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JUL 77 E R DIXON, B M THOMSON

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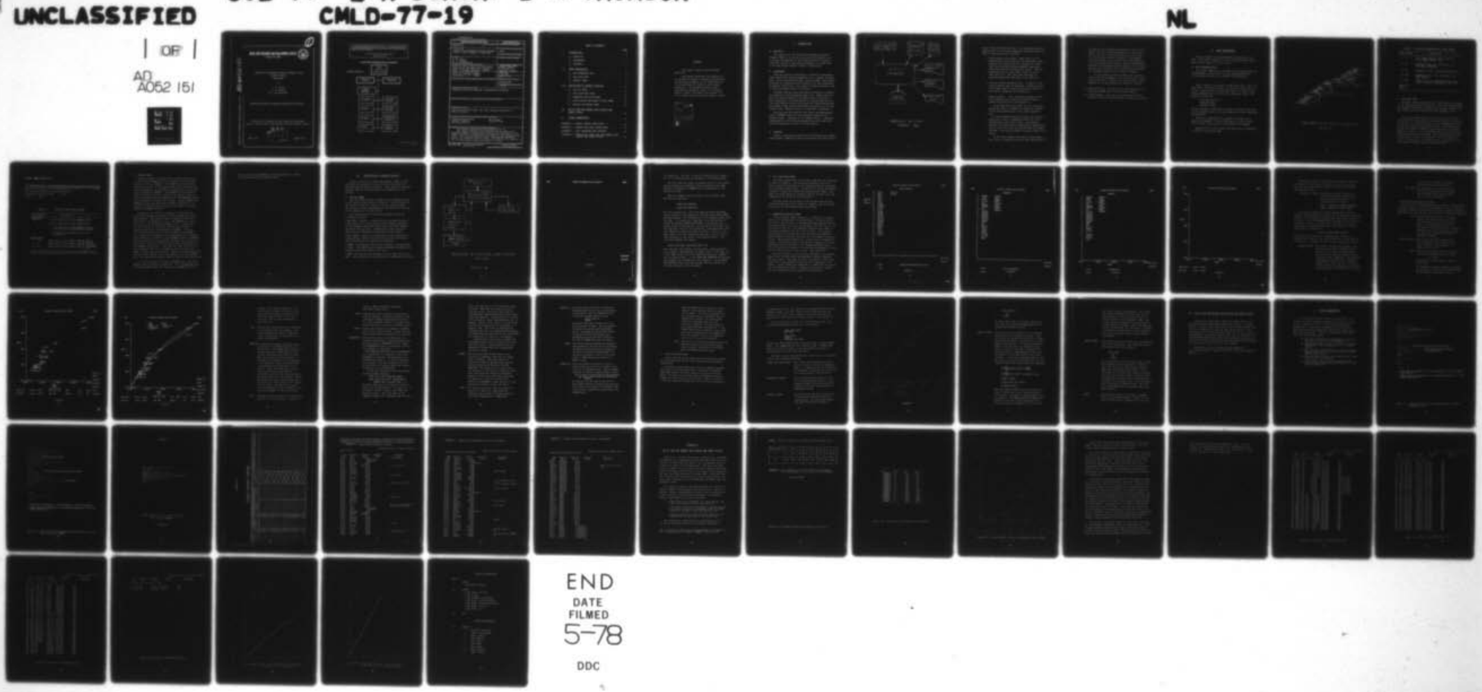

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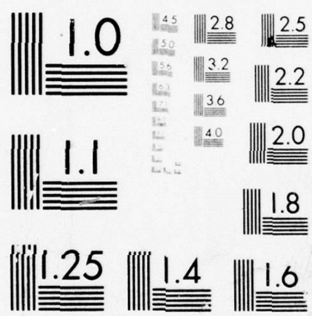

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INTERACTIVE PARAMETER ANALYSIS PROGRAM (IPAP)

NAVAL SHIP RESEARCH AND DEVELOPMENT CENTER

Bethesda, Md. 20084

INTERACTIVE PARAMETER ANALYSIS PROGRAM (IPAP)
(USER'S MANUAL)
(REVISION)

by

E. R. Dixon
B. M. Thomson
W. F. Starkweather

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Computation, Mathematics and Logistics Department
David W. Taylor Naval Ship Research and Development Center

JULY 1977 CMLD-77-19

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Naval Ship Research and Development Center

Bethesda, Md. 20034

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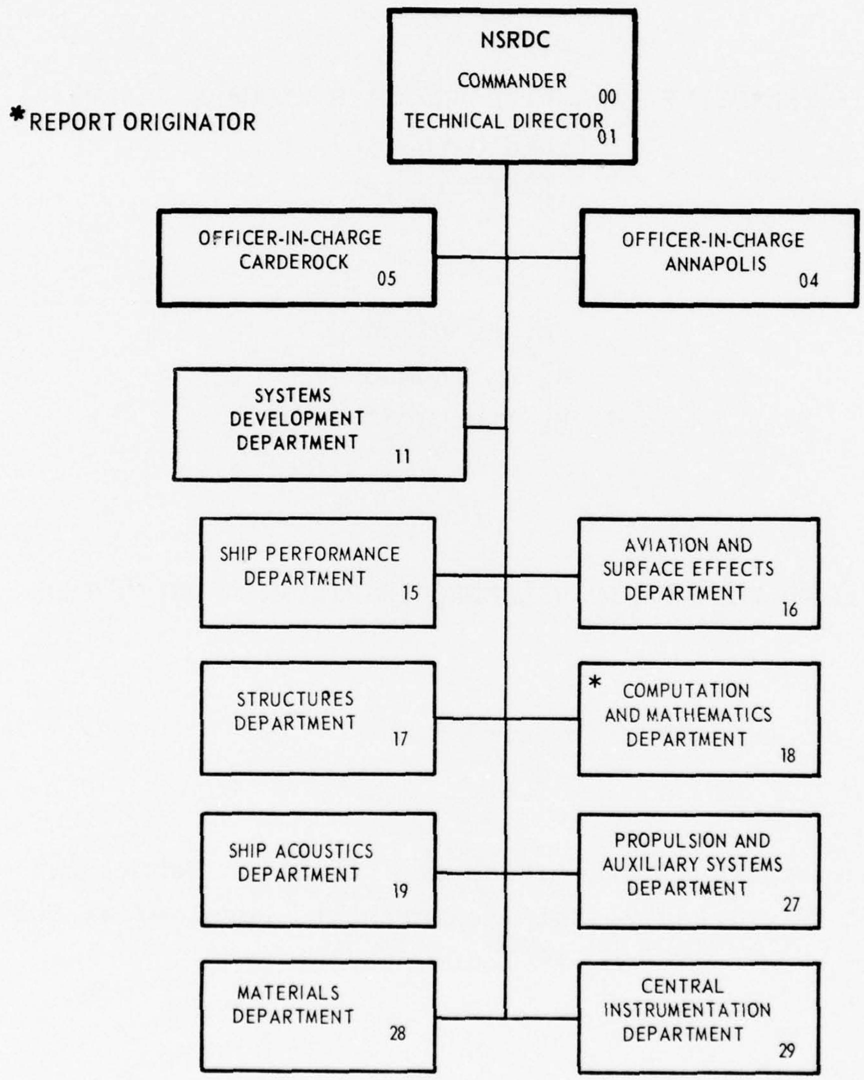

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This manual updates and supersedes CMD-13-76.

This manual describes the operation of an interactive graphics computer program which assists ship designers in the identification of correlations and trends in ship design parameters. The program displays points representing parameter values of a selected group of ships, and enables the engineer to fit to these points and record analytic curves.

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TABLE OF CONTENTS

ABSTRACT

This manual updates and supersedes CMD-13-76.

This manual describes the operation of an interactive graphics computer program which assists ship designers in the identification of correlations and trends in ship design parameters. The program displays points representing parameter values of a selected group of ships, and enables the engineer to fit to these points and record analytic curves.

I. INTRODUCTION

A. OBJECTIVE

The objective of the Interactive Parameter Analysis Program (IPAP) is to provide an interactive graphics tool to assist the engineer in the identification of correlations and trends in ship design parameters, to enable him to fit and record analytic curves to these data.

