page flag

        switch(plot_page)
        {
        case 4:{ TextOut(PaintDC,(int)(320*width/640.0),
```

```
                    (int)(10*height/480.0), "INPUT BLADE GRID AND B-SPLINE NET\0",
                    strlen("INPUT BLADE GRID AND B-SPLINE NET\0"));
    break; }
    case 5:{ TextOut(PaintDC,(int)(320*width/640.0),
                    (int)(10*height/480.0), "OUTPUT BLADE GRID AND CENTERBODY\0",
                    strlen("OUTPUT BLADE GRID AND CENTERBODY\0"));
    break; }
    }
```

The text alignment is restored to left adjusted and an origin is defined for use in drawing the xyz axis on the plot.

```
    SetTextAlign(PaintDC,TA_LEFT);

//define the axis origin

    origin_axis.x = (int)(40*width/640.0);
    origin_axis.y = (int)(410*height/640.0);
```

The wireframe diagram is then drawn using two sets of two for loops. The first set of two for loops is used to loop through the data array and draw lines connecting each point in succeeding rows. The second set of two loops connects each point in succeeding columns.

The rotation_projection function receives floating point x, y, and z cartesian coordinates and pointers to the x and y coordinate variables, X and Y. The function rotates the point about the appropriate axis using the globally defined and user input pitch, roll, and yaw angles, and projects the point onto the z = 0 plane in order to prepare the three dimensional data for two dimensional plotting. The x and y values are assigned to the X and Y variables. This is done to allow the user to view the output data in any orientation. The rotation_projection function will be described in more detail below.

The MoveTo function is used to change the pen location to a point corresponding to the first point in the next row or column without drawing a line. The LineTo calls are used to connect the subsequent points in the row or column. The x and y screen coordinate points are scaled by the user determined scale factor internal to the MoveTo and LineTo calls so the output may be viewed in any scale.

```
// draw wireframe diagram

        for (i=0; i<lines; i++) {

                rotation_projection(points[i*points_per_line].x, points[i*points_per_line].y,
                        points[i*points_per_line].z, &X, &Y);

                MoveTo(PaintDC,(int)((origin.x+scale*(X))*width/640.0),
                        (int)((origin.y-scale*(Y))*height/480.0));


        for (j=1; j<points_per_line; j++){

                rotation_projection(points[i*points_per_line+j].x, points[i*points_per_line+j].y,
                        points[i*points_per_line+j].z, &X, &Y);

                LineTo(PaintDC,(int)((origin.x+scale*(X))*width/640.0),
                        (int)((origin.y-scale*(Y))*height/480.0));

                                }
                        }

        for (j=0; j<points_per_line; j++) {

                rotation_projection(points[j].x, points[j].y,
                        points[j].z, &X, &Y);

                MoveTo(PaintDC,(int)((origin.x+scale*(X))*width/640.0),
                        (int)((origin.y-scale*(Y))*height/480.0));

        for (i=1; i<lines; i++) {

                rotation_projection(points[i*points_per_line+j].x,
                points[i*points_per_line+j].y,
                points[i*points_per_line+j].z, &X, &Y);

                LineTo(PaintDC,(int)((origin.x+scale*(X))*width/640.0),
                        (int)((origin.y-scale*(Y))*height/480.0));

                        }
                                }
```

The memory allocated to store the plot data is then freed using the free function. The original pen is selected back into the device context and the xyz axes are drawn, rotated through the same pitch, roll, and yaw angles as the wireframe diagram.

```
//free the allocated memory

        free( points );
        }
```

```
//select the original pen into the device context and label the (x,y,z) axes

        SelectPen(PaintDC, hOldPen);

//draw the xyz axes

        rotation_projection(axis + 1.0, 0.0, 0.0, &X, &Y);

                length = sprintf(buffer, "x");

                TextOut(PaintDC, (int)((origin_axis.x+X)*width/640.0),
                        (int)((origin_axis.y-Y)*height/480.0),
                        buffer, length);

                rotation_projection(0.0, axis + 1.0, 0.0, &X, &Y);

                length = sprintf(buffer, "y");

                TextOut(PaintDC, (int)((origin_axis.x+X)*width/640.0),
                        (int)((origin_axis.y-Y)*height/480.0),
                        buffer, length);

                rotation_projection(0.0, 0.0, axis + 1.0, &X, &Y);

                length = sprintf(buffer, "z");

                TextOut(PaintDC, (int)((origin_axis.x+X)*width/640.0),
                        (int)((origin_axis.y-Y)*height/480.0),
                        buffer, length);

                rotation_projection(axis, 0.0, 0.0, &X, &Y);

                MoveTo(PaintDC,(int)((origin_axis.x+X)*width/640.0),
                        (int)((origin_axis.y-Y)*height/480.0));

                LineTo(PaintDC,(int)((origin_axis.x)*width/640.0),
                        (int)((origin_axis.y)*height/480.0));

                rotation_projection(0.0, axis, 0.0, &X, &Y);

                LineTo(PaintDC,(int)((origin_axis.x+X)*width/640.0),
                        (int)((origin_axis.y-Y)*height/480.0));

                rotation_projection(0.0, 0.0, axis, &X, &Y);

                MoveTo(PaintDC,(int)((origin_axis.x+X)*width/640.0),
                        (int)((origin_axis.y-Y)*height/480.0));

                LineTo(PaintDC,(int)((origin_axis.x)*width/640.0),
                        (int)((origin_axis.y)*height/480.0));
```

The original font is selected back into the device context and the pens and font created for this function are deleted.

```
//select the original font back into the device context

        SelectFont(PaintDC,hOldFont);

//delete the pens and font created for this function

        DeleteObject(hPen[0]);
        DeleteObject(hPen[1]);

        DeleteFont(hFont);
}
```

The rotation_projection function receives an xyz point and pointers to two floating point X and Y values. The function rotates the xyz point through the user defined pitch, roll, and yaw angles, and projects it onto the Z = 0 plane in order to prepare it for plotting on the monitor or printer. The result is placed in X and Y variables.

```
void rotation_projection(float x, float y, float z, float * X, float * Y )
{
        extern float cos_roll;
        extern float sin_roll;
        extern float cos_yaw;
        extern float sin_yaw;
        extern float cos_pitch;
        extern float sin_pitch;

                float dz = 10.0;
                float xa,ya,za;


        xa = cos_yaw * x - sin_yaw * z;
        za = sin_yaw * x + cos_yaw * z;

        *X =  cos_roll * xa + sin_roll * y;

        ya =  cos_roll * y - sin_roll * xa;

        *Y =  sin_pitch * za + cos_pitch * ya;

        *X = (dz * (*X));
        *Y = (dz * (*Y));
        }
```

C.4.8 The paint_hub function.

The paint_hub function receives the handle to a device context, a point on the screen to use as the plot origin, and a pointer to a FILE structure. It draws the centerbody described in the data file to the screen or the printer depending on the device context passed.

```
void paint_hub(HDC PaintDC, POINT origin, FILE *plot)
{

/******************************************************************
* declare variables that are defined in the pll.c file and that    *
* will be used in this function                         *
*******************************************************************/

        extern  float    scale_factor;

        extern  struct   D7POINT {  /* 7-D pt */

                float x,y,z,r,u,v,w;

                                } D7POINT;

/******************************************************************
*  Variable declarations                               *
*******************************************************************/

        int     i, j,                               //loop counters
                nextchar=1,                         //used for reading input file
                                                    // character by character

                points_per_line,                    //dimensions of array of xyz
                lines;                              // points describing the hub

        struct  D7POINT *points;                    //pointer to 7d point array used for
                                                    //reading and storing description of
                                                    //hub

        float   width, height,                      //display size scaled to 640/480
                X, Y,                               //3d point converted to screen
                                                    // coordinates

                scale=15.0;                         //scale factor to fit plot on screen

/******************************************************************
*  declare structure variables                                 *
*******************************************************************/
```

```
HPEN    hRedPen, hOldPen;                                   //pens for drawing hub
```

The function creates a red pen for drawing the output. The size of the display area is calculated and a scale to be used to plot the data is calculated based on user input provided with the PBD Plot Geometry dialog box.

```
/*******************************************************************
* determine the size of the device context to be written to, this *
* allows the function to be device independent                    *
*******************************************************************/

//create a red pen and store a handle to it

        hRedPen = CreatePen(PS_SOLID, 1, RGB(255,0,0));

//determine the width of the display in pixels and the height of the display in raster lines and cast
// them as floats

        width  = (float)GetDeviceCaps (PaintDC, HORZRES);
        height = (float)GetDeviceCaps (PaintDC, VERTRES);

//since the normal display aspect ratio is 4 to 3, ensure that the graphical
// output made by the program is in that aspect ratio

        if((width/height)>(4.0/3.0))
                width = height*(4.0/3.0);
        else
                height = width*(3.0/4.0);

//select the red pen and save a handle to the original pen

        hOldPen = SelectPen(PaintDC,hRedPen);

//adjust the scale factor by an amount determined by the user

        scale = scale_factor * scale;
```

The number of lines of data and number of points per line is extracted as described in section C.4.7 above.

```
//read in the data to be plotted

//scrap the first line

        while (nextchar!=13&&nextchar!=10)
                nextchar = getc(plot);
        nextchar =1;

//scrap the second line
```

```
        while (nextchar!=13&&nextchar!=10)
                nextchar = getc(plot);
        nextchar =1;

//extract the number of points_per_line and the number of lines

//read the third line, looking for the first equal sign

        while (nextchar!=61)
                nextchar = getc(plot);
        nextchar =1;

//continue reading the third line, looking for the first second equal sign

        while (nextchar!=61)
                nextchar = getc(plot);

//read the points per line

        fscanf(plot,"%d",&points_per_line);

        nextchar=1;

//continue reading the third line, looking for the first second equal sign

        while (nextchar!=61)
                nextchar = getc(plot);

        fscanf(plot,"%d",&lines);

//scrap the rest of line

                while (nextchar!=13&&nextchar!=10)
                        nextchar = getc(plot);
```

Memory is allocated, the data file is read, and the wireframe diagram is drawn in the same way as described in section C.4.7 above.

```
//allocate memory for storing the points that describe the hub

        points = (struct D7POINT * ) malloc((lines*points_per_line)*sizeof (struct D7POINT));

//read and store the point data

        for (i=0; i<lines; i++)  {

                for (j=0; j<points_per_line; j++)  {

        fscanf(plot,"%f %f %f %f %f %f %f", &points[i*points_per_line+j].x,
                &points[i*points_per_line+j].y, &points[i*points_per_line+j].z,
                &points[i*points_per_line+j].r, &points[i*points_per_line+j].u,
```

```
&points[i*points_per_line+j].v, &points[i*points_per_line+j].w);
            }
        }

//draw the wireframe diagram

    for (i=0; i<lines; i++) {

        rotation_projection(points[i*points_per_line].x, points[i*points_per_line].y,
            points[i*points_per_line].z, &X, &Y);

        MoveTo(PaintDC,(int)((origin.x+scale*(X))*width/640.0),
            (int)((origin.y-scale*(Y))*height/480.0));

    for (j=1; j<points_per_line; j++){

        rotation_projection(points[i*points_per_line+j].x, points[i*points_per_line+j].y,
            points[i*points_per_line+j].z, &X, &Y);

        LineTo(PaintDC,(int)((origin.x+scale*(X))*width/640.0),
            (int)((origin.y-scale*(Y))*height/480.0));

            }
        }
    for (j=0; j<points_per_line; j++) {

        rotation_projection(points[j].x, points[j].y, points[j].z, &X, &Y);

        MoveTo(PaintDC,(int)((origin.x+scale*(X))*width/640.0),
            (int)((origin.y-scale*(Y))*height/480.0));

    for (i=1; i<lines; i++) {

        rotation_projection(points[i*points_per_line+j].x, points[i*points_per_line+j].y,
            points[i*points_per_line+j].z, &X, &Y);

        LineTo(PaintDC,(int)((origin.x+scale*(X))*width/640.0),
            (int)((origin.y-scale*(Y))*height/480.0));
        }
            }
```

The memory used to store the plot data is freed using the free function, the original pen is selected back into the device context, and the pen created for this function is deleted.

```
//free the allocated memory

    free( points );
```

```
//select the original pen back into the device context

        SelectPen(PaintDC, hOldPen);

//delete the pen created for this function

        DeleteObject(hRedPen);
}
```

C.4.9 The paint_gsp function.

The paint_gsp function draws the circulation contour plots described in the PBDOUT.GSP or PBDOUT.SOL files to the monitor or printer. The function receives a handle to the device context, the origin at which the plot is to be printed, and a pointer a FILE structure that contains information regarding the data file to be plotted.

```
void paint_gsp(HDC PaintDC, POINT origin, FILE *plot)
{
/******************************************************************
* declare variables that are defined in the pll.c file and that    *
* will be used in this function                                    *
******************************************************************/

extern  struct  D7POINT {  /* 7-D pt */

        float   x,y,z,r,u,v,w;

                        } D7POINT;

extern  float   scale_factor;

/******************************************************************
*  Variable declarations                                           *
******************************************************************/

        char    buffer[120],                        //character string for text output
                title[81]= "BOUND CIRCULATION STRENGTH\0";      //plot title

        int     i=0, j,                             //loop counters
                nextchar=1,                         //used for reading input file
                                                    // character by character

                points_per_line,                    //dimensions of array of xyz
                lines,                              // points describing the wireframes
                length,                             //length of text output strings
                id,                                 //index indicating color to paint
                                                    // the contour plot polygon
```

```
		dummy;					//dummy integer for reading
integer
							// data not used by this function

	struct	D7POINT *points;			//pointer to 7d point array used
							// for reading and storing
							// the plot data

	float	width, height,				//display size scaled to 640/480

		scale=150.0,				//scale factor to fit plot on
							// screen

		max_discrete = -100.0,			//max and min values for the
		min_discrete = 100.0,			// bound vortex strength
		max_density = -100.0,
		min_density = 100.0;

	HPEN	hPen[6],				//pens for drawing the plots
		hOldPen;

	HBRUSH		hBrush[6],		//brushes for drawing the plots
		hOldBrush;

	HFONT hFont,					//fonts for writing text output
		hOldFont;

	POINT	origin_axis,				//origin for the axis plot
		origin_dis,				//origin for the discrete plot
		origin_den,				//origin for the density plot
		poly[5];				//array of points that define
							// the polygons to be plotted
```

Origins for the discrete and density plots are calculated based on the origin passed with the function call. Six pens and brushes are created for drawing the contour plots. The device default font is created and the size of the display is calculated.

```
//define the origins of the discrete and the density plots based on the origin passed with the function call

	origin_dis.x = origin.x-240;
	origin_dis.y = origin.y;

	origin_den.x = origin.x+80;
	origin_den.y = origin.y;

//create brushes and pens used for drawing the contour plots

	hBrush[0] = CreateSolidBrush (RGB(255,0,0));
	hBrush[1] = CreateSolidBrush (RGB(255,255,0));
	hBrush[2] = CreateSolidBrush (RGB(0,255,0));
	hBrush[3] = CreateSolidBrush (RGB(0,225,255));
```

```
        hBrush[4] = CreateSolidBrush (RGB(0,0,255));
        hBrush[5] = CreateSolidBrush (RGB(255,0,255));

        hPen[0] = CreatePen (PS_SOLID, 1, RGB(255,0,0));
        hPen[1] = CreatePen (PS_SOLID, 1, RGB(255,255,0));
        hPen[2] = CreatePen (PS_SOLID, 1, RGB(0,255,0));
        hPen[3] = CreatePen (PS_SOLID, 1, RGB(0,225,255));
        hPen[4] = CreatePen (PS_SOLID, 1, RGB(0,0,255));
        hPen[5] = CreatePen (PS_SOLID, 1, RGB(255,0,255));

//get a handle to the device default font

        hFont = GetStockFont(DEVICE_DEFAULT_FONT);

//determine the width of the display in pixels and the height of the display in raster lines and cast them
// as floats

        width  = (float)GetDeviceCaps (PaintDC, HORZRES);
        height = (float)GetDeviceCaps (PaintDC, VERTRES);

//since the normal display aspect ratio is 4 to 3, ensure that the graphical
// output made by the program is in that aspect ratio

        if((width/height)>(4.0/3.0))
                width = height*(4.0/3.0);
        else
                height = width*(3.0/4.0);

//select the device default font and a new pen and brush and save handles to the original font, brush,
// and pen

        hOldFont = SelectFont(PaintDC, hFont);

        hOldPen = SelectPen(PaintDC,hPen[0]);

        hOldBrush = SelectObject(PaintDC,hBrush[0]);
```

The plots are labeled and the data is read in the way described in section C.4.7.

```
//print the title and the plot labels

        SetTextAlign(PaintDC,TA_CENTER);

        TextOut(PaintDC,(int)(320*width/640.0), (int)(10*height/480.0), title, strlen(title));

        SetTextAlign(PaintDC,TA_LEFT);

        TextOut(PaintDC,(int)((origin_dis.x+50)*width/640.0),
                (int)((origin_dis.y-180)*height/480.0), "Discrete\0", strlen("Discrete\0"));

        TextOut(PaintDC,(int)((origin_den.x+50)*width/640.0),
                (int)((origin_den.y-180)*height/480.0), "Vortex Sheet\0", strlen("Vortex Sheet\0"));
```

```
//read in the data to be plotted

//scrap the first line

        while (nextchar!=13&&nextchar!=10)
                nextchar = getc(plot);
        nextchar =1;

//scrap the second line

        while (nextchar!=13&&nextchar!=10)
                nextchar = getc(plot);
        nextchar =1;

//extract the number of points_per_line and the number of lines

//read the third line, looking for the first equal sign

        while (nextchar!=61)
                nextchar = getc(plot);
        nextchar =1;

//continue reading the third line, looking for the first second equal sign

        while (nextchar!=61)
                nextchar = getc(plot);

//read the points per line

        fscanf(plot,"%d",&points_per_line);

        nextchar=1;

//continue reading the third line, looking for the first second equal sign

        while (nextchar!=61)
                nextchar = getc(plot);

        fscanf(plot,"%d",&lines);

//scrap the rest of line

                while (nextchar!=13&&nextchar!=10)
                        nextchar = getc(plot);

//allocate memory for storing the points that describe the contour plots

        points = (struct D7POINT * ) malloc((lines*points_per_line)*sizeof (struct D7POINT));

//read the point data

        for (i=0; i<lines; i++)  {

                for (j=0; j<points_per_line; j++)  {
```

The first data value on each data line of the file is discarded by reading it into the dummy variable. Note that only five values are provided on each line instead of the seven provided in the data files described previously. The maximum and minimum values of circulation for the discrete and density plots are calculated during the data reading process.

```
//read the index into dummy, read the radius into x, the chord into y, Gdiscrete*1000 into z, and
// Gdensity*1000 into r

        fscanf(plot,"%d %f %f %f %f ", &dummy, &points[i*points_per_line+j].x,
            &points[i*points_per_line+j].y, &points[i*points_per_line+j].z,
            &points[i*points_per_line+j].r);

//find the max and min values of the discrete and density values

        max_discrete = max(points[i*points_per_line+j].z,max_discrete);

        min_discrete = min(points[i*points_per_line+j].z,min_discrete);

        max_density  = max(points[i*points_per_line+j].r,max_density);

        min_density  = min(points[i*points_per_line+j].r,min_density);

                                        }
                            }
```

The first step in drawing the contour plots is to loop through the data points. A weighted average circulation strength is calculated for each point using the adjacent points. The weighted average is cast as an integer index on the same scale as the pens and brushes (0-6) and used to select the appropriate pen and brush. The vertices of a polygon are calculated using the coordinates of the adjacent points, and the Polygon function is used to draw the polygon. The Polygon function receives a handle to the device context, the address of an array with the vertices, and the number of points in the array. It causes a polygon to be draw with the pen and brush currently selected into the device context.

```
//loop through the points

        for (i=0; i<lines-1; i++)  {
```

```
for (j=1; j<points_per_line-1; j++) {

//calculate the color to paint the polygon on the discrete plot by calculating
// an average of the values of bound circulation at the vertices

        id = (int)(5.0*(((points[i*points_per_line+j].z+
                points[(i+1)*points_per_line+j].z+points[(i+1)*points_per_line+j+1].z+
                points[i*points_per_line+j+1].z)/4.0)-min_discrete)/(max_discrete-min_discrete));

// select the appropriate brush and pen

        SelectPen(PaintDC,hPen[id]);
        SelectObject(PaintDC,hBrush[id]);

//assign xy values in screen coordinates to the vertices of the polygon

        poly[0].x = (int)((origin_dis.x+scale*points[i*points_per_line+j].x)*width/640.0);
        poly[0].y = (int)((origin_dis.y-scale*points[i*points_per_line+j].y)*height/480.0);
        poly[1].x = (int)((origin_dis.x+scale*points[i*points_per_line+j+1].x)*width/640.0);
        poly[1].y = (int)((origin_dis.y-scale*points[i*points_per_line+j+1].y)*height/480.0);
        poly[2].x = (int)((origin_dis.x+scale*points[(i+1)*points_per_line+j+1].x)*width/640.0);
        poly[2].y = (int)((origin_dis.y-scale*points[(i+1)*points_per_line+j+1].y)*height/480.0);
        poly[3].x = (int)((origin_dis.x+scale*points[(i+1)*points_per_line+j].x)*width/640.0);
        poly[3].y = (int)((origin_dis.y-scale*points[(i+1)*points_per_line+j].y)*height/480.0);
        poly[4].x = (int)((origin_dis.x+scale*points[i*points_per_line+j].x)*width/640.0);
        poly[4].y = (int)((origin_dis.y-scale*points[i*points_per_line+j].y)*height/480.0);

//draw the polygon

        Polygon(PaintDC,poly,5);
```

The process is repeated for the density plot.

```
//calculate the color to paint the polygon on the density plot by calculating
// an average of the values of bound circulation at the vertices

        id = (int)(5.0*(((points[i*points_per_line+j].r+points[(i+1)*points_per_line+j].r+
                points[(i+1)*points_per_line+j+1].r+points[i*points_per_line+j+1].r)/4.0)
                -min_density)/(max_density-min_density));

// select the appropriate brush and pen

        SelectPen(PaintDC,hPen[id]);
        SelectObject(PaintDC,hBrush[id]);

//assign xy values in screen coordinates to the vertices of the polygon

        poly[0].x = (int)((origin_den.x+scale*points[i*points_per_line+j].x)*width/640.0);
        poly[0].y = (int)((origin_den.y-scale*points[i*points_per_line+j].y)*height/480.0);
        poly[1].x = (int)((origin_den.x+scale*points[i*points_per_line+j+1].x)*width/640.0);
        poly[1].y = (int)((origin_den.y-scale*points[i*points_per_line+j+1].y)*height/480.0);
        poly[2].x = (int)((origin_den.x+scale*points[(i+1)*points_per_line+j+1].x)*width/640.0);
```

```
        poly[2].y = (int)((origin_den.y-scale*points[(i+1)*points_per_line+j+1].y)*height/480.0);
        poly[3].x = (int)((origin_den.x+scale*points[(i+1)*points_per_line+j].x)*width/640.0);
        poly[3].y = (int)((origin_den.y-scale*points[(i+1)*points_per_line+j].y)*height/480.0);
        poly[4].x = (int)((origin_den.x+scale*points[i*points_per_line+j].x)*width/640.0);
        poly[4].y = (int)((origin_den.y-scale*points[i*points_per_line+j].y)*height/480.0);

//draw the polygon

        Polygon(PaintDC,poly,5);

                        }
                }
```

A legend is drawn by using the Rectangle function to draw a series of rectangles with all of the colors used in the plots. The maximum and minimum circulation values for the two plots are drawn to indicate the scale.

```
//draw the plot legend

        for (i=0;i<6;i++) {

//select each pen and brush in turn

        SelectObject(PaintDC,hBrush[i]);
        SelectPen(PaintDC,hPen[i]);

//draw a small rectangle for each color under each plot

        Rectangle (PaintDC,(int)((origin_dis.x+70+i*10)*width/640.0),
                (int)((origin_dis.y+50)*height/480.0),
                (int)((origin_dis.x+70+(i+1)*10)*width/640.0),
                (int)((origin_dis.y+60)*height/480.0));

        Rectangle (PaintDC,(int)((origin_den.x+70+i*10)*width/640.0),
                (int)((origin_den.y+50)*height/480.0),
                (int)((origin_den.x+70+(i+1)*10)*width/640.0),
                (int)((origin_den.y+60)*height/480.0));

                }

//label the legend with the max and min values

        length = sprintf(buffer, "%2.1f   %2.1f", min_discrete, max_discrete);

        TextOut(PaintDC, (int)((origin_dis.x+60)*width/640.0),
                (int)((origin_dis.y+70)*height/480.0), buffer, length);

        length = sprintf(buffer, "%2.1f   %2.1f", min_density, max_density);

        TextOut(PaintDC, (int)((origin_den.x+60)*width/640.0),
```

```
        (int)((origin_den.y+70)*height/480.0), buffer, length);

//select the original pen back into the device context

    SelectPen (PaintDC,hOldPen);
```

An axis is drawn to indicate the radial and chordwise directions on the plots.

```
//define the axis origin

    origin_axis.x = (int)(30*width/640.0);
    origin_axis.y = (int)(480*height/640.0);

//label the axes

    length = sprintf(buffer, "Radius");

    TextOut(PaintDC, (int)((origin_axis.x+45)*width/640.0),
        (int)((origin_axis.y)*height/480.0), buffer, length);


    length = sprintf(buffer, "Chord");

    TextOut(PaintDC, (int)((origin_axis.x)*width/640.0),
        (int)((origin_axis.y-45)*height/480.0), buffer, length);

//draw the axes

    MoveTo(PaintDC,(int)((origin_axis.x+30)*width/640.0),
        (int)((origin_axis.y)*height/480.0));

    LineTo(PaintDC,(int)((origin_axis.x)*width/640.0),
        (int)((origin_axis.y)*height/480.0));

    LineTo(PaintDC,(int)((origin_axis.x)*width/640.0),
        (int)((origin_axis.y-30)*height/480.0));

//select the original font and brush back into the device context

    SelectFont(PaintDC,hOldFont);
    SelectObject(PaintDC,hOldBrush);
```

The font, brushes, and pens created for this function are deleted.

```
//delete the font, brushes, and pens created for this function

    DeleteFont(hFont);

    for(i=0;i<6;i++){

        DeleteObject(hPen[i]);
```

```
DeleteObject(hBrush[i]);

                }
}
```

C.4.10 The paint_vcp function.

The paint_vcp function draws the fluid velocities at the blade control points. The function receives a handle to the device context, a point indicating the origin at which the plot is to be drawn, and a pointer to the FILE structure that describes the file used to provide the plot data.

```
void paint_vcp(HDC PaintDC, POINT origin, FILE *plot)
{

/*******************************************************************
* declare variables that are defined in the pll.c file and that     *
* will be used in this function                                     *
*******************************************************************/

        extern  float   scale_factor;

        extern  struct  D7POINT {   /* 7-D pt */

                float   x,y,z,r,u,v,w;

                        } D7POINT;

/*******************************************************************
*  Variable declarations                                            *
*******************************************************************/

        struct  D7POINT *points;                //pointer to 7d point array used
                                                // for reading and storing
                                                // description of hub

        float   width, height,                  //display size scaled to 640/480
                X, Y,                           //3d point converted to screen
                                                // coordinates
                scale=15.0,                     //scale factor to fit plot on screen
                velocity_scale=0.05,            //scale factor for velocity vectors
                axis = 2.0;                     //scale factor for the axis plot

        int     i, j,                           //loop counters
                nextchar=1,                     //used for reading input file
                                                // character by character
                points_per_line,                //dimensions of array of xyz
                lines,                          // points describing the hub
```

```
        length;                         //length of text output strings
char    buffer[120];                    //character string for text output
HPEN    hPen[2], hOldPen;               //pens for drawing the plots
POINT   origin_axis;                    //origin for drawing the axis plot
HFONT hFont, hOldFont;                  //fonts for drawing the text output
```

After variable declarations are made, the function creates a blue and a green pen for drawing output and gets a handle to the device default font. The size of the display area is calculated. A scale to be used to plot the data is calculated based on user input provided with the PBD Plot Geometry dialog box.

```
//create a blue and a green pen for drawing the control point grid and the velocity vectors

    hPen[0] = CreatePen(PS_SOLID, 1, RGB(0,0,255));
    hPen[1] = CreatePen(PS_SOLID, 1, RGB(0,128,64));

//get a handle to the device default font

    hFont = GetStockFont(DEVICE_DEFAULT_FONT);

//determine the width of the display in pixels and the height of the display in raster lines and cast
// them as floats

    width  = (float)GetDeviceCaps (PaintDC, HORZRES);
    height = (float)GetDeviceCaps (PaintDC, VERTRES);

//since the normal display aspect ratio is 4 to 3, ensure that the graphical
// output made by the program is in that aspect ratio

    if((width/height)>(4.0/3.0))
        width = height*(4.0/3.0);
    else
        height = width*(3.0/4.0);

//select the device default font and the blue pen into the device context and save handles to the original
font
// and pen

    hOldFont = SelectFont(PaintDC, hFont);

    hOldPen = SelectPen(PaintDC,hPen[0]);

//adjust the scale factor by an amount determined by the user

    scale = scale_factor * scale;
```

The data is read in the same manner as described in section C.4.7 above.

```
//read in the data to be plotted

//scrap the first line

        while (nextchar!=13&&nextchar!=10)
                nextchar = getc(plot);
        nextchar = 1;

//scrap the second line

        while (nextchar!=13&&nextchar!=10)
                nextchar = getc(plot);
        nextchar =1;

//extract the number of points_per_line and the number of lines

//read the third line, looking for the first equal sign

        while (nextchar!=61)
                nextchar = getc(plot);
        nextchar =1;

//continue reading the third line, looking for the second equal sign

        while (nextchar!=61)
                nextchar = getc(plot);

//read the points per line

        fscanf(plot,"%d",&points_per_line);

        nextchar=1;

//continue reading the third line, looking for the third equal sign

        while (nextchar!=61)
                nextchar = getc(plot);

        fscanf(plot,"%d",&lines);

//scrap the rest of line

        while (nextchar!=13&&nextchar!=10)
                nextchar = getc(plot);

//allocate memory for storing the points that describe the control points and
// the velocity vector associated with each control point

        points = (struct D7POINT * ) malloc((lines*points_per_line)*sizeof (struct D7POINT));
```

//read and store the point data

```
for (i=0; i<lines; i++) {

        for (j=0; j<points_per_line; j++) {

        fscanf(plot,"%f %f %f %f %f %f %f", &points[i*points_per_line+j].x,
                &points[i*points_per_line+j].y, &points[i*points_per_line+j].z,
                &points[i*points_per_line+j].r, &points[i*points_per_line+j].u,
                &points[i*points_per_line+j].v, &points[i*points_per_line+j].w);

                        }
                }
```

The plot is labeled, the axis origin is calculated, and a wireframe diagram of the blade control points is drawn in the same manner as is described in section C.4.7 above.

```
//label the plot

        SetTextAlign(PaintDC,TA_CENTER);

        TextOut(PaintDC,(int)(320*width/640.0),
                (int)(10*height/480.0), "VELOCITY AT CONTROL POINTS\0",
                strlen("VELOCITY AT CONTROL POINTS\0"));

        SetTextAlign(PaintDC,TA_LEFT);

//define the axis origin

        origin_axis.x = (int)(40*width/640.0);
        origin_axis.y = (int)(410*height/640.0);

// draw wireframe diagram

        for (i=0; i<lines; i++) {

                rotation_projection(points[i*points_per_line].x, points[i*points_per_line].y,
                        points[i*points_per_line].z, &X, &Y);

                MoveTo(PaintDC,(int)((origin.x+scale*(X))*width/640.0),
                        (int)((origin.y-scale*(Y))*height/480.0));


        for (j=1; j<points_per_line; j++){

                rotation_projection(points[i*points_per_line+j].x, points[i*points_per_line+j].y,
                        points[i*points_per_line+j].z, &X, &Y);

                LineTo(PaintDC,(int)((origin.x+scale*(X))*width/640.0),
                        (int)((origin.y-scale*(Y))*height/480.0));

                        }
```

```
			}

	for (j=0; j<points_per_line; j++) {

		rotation_projection(points[j].x, points[j].y,
			points[j].z, &X, &Y);

		MoveTo(PaintDC,(int)((origin.x+scale*(X))*width/640.0),
			(int)((origin.y-scale*(Y))*height/480.0));

		for (i=1; i<lines; i++) {

			rotation_projection(points[i*points_per_line+j].x,
points[i*points_per_line+j].y,
				points[i*points_per_line+j].z, &X, &Y);

			LineTo(PaintDC,(int)((origin.x+scale*(X))*width/640.0),
				(int)((origin.y-scale*(Y))*height/480.0));

			}
				}

//select the green pen and draw the velocities

	SelectPen(PaintDC, hPen[1]);
```

After the green pen is selected, the velocity vectors are drawn. The vectors are drawn with the tails at the control points. They are drawn using the LineTo function to a point displaced from the control points by the velocity components scaled by a velocity scale factor. The rotation_projection function is used to convert the three dimensional points to two dimensionsal points for plotting on the monitor or printer.

```
	for (i=0; i<lines; i++) {

		for (j=0; j<points_per_line; j++){

			rotation_projection(points[i*points_per_line+j].x,
points[i*points_per_line+j].y,
				points[i*points_per_line+j].z, &X, &Y);

			MoveTo(PaintDC,(int)((origin.x+scale*(X))*width/640.0),
				(int)((origin.y-scale*(Y))*height/480.0));

			rotation_projection(points[i*points_per_line+j].x+
				velocity_scale*points[i*points_per_line+j].u,
				points[i*points_per_line+j].y+velocity_scale*
				points[i*points_per_line+j].v,
				points[i*points_per_line+j].z+velocity_scale*
				points[i*points_per_line+j].w, &X, &Y);
```

```
LineTo(PaintDC,(int)((origin.x+scale*(X))*width/640.0),
        (int)((origin.y-scale*(Y))*height/480.0));

            }
    }
```

An xyz axis is drawn, rotated through the same pitch, roll and yaw angles as the velocity plot.

```
//select the original pen into the device context, draw and label the (x,y,z) axes

    SelectPen(PaintDC, hOldPen);

    rotation_projection(axis + 1.0, 0.0, 0.0, &X, &Y);

        length = sprintf(buffer, "x");

        TextOut(PaintDC, (int)((origin_axis.x+X)*width/640.0),
                (int)((origin_axis.y-Y)*height/480.0), buffer, length);

        rotation_projection(0.0, axis + 1.0, 0.0, &X, &Y);

        length = sprintf(buffer, "y");

        TextOut(PaintDC, (int)((origin_axis.x+X)*width/640.0),
                (int)((origin_axis.y-Y)*height/480.0), buffer, lengt

        rotation_projection(0.0, 0.0, axis + 1.0, &X, &Y);

        length = sprintf(buffer, "z");

        TextOut(PaintDC, (int)((origin_axis.x+X)*width/640.0),
                (int)((origin_axis.y-Y)*height/480.0), buffer, length);

        rotation_projection(axis, 0.0, 0.0, &X, &Y);

        MoveTo(PaintDC,(int)((origin_axis.x+X)*width/640.0),
                (int)((origin_axis.y-Y)*height/480.0));

        LineTo(PaintDC,(int)((origin_axis.x)*width/640.0),
                (int)((origin_axis.y)*height/480.0));

        rotation_projection(0.0, axis, 0.0, &X, &Y);

        LineTo(PaintDC,(int)((origin_axis.x+X)*width/640.0),
                (int)((origin_axis.y-Y)*height/480.0));

        rotation_projection(0.0, 0.0, axis, &X, &Y);

        MoveTo(PaintDC,(int)((origin_axis.x+X)*width/640.0),
                (int)((origin_axis.y-Y)*height/480.0));
```

```
		LineTo(PaintDC,(int)((origin_axis.x)*width/640.0),
			(int)((origin_axis.y)*height/480.0));

//select the original font back into the device context

		SelectFont(PaintDC,hOldFont);
```

The pens and font created for this function are deleted and the allocated memory is freed using the free function.

```
//delete the pens and font created for this function

	DeleteObject(hPen[0]);
	DeleteObject(hPen[1]);

	DeleteFont(hFont);

//free the allocated memory

	free( points );
}
```

C.4.11 The paint_cmv function.

The paint_cmv function draws a plot of circumferential mean blade velocity plot to the passed screen or the printer. The function receives a handle to the device context, an origin for the plot, and a pointer to the FILE structure containing the data. The function works in the same way as the paint_vcp function except that a wireframe is not drawn.