B. BACKGROUND

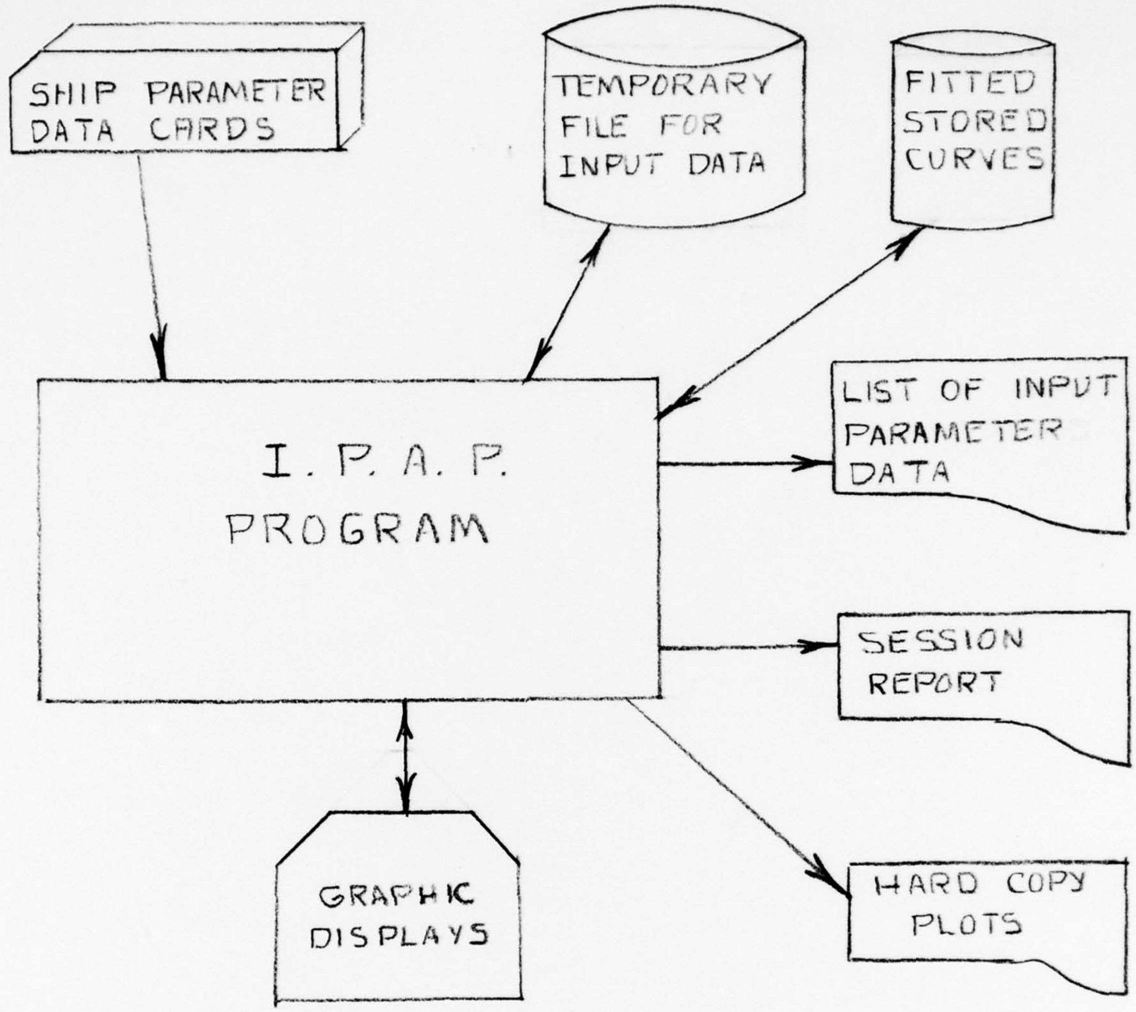
IPAP was initially undertaken to identify correlations among significant design parameters (e.g., length, displacement, specific machinery weight, payload weight, SES cushion pressure) for advanced marine vehicles, but the program may be applied effectively to any types of ships for which a set of design parameter data is available.

Although IPAP has been developed principally to address the analysis of ship parameter data (e.g., IPAP's data formats have been designed to streamline data collection of ship parameters), the capabilities to display data and fit, store and display curves can be used for other applications. For example, IPAP has been employed successfully to fit and display ships' Bonjean curves, as described in Appendix D.

IPAP has been developed for the Naval Ship Engineering Center (NAVSEC) under the task Advanced Techniques for Vehicle Design, a segment of the CASDAC project. Desirable enhancements to the existing program have been identified and are recorded in Section V of this report.

C. OVERVIEW

Figure 1 presents an overview of the interactive graphics IPAP program, emphasizing the various input and output inter-



OVERVIEW OF I.P.A.P.
FIGURE ONE

faces between IPAP and the user. The reader may gain an appreciation for the major components and capabilities of IPAP by examining these interfaces:

- Ship Parameter Data Cards - Input data for the program must be collected by the responsible user/ engineer and entered into the program via cards. Input data includes design parameter names and values associated with particular ships. The program processes the card input, stores it on an input data file, and calls upon this data as required during the remainder of the IPAP run.

- Listing of Input Parameter Data - A report of the input parameter data is produced, listing the data in the same order it was read and also sorted by ship and by parameter (See Appendix C).

- Graphic Display - The interactive graphics interface comprises four principal graphics display frames (See Section III and Figure 3).

  In the Ship Selection Frame the user indicates whether he wants to examine all ships or a subset of the ships represented in the input parameter data.

  In the Parameter Selection Frame, the engineer identifies a pair of parameters which are to be represented on the X and Y axes. The program examines the input data to determine an appropriate initial scale for each axis and displays and labels the axes. The user may adjust the axes scales if he wishes.

  In the Point Display and Curve Fitting Frame, a data point is displayed for each ship represented in the data by the designated parameters, and the ship identification is displayed adjacent to each data point. The user then designates one or more types of curves to be fitted to the data. The program fits and displays the selected curves superimposed over the displayed data points, and the mathematical equation of the displayed curve appears on the scope. The user may designate that fitted curves be stored on a permanent disk file for future redisplay.

In the Display Old Curves Frame, the user may recall from the permanent file any previously fitted and stored curve. Several such curves may be superimposed, as in the display of a family of curves.

- Hard Copy Plots - The user may at any time ask for a hardcopy CALCOMP plot of the current display.
- Printed Report - The user may at any time ask for a printed record of curves and data currently in display.

II. INPUT PREPARATION

Figure 2 depicts the card deck setup required to run IPAP. Card input consists of a set of ship parameter input cards and two cards of auxiliary data.

A. SHIP PARAMETER DATA

The typical IPAP user is assumed to be investigating the relationships between pairs of ship design parameters for each design taken over a number of ship designs.

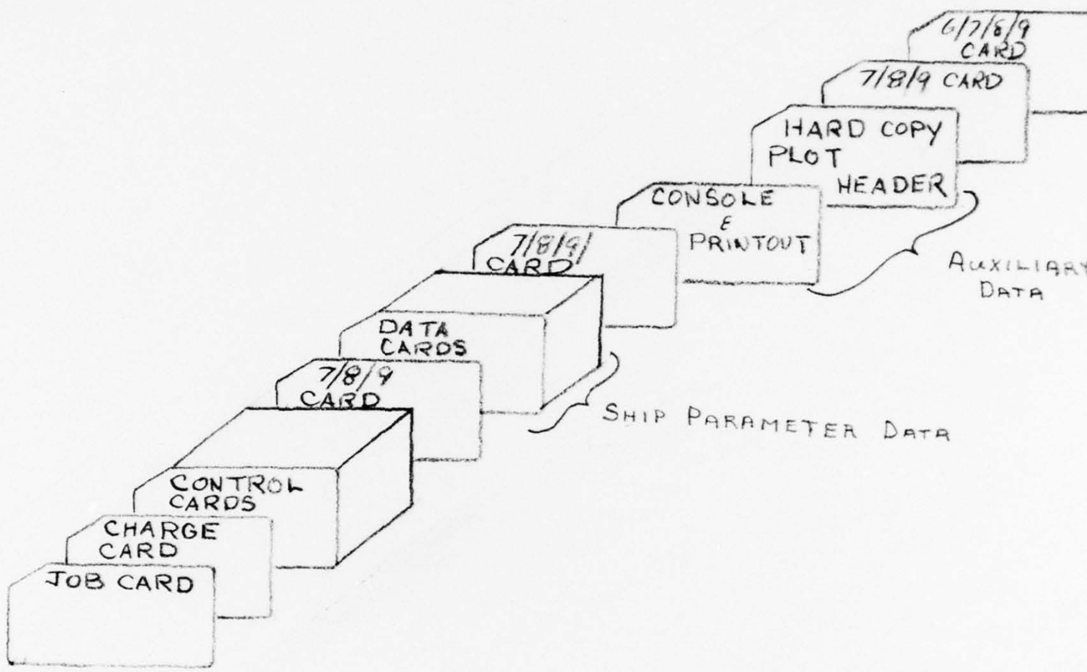
Table 1 defines the format of IPAP card input. The first three data fields are required, the last two fields are optional. Each card will contain the name of a single scalar design parameter and its value for a particular ship. The required fields are:

Ship Identification
Parameter Name
Parameter Value

The two optional fields allow the user to indicate the units of the parameter and to give any comments or notes respecting the parameter.