```
void paint_cmv(HDC PaintDC, POINT origin, FILE *plot)
{

/*******************************************************************
* declare variables that are defined in the pll.c file and that     *
* will be used in this function                                     *
********************************************************************/

	extern	float	scale_factor;

	extern	struct	D7POINT {	/* 7-D pt */

		float	x,y,z,r,u,v,w;

				} D7POINT;

/*******************************************************************
```

```
* Variable declarations                                    *
***************************************************************/

        struct   D7POINT point;                  //pointer to 7d point array used
                                                 // for reading and storing
                                                 // description of hub

        float    width, height,                  //display size scaled to 640/480
                 X, Y,                           //3d point converted to screen
                                                 // coordinates

                 scale=15.0,                     //scale factor to fit plot on screen
                 velocity_scale=0.2,             //scale factor for velocity vectors
                 axis = 2.0;                     //scale factor for the axis plot

        int      i=0,                            //loop counters
                 nextchar=1,                     //used for reading input file
                                                 // character by character
                 num_points,                     //total number of points to plot
                 length;                         //length of text output strings

        char     buffer[120],                    //character string for text output
                 title[]=                        //plot title
                 "CIRCUMFERENTIAL MEAN BLADE VELOCITY\0";

        HPEN     hPen, hOldPen;                  //pens for drawing the plots

        POINT    origin_axis,                    //origin for drawing the axis plot
                 plot_point[2];                  //array of points for plotting the
                                                 // velocity vectors

        HFONT hFont, hOldFont;                   //fonts for drawing the text output

//create a green pen for drawing the velocity vectors

        hPen = CreatePen(PS_SOLID, 1, RGB(0,128,64));

//get a handle to the device default font

        hFont = GetStockFont(DEVICE_DEFAULT_FONT);

//determine the width of the display in pixels and the height of the display
// in raster lines and cast them as floats

        width  = (float)GetDeviceCaps (PaintDC, HORZRES);
        height = (float)GetDeviceCaps (PaintDC, VERTRES);

//since the normal display aspect ratio is 4 to 3, ensure that the graphical
// output made by the program is in that aspect ratio

        if((width/height)>(4.0/3.0))
                width = height*(4.0/3.0);
        else
                height = width*(3.0/4.0);
```

```
//select the device default font and the green pen into the device context and
// save handles to the original font and pen

        hOldFont = SelectFont(PaintDC, hFont);

        hOldPen = SelectPen(PaintDC,hPen);

//adjust the scale factor by an amount determined by the user

        scale = scale_factor * scale;

//draw the title to the device context

        SetTextAlign(PaintDC,TA_CENTER);

        TextOut(PaintDC,(int)(320*width/640.0), (int)(10*height/480.0),title, strlen(title));

        SetTextAlign(PaintDC,TA_LEFT);

//read in the data to be plotted

//scrap the first line

        while (nextchar!=13&&nextchar!=10)
                nextchar = getc(plot);
        nextchar = 1;

//scrap the second line

        while (nextchar!=13&&nextchar!=10)
                nextchar = getc(plot);
        nextchar =1;

//extract the total number of points

//read the third line, looking for the first equal sign

        while (nextchar!=61)
                nextchar = getc(plot);
        nextchar =1;

//continue reading the third line, looking for the second equal sign

        while (nextchar!=61)
                nextchar = getc(plot);

//read the number of points

        fscanf(plot,"%d",&num_points);

        nextchar=1;

//scrap the rest of line
```

```
		while (nextchar!=13&&nextchar!=10)
			nextchar = getc(plot);

//read and plot the velocity vector data, one data point at a time

//loop through all of the data points

	for (i=0; i<num_points; i++) {

//read the data into a 7d point

	fscanf(plot,"%f %f %f %f %f %f ", &point.x, &point.y, &point.z, &point.u, &point.v, &point.w);

//calculate the screen coordinates of the root of the velocity vector

	rotation_projection(point.x, point.y, point.z, &X, &Y);

//assign the X and Y screen coordinates to the first point of the plot_point array

	plot_point[0].x = (int)((origin.x+scale*(X))*width/640.0);
	plot_point[0].y = (int)((origin.y-scale*(Y))*height/480.0);

//calculate the screen coordinates of the tip of the velocity vector

	rotation_projection(point.x+velocity_scale*point.u, point.y+velocity_scale*point.v,
		point.z+velocity_scale*point.w, &X, &Y);

//assign the X and Y screen coordinates to the first point of the plot_point array

	plot_point[1].x = (int)((origin.x+scale*(X))*width/640.0);
	plot_point[1].y = (int)((origin.y-scale*(Y))*height/480.0);

//plot the vector as a polyline

	Polyline(PaintDC,plot_point,2);

				}

//select the original pen into the device context, draw and label the (x,y,z) axes

	SelectPen(PaintDC, hOldPen);

//define the axis origin

	origin_axis.x = (int)(40*width/640.0);
	origin_axis.y = (int)(410*height/640.0);

	rotation_projection(axis + 1.0, 0.0, 0.0, &X, &Y);

		length = sprintf(buffer, "x");

		TextOut(PaintDC, (int)((origin_axis.x+X)*width/640.0),
			(int)((origin_axis.y-Y)*height/480.0), buffer, length);
```

```
rotation_projection(0.0, axis + 1.0, 0.0, &X, &Y);

length = sprintf(buffer, "y");

TextOut(PaintDC, (int)((origin_axis.x+X)*width/640.0),
        (int)((origin_axis.y-Y)*height/480.0), buffer, length);

rotation_projection(0.0, 0.0, axis + 1.0, &X, &Y);

length = sprintf(buffer, "z");

TextOut(PaintDC, (int)((origin_axis.x+X)*width/640.0),
        (int)((origin_axis.y-Y)*height/480.0), buffer, length);

rotation_projection(axis, 0.0, 0.0, &X, &Y);

MoveTo(PaintDC,(int)((origin_axis.x+X)*width/640.0),
        (int)((origin_axis.y-Y)*height/480.0));

LineTo(PaintDC,(int)((origin_axis.x)*width/640.0),
        (int)((origin_axis.y)*height/480.0));

rotation_projection(0.0, axis, 0.0, &X, &Y);

LineTo(PaintDC,(int)((origin_axis.x+X)*width/640.0),
        (int)((origin_axis.y-Y)*height/480.0));

rotation_projection(0.0, 0.0, axis, &X, &Y);

MoveTo(PaintDC,(int)((origin_axis.x+X)*width/640.0),
        (int)((origin_axis.y-Y)*height/480.0));

LineTo(PaintDC,(int)((origin_axis.x)*width/640.0),
        (int)((origin_axis.y)*height/480.0));

//select the original font back into the device context

        SelectFont(PaintDC,hOldFont);

//delete the pen and font created for this function

        DeleteObject(hPen);
        DeleteFont(hFont);
}
```

C.4.12 The paint_rdc function.

The paint_rdc function draws a plot of circulation vs. radial position using data from a PBDOUT.RDC or PBDOUT.SGR file. The function receives a handle to the device context and a pointer to the FILE structure that contains information about the data file.

```
void paint_rdc(HDC PaintDC, FILE *plot)
{

/*********************************************************************
*  Variable declarations                              *
*********************************************************************/

        char    buffer[120],                       //character string for text output
                title[81];                         //title of the plot

        int     i=0,                               //loop counter
                num_points,                        //# of points to be plotted
                decimal_places = 2,                //indicator of decimal places
                                                   // to print in y-axis labels
                nextchar=1,                        //used for reading input file
                                                   // character by character
                shift=3,                           //number of pixels to shift
                                                   // y-axis labels
                length,                            //length of text output strings
                del_x=30,                          //x and y spacing for graph in
                del_y=20;                          // pixels

        float   width, height,                     //display size scaled to 640/480
                delta_G,                           //difference between max and min
                                                   // G
                max_G=-100.0,                      //max and min circulation
                min_G=100.0,
                max_r=0.0;                         //max radius

        float   * r,                               //pointers to float arrays for
                * G;                               // radius and circulation

/*********************************************************************
*  declare structure variables                                       *
*********************************************************************/

        HPEN    hPlotPen,                          //pens for drawing the graph
                hThickPen,
                hThinPen,
                hOldPen;

        HFONT hFont,                               //fonts for drawing the text
                hSmallFont,                        // output
                hOldFont;

        LOGFONT lFont;                             //logical font structure for
                                                   // creating fonts

        HBRUSH          hBrush,                    //brushes for drawing the graph
                hOldBrush;

        POINT   origin={170,300};                  //origin of the plot in screen
                                                   // coordinates
```

```
    POINT  * point;                                    //pointer to an array of points

/**********************************************************************
* determine the size of the device context to be written to. this *
* allows the function to be device independent              *
**********************************************************************/
```

The function creates a blue pen for drawing circulation versus radial position, a thin black pen for drawing horizontal and vertical grid lines, and a thick black pen for drawing a frame around the plot. The function also creates a hollow brush, and small and normal sized fonts. The display size is calculated.

```
//create a blue pen for plotting G vs. r and a thin and a thick black pen for drawing the graph axes

    hPlotPen = CreatePen(PS_SOLID, 1, RGB(0,0,255));
    hThickPen = CreatePen(PS_SOLID, 2, RGB(0,0,0));
    hThinPen = CreatePen(PS_SOLID, 1, RGB(0,0,0));

//create a hollow brush

    hBrush = GetStockBrush(HOLLOW_BRUSH);

//get a handle to the device default font

    hFont = GetStockFont(DEVICE_DEFAULT_FONT);

//fill a logical font structure using the device default font

    GetObject(hFont,sizeof(LOGFONT),&lFont);

//adjust the font size and create a small font for labeling the axes

        lFont.lfHeight = -10;

    hSmallFont = CreateFontIndirect(&lFont);

//select the hollow brush, default font, and thick black pen into the device
// context and save handles to the original brush, font, and pen

    hOldBrush = SelectObject(PaintDC, hBrush);

    hOldFont = SelectFont(PaintDC, hFont);

    hOldPen = SelectPen(PaintDC, hThickPen);

//determine the width of the display in pixels and the height of the display
// in raster lines and cast them as floats

    width  = (float)GetDeviceCaps (PaintDC, HORZRES);
```

```
        height = (float)GetDeviceCaps (PaintDC, VERTRES);

//since the normal display aspect ratio is 4 to 3, ensure that the graphical
// output made by the program is in that aspect ratio

        if((width/height)>(4.0/3.0))
                width = height*(4.0/3.0);
        else
                height = width*(3.0/4.0);
```

The first line of the data file is read character by character in order to locate and read the plot title.

```
//read in the data to be plotted

//read the first line and find the title

        while (nextchar!=13&&nextchar!=10&&nextchar!=34)
                nextchar = getc(plot);
        nextchar = getc(plot);

        while (nextchar!=34) {

                title[i]=nextchar;
                i++;
                nextchar = getc(plot);
                                }

                title[i]='\0';

//scrap the rest of the first line

        while (nextchar!=13&&nextchar!=10)
                nextchar = getc(plot);
        nextchar =1;
```

The second line of the data file is discarded and the third line is read character by character to find the number of data points in the file.

```
//scrap the second line

        while (nextchar!=13&&nextchar!=10)
                nextchar = getc(plot);
        nextchar =1;

//extract the number of points

//read the third line, looking for the equal sign

        while (nextchar!=61)
                nextchar = getc(plot);
        nextchar =1;
```

```
//continue reading the third line, looking for the second equal sign

        while (nextchar!=61)
                nextchar = getc(plot);

//read the number of points

        fscanf(plot,"%d",&num_points);

        nextchar=1;

//scrap the rest of line

                while (nextchar!=13&&nextchar!=10)
                        nextchar = getc(plot);
```

Memory is allocated for the radius and circulation data and for an array of POINT structures that will be used to plot the graph.

```
//allocate memory for the radius, circulation, and point vectors

        r       = (float * ) malloc((num_points)*sizeof (float));

        G       = (float * ) malloc((num_points)*sizeof (float));

        point   = ( POINT * ) malloc((num_points)*sizeof ( POINT));
```

The data is read using a for loop. The maximum values of circulation and radius and the minimum value of circulation are determined using the same for loop.

```
//read the point data and check for the maximum and minimum values of G and the maximum value of r

        for (i=0; i<num_points; i++)  {

                fscanf(plot,"%f %f ", &r[i], &G[i]);
                max_G = max(max_G,G[i]);
                min_G = min(min_G,G[i]);
                max_r = max(max_r,r[i]);
                                        }
```

The graph and the horizontal and vertical axes are labeled. A frame is drawn around the graph with the thick pen using the Rectangle function.

```
//print the title and label the graph

        SetTextAlign(PaintDC,TA_CENTER);

        TextOut(PaintDC,(int)(320*width/640.0), (int)(10*height/480.0),title, strlen(title));
```

```
        SetTextAlign(PaintDC,TA_LEFT);

        TextOut(PaintDC,(int)((origin.x+10*del_x+30)*width/640.0),
                (int)((origin.y)*height/480.0),"r/R\0",strlen("r/R\0"));

        TextOut(PaintDC,(int)((origin.x-60)*width/640.0),
                (int)((origin.y-6*del_y)*height/480.0),"G\0", strlen("G\0"));

//draw the outline of the graph

        Rectangle(PaintDC, (int)((origin.x)*width/640.0), (int)((origin.y)*height/480.0),
                (int)((origin.x+10*del_x)*width/640.0), (int)((origin.y-10*del_y)*height/480.0));
```

The horizontal and vertical grid lines are drawn using a for loop and a series of Rectangle function calls.

```
//select the thin pen and draw the horizontal and vertical lines on the graph as a series of rectangles

        SelectPen(PaintDC,hThinPen);

        for(i=1;i<10;i++) {

                Rectangle(PaintDC, (int)((origin.x)*width/640.0), (int)((origin.y)*height/480.0),
                        (int)((origin.x+i*del_x)*width/640.0), (int)((origin.y-
10*del_y)*height/480.0));

                Rectangle(PaintDC,
                        (int)((origin.x)*width/640.0), (int)((origin.y)*height/480.0),
                        (int)((origin.x+10*del_x)*width/640.0), (int)((origin.y-
i*del_y)*height/480.0));
                        }
```

The x axis is labeled using the small font. The maximum and minimum values for the graph are calculated and adjusted. The number of decimal places to be used in the y axis labels is then determined.

```
//select the small font and label the x-axis of the plot

        SelectFont(PaintDC, hSmallFont);

        for(i=0;i<11;i++){

                length = sprintf(buffer, "%2.1f",(i*max_r)/10.0);

                TextOut(PaintDC, (int)((origin.x-5+i*del_x)*width/640.0),
                        (int)((origin.y+10)*height/480.0), buffer, length);

                        }
```

```
//if the maximum value is greater than zero, use logs to establish the maximum value as a round number
// slightly higher than the maximum value, otherwise set the maximum value to 0.0

        if(max_G >= del)

                max_G = pow(10.0,floor(log10(max_G)))*
                                (1.0+floor(max_G/(pow(10.0,floor(log10(max_G))))));

        else if(max_G <= -del)

                max_G = 0.0;

//if the minimum value is less than zero, use logs to establish the minimum value as a round number
// slightly lower than the minimum value, otherwise set the minimum value to 0.0

        if(min_G <= -del)

                min_G = -(pow(10.0,floor(log10(fabs(min_G))))*
                        (1.0+floor(fabs(min_G)/(pow(10.0,floor(log10(fabs(min_G))))))));

        else if(min_G >= 0)

                min_G = 0.0;

//if the maximum and minimum values are very close together, spread them apart slightly

        if(max_G - min_G<del)

        {       max_G = max_G + 0.1;

                        if((min_G - 0.1)> 0.0)

                                min_G = min_G - 0.1;
        }

//find the difference between the maximum and minimum values

        delta_G = max_G - min_G;

        if(fabs(max_G)>del)

                decimal_places = min(floor(log10(fabs(max_G))),decimal_places);

        if(fabs(min_G)>del)

                decimal_places = min(floor(log10(fabs(min_G))),decimal_places);

//label the y-axis based on the value of the decimal_places indicator

switch(decimal_places){

   case 2:
   {
```

```
 for(i=0;i<11,i++){

length = sprintf(buffer, "%d",(int)(max_G-((i*delta_G)/10.0)));

          TextOut(PaintDC,(int)((origin.x+ hift*4-40)*width/640.0),
                   (int)((origin.y-3+(i-10)*del_y)*height/480.0), buffer, length);

                    }

  break;}

  case 1:
  {
 for(i=0;i<11;i++){

length = sprintf(buffer, "%5.0f",max_G-((i*delta_G)/10.0));

TextOut(PaintDC,(int)((origin.x+
                              shift*3-40)*width/640.0),
                    (int)((origin.y-3+(i-10)*del_y)*height/480.0), buffer, length);
                    }

        break;}

  case 0:
  {
 for(i=0;i<11;i++){

length = sprintf(buffer, "%5.1f",max_G-((i*delta_G)/10.0));

TextOut(PaintDC,(int)((origin.x+shift*3-40)*width/640.0),
                    (int)((origin.y-3+(i-10)*del_y)*height/480.0), buffer, length);
                    }

  break;}

  case -1:
  {
 for(i=0;i<11;i++){

length = sprintf(buffer, "%5.2f",max_G-((i*delta_G)/10.0));

TextOut(PaintDC,(int)((origin.x+shift*2-40)*width/640.0),
                    (int)((origin.y-3+(i-10)*del_y)*height/480.0), buffer, length);

                    }

  break;}

  case -2:
  {
 for(i=0;i<11;i++){

length = sprintf(buffer, "%5.3f",max_G-((i*delta_G)/10.0));
```

```
TextOut(PaintDC,(int)((origin.x+shift*1-40)*width/640.0),
                (int)((origin.y-3+(i-10)*del_y)*height/480.0), buffer, length);
                }

   break;}

  default :
  {
 for(i=0;i<11;i++){

length = sprintf(buffer, "%5.4f",max_G-((i*delta_G)/10.0));

TextOut(PaintDC,(int)((origin.x-40)*width/640.0),
              (int)((origin.y-3+(i-10)*del_y)*height/480.0), buffer, length);
                }

   break;}

}
```

The blue pen is selected and the screen coordinates of the points to be plotted are then calculated and stored in the point array. A circle is drawn at each point.

```
//select the blue pen for plotting the curve

        SelectPen(PaintDC, hPlotPen);

//calculate the screen coordinates corresponding to each point (r,G), store
// the values in point[i], and draw an ellipse there

        for(i=0;i<num_points;i++){

                point[i].x = (int)((origin.x+(r[i]/max_r)*10*del_x)*width/640.0);
                point[i].y = (int)((origin.y-((G[i]-min_G)/delta_G)*10*del_y)*height/480.0);

                Ellipse(PaintDC, point[i].x-2, point[i].y-2, point[i].x+2, point[i].y+2);
                                        }
```

A curve is drawn through the points using the Polyline function. The original pen, font, and brush are then selected back into the device context and the pens, font, and brush created for this function are deleted. The memory allocated for data storage is then freed using the free function.