The user is responsible to provide all values for a particular parameter in consistent units; no units conversion or units verification is performed by the program.

Appendix B is a data coding form which may be reproduced to assist in preparing input.



CARD DECK SETUP FOR IPAP EXECUTION

FIGURE 2

TABLE 1 - IPAP SHIP PARAMETER DATA INPUT FORMAT

Card Column	Description
1 - 8	Ship identification, left justified, e.g., DD963, HYDF1, LHA17.
11 - 18	Parameter name, left justified, e. g., LBP, BEAM, SPEEDMAX.
21 - 30	Parameter value, including decimal point
31 - 42*	Parameter units, left justified, e.g., FEET, KNOTS.
51 - 80*	Comments or notes respecting this parameter, origin of information, date, etc.
*Optional data	

B. AUXILIARY DATA

Two input cards of program control data must be provided in the formats described in Table 2. The first card contains two integer fields which designate the graphics display site and control the early printout of ship parameter input.

The second program control data card contains information which will be reproduced as a banner frame (a frame containing text to identify the user) at the beginning and end of any hard copy plots produced by IPAP. This information assists the computer operator in matching plots with their respective users. It is recommended that the users name and organizational code be included. Data punched in the first 30 characters of this card appears as three 10-character lines of characters on the banner frame. An example of the hard copy plot header card is reproduced below.

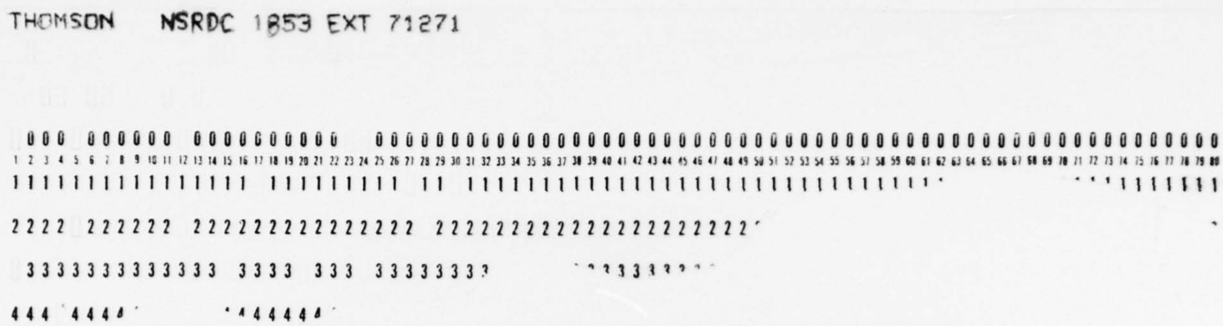


TABLE 2 - AUXILIARY DATA INPUT FORMAT

Card Column	Description	
<u>First Card</u>		
2 - 3	= 01 for operation on the DTNSRDC scope.	
	= 17 for operation on the NAVSEC scope.	
6	= 1 for printout of ship parameter input prior to initiating graphics sessions.	
	= 0 to defer early printout until job completion.	
<u>Second Card</u>		
1 - 10	First line of plot banner frame*	Should contain user name, code, phone, etc.
11 - 20	Second line of plot banner frame	
21 - 30	Third line of plot banner frame	

*Banner frames are available on output from the NAVSEC plotter.

C. CONTROL CARDS

IPAP can produce plotted output on either the 11-inch or the 30-inch CALCOMP plotters at NAVSEC or on the newer 30-inch plotter at DTNSRDC. The NAVSEC plotters are more convenient to use, in that they produce plots automatically at the termination of the IPAP run, whether the job is executed at NAVSEC or DTNSRDC. The DTNSRDC plotter produces higher resolution plots of superior line quality, but requires two additional job submissions at the DTNSRDC central site subsequent to termination of IPAP. Because NAVSEC and DTNSRDC plotters are driven by different software, it is necessary to have separate control card setups to use the NAVSEC and DTNSRDC plotters.

Figures A1, A2, and A3 of Appendix A illustrate the control card sequence required to execute IPAP on the CDC 6700 computer. The control cards of Figure A1 will execute IPAP at the NAVSEC site or at the DTNSRDC site, providing plots on the NAVSEC CALCOMP plotter. (Note that the first Auxiliary Data Card, Table 2, must reflect whether operation is from NAVSEC or DTNSRDC). The control cards of Figure A2 will execute IPAP at the DTNSRDC site, producing a permanent file containing plotter instructions which are acceptable to the CALCOMP plotter at DTNSRDC. Having executed the run described in Figure A2 to create the plot file, a batch job (See Figure A3) must be submitted at the DTNSRDC Central Site. This job will copy the plot file from permanent disk file to magnetic tape; the user must submit a blank tape with the job. When this run has executed, the user must complete an Off-Line Request for the CALCOMP plot, and submit this request with the tape at the Central Site.

It is also possible to create a DTNSRDC plot file from NAVSEC using the setup in Figure A2. It is recommended that occasional NAVSEC needs for high quality DTNSRDC plots be met by liaison with DTNSRDC Code 1853 personnel to submit the second and third processing steps.

III. DESCRIPTION OF GRAPHICS DISPLAYS

Figure 3 depicts the principal display frames of IPAP and shows the sequence in which the user may direct the program from one frame to another. These displays and their inherent options are described in the remainder of this section.

A. INITIAL FRAME

The first IPAP display to appear on the graphics scope is the Initial Frame, shown in Figure 4. At this point the user directs IPAP into either of its two primary modes: the display of input ship parameter data and curve fitting, or the redisplay of stored curves.

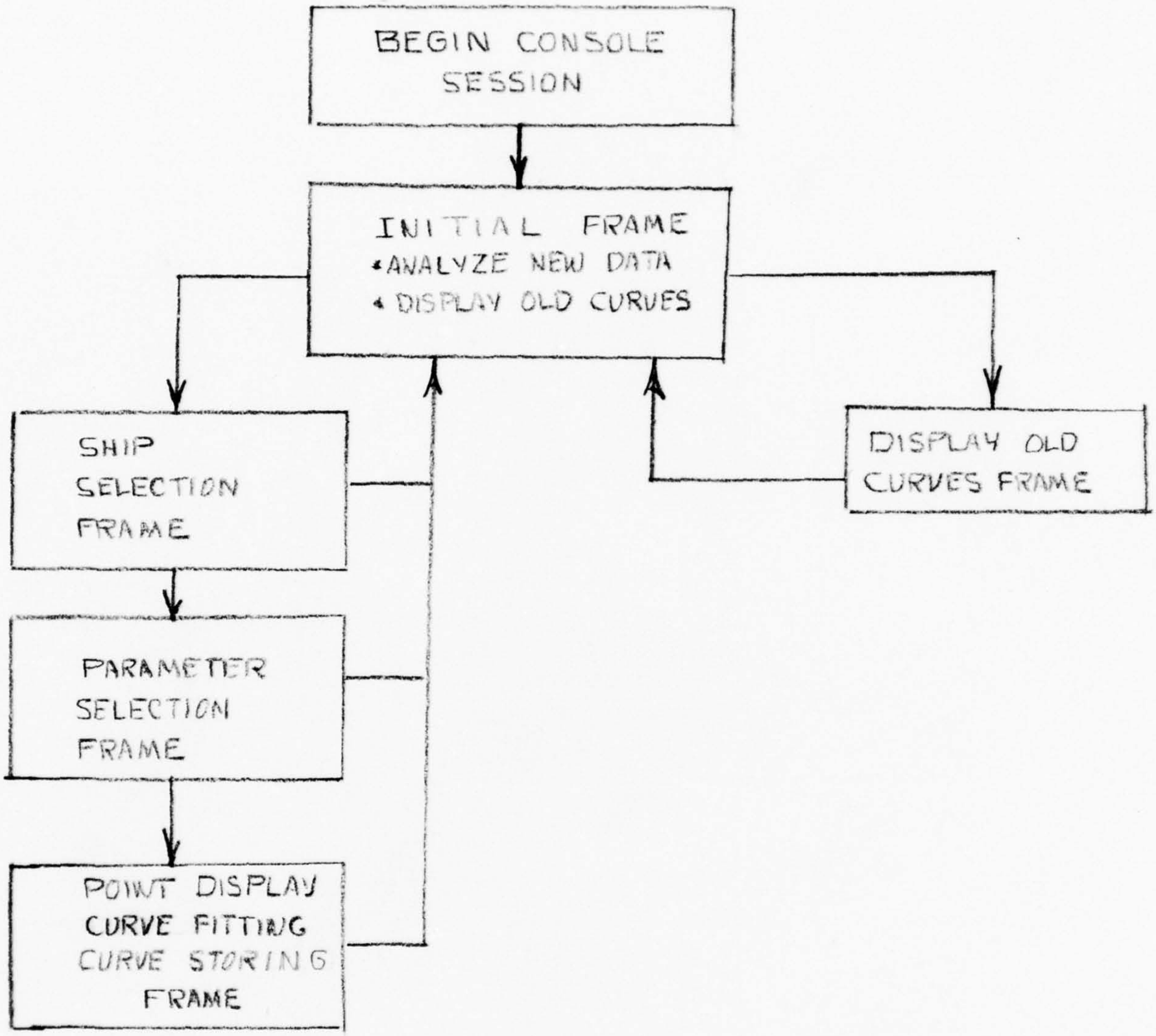
The light buttons of the Initial Frame perform the following functions:

* NEW DATA - Control is transferred to the Ship Selection Frame (Figure 5), after which the user normally proceeds to the Parameter Selection Frame and to the Point Display and Curve Fitting Frame. Parameter data from the card input deck is displayed and analyzed in these frames.

* OLD CURVES - Control is transferred to the Stored Curves Display Frame, wherein curves which have been previously fitted and stored are recalled for redisplay.

* ABORT - Picking the light button terminates the execution of IPAP. The *ABORT button remains displayed throughout the program and may be picked at any time.

* DUMP - This button will produce an octal dump of the program. The button must be picked twice in succession to effect



SEQUENCE OF PRINCIPAL IPAP DISPLAY FRAMES

FIGURE 3


DIM
INTERACTIVE PARAMETER ANALYSIS PROGRAM
ABORT
OLD CURVES
NEW DATA

FIGURE 4

its operation. The user is urged to exercise this capability if he should believe the program to be malfunctioning.

The pick should be made at whatever point in the program deviate behavior is observed, and the ensuing octal dump should be forwarded to DTNSRDC with a description of the observed problem.

When the *DUMP button is picked, the following light buttons are displayed:

*DUMP AND CONTINUE

*DUMP AND TERMINATE

The first button will, after the dump has been performed, return control to the program at the same point where *DUMP had been picked. The second button will terminate IPAP after the dump. In either case, when one of the two buttons is picked the message ENTER FIRST WORD is displayed, and a typing cursor is displayed at the bottom of the screen. The user must now type in a ten-character, right-justified octal core address at which the dump will start. To get a full dump, space over nine characters and type a one (1) in the last character of the cursor, and carriage return. The following message will appear:

ENTER LAST WORD, THEN MAKE NEXT PICK

The user must type another ten-character, right-justified octal address, representing the upper limit of the dump. For a full dump, space over four characters and type "100000", then carriage return. If the *DUMP AND TERMINATE option had been picked, the program will now terminate. If the *DUMP AND CONTINUE button had been picked, the user should now continue execution of the program.

B. SHIP SELECTION FRAME

All ships represented in the input card data are displayed as shown in Figure 5. The user may designate that all of these ships be represented in the ensuing analysis by picking the *ALL SHIPS light button. Alternatively, he may designate a subset of ships for analysis by picking their names. The names of picked ships are removed from the original list and redisplayed in the center of the display.

Picking either the *X AXIS or the *Y AXIS light button signifies that the list of ships is complete, and will transfer control to the Parameter Selection Frame.

C. PARAMETER SELECTION FRAME

In this display frame (Figures 6, 7, and 8) the construction of the display axes is accomplished. Having selected the X axis, for instance, a prompting message appears instructing the operator to select the parameter for the X axis. At this point a new list is displayed, containing the names of all known parameters for the selected ships. The operator selects one of the parameters, and the selected parameter name disappears from the selection list and appears along the X axis. The program examines all values of the X parameters found in the selected ships, and initially displays an X axis extending from the minimum to the maximum parameter value. This initial scale consists of tick marks and parameter values at the quarter points of the X axis. (See Figure 7)

Once the initial X scale has been displayed, the operator <u>must</u> select *Y AXIS button and designate another parameter for the Y axis. Note that the user is allowed to first designate the Y axis parameter and then the X parameter if he wishes. He may change the parameter or either axis by re-picking the appropriate button. Parameters assigned to either axis are removed from the parameter selection list.