```
//plot the curve by drawing a polyline through the points

        Polyline(PaintDC,point,num_points);
```

```
//select the original pen, fonts, and brush back into the device context

        SelectPen(PaintDC, hOldPen);
        SelectFont(PaintDC,hOldFont);
        SelectObject(PaintDC,hOldBrush);

//delete the pens, brush, and fonts created for this function

        DeleteObject(hPlotPen);
        DeleteObject(hThinPen);
        DeleteObject(hThickPen);

        DeleteObject(hBrush);

        DeleteFont(hFont);
        DeleteFont(hSmallFont);

//free the allocated memory

        free(point);
        free(r);
        free(G);
}
```

C.4.13 The write_output_file function.

The write_output_file function writes an output file that contains all of the PLL text data available in the Output Viewer window. The function receives the handle to the output file selected by the user.

```
void write_output_file(HFILE out)
 {
/*********************************************************************
*  Variable declarations                              *
*********************************************************************/

        char    * buffer;                               //pointer to a character buffer

        int     num_bytes;                              //number of bytes read by _lread

        HFILE  in;                                      //pointer to a file
```

The write_output_file uses the malloc function to allocate a storage buffer that is used for reading the data files and writing the data into the combined output file.

```
//allocate memory for reading the files into

        buffer  = (char *) malloc((max_buf_sz)*sizeof (char));
```

The function tests for the existence of each possible output file using the access function. Each file that is found to exist is opened with read access using the _lopen function, is read with the _lread function, is written to the output file using the _lwrite function, and is closed using the _lclose function.

```
//read, and write to the overall output file, each available output file

        if (access("summary.out", 0) == 0) {
        in = _lopen("summary.out", READ);
        num_bytes= _lread(in, buffer, max_buf_sz);
        _lwrite(out, buffer, num_bytes);
        _lclose(in);                    }

        if (access("detail1.out", 0) == 0)  {
        in = _lopen("detail1.out", READ);
        num_bytes= _lread(in, buffer, max_buf_sz);
        _lwrite(out, buffer, num_bytes);
        _lclose(in);                    }

        if (access("detail2.out", 0) == 0)  {
        in = _lopen("detail2.out", READ);
        num_bytes= _lread(in, buffer, max_buf_sz);
        _lwrite(out, buffer, num_bytes);
        _lclose(in);                    }

        if (access("fards.out", 0) == 0)  {
        in = _lopen("fards.out", READ);
        num_bytes= _lread(in, buffer, max_buf_sz);
        _lwrite(out, buffer, num_bytes);
        _lclose(in);                    }

        if (access("duct.geo", 0) == 0)  {
        in = _lopen("duct.geo", READ);
        num_bytes= _lread(in, buffer, max_buf_sz);
        _lwrite(out, buffer, num_bytes);
        _lclose(in);                    }

        if (access("stress.out", 0) == 0)  {
        in = _lopen("stress.out", READ);
        num_bytes= _lread(in, buffer, max_buf_sz);
        _lwrite(out, buffer, num_bytes);
        _lclose(in);                    }

        if (access("nonaxi.cir", 0) == 0)  {
        in = _lopen("nonaxi.cir", READ);
        num_bytes= _lread(in, buffer, max_buf_sz);
        _lwrite(out, buffer, num_bytes);
        _lclose(in);                    }

        if (access("nonaxi.for", 0) == 0)  {
```

```
        in = _lopen("nonaxi.for", READ);
        num_bytes= _lread(in, buffer, max_buf_sz);
        _lwrite(out, buffer, num_bytes);
        _lclose(in);                }

        if (access("nonaxi.cmp", 0) == 0)  {
        in = _lopen("nonaxi.cmp", READ);
        num_bytes= _lread(in, buffer, max_buf_sz);
        _lwrite(out, buffer, num_bytes);
        _lclose(in);                }

        if (access("nonaxi.har", 0) == 0)  {
        in = _lopen("nonaxi.har", READ);
        num_bytes= _lread(in, buffer, max_buf_sz);
        _lwrite(out, buffer, num_bytes);
        _lclose(in);                }

}
```

C.4.14 The write_pbd_files function.

The write_pbd_files function makes copies of the existing PBD output files using the output file root specified in the PBD Settings dialog box. The function receives no arguments.

```
void    write_pbd_files(void)
{

/*******************************************************************
* declare variables that are defined in the pll.c file and that     *
* will be used in this function                                    *
*******************************************************************/

extern  char      pbd_output_root[9];

/*******************************************************************
*  Variable declarations                                           *
*******************************************************************/

        char      dest[MAXFILE + MAXEXT];              //destination file name

        OFSTRUCT ofsource;                             //data structure containing
        OFSTRUCT ofdest;                               // information on the opened file

        HFILE   hfsource,                              //handles to the source and
                hfdest;                                // destination files
```

The function tests for the existence of each possible PBD output file using the access function. A destination filename is created for each file that is found to exist with

the fnmerge function. The fnmerge function receives a pointer to a filename, a pointer to a drive, a pointer to a directory, a pointer to a file root and a pointer to a file extension. The function builds a filename from the components supplied and stores it in the filename array passed as the first argument.

Each source and destination file is then opened using the LZOpenFile function. The source file is copied directly into the destination file using the LZCopy function and both files are closed using the LZClose function.

```
//if the pbdout.ibg file exists,

        if(access("pbdout.ibg", 0) == 0) {

//then create a destination file name by merging the pbd_output_root name and
// the .ibg extension

                fnmerge(dest,NULL,NULL,pbd_output_root,".ibg");

//open the source and destination files

                hfsource = LZOpenFile("pbdout.ibg", &ofsource, OF_READ);

                hfdest = LZOpenFile(dest, &ofdest, OF_CREATE);

//copy the source file into the destination file

                LZCopy(hfsource, hfdest);

//close both files

                LZClose(hfsource);

                LZClose(hfdest);            }

//repeat the process for all possible pbd output files


        if(access("pbdout.cbd", 0) == 0) {
                fnmerge(dest,NULL,NULL,pbd_output_root,".cbd");
                hfsource = LZOpenFile("pbdout.cbd", &ofsource, OF_READ);
                hfdest = LZOpenFile(dest, &ofdest, OF_CREATE);
                LZCopy(hfsource, hfdest);
                LZClose(hfsource);
                LZClose(hfdest);            }

        if(access("pbdout.hub", 0) == 0) {
                fnmerge(dest,NULL,NULL,pbd_output_root,".hub");
                hfsource = LZOpenFile("pbdout.hub", &ofsource, OF_READ);
```

```
		hfdest = LZOpenFile(dest, &ofdest, OF_CREATE);
		LZCopy(hfsource, hfdest);
		LZClose(hfsource);
		LZClose(hfdest);		}

	if(access("pbdout.cmv", 0) == 0) {
		fnmerge(dest,NULL,NULL,pbd_output_root,".cmv");
		hfsource = LZOpenFile("pbdout.cmv", &ofsource, OF_READ);
		hfdest = LZOpenFile(dest, &ofdest, OF_CREATE);
		LZCopy(hfsource, hfdest);
		LZClose(hfsource);
		LZClose(hfdest);		}

	if(access("pbdout.cmf", 0) == 0) {
		fnmerge(dest,NULL,NULL,pbd_output_root,".cmf");
		hfsource = LZOpenFile("pbdout.cmf", &ofsource, OF_READ);
		hfdest = LZOpenFile(dest, &ofdest, OF_CREATE);
		LZCopy(hfsource, hfdest);
		LZClose(hfsource);
		LZClose(hfdest);		}

	 ccess("pbdout.tot", 0) == 0) {
		fnmerge(dest,NULL,NULL,pbd_output_root,".tot");
		hfsource = LZOpenFile("pbdout.tot", &ofsource, OF_READ);
		hfdest = LZOpenFile(dest, &ofdest, OF_CREATE);
		LZCopy(hfsource, hfdest);
		LZClose(hfsource);
		LZClose(hfdest);		}

	if(access("pbdout.gsp", 0) == 0) {
		fnmerge(dest,NULL,NULL,pbd_output_root,".gsp");
		hfsource = LZOpenFile("pbdout.gsp", &ofsource, OF_READ);
		hfdest = LZOpenFile(dest, &ofdest, OF_CREATE);
		LZCopy(hfsource, hfdest);
		LZClose(hfsource);
		LZClose(hfdest);		}

	if(access("pbdout.sol", 0) == 0) {
		fnmerge(dest,NULL,NULL,pbd_output_root,".sol");
		hfsource = LZOpenFile("pbdout.sol", &ofsource, OF_READ);
		hfdest = LZOpenFile(dest, &ofdest, OF_CREATE);
		LZCopy(hfsource, hfdest);
		LZClose(hfsource);
		LZClose(hfdest);		}

	if(access("pbdout.ktq", 0) == 0) {
		fnmerge(dest,NULL,NULL,pbd_output_root,".ktq");
		hfsource = LZOpenFile("pbdout.ktq", &ofsource, OF_READ);
		hfdest = LZOpenFile(dest, &ofdest, OF_CREATE);
		LZCopy(hfsource, hfdest);
		LZClose(hfsource);
		LZClose(hfdest);		}

	if(access("pbdout.obg", 0) == 0) {
```

```
		fnmerge(dest,NULL,NULL,pbd_output_root,".obg");
		hfsource = LZOpenFile("pbdout.obg", &ofsource, OF_READ);
		hfdest = LZOpenFile(dest, &ofdest, OF_CREATE);
		I ZCopy(hfsource, hfdest);
		LZClose(hfsource);
		LZClose(hfdest);		}

	if(access("pbdout.bsn", 0) == 0) {
		fnmerge(dest,NULL,NULL,pbd_output_root,".bsn");
		hfsource = LZOpenFile("pbdout.bsn", &ofsource, OF_READ);
		hfdest = LZOpenFile(dest, &ofdest, OF_CREATE);
		LZCopy(hfsource, hfdest);
		LZClose(hfsource);
		LZClose(hfdest);		}

	if(access("pbdout.sgr", 0) == 0) {
		fnmerge(dest,NULL,NULL,pbd_output_root,".sgr");
		hfsource = LZOpenFile("pbdout.sgr", &ofsource, OF_READ);
		hfdest = LZOpenFile(dest, &ofdest, OF_CREATE);
		LZCopy(hfsource, hfdest);
		LZClose(hfsource);
		LZClose(hfdest);		}

	if(access("pbdout.rdc", 0) == 0) {
		fnmerge(dest,NULL,NULL,pbd_output_root,".rdc");
		hfsource = LZOpenFile("pbdout.rdc", &ofsource, OF_READ);
		hfdest = LZOpenFile(dest, &ofdest, OF_CREATE);
		LZCopy(hfsource, hfdest);
		LZClose(hfsource);
		LZClose(hfdest);		}

	if(access("pbdout.vcp", 0) == 0) {
		fnmerge(dest,NULL,NULL,pbd_output_root,".vcp");
		hfsource = LZOpenFile("pbdout.vcp", &ofsource, OF_READ);
		hfdest = LZOpenFile(dest, &ofdest, OF_CREATE);
		LZCopy(hfsource, hfdest);
		LZClose(hfsource);
		LZClose(hfdest);		}

	if(access("pbdout.hdi", 0) == 0) {
		fnmerge(dest,NULL,NULL,pbd_output_root,".hdi");
		hfsource = LZOpenFile("pbdout.hdi", &ofsource, OF_READ);
		hfdest = LZOpenFile(dest, &ofdest, OF_CREATE);
		LZCopy(hfsource, hfdest);
		LZClose(hfsource);
		LZClose(hfdest);		}

	if(access("currpbd.err", 0) == 0) {
		fnmerge(dest,NULL,NULL,pbd_output_root,".err");
		hfsource = LZOpenFile("currpbd.err", &ofsource, OF_READ);
		hfdest = LZOpenFile(dest, &ofdest, OF_CREATE);
		LZCopy(hfsource, hfdest);
		LZClose(hfsource);
		LZClose(hfdest);		}
```

```
if(access("currpbd.ebs", 0) == 0) {
        fnmerge(dest,NULL,NULL,pbd_output_root,".ebs");
        hfsource = LZOpenFile("currpbd.ebs", &ofsource, OF_READ);
        hfdest = LZOpenFile(dest, &ofdest, OF_CREATE);
        LZCopy(hfsource, hfdest);
        LZClose(hfsource);
        LZClose(hfdest);            }
}
```

APPENDIX C.5

Miscellaneous PLL functions.

C.5 Miscellaneous PLL functions.

The PLL Windows™ application uses 21 different functions in addition to those already described in sections C.1 through C.4. Two of the functions are used to handle the Output Viewer window scroll bar input. Ten of the functions are used to write files that provide input to the PLL and PBD FORTRAN executables. Seven functions are used to read standard PLL input data or project files and files written by the PLL FORTRAN executable. The final two functions are used to initialize global variables and to delete temporary data files. The function declarations are listed below in the order in which the functions will be presented.

```
//scroll bar handlers
void    WMVScroll_Handler(HWND hWnd, HWND hwndCtl, UINT code, int pos);
void    WMKeydown_Handler(HWND hWnd, UINT vk, BOOL fDown, int cRepeat, UINT flags);

//file writing functions
void    write_input_file(FILE *blade);
void    write_project_file(FILE *blade);
void    write_pbdadmin_file(void);
void    write_default_file(FILE *blade);
void    write_wakecalc_file(FILE *blade);
void    write_ductforc_file(FILE *blade);
void    write_absrules_file(FILE *blade);
void    write_thsttorq_file(FILE *blade);
void    write_wkalcirc_file(FILE *blade);
void    write_misc_files(void);

//file reading functions
void    read_blade_file(FILE *blade, int component);
void    read_wake_file(FILE *blade, int component);
void    read_input_file(FILE *blade);
void    read_project_file(FILE *blade);
void    read_plot_file(FILE *blade);
void    read_glauert_file(FILE *blade);
void    read_unload_dat_file(FILE *blade);

//misc functions
void    initialize(void);
void    delete_files(int file_flag);
```

C.5.1 The WMVScroll_Handler function.

The WMVScroll_Handler function responds to WM_VSCROLL messages. The function uses a switch to determine and perform the required response.

```
void WMVScroll_Handler(HWND hWnd, HWND hwndCtl, UINT code, int pos)
{
```

The function uses a local integer variable to record the inital position of the scroll box.

```
        int        temp;                              //temporary integer value used to
                                                      // detect changes in scroll
                                                      // bar position
//record the initial scroll bar position

        temp = Scroll_Pos;

//this switch specifies the response the scroll bar messages
```

The switch responds to messages generated by clicking on the upper and lower arrows of the scroll bar, the scroll bar regions above and below the scroll box, and clicking and dragging the scroll box itself.

```
        switch(code)
        {
```

Clicking on the up and down arrows on the scroll bar causes messages with the SB_LINEUP and SB_LINEDOWN codes. The response in these cases is to increment or decrement the Scroll_Pos variable by one. The Scroll_Pos variable is a global variable that reflects the position of the scroll box on the Output Viewer window vertical scroll bar.

```
//alter the value of Scroll_Pos as indicated by the message

        case SB_LINEUP:
        {       Scroll_Pos--;
                break;
        }

        case SB_LINEDOWN:
```

```
{         Scroll_Pos++;
          break;
}
```

Clicking on the scroll bar above or below the scroll box causes messages with the SB_PAGEUP and SB_PAGEDOWN codes. The response in these cases is to increment or decrement the Scroll_Pos variable by the number equal to the number of lines that may be displayed in one page.

```
 case SB_PAGEUP:
{         Scroll_Pos-=LinesInWindow;
          break;
}

 case SB_PAGEDOWN:
{         Scroll_Pos+=LinesInWindow;
          break;
}
```

The SB_THUMBTRACK case responds to the user moving the scroll box.

```
 case SB_THUMBTRACK:
{         Scroll_Pos=pos;
          break;
}
}
```

The Scroll_Pos variable is constrained to be between zero and the total number of lines of text being displayed, the current range of the scroll bar, by a pair of max and min macro calls.

```
//Scroll_Pos must be between 0 and the total lines of text

          Scroll_Pos = max(Scroll_Pos,0);
          Scroll_Pos = min(Total_Lines, Scroll_Pos);
```

The scroll bar postion is set to the position indicated by the Scroll_Pos variable, and the Output Viewer window is repainted if the new scroll bar position is not the same as the initial scroll bar position.

```
//set the scroll bar position to that indicated by Scroll_Pos

          SetScrollPos(hWnd, SB_VERT, Scroll_Pos, TRUE);
```

```
//if Scroll_Pos has changed, cause the screen to be repainted

        if(Scroll_Pos!=temp) InvalidateRect(hWnd, NULL, TRUE);
}
```

C.5.2 The WMKeydown_Handler function.

The WMKeydown_Handler function translates keyboard entries and sends appropriate messages to the vertical scroll bar. This is done in order to allow the user to contol the Output Viewer window vertical scroll bar messages using the Up Arrow, Down Arrow, Page Up and Page Down keys.

```
void WMKeydown_Handler(HWND hWnd, UINT vk, BOOL fDown, int cRepeat, UINT flags)
{
 switch(vk)
 {
//if the up arrow, down arrow, page up, or page down key is pressed, send the appropriate message to the
// scroll handler
```

This switch tests the unsigned integer identifier of keyboard entry messages. Messages corresponding to the Up Arrow, Down Arrow, Page Up and Page Down keys cause the SendMessage function to be used to send a WM_VSCROLL message with the appropriate code to the Output Viewer window. This allows keyboard input to operate the vertical scroll bar.

```
        case VK_UP:

        {       SendMessage(hWnd, WM_VSCROLL, SB_LINEUP, 0L);
                break;
        }

        case VK_DOWN:
        {       SendMessage(hWnd, WM_VSCROLL, SB_LINEDOWN, 0L);
                break;
        }

        case VK_PRIOR:
        {       SendMessage(hWnd, WM_VSCROLL, SB_PAGEUP, 0L);
                break;
        }

        case VK_NEXT:
```

```
        {       SendMessage(hWnd, WM_VSCROLL, SB_PAGEDOWN, 0L);
                break;
        }
        }
        return;
}
```

C.5.3 The write_input_file function.

The write_input_file function is used to write temporary input files in the format of standard PLL input files. The files written are used as input for the PLL FORTRAN executable. The function receives a pointer to a FILE structure as an argument.

```
void write_input_file(FILE *input)
{
/*********************************************************************
* declare variables that are defined in the pll.c file and that will be used in this function   *
*********************************************************************/

extern  char    RUN_ID[21], image_hub, image_duct, ringed_propeller[max_comp],
                BLDIN[max_comp][21], WKIN[max_comp][21];

extern  int     use_curr_blade, NBLADE[max_comp], LDEV;

extern  float   DCHD, DCD, DTHK, DDIAM, XDUCT, VS, RHO, DSHAFT,
                XDLOC[max_comp], XDIAM[max_comp], XWDIAM[max_comp];

/*********************************************************************
*   Variable declarations                                             *
*********************************************************************/

        struct  date d;                                 //date structure

        int     M;                                      //loop counter

//fill the date structure with the current date

        getdate(&d);

//write the RUN_ID line

        fprintf(input,"     PROPELLER LIFTING LINE RUN: %s     %d/%d/%d \n",
                RUN_ID,d.da_mon,d.da_day,d.da_year);

//write the file description

        fprintf(input,"         OVERALL INPUT FILE \n");

//write the ship speed
```

```
        fprintf(input,"%f . . . . . . . . . .Ship speed (ft/sec)\n", VS);

//write the fluid density

        fprintf(input,"%f . . . . . . . . . .Fluid Density\n",RHO);

//write the shaft centerline depth

        fprintf(input,"%f . . . . . . . . . .Shaft centerline depth (ft)\n",
                        DSHAFT);

//write the number of components

        fprintf(input,"%d . . . . . . . . . .Number of components\n",LDEV);

//write whether or not an image hub is used

        if(image_hub=='Y')

                fprintf(input,"%c . . . . . . . . . .Image hub to be used\n", image_hub);

        else

                fprintf(input,"%c . . . . . . . . . .No image hub to be used\n", image_hub);

//write whether or not an image duct is used

        if(image_duct=='Y')

                fprintf(input,"%c . . . . . . . . . .Image duct to be used\n", image_duct);

        else

                fprintf(input,"%c . . . . . . . . . .No image duct to be used\n", image_duct);


//write the duct data, if there is one

        if(image_duct=='Y'){

//write the duct chord length

                fprintf(input,"%f . . . . . . . . . .(Duct chord length)/ (Component #1
diameter)\n",DCHD);

//write the duct drag coefficient

                fprintf(input,"%f . . . . . . . . . .Drag coefficient for the duct\n",DCD);

//write the duct thickness

                fprintf(input,"%f . . . . . . . . . .(Duct thickness)/ (Component #1 diameter)\n",DTHK);

//write the duct diameter
```

```
                    fprintf(input,"%f . . . . . . . . . .Duct diameter (ft)\n",
                              DDIAM);

//write the duct axial location

                    fprintf(input,"%f . . . . . . . . . .Axial location of duct mid-chord (ft)\n",XDUCT);

                         }

          for(M=0;M<LDEV;M++){

//if there is no image duct,

          if(image_duct == 'N') {

//write whether or not the propeller is ringed

                    if(ringed_propeller[M]=='Y')

                              fprintf(input,"%c                  Component %d is \
a ringed propeller\n",ringed_propeller[M],M+1);

                    else

                    fprintf(input,"%c                  Component %d is not a \
ringed propeller\n",ringed_propeller[M],M+1);

                              }

//write the axial location if there is more than 1 propeller

          if(LDEV>1){

                    fprintf(input,"%f . . . . . . . . . .Axial location of component %d
(ft)\n",XDLOC[M],M+1);

                    }

//write the number of blades

          fprintf(input,"%d . . . . . . . . . .Number of blades on component %d\n",NBLADE[M],M+1);

//write the diameter of the propeller

          fprintf(input,"%f . . . . . . . . . .Diameter of component %d (ft)\n", XDIAM[M],M+1);

//write the blade file name

          if(use_curr_blade)

                    fprintf(input,"curr%d.bld          File containing blade inputs for comp. %d\n",M+1);

          else
```

```
                fprintf(input,"%s                File containing blade \
inputs for comp. %d\n",BLDIN[M*21],M+1);

//write the diameter of the wake

        fprintf(input,"%f..........Diameter of wake for component %d (ft)\n",XWDIAM[M],M+1);

//write the wake file name

        fprintf(input,"%s                File containing wake inputs for comp. %d\n",WKIN[M*21],M+1);

                        }

//zero the use_curr_blade flag

        use_curr_blade = 0;

}
```

C.5.4 The write_project_file function.

The write_project_file function is used to write project files in response to File|Save Project selections from the main menu. The function receives a pointer to a FILE structure as an argument.

```
 void write_project_file(FILE *proj)
 {

/*************************************************************************
* declare variables that are defined in the pll.c file and that will be used in this function    *
*************************************************************************/

extern char     RUN_ID[21], INPUTFILE[20];

extern int      LDEV, optimize_rpm, optimize_diameter, maximize_thrust, no_runtime_options,
                effective_wake_flag, tunnel_operation_flag, duct_forces_flag,
                duct_ring_vortex_forces_flag, circ_opt_wake_alignment_flag,
                estimate_duct_circulation_flag, estimate_damping_flag, NPANEL,
                contraction_ratio_flag, wake_alignment_flag, circulation_optimization_flag,
                chord_optimization_flag, duct_mean_line_flag, empirical_vcd_flag,
propeller_type_flag,
                propeller_material;

extern float    horsepower, RPM[max_comp], thrust_coefficient, estimated_duct_circulation,
                torque_ratio, damping, propeller_duct_thrust_ratio, propeller_ring_thrust_ratio,
                thrust_estimate, CLMAX, TCHDMAX, HUBCHD[max_comp], TTIP, CDCON,
                RHVOR, PL1, PL2, CONRAT, GAPFAC,
                material_constant[user_defined_material+1][2], rake[2];
```

```
/************************************************************************
* Variable declarations                                                *
************************************************************************/

        struct   date d;              //date structure

        int      M;                   //loop counter

//fill the date structure with the current date

        getdate(&d);

//write the RUN_ID line

        fprintf(proj,"    PROPELLER LIFTING LINE RUN: %s    %d/%d/%d \n",
                RUN_ID,d.da_mon,d.da_day,d.da_year);

//write the file description

        fprintf(proj,"        OVERALL PROJECT FILE \n%20s    Overall input \
filename\n",INPUTFILE);


//write the RUN_ID

        fprintf(proj,"%s                    RUN ID\n",RUN_ID);

//write the number of components

        fprintf(proj,"%d . . . . . . . . . .Number of components\n",LDEV);


//write the rpm for each component

        for(M=0;M<LDEV;M++)


        fprintf(proj,"%f . . . . . . . . . .RPM of component #%d\n", RPM[M],M+1);

//write the Optimize rpm flag

        fprintf(proj,"%d . . . . . . . . . .Optimize rpm flag\n", optimize_rpm);

//write the Optimize diameter flag

        fprintf(proj,"%d . . . . . . . . . .Optimize diameter flag\n", optimize_diameter);

//write the Maximize thrust flag

        fprintf(proj,"%d . . . . . . . . . .Maximize thrust flag\n", maximize_thrust);

//write the Horsepower for maximizing thrust

        fprintf(proj,"%f . . . . . . . . . .Horsepower for maximizing thrust\n", horsepower);
```

```
//write the Thrust coefficient for maximizing thrust

        fprintf(proj,"%f..........Thrust coefficient for maximizing thrust\n",thrust_coefficient);

//write the No runtime options flag

        fprintf(proj,"%d..........No runtime options flag\n", no_runtime_options);

//write the Effective wake flag

        fprintf(proj,"%d..........Effective wake flag\n", effective_wake_flag);

//write the Tunnel operation flag

        fprintf(proj,"%d..........Tunnel operation flag\n", tunnel_operation_flag);

//write the Duct forces flag

        fprintf(proj,"%d..........Duct forces flag\n", duct_forces_flag);

//write the Duct ring vortex forces flag

        fprintf(proj,"%d..........Duct ring vortex forces flag\n", duct_ring_vortex_forces_flag);

//write the Circ opt wake alignment flag

        fprintf(proj,"%d..........Circ opt wake alignment flag\n", circ_opt_wake_alignment_flag);

//write the Estimate duct circulation flag

        fprintf(proj,"%d..........Estimate duct circulation flag\n", estimate_duct_circulation_flag);

//write the Estimate duct circulation flag

        fprintf(proj,"%d..........Estimate damping flag\n", estimate_damping_flag);

//write the Estimated duct circulation

        fprintf(proj,"%f..........Estimated duct circulation\n", estimated_duct_circulation);

//write the Torque ratio

        fprintf(proj,"%f..........Torque ratio\n", torque_ratio);

//write the Damping

        fprintf(proj,"%f..........Damping\n", damping);

//write the Propeller duct thrust ratio

        fprintf(proj,"%f..........Propeller duct thrust ratio\n", propeller_duct_thrust_ratio);

//write the Propeller ring thrust ratio
```

```
        fprintf(proj,"%f..........Propeller ring thrust ratio\n", propeller_ring_thrust_ratio);

//write the Thrust estimate

        fprintf(proj,"%f..........Thrust estimate\n", thrust_estimate);

//write the maximum lift coefficient

        fprintf(proj,"%f..........Maximum lift coefficient\n", CLMAX);

//write the maximum thickness to chord ratio

        fprintf(proj,"%f..........Maximum thickness to chord ratio\n", TCHDMAX);

//write the minimum chord/diameter ratio at the root for each component

        for(M=0;M<LDEV;M++)

                fprintf(proj,"%f..........Minimum chord/diameter ratio at \
the root for each component\n",HUBCHD[M]);

//write the tip thickness to chord ratio

        fprintf(proj,"%f..........Tip thickness to chord ratio\n", TTIP);

//write the number of panels

        fprintf(proj,"%d..........Number of panels\n", NPANEL);

//write the drag coefficient multiplier

        fprintf(proj,"%f..........Drag coefficient multiplier\n", CDCON);

//write the hub vortex radius to hub radius ratio

        fprintf(proj,"%f..........Hub vortex to hub radius ratio\n", RHVOR);

//write the first Lagrange multiplier

        fprintf(proj,"%f..........First Lagrange multiplier\n", PL1);

//write the second Lagrange multiplier

        fprintf(proj,"%f..........Second Lagrange multiplier\n", PL2);

//write the contraction ratio flag

        fprintf(proj,"%d..........Contraction ratio flag\n", contraction_ratio_flag);

//write the conrat to the file

        fprintf(proj,"%f..........Contraction ratio\n", CONRAT);
```

```
//write the wake_alignment_flag

        fprintf(proj,"%d..........Wake alignment flag\n", wake_alignment_flag);

//write the circulation_optimization_flag

        fprintf(proj,"%d..........Circulation optimization flag\n", circulation_optimization_flag);

//write the chord_optimization_flag

        fprintf(proj,"%d..........Chord optimization flag\n", chord_optimization_flag);

//write the duct_mean_line_flag

        fprintf(proj,"%d..........Duct mean line flag\n", duct_mean_line_flag);

//write the empirical_vcd_flag

        fprintf(proj,"%d..........Empirical vcd flag\n", empirical_vcd_flag);

//write the duct tip gap factor

        fprintf(proj,"%f..........Duct tip gap factor\n", GAPFAC);

//write the propeller_type_flag

        fprintf(proj,"%d..........Propeller type flag\n", propeller_type_flag);

//write the propeller_material

        fprintf(proj,"%d..........Propeller material\n", propeller_material);

//write the user defined propeller material constants

        fprintf(proj,"%f..........Ultimate Tensile Strength(ksi)\n",
                        material_constant[user_defined_material][0]);

        fprintf(proj,"%f..........Specific Weight(lb/in^3)\n",
                        material_constant[user_defined_material][1]);

//write the rake at hub and tip for abs calculations

        fprintf(proj,"%f..........Rake at hub\n", rake[0]);

        fprintf(proj,"%f..........Rake at tip\n", rake[1]);

}
```

C.5.5 The write_pbdadmin_file function.

The write_pbdadmin_file function writes temporary PBD main administrative files for use by the PBD FORTRAN executable using the settings in the PBD Settings dialog box. The function receives no arguments.

```
void write_pbdadmin_file(void)
{

/*******************************************************************
* declare variables that are defined in the pll.c file and that  will be used in this function    *
*******************************************************************/

extern  char      RUN_ID[21], pbd_run_title[81], image_hub, image_duct;

extern  int       NBLADE[max_comp], NKEY, MKEY, ISPN, MCTRP, IHUB, IDUC,
                  MRPIN[max_comp], MLTYPE, MTHICK, IMODE, NWIMAX, NITER, RADWGT,
                  NUFIX, NPLOT, pbd_component;

extern  float     DGAP, TWEAK, BULGE, HGAP, HUBSHK, CDRAG, VS, RPM[max_comp],
                  XDIAM[max_comp], XULT, XFINAL, DTPROP;

/*******************************************************************
*  Variable declarations                            *
*******************************************************************/

        FILE    *proj, *dat;                            //pointers to file structures

        int     i, j;                                   //loop counters

        float   temp,                                   //temporary float for reading data
                ADVCO;                                  //advance coefficient of the
                                                        // propeller, J_s=(V_s/nD)

//open the file to be written

        proj = fopen("currpbd.pbd", "w");

//write the RUN_ID line

        fprintf(proj,"PBD14.2 currpbd.pbd %s \n", pbd_run_title);

//write the name of the b-spline file

        if(pbd_component==0)

                fprintf(proj,"currpbd1.bsn\n");

        else

                fprintf(proj,"currpbd2.bsn\n");
```

```
//write the name of the velocity file

        fprintf(proj,"currpbd.vel\n");

//write nblade, nkey, and mkey

        fprintf(proj," %d %d %d \n",NBLADE[pbd_component],NKEY, MKEY);

//write ispn

        fprintf(proj," %d \n",ISPN);

//write mctrp and the control points

        fprintf(proj," %d ",MKEY-1);

        for(i=1; i<=MKEY-1; i++)

                fprintf(proj," %d", i);

//write ihub, hgap, iduc, dgap

        if(image_hub=='Y')

                fprintf(proj,"\n %d ", (int)((float)(MKEY)/3.0));

        else

                fprintf(proj,"\n 0 ");

        fprintf(proj," %f ", HGAP);

        if(image_duct=='Y')

                fprintf(proj," %d ", (int)((float)(MKEY)/3.0));

        else

                fprintf(proj," 0 ");

        fprintf(proj," %f \n", DGAP);

//write nx, -nx, mltype, mlthick

        fprintf(proj," %d %d %d %d \n", MRPIN[pbd_component],-MRPIN[pbd_component], MLTYPE,
                                        MTHICK);

//write imode

        fprintf(proj," %d \n", IMODE);

//write nwimax
```

```
        fprintf(proj," %d \n", NWIMAX);

//write niter, tweak, bulge, radwgt, nufix

        fprintf(proj," %d %f %f %d %d \n", NITER, TWEAK, BULGE, RADWGT, NUFIX);

//write nplot and hubshk

        fprintf(proj," %d %f \n", NPLOT, HUBSHK);

//write cdrag

        fprintf(proj," %f \n", CDRAG);

//calculate the advance coefficient, use 200 if the component is a stator and use RPM[0] if the absolute
value
// of RPM[0] is <3.0(already an advance coefficient)

        if(fabs(RPM[pbd_component])<del)

                ADVCO =200.0;

        else

                if(fabs(RPM[pbd_component])<3.0&&fabs(RPM[pbd_component])>del)

                        ADVCO = RPM[pbd_component];

                else

                        ADVCO = ((RPM[pbd_component]*2.0*PI/60.0)*XDIAM[pbd_component]);

//write advance coefficient, xult, xfinal, and dtprop

        fprintf(proj," %f %f %f %f", ADVCO, XULT, XFINAL, DTPROP);

//open the file containing G, r/R, t/s, UA, UAU, UT, and UTU

        if(pbd_component==0)

                dat = fopen("PBDADM1.DAT", "r");

        else

                dat = fopen("PBDADM2.DAT", "r");


//loop through the data, read from the dat file and write to the proj file

        for(i=0; i<7; i++) {

          fprintf(proj,"\n");

                for(j=0; j<MRPIN[pbd_component]; j++) {
```

```
fscanf(dat,"%f",&temp);

  fprintf(proj," %f", temp);

                                    }

              }

//close both files

        fclose(proj);
        fclose(dat);

}
```

C.5.6 The write_default_file function.

The write_default_file function writes the default value file that the PLL FORTRAN executable uses to initialize the variables that appear in the Current Settings menu of the original version of PLL. It receives a pointer to a FILE structure as an argument.

```
 void write_default_file(FILE *blade)
 {

/******************************************************************
* declare variables that are defined in the pll.c file and that will be used in this function    *
******************************************************************/

extern  float       CLMAX, TCHDMAX, HUBCHD[max_comp], TTIP, CDCON, RHVOR, PL1, PL2,
                    GAPFAC, CONRAT;

extern  int         NPANEL, contraction_ratio_flag, wake_alignment_flag, circulation_optimization_flag,
                    chord_optimization_flag, duct_mean_line_flag, empirical_vcd_flag, LDEV;

/******************************************************************
*  Variable declarations                              *
******************************************************************/

        int         M;                                          //counter for the loops

//write the maximum lift coefficient

        fprintf(blade,"%f\n",CLMAX);

//write the maximum thickness to chord ratio

        fprintf(blade,"%f\n",TCHDMAX);
```

```
//write the minimum chord/diameter ratio at the root for each component

        for(M=0;M<LDEV;M++)

                fprintf(blade,"%f\n",HUBCHD[M]);

//write the tip thickness to chord ratio

        fprintf(blade,"%f\n",TTIP);

//write the number of panels

        fprintf(blade,"%d\n",NPANEL);

//write the drag coefficient multiplier

        fprintf(blade,"%f\n",CDCON);

//write the hub vortex radius to hub radius ratio

        fprintf(blade,"%f\n",RHVOR);

//write the first Lagrange multiplier

        fprintf(blade,"%f\n",PL1);

//write the second Lagrange multiplier

        fprintf(blade,"%f\n",PL2);

//write the contraction ratio flag

        fprintf(blade,"%d\n",contraction_ratio_flag);

//if the contraction_ratio_flag = 1, the entry will be the default value, otherwise, must write the conrat to
// the file

        if( contraction_ratio_flag == 0)

                fprintf(blade,"%f\n",CONRAT);

//write the wake_alignment_flag

        fprintf(blade,"%d\n",wake_alignment_flag);

//write the circulation_optimization_flag

        fprintf(blade,"%d\n",circulation_optimization_flag);

//write the chord_optimization_flag

        fprintf(blade,"%d\n",chord_optimization_flag);

//write the duct_mean_line_flag
```

```
        fprintf(blade,"%d\n",duct_mean_line_flag);
//write the empirical_vcd_flag
        fprintf(blade,"%d\n",empirical_vcd_flag);
//write the duct tip gap factor
        fprintf(blade,"%f\n",GAPFAC);
}
```

C.5.7 The write_wakecalc_file function.

The write_wakecalc_file function writes the file that is read by the PLL FORTRAN executable to determine if the effective wake should be calculated and if the component(s) is(are) operating in a tunnel. The function receives a pointer to a FILE structure as an argument.