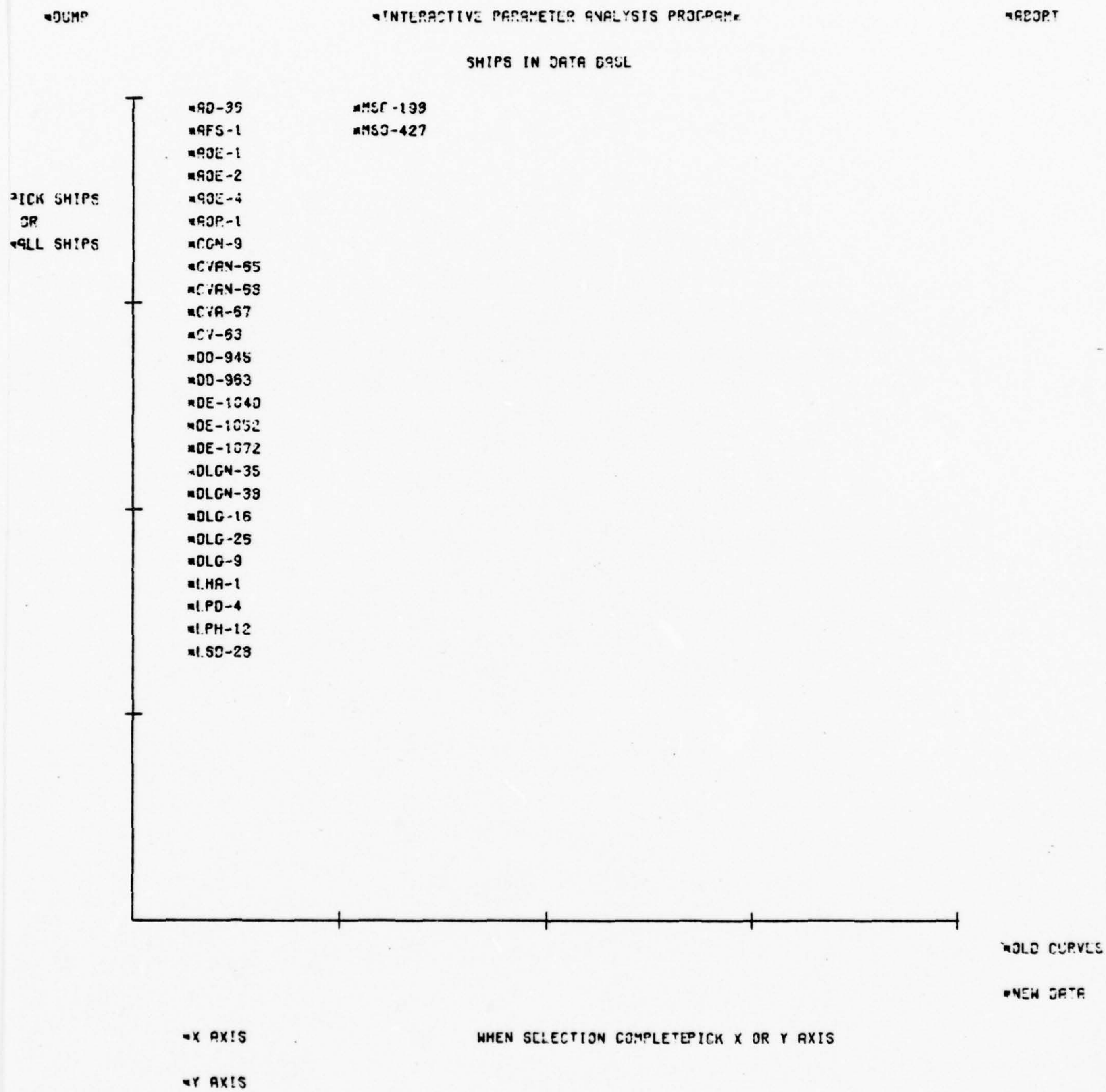

*DUMP
INTERACTIVE PARAMETER ANALYSIS PROGRAM
*ABORT
SHIPS IN DATA BASE
PICK SHIPS
OR
*ALL SHIPS
*AD-39
*AFS-1
*AOE-1
*AOE-2
*AOE-4
*AOR-1
*CGN-9
*CVAN-65
*CVAN-68
*CVA-67
*CV-63
*DD-945
*DD-963
*DE-1040
*DE-1052
*DE-1072
*DLGN-35
*DLGN-38
*DLG-16
*DLG-26
*DLG-9
*LHA-1
*LPD-4
*LPH-12
*LSD-28
*MSC-199
*MSO-427
*OLD CURVES
*NEW DATA
*X AXIS
*Y AXIS
WHEN SELECTION COMPLETEPICK X OR Y AXIS

FIGURE 5

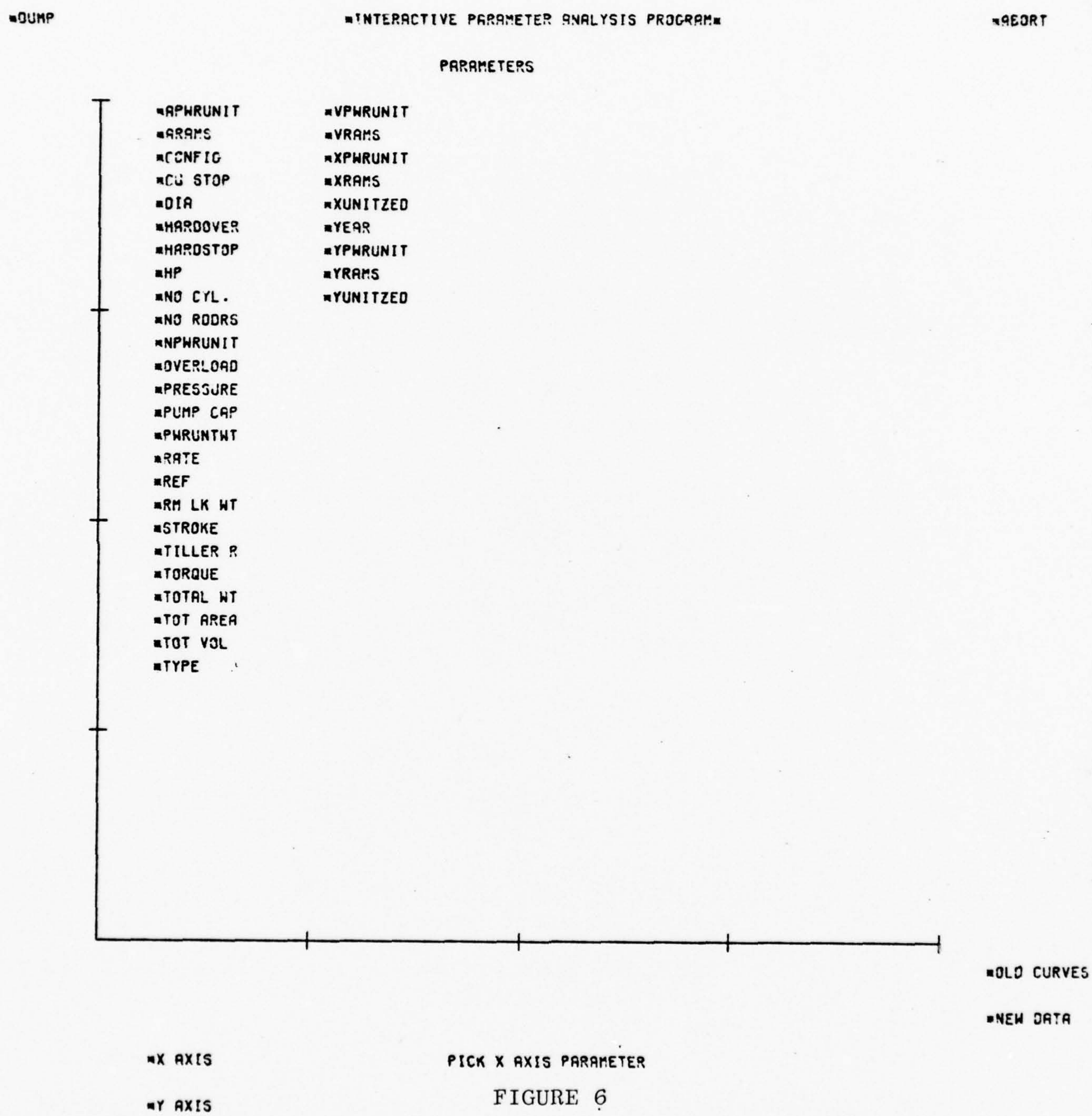

■DUMP
■INTERACTIVE PARAMETER ANALYSIS PROGRAM■
■ABORT
PARAMETERS
■APWRUNIT
■ARAMS
■CONFIG
■CU STOP
■DIA
■HARDOVER
■HARDSTOP
■HP
■NO CYL.
■NO RODRS
■NPWRUNIT
■OVERLOAD
■PRESSURE
■PUMP CAP
■PWRUNTWT
■RATE
■REF
■RM LK WT
■STROKE
■TILLER R
■TORQUE
■TOTAL WT
■TOT AREA
■TOT VOL
■TYPE
■VPWRUNIT
■VRAMS
■XPWRUNIT
■XRAMS
■XUNITZED
■YEAR
■YPWRUNIT
■YRAMS
■YUNITZED
■OLD CURVES
■NEW DATA
■X AXIS
PICK X AXIS PARAMETER
■Y AXIS