```
void write_wakecalc_file(FILE *blade)
{

/************************************************************************
* declare variables that are defined in the pll.c file and that will be used in this function    *
************************************************************************/

extern   int        effective_wake_flag, tunnel_operation_flag;

//write the effective wake flag
        fprintf(blade,"%d\n",effective_wake_flag);
//write the tunnel_operation_flag
        fprintf(blade,"%d",tunnel_operation_flag);
}
```

C.5.8 The write_ductforc_file function.

The write_ductforc_file function writes the file that is read by the PLL FORTRAN executable to determine if the duct forces or duct ring vortex forces should be ignored and if an estimate of duct circulation should be used and the value of the estimate. The function receives a pointer to a FILE structure as an argument.

```
void write_ductforc_file(FILE *blade)
{
/**********************************************************************
* declare variables that are defined in the pll.c file and that will be used in this function    *
**********************************************************************/

extern int      duct_ring_vortex_forces_flag, duct_forces_flag, estimate_duct_circulation_flag;

extern float    estimated_duct_circulation;


//write the duct ring vortex forces flag

        fprintf(blade,"%d\n",duct_ring_vortex_forces_flag);

//write the duct forces flag

        fprintf(blade,"%d\n",duct_forces_flag);

//write the estimate duct circulation flag

        fprintf(blade,"%d\n",estimate_duct_circulation_flag);

//write the estimated duct circulation

        fprintf(blade,"%f\n",estimated_duct_circulation);

}
```

C.5.9 The write_absrules_file function.

The write_absrules_file function writes the file that is read by the PLL FORTRAN executable to determine whether the propeller is fixed or controllable pitch, the rake, and the material properties for the purposes of the ABS Rules strength calculations. The function receives a pointer to a FILE structure as an argument.

```
void write_absrules_file(FILE *blade)
{

/**********************************************************************
* declare variables that are defined in the pll.c file and that will be used in this function    *
**********************************************************************/

extern int      propeller_type_flag, propeller_material;

extern float    material_constant[user_defined_material+1][2], rake[2];
```

```
//write the propeller_type_flag

        fprintf(blade,"%d\n",propeller_type_flag);

//write the material UTS in ksi

        fprintf(blade,"%f\n",material_constant[propeller_material][0]);

//write the material specific weight in lbs per cubic inch

        fprintf(blade,"%f\n",material_constant[propeller_material][1]);

//write the rake/diameter at the tip

        fprintf(blade,"%f\n",rake[1]);

//write the rake/diameter at the hub

        fprintf(blade,"%f\n",rake[0]);

}
```

C.5.10 The write_thsttorq_file function.

The write_thsttorq_file function writes the file that is read by the PLL FORTRAN executable to determine the thrust estimate for the project and the desired ratio of thrust between components two and one and the ratio of duct or ring thrust to total thrust. The function receives a pointer to a FILE structure as an argument.

```
void write_thsttorq_file(FILE *blade)
{

/************************************************************************
* declare variables that are defined in the pll.c file and that will be used in this function    *
************************************************************************/

extern float      thrust_estimate, torque_ratio, propeller_duct_thrust_ratio, propeller_ring_thrust_ratio;

//write the thrust estimate

        fprintf(blade,"%f\n",thrust_estimate);

//write the torque ratio

        fprintf(blade,"%f\n",torque_ratio);

//write the thrust ratio between the propeller and the total thrust for the ducted case
```

```
        fprintf(blade,"%f\n",propeller_duct_thrust_ratio);
//write the thrust ratio between the propeller and the total thrust for the ringed case
        fprintf(blade,"%f\n",propeller_ring_thrust_ratio);
}
```

C.5.11 The write_wkalcirc_file function.

The write_wkalcirc_file function writes the file that is read by the PLL FORTRAN executable to determine if the wake should be aligned during the circulation optimization procedure. The function receives a pointer to a FILE structure as an argument.

```
  void write_wkalcirc_file(FILE *blade)
 {

/**********************************************************************
* declare variables that are defined in the pll.c file and that will be used in this function    *
**********************************************************************/

extern int          circ_opt_wake_alignment_flag;

//write the circ_opt_wake_alignment_flag

        fprintf(blade,"%d\n",circ_opt_wake_alignment_flag);
}
```

C.5.12 The write_misc_files function.

The write_misc_files function writes several input files that are read by the PLL FORTRAN executable. Some of the files are written using fprintf function calls while others are written by calling functions described elsewhere in this appendix. The function receives no arguments.

```
 void write_misc_files(void)
 {

/**********************************************************************
* declare variables that are defined in the pll.c file and that  will be used in this function    *
**********************************************************************/

extern  float       pbd_skew[max_rad][max_comp], pbd_rake[max_rad][max_comp], damping,
                    horsepower, thrust_coefficient;
```

```
extern int      pbd_file_flag, NKEY, MKEY, MRPIN[max_comp], estimate_damping_flag,
                optimize_rpm, optimize_diameter, maximize_thrust, unload_flag, match_EAR_flag,
                eval_nonaxi_stator, no_runtime_options;


/*********************************************************************
*  Variable declarations                          *
*********************************************************************/

        FILE    *out;                                   //pointer to a file structure

        struct  date d;                                 //date structure

        struct  time t;                                 //time structure

        int     k;                                      //loop counter
```

These three blocks of code open, write, and close temporary default settings, project, and input files.

```
        out = fopen("temp.def", "w");
        write_default_file(out);
        fclose(out);


        out = fopen("temp.prj", "w");
        write_project_file(out);
        fclose(out);


        out = fopen("temp.inp", "w");
        write_input_file(out);
        fclose(out);
```

If the pbd_file_flag flag is set, a temporary file that is used by the PLL FORTRAN executable to write the PBD B-spline file is written.

```
        if(pbd_file_flag){

                out = fopen("PBDDEF.DAT", "w");

                fprintf(out," %d   %d\n", NKEY, MKEY);

                for(k=0; k<MRPIN[0]; k++)

                        fprintf(out," %f   %f\n", pbd_skew[k][0], pbd_rake[k][0]);

                fclose(out);
```

```
}
```

The next five blocks of code open, write, and close temporary files that are used by the PLL FORTRAN executable. Functions described elsewhere in this appendix are used in these blocks.

```
out = fopen("wakecalc.set", "w");
write_wakecalc_file(out);
fclose(out);

out = fopen("ductforc.set", "w");
write_ductforc_file(out);
fclose(out);

out = fopen("thsttorq.set", "w");
write_thsttorq_file(out);
fclose(out);

out = fopen("absrules.set", "w");
write_absrules_file(out);
fclose(out);

out = fopen("wkalcirc.set", "w");
write_wkalcirc_file(out);
fclose(out);
```

The last four blocks of code write files used by the PLL FORTRAN executable by using *fprintf* function calls.

```
out = fopen("damp.flg", "w");
fprintf(out,"%d \n%f",estimate_damping_flag,damping);
fclose(out);

out = fopen("options.set", "w");
if(optimize_rpm)          fprintf(out,"0\n");
if(optimize_diameter)     fprintf(out,"1\n");
if(maximize_thrust)       fprintf(out,"2\n");
if(unload_flag)           fprintf(out,"3\n");
if(match_EAR_flag)        fprintf(out,"4\n");
if(eval_nonaxi_stator)    fprintf(out,"5\n");
if(no_runtime_options)    fprintf(out,"99\n");
```

```
                                        fprintf(out,"%f\n", horsepower);
                                        fprintf(out,"%f\n", thrust_coefficient);
        fclose(out);

        out = fopen("pbd.set", "w");
        fprintf(out,"%d\n",pbd_file_flag);
        fclose(out);


        out = fopen("time.dat", "w");
        gettime(&t);
        fprintf(out," %02d:%02d\n", t.ti_hour, t.ti_min);
        getdate(&d);
        fprintf(out,"   %02d/%02d/%02d/n", d.da_mon,d.da_day,d.da_year);
        fclose(out);

}
```

C.5.13 The read_blade_file function.

The read_blade_file function reads standard PLL blade data files. It receives a pointer to a FILE structure and the component number for which the file is being read. The function is compatible with files written by and for the original FORTRAN version of PLL and files written by the MIT-PLL Editor program.

```
 void read_blade_file(FILE *blade, int component)
 {

/*****************************************************************************
* declare variables that are defined in the pll.c file and that will be used in this function    *
*****************************************************************************/

extern  int     MRPIN[max_comp], MBIN[max_comp];

extern  float   XRPIN[max_rad][max_comp], XCHD[max_rad][max_comp],
                XTHK[max_rad][max_comp], XCD[max_rad][max_comp],
                XG[max_rad][max_comp], BAR[max_comp],
                BANGIN[max_ang][max_comp], BCHDIN[max_ang][max_comp],
                BTHKIN[max_ang][max_comp], BCDIN[max_ang][max_comp],
                BCIRIN[max_ang][max_comp];

/*****************************************************************************
*  Variable declarations                          *
*****************************************************************************/


        int     M,                                      //loop counter
                nextchar = 1;                           //integer variable for reading
                                                        // data character by character
```

```
//scrap first line

        while (nextchar!=13&&nextchar!=10)
                nextchar = getc(blade);
        nextchar =1;

//scrap second line

        while (nextchar!=13&&nextchar!=10)
                nextchar = getc(blade);
        nextchar =1;

//scrap third line

        while (nextchar!=13&&nextchar!=10)
                nextchar = getc(blade);
        nextchar =1;

//read in the number of radii

        fscanf(blade,"%d ",&MRPIN[component]);

//scrap fifth line

        while (nextchar!=13&&nextchar!=10)
                nextchar = getc(blade);
        nextchar =1;

//loop through the components and read in the radii

        for(M=0;M<MRPIN[component];M++)

                fscanf(blade,"%f ",&XRPIN[M][component]);

//scrap seventh line

        while (nextchar!=13&&nextchar!=10)
                nextchar = getc(blade);
        nextchar =1;

//read in the blade chords

        for(M=0;M<MRPIN[component];M++)

                fscanf(blade,"%f ",&XCHD[M][component]);

//scrap ninth line

        while (nextchar!=13&&nextchar!=10)
                nextchar = getc(blade);
        nextchar =1;

//read in the blade thicknesses
```

```
	for(M=0;M<MRPIN[component];M++)

		fscanf(blade,"%f ",&XTHK[M][component]);

//scrap eleventh line

	while (nextchar!=13&&nextchar!=10)
		nextchar = getc(blade);
	nextchar =1;

//read in the blade viscous drag coefficients

	for(M=0;M<MRPIN[component];M++)

		fscanf(blade,"%f ",&XCD[M][component]);

//scrap thirteenth line

	while (nextchar!=13&&nextchar!=10)
		nextchar = getc(blade);
	nextchar =1;

//read in the blade circulation

	for(M=0;M<MRPIN[component];M++)

		fscanf(blade,"%f ",&XG[M][component]);


//if the next character is not the EOF, then read in the ring data


	if(getc(blade)!=EOF) {

//scrap fifteenth line

		while (nextchar!=13&&nextchar!=10)
			nextchar = getc(blade);
		nextchar =1;

//read in the angular extent of the ring

		fscanf(blade,"%f ",&BAR[component]);

//scrap seventeenth line

		while (nextchar!=13&&nextchar!=10)
			nextchar = getc(blade);
		nextchar =1;

//read in the number of angles

		fscanf(blade,"%d ",&MBIN[component]);
```

```
//scrap nineteenth line

        while (nextchar!=13&&nextchar!=10)
                nextchar = getc(blade);
        nextchar =1;

//read in the angles

        for(M=0;M<MBIN[component];M++)

                fscanf(blade,"%f ",&BANGIN[M][component]);

//scrap twenty-first line

        while (nextchar!=13&&nextchar!=10)
                nextchar = getc(blade);
        nextchar =1;

//read in the ring chords

        for(M=0;M<MBIN[component];M++)

                fscanf(blade,"%f ",&BCHDIN[M][component]);

//scrap twenty-third line

        while (nextchar!=13&&nextchar!=10)
                nextchar = getc(blade);
        nextchar =1;

//read in the ring thicknesses

        for(M=0;M<MBIN[component];M++)

                fscanf(blade,"%f ",&BTHKIN[M][component]);

//scrap twenty-fifth line

        while (nextchar!=13&&nextchar!=10)
                nextchar = getc(blade);
        nextchar =1;

//read in the ring viscous drag coefficients

        for(M=0;M<MBIN[component];M++)

                fscanf(blade,"%f ",&BCDIN[M][component]);

//scrap twenty-seventh line

        while (nextchar!=13&&nextchar!=10)
                nextchar = getc(blade);
        nextchar =1;
```

```
//read in the ring circulations

                for(M=0;M<MBIN[component];M++)

                        fscanf(blade,"%f ",&BCIRIN[M][component]);

                        }
}
```

C.5.14 The read_wake_file function.

The read_wake_file function reads standard PLL wake data files. It receives a pointer to a FILE structure and the component number for which the file is being read. The function is compatible with files written by and for the original FORTRAN version of PLL and files written by the MIT-PLL Editor program.

```
 void read_wake_file(FILE *wake, int component)
 {

/*********************************************************************
* declare variables that are defined in the pll.c file and that will be used in this function    *
*********************************************************************/

extern  int     NRWIN[max_comp], NHARMA[max_comp], NHARMR[max_comp],
                NHARMT[max_comp];

extern  float   XRWIN[max_wake_rad][max_comp],
                XVA[max_wake_rad][max_wake_har][2][max_comp],
                XVR[max_wake_rad][max_wake_har][2][max_comp],
                XVT[max_wake_rad][max_wake_har][2][max_comp];

/*********************************************************************
*  Variable declarations                              *
*********************************************************************/

        int     M,J,                                        //loop counters
                nextchar = 1;                               //integer variable for reading
                                                                    // data character by
character

//scrap first line

        while (nextchar!=13&&nextchar!=10)
                nextchar = getc(wake);
        nextchar =1;

//scrap second line
```

```
		while (nextchar!=13&&nextchar!=10)
			nextchar = getc(wake);
		nextchar =1;

//scrap third line

		while (nextchar!=13&&nextchar!=10)
			nextchar = getc(wake);
		nextchar =1;

//read in the number of radii

		fscanf(wake,"%d ",&NRWIN[component]);

//scrap fifth line

		while (nextchar!=13&&nextchar!=10)
			nextchar = getc(wake);
		nextchar =1;

//read in the NUMBER OF HARMONIC COEFFICIENTS (axial, radial, tangential)

		fscanf(wake,"%d ",&NHARMA[component]);
		fscanf(wake,"%d ",&NHARMR[component]);
		fscanf(wake,"%d ",&NHARMT[component]);

//scrap seventh line

		while (nextchar!=13&&nextchar!=10)
			nextchar = getc(wake);
		nextchar =1;

//read in the NONDIMENSIONAL RADII FOR INPUTS

		for(M=0;M<NRWIN[component];M++)

			fscanf(wake,"%f ",&XRWIN[M][component]);

//scrap a line

		while (nextchar!=13&&nextchar!=10)
			nextchar = getc(wake);
		nextchar =1;

//read in the AXIAL COSINE HARMONIC COEFFICIENTS

		for(J=0;J<NHARMA[component];J++){

			for(M=0;M<NRWIN[component];M++){

				fscanf(wake,"%f ",&XVA[M][J][0][component]);

				}
```

```
                                        }
//scrap a line

          while (nextchar!=13&&nextchar!=10)
                    nextchar = getc(wake);
          nextchar =1;

//read in the AXIAL SINE HARMONIC COEFFICIENTS

          for(J=0;J<NHARMA[component];J++){

                    for(M=0;M<NRWIN[component];M++){

                              fscanf(wake,"%f ",&XVA[M][J][1][component]);

                                                  }
                                        }

//handle the radial coefficients if there are any

          if(NHARMR[component]>0){

//scrap a line

          while (nextchar!=13&&nextchar!=10)
                    nextchar = getc(wake);
          nextchar =1;

//read in the RADIAL COSINE HARMONIC COEFFICIENTS

          for(J=0;J<NHARMR[component];J++){

                    for(M=0;M<NRWIN[component];M++){

                              fscanf(wake,"%f ",&XVR[M][J][0][component]);

                                                  }
                                        }

//scrap a line

          while (nextchar!=13&&nextchar!=10)
                    nextchar = getc(wake);
          nextchar =1;

//read in the RADIAL SINE HARMONIC COEFFICIENTS

          for(J=0;J<NHARMR[component];J++){

                    for(M=0;M<NRWIN[component];M++){

                              fscanf(wake,"%f ",&XVR[M][J][1][component]);
```

```
                                                }
                                        }
                                }
//handle the tangential coefficients if there are any

        if(NHARMT[component]>0){


//scrap a line

        while (nextchar!=13&&nextchar!=10)
                nextchar = getc(wake);
        nextchar =1;

//read in the TANGENTIAL COSINE HARMONIC COEFFICIENTS

        for(J=0;J<NHARMT[component];J++){

                for(M=0;M<NRWIN[component];M++){

                        fscanf(wake,"%f ",&XVT[M][J][0][component]);

                                                }
                                        }

//scrap a line

        while (nextchar!=13&&nextchar!=10)
                nextchar = getc(wake);
        nextchar =1;

//read in the TANGENTIAL SINE HARMONIC COEFFICIENTS

        for(J=0;J<NHARMT[component];J++){

                for(M=0;M<NRWIN[component];M++){

                        fscanf(wake,"%f ",&XVT[M][J][1][component]);

                                                }
                                        }
                                }
}
```

C.5.15 The read_input_file function.

The read_input_file function reads standard PLL input data files. It receives a pointer to a FILE structure. The function is compatible with files written by and for the original FORTRAN version of PLL and files written by the MIT-PLL Editor program.