FIGURE 6

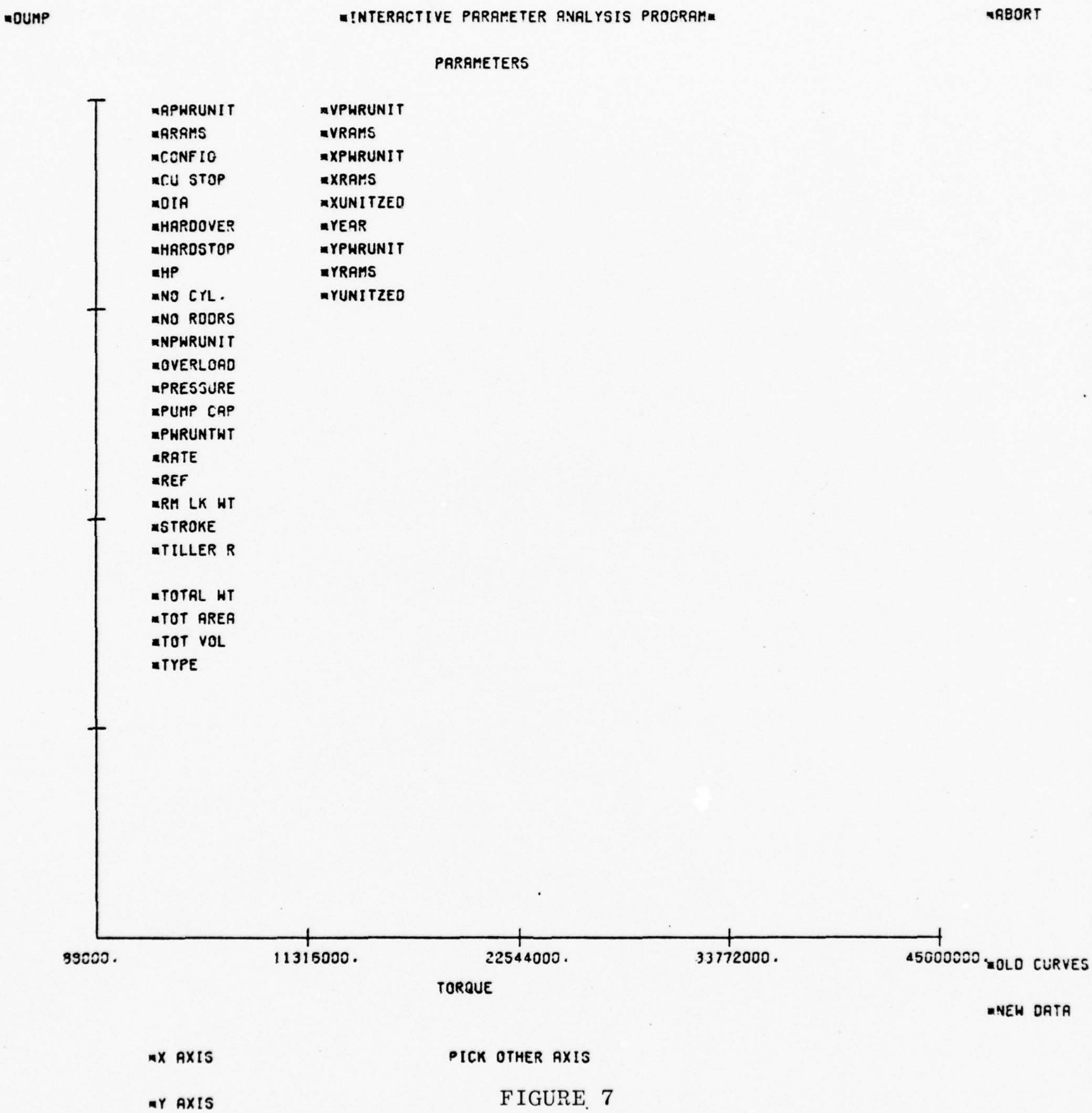

*DUMP
INTERACTIVE PARAMETER ANALYSIS PROGRAM
*ABORT
PARAMETERS
*APWRUNIT
*ARAMS
*CONFIG
*CU STOP
*DIA
*HARDOVER
*HARDSTOP
*HP
*NO CYL.
*NO RODRS
*NPWRUNIT
*OVERLOAD
*PRESSURE
*PUMP CAP
*PWRUNTWT
*RATE
*REF
*RM LK WT
*STROKE
*TILLER R
*TOTAL WT
*TOT AREA
*TOT VOL
*TYPE
*VPWRUNIT
*VRAMS
*XPWRUNIT
*XRAMS
*XUNITZED
*YEAR
*YPWRUNIT
*YRAMS
*YUNITZED
88000.
11316000.
22544000.
33772000.
45000000.
TORQUE
*OLD CURVES
*NEW DATA
*X AXIS
*Y AXIS
PICK OTHER AXIS

FIGURE 7

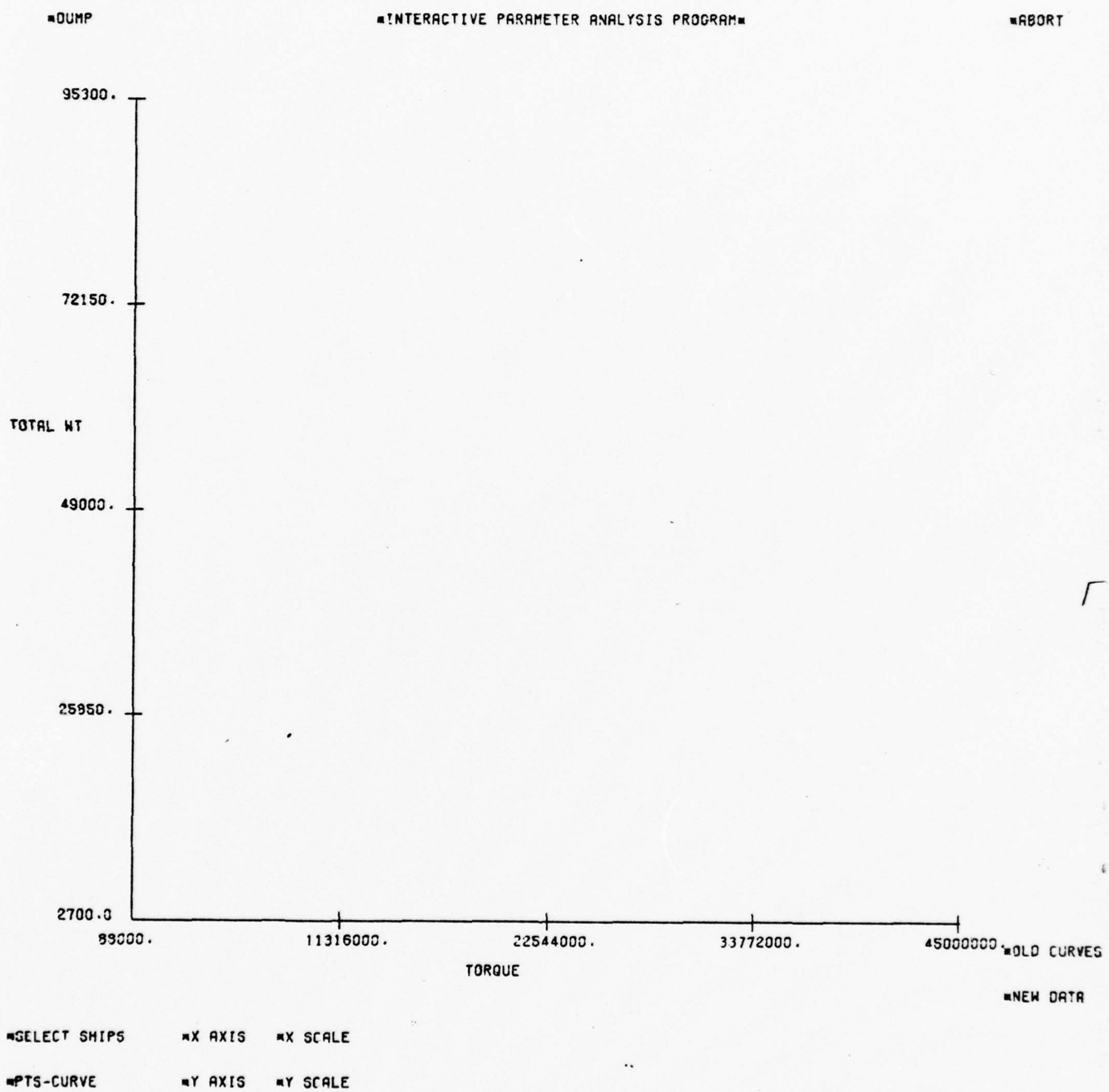

*DUMP
INTERACTIVE PARAMETER ANALYSIS PROGRAM
*ABORT
95300.
72150.
TOTAL WT
49000.
25950.
2700.0
89000.
11316000.
22544000.
33772000.
45000000.
TORQUE
*OLD CURVES
*NEW DATA
*SELECT SHIPS
*X AXIS
*X SCALE
*PTS-CURVE
*Y AXIS
*Y SCALE

FIGURE 8

The program, having recognized that parameters now have been chosen for both axes, proceeds to offer the operator the four new light buttons shown at the bottom of Figure 8 and discussed below.

*X SCALE, *Y SCALE - These buttons allow the user to override the default scales. Picking either button causes the following prompter to appear:

TYPE IN "MINVALUE" COMMA "MAXVALUE" COMMA "NUMBER OF TICKS" RETURN

The operator types the minimum and maximum values he desires, each followed by a comma, and the number of divisions (number of ticks minus 1) desired along the entire length of the axis. (It is recommended that the number of divisions be a multiple of four, to align ticks with the large ticks at the quarter points which remains in the display.) Typical typed input is shown below:

0,100,20 (PUSH RETURN BUTTON)

This input would result in a minimum scale value of 0, a maximum scale value of 100, and 5 divisions in each quarter of the axis. A maximum of 40 ticks per axis may be selected.

*SELECT SHIPS - This button returns the program to the Ship Selection Frame, allowing the operator to re-select ships but without causing him to sequence through all the steps previously explained. Designations of parameter axes and scale tick marks remain valid. Only the set of ships to be analyzed will be changed, as directed by the operator. The re-selection of ships allows the user to "remove" any displayed data points not desired for curve fit.

*PTS CURVE - This button must be selected to proceed to the curve fitting feature of IPAP. Selecting this button indicates that all adjustments to the axes are completed.

D. POINT DISPLAY AND CURVE FITTING FRAME

Selection of the *PTS CURVE light button will produce a display similar to the one in Figure 9. Data points are displayed as small triangles, and each point is annotated with the name of the ship it represents. Additional light buttons are also displayed, which perform the functions described below.

*LIN - Picking the button will cause a first order (linear) least square curve to be fitted to the data points, and the curve will be displayed. The linear equation of the curve will appear at the top of the screen. Successive additional picks of the *LIN button will cause the linear curve and equation to alternately disappear and reappear.

*PAR, *CUB, *QUR - These buttons control the fitting and display of parabolic, cubic, and quartic least-square polynomials. Their operation is similar to that of *LIN.

*EXP - This button controls the fitting and display of a least-square exponential curve of the form

$$Y = A \div Be^{CX}$$

The operation of the *EXP button is similar to that of *LIN.

Any combination of the five curves may be displayed at a given time. (Figure 10 illustrates the simultaneous display of the parabolic and cubic

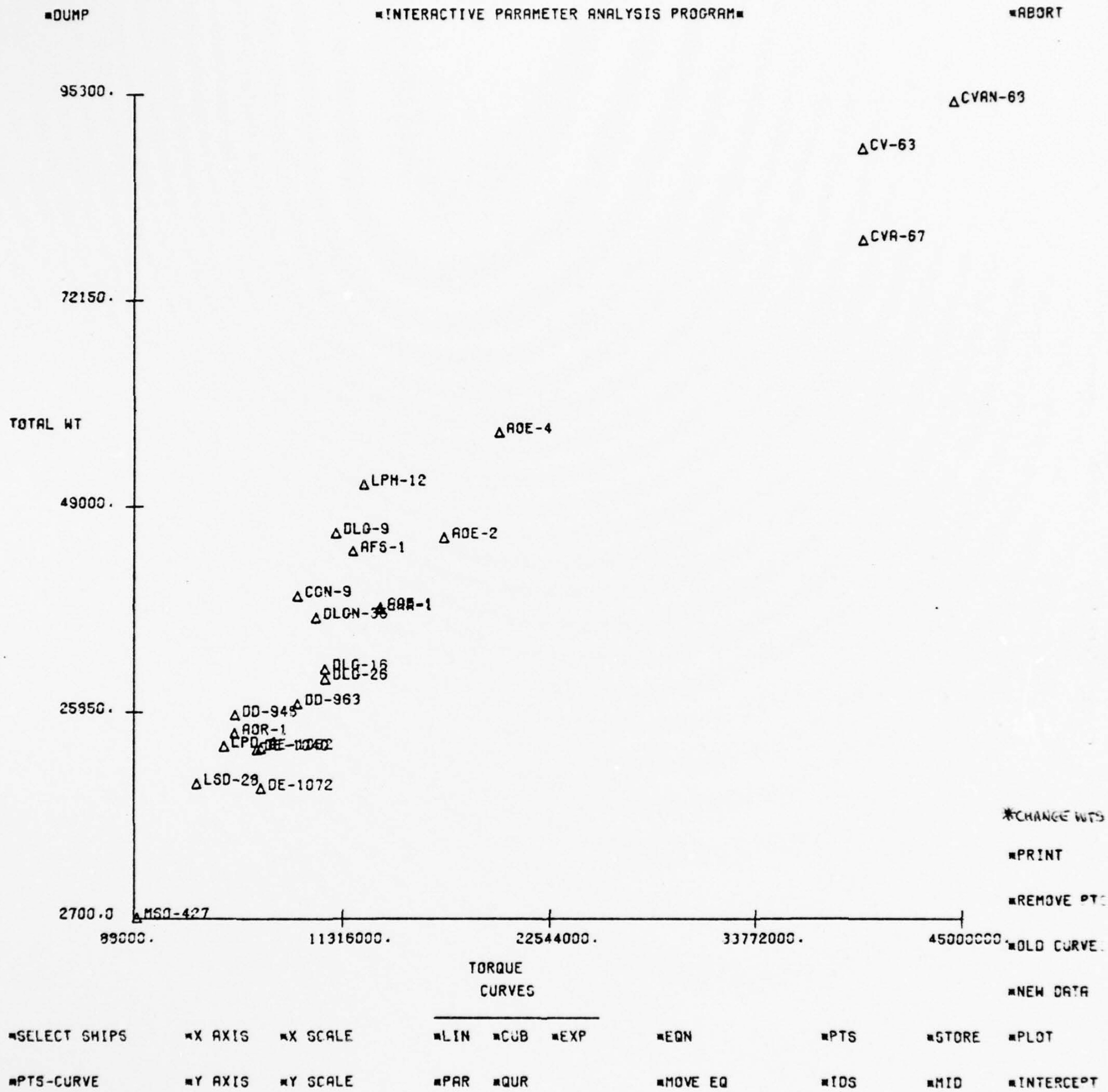

*DUMP
INTERACTIVE PARAMETER ANALYSIS PROGRAM
*ABORT
95300.
72150.
49000.
25950.
2700.0
TOTAL WT
CVAN-63
CV-63
CVA-67
AOE-4
LPH-12
DLG-9
AOE-2
AFS-1
CGN-9
DLGN-36
DLG-16
DLG-26
DD-963
DD-945
AOR-1
LSD-28
DE-1072
MSO-427
89000.
11316000.
22544000.
33772000.
45000000.
TORQUE
CURVES
*CHANGE WTS
*PRINT
*OLD CURVE
*NEW DATA
*SELECT SHIPS
*X AXIS
*X SCALE
*LIN
*CUB
*EXP
*EQN
*PTS
*STORE
*PLOT
*PTS-CURVE
*Y AXIS
*Y SCALE
*PAR
*QUR
*MOVE EQ
*IDS
*MID