```
void read_input_file(FILE *blade)
{
/*********************************************************************
* declare variables that are defined in the pll.c file and that will be used in this function    *
*********************************************************************/

extern  char    RUN_ID[21], image_hub, image_duct, ringed_propeller[max_comp],
                BLDIN[max_comp][21], WKIN[max_comp][21];

extern  int     use_curr_blade, NBLADE[max_comp], LDEV;

extern  float   DCHD, DCD, DTHK, DDIAM, XDUCT, VS, RHO, DSHAFT,
                XDLOC[max_comp], XDIAM[max_comp], XWDIAM[max_comp];

/*********************************************************************
*  Variable declarations                      *
*********************************************************************/

        int     M,                                      //loop counter
                nextchar = 1;                           //integer variable for reading
                                                        // data character by character

//scrap first line

        while (nextchar!=13&&nextchar!=10)
                nextchar = getc(blade);
        nextchar =1;

//scrap second line

        while (nextchar!=13&&nextchar!=10)
                nextchar = getc(blade);
        nextchar =1;

//read in the ship speed

        fscanf(blade,"%f",&VS);

//scrap the rest of the line

        while (nextchar!=13&&nextchar!=10)
                nextchar = getc(blade);
        nextchar =1;

//read in the fluid density

        fscanf(blade,"%f",&RHO);

//scrap the rest of line

        while (nextchar!=13&&nextchar!=10)
                nextchar = getc(blade);
```

```
        nextchar =1;

//read in the shaft centerline depth

        fscanf(blade,"%f",&DSHAFT);

//scrap the rest of line

        while (nextchar!=13&&nextchar!=10)
                nextchar = getc(blade);
        nextchar =1;

//read in the number of components

        fscanf(blade,"%d",&LDEV);

//scrap the rest of line
        while (nextchar!=13&&nextchar!=10)
                nextchar = getc(blade);
        nextchar =32;

//find out if an image hub is to be used

        while (nextchar==32||nextchar==9||nextchar==10||nextchar==13)
                nextchar = getc(blade);

        if(nextchar==(int)('Y')||nextchar==(int)('y'))

                image_hub = 'Y';
        else
                image_hub = 'N';

        nextchar =1;

//scrap the rest of line

        while (nextchar!=13&&nextchar!=10)
                nextchar = getc(blade);
        nextchar =32;

//find out if an image duct is to be used, this while statement rejects spaces, tabs, carriage returns, and line
// feeds so that extra lines in an input file won't crash the program

        while (nextchar==32||nextchar==9||nextchar==10||nextchar==13)
                nextchar = getc(blade);

        if(nextchar==(int)('Y')||nextchar==(int)('y'))

                image_duct = 'Y';
        else
                image_duct = 'N';

        nextchar =1;
```

```
//scrap the rest of line

          while (nextchar!=13&&nextchar!=10)
                    nextchar = getc(blade);
          nextchar =32;

//read the duct data if there is one

          if(image_duct == 'Y') {

//read the duct chord

                    fscanf(blade,"%f",&DCHD);

//scrap the rest of line

                    while (nextchar!=13&&nextchar!=10)
                              nextchar = getc(blade);
                    nextchar =1;

//read the duct drag coefficient

                    fscanf(blade,"%f",&DCD);

//scrap the rest of line

                    while (nextchar!=13&&nextchar!=10)
                              nextchar = getc(blade);
                    nextchar =1;

//read the duct thickness

                    fscanf(blade,"%f",&DTHK);

//scrap the rest of line

                    while (nextchar!=13&&nextchar!=10)
                              nextchar = getc(blade);
                    nextchar =1;

//read the duct diameter

                    fscanf(blade,"%f",&DDIAM);

//scrap the rest of line

                    while (nextchar!=13&&nextchar!=10)
                              nextchar = getc(blade);
                    nextchar =1;

//read the duct axial location

                    fscanf(blade,"%f",&XDUCT);
```

```
//scrap the rest of line

                while (nextchar!=13&&nextchar!=10)
                        nextchar = getc(blade);
                nextchar =32;

                        }

//handle both propellers, if there are two

        for(M=0;M<LDEV;M++){

                if(image_duct == (char)(78)) {

//find out if the propeller is ringed

        while (nextchar==32||nextchar==9||nextchar==10||nextchar==13)
                nextchar = getc(blade);

        if(nextchar==89||nextchar==121)

                ringed_propeller[M] = (char)(89);
        else
                ringed_propeller[M] = (char)(78);

        nextchar =1;

//scrap the rest of line

                while (nextchar!=13&&nextchar!=10)
                        nextchar = getc(blade);
                nextchar =1;

                                                }

//read the axial location if there is more than 1 propeller

        if(LDEV>1){

                fscanf(blade,"%f",&XDLOC[M]);

//scrap the rest of line
                while (nextchar!=13&&nextchar!=10)
                        nextchar = getc(blade);
                nextchar =1;

                  }
        else
                XDLOC[M]=0.0;

//read the number of blades

        fscanf(blade,"%d",&NBLADE[M]);
```

```
//scrap the rest of line

        while (nextchar!=13&&nextchar!=10)
                nextchar = getc(blade);
        nextchar =1;

//read the component diameter

        fscanf(blade,"%f",&XDIAM[M]);

//scrap the rest of line

        while (nextchar!=13&&nextchar!=10)
                nextchar = getc(blade);
        nextchar =1;

//read in the blade file name

        fscanf(blade,"%s",&BLDIN[M*21]);

//scrap the rest of line

        while (nextchar!=13&&nextchar!=10)
                nextchar = getc(blade);
        nextchar =1;

//read the wake diameter

        fscanf(blade,"%f",&XWDIAM[M]);

//scrap the rest of line

        while (nextchar!=13&&nextchar!=10)
                nextchar = getc(blade);
        nextchar =1;

//read in the wake file name

        fscanf(blade,"%s",&WKIN[M*21]);

//scrap the rest of line

        while (nextchar!=13&&nextchar!=10)
                nextchar = getc(blade);
        nextchar =1;
                                }
}
```

C.5.16 The read_project_file function.

The read_project_file function reads PLL project files are that written in response the File|Save Project selection from the main menu. The function receives a pointer to a FILE structure.

```
 void read_project_file(FILE *blade)
 {

/*******************************************************************
* declare variables that are defined in the pll.c file and that  will be used in this function   *
********************************************************************/

extern char      RUN_ID[21], INPUTFILE[20];

extern int       LDEV, optimize_rpm, optimize_diameter, maximize_thrust,no_runtime_options,
                 effective_wake_flag, tunnel_operation_flag, duct_forces_flag,
                 duct_ring_vortex_forces_flag, circ_opt_wake_alignment_flag,
                 estimate_duct_circulation_flag, estimate_damping_flag, NPANEL,
                 contraction_ratio_flag, wake_alignment_flag,
                 circulation_optimization_flag, chord_optimization_flag,
                 duct_mean_line_flag, empirical_vcd_flag, propeller_type_flag,
                 propeller_material;

extern float     horsepower, RPM[max_comp], thrust_coefficient,
                 estimated_duct_circulation, torque_ratio, damping,
                 propeller_duct_thrust_ratio, propeller_ring_thrust_ratio,
                 thrust_estimate, CLMAX, TCHDMAX, HUBCHD[max_comp],TTIP, CDCON,
                 RHVOR, PL1, PL2, CONRAT, GAPFAC,
                 material_constant[user_defined_material+1][2], rake[2];

/*******************************************************************
*  Variable declarations                          *
********************************************************************/

        int     M, i,                                   //loop counters
                nextchar = 1;                           //integer variable for reading
                                                                // data character by
character
//scrap first line

        while (nextchar!=13&&nextchar!=10)
                nextchar = getc(blade);
        nextchar =1;

//scrap second line

        while (nextchar!=13&&nextchar!=10)
                nextchar = getc(blade);
        nextchar =1;

//read in the input filename
```

```
        fscanf (blade,"%20s",INPUTFILE);

//scrap the rest of the line

        while (nextchar!=13&&nextchar!=10)
                nextchar = getc(blade);
        nextchar =1;

//read in the RUN ID

        for(i=0;i<20;i++)  RUN_ID[i]=getc(blade);

        RUN_ID[20]=NULL;

//scrap the rest of line

        while (nextchar!=13&&nextchar!=10)
                nextchar = getc(blade);
        nextchar =1;

//read in the number of components

        fscanf(blade,"%d",&LDEV);

//scrap the rest of line

        while (nextchar!=13&&nextchar!=10)
                nextchar = getc(blade);
        nextchar =32;

//read in the rpm for both propellers, if there are two

        for(M=0;M<LDEV;M++) {

                fscanf(blade,"%f",&RPM[M]);

//scrap the rest of line

                while (nextchar!=13&&nextchar!=10&&nextchar!=EOF)
                        nextchar = getc(blade);
                nextchar =1;

                        }

//this if statement recognizes bare project files

        if(fscanf(blade,"%d",&optimize_rpm)!=EOF){

//scrap the rest of line

                while (nextchar!=13&&nextchar!=10)
                        nextchar = getc(blade);
```

```
                nextchar =1;

//read the optimize diameter flag

                fscanf(blade,"%d",&optimize_diameter);

//scrap the rest of line

                while (nextchar!=13&&nextchar!=10)
                        nextchar = getc(blade);
                nextchar =1;

//read the Maximize thrust flag

                fscanf(blade,"%d",&maximize_thrust);

//scrap the rest of line

                while (nextchar!=13&&nextchar!=10)
                        nextchar = getc(blade);
                nextchar =1;

//read the Horsepower for maximizing thrust

                fscanf(blade,"%f",&horsepower);

//scrap the rest of line

                while (nextchar!=13&&nextchar!=10)
                        nextchar = getc(blade);
                nextchar =1;

//read the Thrust coefficient for maximizing thrust

                fscanf(blade,"%f",&thrust_coefficient);

//scrap the rest of line

                while (nextchar!=13&&nextchar!=10)
                        nextchar = getc(blade);
                nextchar =1;

//read the No runtime options flag

                fscanf(blade,"%d",&no_runtime_options);

//scrap the rest of line
                while (nextchar!=13&&nextchar!=10)
                        nextchar = getc(blade);
                nextchar =1;

//read the Effective wake flag

                fscanf(blade,"%d",&effective_wake_flag);
```

```
//scrap the rest of line

                    while (nextchar!=13&&nextchar!=10)
                              nextchar = getc(blade);
                    nextchar =1;

//read the Tunnel operation flag

                    fscanf(blade,"%d",&tunnel_operation_flag);

//scrap the rest of line

                    while (nextchar!=13&&nextchar!=10)
                              nextchar = getc(blade);
                    nextchar =1;

//read the Duct forces flag

                    fscanf(blade,"%d",&duct_forces_flag);

//scrap the rest of line

                    while (nextchar!=13&&nextchar!=10)
                              nextchar = getc(blade);
                    nextchar =1;

//read the Duct ring vortex forces flag

                    fscanf(blade,"%d",&duct_ring_vortex_forces_flag);

//scrap the rest of line

                    while (nextchar!=13&&nextchar!=10)
                              nextchar = getc(blade);
                    nextchar =1;

//read the Circ opt wake alignment flag

                    fscanf(blade,"%d",&circ_opt_wake_alignment_flag);

//scrap the rest of line

                    while (nextchar!=13&&nextchar!=10)
                              nextchar = getc(blade);
                    nextchar =1;

//read the Estimate duct circulation flag

                    fscanf(blade,"%d",&estimate_duct_circulation_flag);

//scrap the rest of line

                    while (nextchar!=13&&nextchar!=10)
```

```
			nextchar = getc(blade);
		nextchar =1;

//read the Estimate duct circulation flag

		fscanf(blade,"%d",&estimate_damping_flag);

//scrap the rest of line

		while (nextchar!=13&&nextchar!=10)
			nextchar = getc(blade);
		nextchar =1;

//read the Estimated duct circulation

		fscanf(blade,"%f",&estimated_duct_circulation);

//scrap the rest of line

		while (nextchar!=13&&nextchar!=10)
			nextchar = getc(blade);
		nextchar =1;

//read the Torque ratio

		fscanf(blade,"%f",&torque_ratio);

//scrap the rest of line

		while (nextchar!=13&&nextchar!=10)
			nextchar = getc(blade);
		nextchar =1;

//read the Damping

		fscanf(blade,"%f",&damping);

//scrap the rest of line

		while (nextchar!=13&&nextchar!=10)
			nextchar = getc(blade);
		nextchar =1;

//read the Propeller duct thrust ratio

		fscanf(blade,"%f",&propeller_duct_thrust_ratio);

//scrap the rest of line

		while (nextchar!=13&&nextchar!=10)
			nextchar = getc(blade);
		nextchar =1;

//read the Propeller ring thrust ratio
```

```
                fscanf(blade,"%f",&propeller_ring_thrust_ratio);

//scrap the rest of line

                while (nextchar!=13&&nextchar!=10)
                        nextchar = getc(blade);
                nextchar =1;

//read the Thrust estimate

                fscanf(blade,"%f",&thrust_estimate);

//scrap the rest of line

                while (nextchar!=13&&nextchar!=10)
                        nextchar = getc(blade);
                nextchar =1;

//read the maximum lift coefficient

                fscanf(blade,"%f",&CLMAX);

//scrap the rest of line

                while (nextchar!=13&&nextchar!=10)
                        nextchar = getc(blade);
                nextchar =1;

//read the maximum thickness to chord ratio

                fscanf(blade,"%f",&TCHDMAX);

//scrap the rest of line

                while (nextchar!=13&&nextchar!=10)
                        nextchar = getc(blade);
                nextchar =1;

//read the minimum chord/diameter ratio at the root for each component

                for(M=0;M<LDEV;M++){

                        fscanf(blade,"%f",&HUBCHD[M]);

//scrap the rest of line
                        while (nextchar!=13&&nextchar!=10&&nextchar!=EOF)
                                        nextchar = getc(blade);
                        nextchar =1;

                                }

//read the tip thickness to chord ratio
```

```
            fscanf(blade,"%f",&TTIP);

//scrap the rest of line

            while (nextchar!=13&&nextchar!=10)
                        nextchar = getc(blade);
            nextchar =1;

//read the number of panels

            fscanf(blade,"%d",&NPANEL);

//scrap the rest of line

            while (nextchar!=13&&nextchar!=10)
                        nextchar = getc(blade);
            nextchar =1;

//read the drag coefficient multiplier

            fscanf(blade,"%f",&CDCON);

//scrap the rest of line

            while (nextchar!=13&&nextchar!=10)
                        nextchar = getc(blade);
            nextchar =1;

//read the hub vortex radius to hub radius ratio

            fscanf(blade,"%f",&RHVOR);

//scrap the rest of line

            while (nextchar!=13&&nextchar!=10)
                        nextchar = getc(blade);
            nextchar =1;

//read the first Lagrange multiplier

            fscanf(blade,"%f",&PL1);

//scrap the rest of line

            while (nextchar!=13&&nextchar!=10)
                        nextchar = getc(blade);
            nextchar =1;

//read the second Lagrange multiplier

            fscanf(blade,"%f",&PL2);

//scrap the rest of line
```

```
            while (nextchar!=13&&nextchar!=10)
                  nextchar = getc(blade);
            nextchar =1;

//read the contraction ratio flag

            fscanf(blade,"%d",&contraction_ratio_flag);

//scrap the rest of line

            while (nextchar!=13&&nextchar!=10)
                  nextchar = getc(blade);
            nextchar =1;

//read the conrat

            fscanf(blade,"%lf",&CONRAT);

//scrap the rest of line

            while (nextchar!=13&&nextchar!=10)
                  nextchar = getc(blade);
            nextchar =1;

//read the wake_alignment_flag

            fscanf(blade,"%d",&wake_alignment_flag);

//scrap the rest of line

            while (nextchar!=13&&nextchar!=10)
                  nextchar = getc(blade);
            nextchar =1;

//read the circulation_optimization_flag

            fscanf(blade,"%d",&circulation_optimization_flag);

//scrap the rest of line

            while (nextchar!=13&&nextchar!=10)
                  nextchar = getc(blade);
            nextchar =1;

//read the chord_optimization_flag

            fscanf(blade,"%d",&chord_optimization_flag);

//scrap the rest of line

            while (nextchar!=13&&nextchar!=10)
                  nextchar = getc(blade);
            nextchar =1;
```

```
//read the duct_mean_line_flag

                fscanf(blade,"%d",&duct_mean_line_flag);

//scrap the rest of line
                while (nextchar!=13&&nextchar!=10)
                        nextchar = getc(blade);
                nextchar =1;

//read the empirical_vcd_flag

                fscanf(blade,"%d",&empirical_vcd_flag);

//scrap the rest of line
                while (nextchar!=13&&nextchar!=10)
                        nextchar = getc(blade);
                nextchar =1;

//read the duct tip gap factor

                fscanf(blade,"%f",&GAPFAC);

//scrap the rest of line

                while (nextchar!=13&&nextchar!=10)
                        nextchar = getc(blade);
                nextchar =1;

//read the propeller_type_flag

                fscanf(blade,"%d",&propeller_type_flag);

//scrap the rest of line

                while (nextchar!=13&&nextchar!=10)
                        nextchar = getc(blade);
                nextchar =1;

//read the propeller_material

                fscanf(blade,"%d",&propeller_material);

//scrap the rest of line

                while (nextchar!=13&&nextchar!=10)
                        nextchar = getc(blade);
                nextchar =1;

//read the user defined propeller material constants

                fscanf(blade,"%f",&material_constant[user_defined_material][0]);

//scrap the rest of line
```

```
			while (nextchar!=13&&nextchar!=10)
				nextchar = getc(blade);
			nextchar =1;

			fscanf(blade,"%f",&material_constant[user_defined_material][1]);

//scrap the rest of line

			while (nextchar!=13&&nextchar!=10)
				nextchar = getc(blade);
			nextchar =1;

//read the rake at hub and tip for abs calculations

			fscanf(blade,"%f",&rake[0]);

//scrap the rest of line

			while (nextchar!=13&&nextchar!=10)
				nextchar = getc(blade);
			nextchar =1;

			fscanf(blade,"%f",&rake[1]);

						}
}
```

C.5.17 The read_plot_file function.

The read_plot_file function reads plot files that are written by the FORTRAN executable. It receives a pointer to a FILE structure as an argument.

```
 void read_plot_file(FILE *plot)
 {

/**********************************************************************
* declare variables that are defined in the pll.c file and that will be used in this function     *
**********************************************************************/

extern int	number_radii[max_comp];

extern float	RADIUS[max_comp][max_rad],CHORDINPUT[max_comp][max_rad],
		PITCHANGLEUNDISTURBED[max_comp][max_rad],
		CHORDCALC[max_comp][max_rad],
		PITCHANGLEINDUCED[max_comp][max_rad],

		UAINEFFECTIVE[max_comp][max_rad], UTIN[max_comp][max_rad],
		UAINDUCED[max_comp][max_rad], UTINDUCED[max_comp][max_rad],

		THICKNESS[max_comp][max_rad], CIRCULATIONINPUT[max_comp][max_rad],
```

```
		DRAG[max_comp][max_rad], CIRCULATIONCALC[max_comp][max_rad],

		LOCALCL[max_comp][max_rad], LOCALCT[max_comp][max_rad],
		LOCALCQ[max_comp][max_rad], CAVITATIONNUMBER[max_comp][max_rad],

		UAINNOMINAL[max_comp][max_rad];

/*******************************************************************
* Variable declarations                        *
*******************************************************************/

	int	component,				//component#, 1 or 2
		i;						//loop counter

//read in the component number

	fscanf(plot,"%d ",&component);

//decrement the component number so that data for component number 1
// will be stored in the [0] variables (C programming convention)

	component--;

//read in the number of radii

	fscanf(plot,"%d ",&number_radii[component]);

//loop through the radii

	for(i=0;i<number_radii[component];i++)

//read in the data for each parameter at the current radius

	fscanf(plot,"%f %f %f %f %f %f %f %f %f", &RADIUS[component][i],
	&CHORDINPUT[component][i], &THICKNESS[component][i],
	&DRAG[component][i], &CIRCULATIONINPUT[component][i],
	&UAINNOMINAL[component][i], &UAINEFFECTIVE[component][i],
	&UTIN[component][i], &PITCHANGLEUNDISTURBED[component][i]);

//loop again through the radii and read the rest of the parameters

	for(i=0;i<number_radii[component];i++)

	fscanf(plot,"%f %f %f %f %f %f %f %f %f %f", &RADIUS[component][i],
	&CHORDCALC[component][i], &PITCHANGLEINDUCED[component][i],
	&CIRCULATIONCALC[component][i], &UAINDUCED[component][i],
	&UTINDUCED[component][i], &LOCALCL[component][i],
	&LOCALCT[component][i], &LOCALCQ[component][i],
	&CAVITATIONNUMBER[component][i]);

}
```

C.5.18 The read_glauert_file function.

The read_glauert_file function reads data from the glauert.coe file written by the FORTRAN executable to be used should the user decide to unload the hub and/or tip of a hubless propeller without a ring or a zero gap duct. The function receives a pointer to a FILE structure as an argument.

```
 void read_glauert_file(FILE *blade)
{

/*********************************************************************
* declare variables that are defined in the pll.c file and that will be used in this function    *
*********************************************************************/

extern  int        NGC,LDEV;

extern  float      GC[max_comp][max_glau_coef];

/*********************************************************************
*  Variable declarations                              *
*********************************************************************/

        int        i,j;                                          //counters for the for loops

//loop through the components

        for(i=0;i<LDEV;i++)        {

//read in the number of coefficients for each component

        fscanf(blade,"%d",&NGC);

//loop through and read in the coefficients

        for(j=0;j<NGC;j++)

        fscanf(blade,"%f ",&GC[i][j]);

                                   }
}
```

C.5.19 The read_unload_dat_file function.

The read_unload_dat_file function reads data from the unload.dat file written by the FORTRAN executable should the user decided to unload the hub and/or tip of a

propeller that has a ring or a zero gap duct or an image hub. The function receives a pointer to a FILE structure as an argument.

```
 void read_unload_dat_file(FILE *blade)
 {

/*********************************************************************
* declare variables that are defined in the pll.c file and that  will be used in this function    *
*********************************************************************/

extern  int          LDEV;

extern  float        hub_circ[max_comp], tip_circ[max_comp], hub_radius[max_comp],
                     tip_radius[max_comp], RZ[max_comp];

/*********************************************************************
*  Variable declarations                              *
*********************************************************************/

        int        i;                                              //loop counter

//loop through the components

        for(i=0;i<LDEV;i++)      {

//read in for each component:

//circulation nearest the hub

                fscanf(blade,"%f",&hub_circ[i]);

//radius nearest the hub

                fscanf(blade,"%f",&hub_radius[i]);

//hub radius

                fscanf(blade,"%f",&RZ[i]);

//circulation nearest the tip

                fscanf(blade,"%f",&tip_circ[i]);

//radius nearest the tip

                fscanf(blade,"%f",&tip_radius[i]);

                                }
}
```

C.5.20 The initialize function.

The initialize function deletes unnecessary data files and initializes global variables in order to prepare PLL to open a new project.

```
 void initialize(void)
 {

/*******************************************************************
* declare variables that are defined in the pll.c file and that will be used in this function     *
*******************************************************************/

extern  int       plot_page, plot_component_flag, draw_plot_flag, unload_flag, optimize_rpm,
                  optimize_diameter, maximize_thrust, match_EAR_flag, use_curr_blade,
                  eval_nonaxi_stator, no_runtime_options, output_flag, component_flag, Scroll_Pos,
                  estimate_duct_circulation_flag, estimate_damping_flag, circ_opt_wake_alignment_flag,
                  NPANEL, contraction_ratio_flag, wake_alignment_flag, circulation_optimization_flag,
                  chord_optimization_flag, duct_mean_line_flag, empirical_vcd_flag,
propeller_type_flag,
                  propeller_material, project_flag, effective_wake_flag, tunnel_operation_flag,
                  duct_forces_flag, duct_ring_vortex_forces_flag, Scroll_Pos, opt_comp;

extern  float     horsepower, thrust_coefficient, RPM[max_comp], CONRAT, GAPFAC,
                  material_constant[user_defined_material+1][2], rake[2], thrust_estimate, torque_ratio,
                  damping, estimated_duct_circulation, propeller_duct_thrust_ratio,
                  propeller_ring_thrust_ratio, CLMAX, TCHDMAX, TTIP, CDCON,
                  HUBCHD[max_comp], RHVOR, PL1, PL2,
                  GC_UNLOAD_FRAC[max_comp][max_glau_coef];

extern  char      ringed_propeller[max_comp], RUN_ID[21], INPUTFILE[20], PROJECTFILE[20];


/*******************************************************************
*  Variable declarations                                    *
*******************************************************************/

        int     M;                                                      //loop counter

//delete temporary files

        unlink("plot1.out");
        unlink("plot2.out");
        unlink("curr1.bld");
        unlink("curr2.bld");
        unlink("detail1.out");
        unlink("detail2.out");
        unlink("summary.out");
        unlink("stress.out");
        unlink("absrules.out");
        unlink("duct.geo");
        unlink("fards.out");
        unlink("nonaxi.cmp");
```

```
        unlink("nonaxi.cir");
        unlink("nonaxi.har");
        unlink("nonaxi.for");
        unlink("currpbd.pbd");
        unlink("currpbd1.bsn");
        unlink("currpbd2.bsn");
        unlink("currpbd.vel");

//delete pre-existing pbd output files

                unlink("pbdout.cbd");
                unlink("pbdout.hub");
                unlink("pbdout.cmv");
                unlink("pbdout.cmf");
                unlink("pbdout.tot");
                unlink("pbdout.gsp");
                unlink("pbdout.sol");
                unlink("pbdout.ibg");
                unlink("pbdout.ktq");
                unlink("pbdout.obg");
                unlink("pbdout.bsn");
                unlink("pbdout.obg");
                unlink("pbdout.rdc");
                unlink("pbdout.sgr");
                unlink("pbdout.vcp");
                unlink("pbdout.hdi");
                unlink("currpbd.err");
                unlink("currpbd.ebs");

//initialize global variables

        for(M=0;M<max_glau_coef;M++){

                GC_UNLOAD_FRAC[0][M]=0.0;

                GC_UNLOAD_FRAC[1][M]=0.0;

                        }

        ringed_propeller[0]='N';
        ringed_propeller[1]='N';

    plot_page=0;

        plot_component_flag=0;

        draw_plot_flag=0;

        unload_flag=0;

        optimize_rpm=0;

        optimize_diameter=0;
```

```
maximize_thrust=0;

match_EAR_flag=0;

use_curr_blade=0;

eval_nonaxi_stator=0;

no_runtime_options=1;

horsepower=0.0;

thrust_coefficient=0.0;

output_flag=0;

component_flag=0;

Scroll_Pos = 0;

strcpy(RUN_ID,"");

strcpy(INPUTFILE,"");

strcpy(PROJECTFILE,"");

project_flag =0;

RPM[0]=100.0;
RPM[1]=100.0;

effective_wake_flag = 0;

thrust_estimate = 0.69;

tunnel_operation_flag = 0;

duct_forces_flag = 1;

duct_ring_vortex_forces_flag = 1;

torque_ratio = 1.0;

estimate_duct_circulation_flag = 0;

estimated_duct_circulation = 0.05;

estimate_damping_flag = 0;

damping = 0.0;

propeller_duct_thrust_ratio = 1.0;

propeller_ring_thrust_ratio = 1.0;
```

```
        circ_opt_wake_alignment_flag = 0;

        CLMAX = 0.6;

        TCHDMAX =0.20;

        TTIP = 0.004;

        NPANEL = 10;

        CDCON = 0.008;

        RHVOR = 0.5;

        PL1 = -1.0;

        PL2 = 0.0;

        contraction_ratio_flag = 1;

        CONRAT=1.0;

        wake_alignment_flag = 1;

        circulation_optimization_flag = 1;

        chord_optimization_flag = 1;

        duct_mean_line_flag = 1;

        empirical_vcd_flag = 1;

        GAPFAC = 1.0;

        propeller_type_flag = 1;

        propeller_material = manganese_bronze;

        material_constant[user_defined_material][0]=70.0;
        material_constant[user_defined_material][1]=0.30;

        rake[0]=0.0;
        rake[1]=0.0;

        Scroll_Pos = 0;
}
```

C.5.21 The delete_files function.

The delete_files function deletes temporary data files according to the integer flag passed as an argument.

```
void delete_files(int file_flag)
{
        if(file_flag==pll_files){

//delete temporary files

        unlink("plot1.out");
        unlink("plot2.out");
        unlink("detail1.out");
        unlink("detail2.out");
        unlink("summary.out");
        unlink("stress.out");
        unlink("absrules.out");
        unlink("duct.geo");
        unlink("fards.out");
        unlink("nonaxi.cmp");
        unlink("nonaxi.cir");
        unlink("nonaxi.har");
        unlink("nonaxi.for");
        unlink("currpbd.pbd");
        unlink("currpbd1.bsn");
        unlink("currpbd2.bsn");
                                        }

        if(file_flag==pbd_files){

//delete pre-existing pbd output files

                unlink("pbdout.cbd");
                unlink("pbdout.hub");
                unlink("pbdout.cmv");
                unlink("pbdout.cmf");
                unlink("pbdout.tot");
                unlink("pbdout.gsp");
                unlink("pbdout.sol");
                unlink("pbdout.ibg");
                unlink("pbdout.ktq");
                unlink("pbdout.bsn");
                unlink("pbdout.obg");
                unlink("pbdout.rdc");
                unlink("pbdout.sgr");
                unlink("pbdout.vcp");
                unlink("pbdout.hdi");
                unlink("currpbd.err");
                unlink("currpbd.ebs");          }
 }
```

APPENDIX C.6

The PLL and PBD FORTRAN programs.

C.6 The PLL and PBD FORTRAN programs.

The MIT-PLL propeller design program uses lifting line theory in representing propellers as a set of straight, radially oriented lifting lines corresponding to the propeller blades. The geometry of the blades is represented in the form of a radial circulation distribution. The program was developed at the MIT Marine Hydrodynamics Laboratory with support from the MIT Sea Grant College Program and the David Taylor Research Center. For this reason the code will not be reproduced in whole or in part in this document, either in its original form or as altered to be called by the PLL Windows™ application.

The PBD-14.2 propeller design program is the product of evolution from a series of earlier codes developed at the MIT Marine Hydrodynamics Laboratory. The program was developed with support provided by the Office of Naval Research Graduate Fellowship Program, the Office of Naval Research, and the David Taylor Model Basin. As in the case of PLL, this code will not be reproduced in whole or in part in this document, either in its original form or as altered to be called by the PLL Windows™ application.

For the purpose of the illustration of a FORTRAN code altered for operation in conjunction with a Windows™ application, a portion of the VLMLE code discussed in Chapter 2 and Appendix B is shown below. The FORTRAN code shown is used to allow the user to interact with the program and provide keyboard input to set the number of panels to be used in modelling a foil. The first line of code writes a prompt to the monitor.

The READ statement that follows causes the execution of the program to pause while the user selects and types an integer value on the keyboard, and presses "enter". The program then reads the value selected by the user and stores it in the variable MC. A test is performed in the third statement. If the value suggested by the user falls outside of the

acceptable range, execution of the program is redirected to statement 90 and the process is repeated.

```
C----Compute vortex and control point positions and weight functions---
C
90      WRITE(*,'(" Enter number of panels (Max:",I4,")... ",$)') MSD
        READ(*,*) MC
        IF(MC.LT.5.OR.MC.GT.MSD) GO TO 90
```

The FORTRAN code shown below replaces the code described above in order to adapt the original VLMLE code for use by a Windows™ executable. The first executable line opens the INPUT.DAT file, a file written by the Windows™ executable, as logical unit 2 to provide the input that is usually provided via terminal interaction. The READ statement reads the first value from the INPUT.DAT file as the number of panels. There is no need to test MC at this point to ensure that it is within the acceptable range, since this action was performed by the Windows™ application. At some point later in this program the INPUT.DAT file will be closed to complete the input process.

```
C----Open the input data file as unit 2-----------------------
        OPEN(2,FILE='INPUT.DAT',STATUS='UNKNOWN',FORM='FORMATTED')
C
C----Compute vortex and control point positions and weight functions---
C
C
        READ(2,*) MC
C
```

Output functions are implemented similarly. Data that is normally written to the screen, or to output text files, or to plot files, is written to files in a format recognized by the Windows™ application. As a preferable alternative, the Windows™ application functions may be written to use output and plot files written by the unaltered FORTRAN code. This alternative minimizes the work necessary to implement later revisions of the

original FORTRAN code for use by the Windows™ application. Both techniques were employed in PLL.

APPENDIX C.7

PLL program listings.

C.7 PLL program listings.

Listings for the MIT-PLL Windows™ application, the MIT-PLL Editor program, and the MIT-PLL Help program are included in this Appendix.

C.7.1 MIT-PLL program listings.

The PLL Windows™ application includes 37 files. Listings for these files are included with this document as Appendix C.7.1 on a 3.5 inch, IBM PC formatted, double sided, high density floppy disk. The files are saved in an ASCII text format which can be read using a DOS text editor or any word processor capable of reading DOS text files. The complete files of this and the other programs in this thesis are not included in the written text of the thesis in the interest of limiting the size of the document. These pages are included with the listings in a file named README.TXT.

The files included on the disk are described below.

PLL.C	-contains the WinMain, FrameWndProc, MDI Child Window Procedure, WMCommand_Handler, scroll bar, and dialog box functions.
WRTEPBD.C	-contains the write_pbdadmin_file function.
PAINTHUB.C	-contains the paint_hub function.
PAINTRDC.C	-contains the paint_rdc function.
PAINTVCP.C	-contains the paint_vcp function.
PAINTTST.C	-contains the paint_graphs and rotation_projection functions.
DELETE.C	-contains the delete_files function.
INITIAL.C	-contains the initialize function.
READGLAU.C	-contains the read_glauert_file and the read_unload_dat_file functions.
WRITEMISC.C	-contains the write_misc_files and the write_pbd_files functions.

WRTEDEF.C	-contains the write_default_file, write_wakecalc_file, write_ductforc_file, write_thsttorq_file, write_absrules_file, and the write_wkalcirc_file functions.
PAINTWAK.C	-contains the paintwake function.
PRINTPLT.C	-contains the printplot and the drawprint functions.
PAINTPLT.C	-contains the paintplot and the draw functions.
PAINTBLD.C	-contains the paintbld function.
READWAK.C	-contains the read_wake_file function.
READPLOT.C	-contains the read_plot_file function.
READBLD.C	-contains the read_blade_file function.
READPRJ.C	-contains the read_project_file function.
WRTEPRJ.C	-contains the write_project_file function.
WRTEINP.C	-contains the write_input_file function.
READINP.C	-contains the read_input_file function.
PRINTOUT.C	-contains the printout function.
PAINTOUT.C	-contains the paintout function.
WRITEOUT.C	-contains the write_output_file function.
PAINTGSP.C	-contains the paint_gsp function.
PAINTCMV.C	-contains the paint_cmv function.
PLL.DEF	-the module definition file.
PLL.RC	-contains definitions of the resources used in the PLL program.
HEADER.H	-contains the #define and #include statements for the PLL program.
PLL.H	-contains the definitions of the Windows™ identifiers.
README.TXT	-contains a copy of these pages.

The following files are not readable text files.

PLL.ICO	-describes the icon used to represent the program in the Windows™ Program Manager.

PLLBLD.ICO -describes the icon used to represent the Blade Viewer window in the MDI Client window.

PLLOUT.ICO -describes the icon used to represent the Output Viewer window in the MDI Client window.

PLLPLOT.ICO -describes the icon used to represent the Plot Viewer window in the MDI Client window.

PLLWAKE.ICO -describes the icon used to represent the Wake Viewer window in the MDI Client window.

PLL.PRJ -the project file read by the compiler.

PLL.PIF -a program information file used by the Windows™ environment to control how the PLL FORTRAN executable is run.

PBD.PIF -a program information file used by the Windows™ environment to control how the PBD FORTRAN executable is run.

Also included with this appendix are are several blade, wake, stator, and overall input files for use with PLL.

C.7.2 MIT-PLL Editor program listings.

The MIT-PLL Editor Windows™ application includes 25 files. Listings for these files are included with this document as Appendix C.7.2 on a 3.5 inch, IBM PC formatted, double sided, high density floppy disk. The files are saved in an ASCII text format which can be read using a DOS text editor or any word processor capable of reading DOS text files. The complete files of this and the other programs in this thesis are not included in the written text of the thesis in the interest of limiting the size of the document. These pages are included with the listings in a file named README.TXT.

The files included on the disk are listed below.

PLLEDIT.C

ADDANGLE.C

ADDRADII.C

COPY.C

DBLCLK.C

DISCARD.C

HEADER.H

PAINTBLD.C

PAINTFIL.C

PAINTSTA.C

PAINTWAK.C

PLLEDIT.DEF

PLLEDIT.H

PLLEDIT.RC

PRINTFIL.C

READBLD.C

READINP.C

READSTAT.C

READWAK.C

WRTEBLD.C

WRTEINP.C

WRTESTAT.C

WRTEWAK.C

README.TXT

The following files are not readable text files.

PLLEDIT.PRJ

PLLPRJ.ICO

C.7.3 MIT-PLL Help program listings.

The MIT-PLL Help Windows™ application includes 10 files. Listings for these files are included with this document as Appendix C.7.3 on a 3.5 inch, IBM PC formatted, double sided, high density floppy disk. The files are saved in an ASCII text format which can be read using a DOS text editor or any word processor capable of reading DOS text files. The complete files of this and the other programs in this thesis are not included in the written text of the thesis in the interest of limiting the size of the document. This page is included with the listings in a file named README.TXT.

The files included on the disk are listed below.

PLLHELP.C

HEADER.H

PAINTFIL.C

PLLHELP.DEF

PLLHELP.H

PLLHELP.RC

PRINTFIL.C

README.TXT

The following files are not readable text files.

PLLHELP.PRJ

PLLHELP.ICO

This appendix also includes the text files displayed by the MIT-PLL Help program. The files used in presenting the contents of the PLL and PBD User's Manuals are not included, for the same reason that the PLL and PBD FORTRAN source code is not included.