FIGURE 9

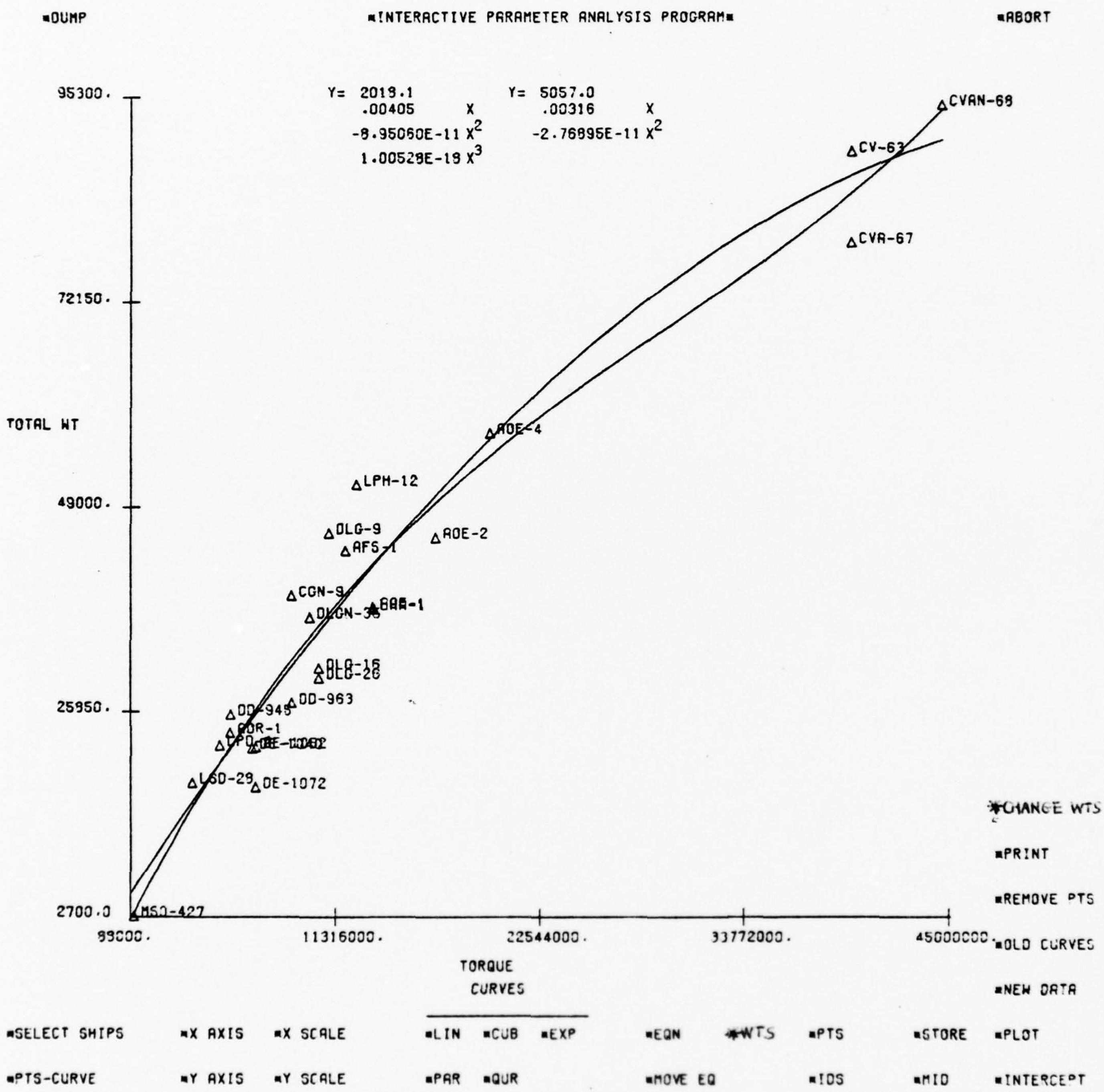

*DUMP
INTERACTIVE PARAMETER ANALYSIS PROGRAM
*ABORT
Y= 2019.1
.00405 X
-8.95060E-11 X2
1.00529E-19 X3
Y= 5057.0
.00316 X
-2.76895E-11 X2
95300.
72150.
49000.
25950.
2700.0
TOTAL WT
CVAN-68
CV-63
CVA-67
AOE-4
LPH-12
DLG-9
AFS-1
AOE-2
CGN-9
DLGN-36
DLG-16
DLG-26
DD-963
DD-945
AOR-1
DE-1072
MSO-427
93000.
11316000.
22544000.
33772000.
45000000.
TORQUE
CURVES
*CHANGE WTS
*PRINT
*REMOVE PTS
*OLD CURVES
*NEW DATA
*SELECT SHIPS
*X AXIS
*X SCALE
*LIN
*CUB
*EXP
*EQN
*WTS
*PTS
*STORE
*PLOT
*PTS-CURVE
*Y AXIS
*Y SCALE
*PAR
*QUR
*MOVE EQ
*IDS
*MID
*INTERCEPT

FIGURE 10

curves.) Note that the terms of each equation are arranged vertically, and that negative terms are explicitly denoted by a minus sign (-) but that positive terms are not preceded by a plus sign (+).

*EQN - Picking this button causes all equations to be removed from the display, Successive additional picks of *EQN will cause the equations to alternately disappear and reappear.

*MOVE EQ - This button allows the user to move equations to a different position in the display. When *MOVE EQ is selected, a prompter appears instructing the user to pick the equation he wishes to move. When the equation has been picked, a tracking cross appears at the beginning of the equation, and a new button *ACC is displayed near the bottom of the screen. Using the light pen, the operator picks the cross and "drags" it across the screen to the position where he would like to see the equation Having positioned the cross, the operator must now select the *ACC Button at the bottom of the screen. The equation selected will now disappear from its present location and reappear at the new location.

*PTS - Picking this button removes the points and ship ID's from the display. Successive picks of *PTS alternately redisplay and remove these items.

*IDS - Picking this button removes the ship ID's from the display. Successive picks of *IDS alternately redisplay and remove the ID's. It is not possible, however, to display IDs unless the points are also in display status.

*PLOT - Picking this button will produce a CALCOMP plot of the current display, except that all light buttons will be edited out of the plot.

*INTERCEPT - The user may request interpolations for values on either axis of any displayed curve by selecting the *INTERCEPT button. When the *INTERCEPT button is picked the following prompter is displayed:

PICK EQUATION OF CURVE TO BE INTERPOLATED

(If no equation is in display at the time INTERCEPT is selected, the equations will automatically appear. If only one equation is in display, the above prompter will be omitted and it is assumed that this equation is the one to be interpolated.)

After the equation has been determined, another prompter appears:

TYPE X OR Y AND CARRIAGE RETURN
TYPE VALUES OF X OR Y SEPARATED BY
COMMAS (MAX 5 VALUES) AND C. R.

The user types in X if he wants to enter X values for interpolation of Y values, or Y if he wants to enter Y values, and types the carriage return. The first part of the prompter message will disappear and the user must type from one to five values for interpolation. When the user again types the carriage return, the values given and the corresponding interpolated values will appear under the equation. Interpolation of X given Y for paraboles, cubics and quarters will, in general, result in two, three, or four interpolated values which will be displayed in tabular form. Note that all mathematical interpolations will be computed and displayed, including those on portions of the curve which are beyond the X-Y limits of the display.

Interpolated values will be hidden and redisplayed along with the equations via the *EQ light button. Interpolated values are permanently erased when the corresponding equation is moved.

*STORE - This button allows fitted curves to be stored on a permanent disk file for subsequent redisplay. When this button is selected a prompter appears just over the button directing the operator to PICK EQUATION. The operator is to then select the equation of the curve he wishes to store. After selecting the equation a prompted appears at the top of the screen directing the operator to type in a 10-or-less character alphanumeric label which will subsequently be used to recall the curve.

*MID - This button allows the user to adjust the location of ship ID's, employing the tracking cross similar to moving equation. (See above explanation of *MOVE EQ.)

*REMOVE PTS - This button allows the operator to remove any displayed points from the set of selected ships being displayed. When the *REMOVE PTS button is selected a prompter appears stating,

SELECT POINT IDs
*RETURN

The operator then picks the point IDs of the points he wishes to remove. When the selection is complete the operator picks the *RETURN button. The program now automatically removes the points selected and recalculates and redisplays any curves that were in display at the time the *REMOVE PTS button was selected.

*PRINT - This button causes all mathematical information (axis parameters, data point IDs and coordinates, and display of equations) which is displayed at the time of selecting the *PRINT BUTTON to be printed by the printer at the end of the scope session. *PRINT button may be selected any number of times.

*CHANGE WTS - This button permits the operator to type in a single weight value which can be assigned to any or many of the displayed points. When the *CHANGE WTS button is selected a prompter appears stating,

TYPE IN VALUE OF POINT WEIGHT AND CARRIAGE RETURN
THEN SELECT POINT OR POINTS TO BE WEIGHTED
*RETURN

The operator will then type the value of the point weight, execute the carriage return and then select the IDs of the points to be weighted. When the selection is complete the operator selects the *RETURN button.

When the *RETURN button is selected all curves, equations, and interpolated values in display will be removed. The curves and equations will be recalculated but any interpolated values in display will be removed. The current weight value will be displayed under each point selected for weighting. The weight values can not be moved with their associated IDs. If the *SELECT SHIPS button is chosen the current weight factor will be eliminated and all assignments of it will be canceled. That is, all weights are reset to one (1) as they are initially.

*WTS - This button is an "on-off" switch which permits the operator to display or hide any point weights greater than one. This button is not displayed until the *CHANGE WTS button is used.

E. DISPLAY OLD CURVES FRAME

In this frame the user may display any curves which have previously been fitted and stored by IPAP. Up to seven curves may be displayed simultaneously.

This frame is entered when the user picks the *DISPLAY OLD CURVES light button in the initial IPAP frame. The tutorial TYPE DESIRED CURVE LABEL instructs the user to identify the curve he wants displayed. The label is a ten-or-less character alphanumeric identifier assigned by the user when the curve was stored. When the user types a valid curve label and carriage return, the curve will be displayed at an appropriate scale, the axes will be labeled with the correct parameter names, the curve label will be displayed near the center of the curve, and a number of new light buttons are displayed for the exercise of other options. (See Figure 11).

If the user types a label for a non-existent curve, the following message and options will be displayed:

LABEL NOT FOUND
BAD LABEL

*TRY AGAIN
*ABORT
*ANALYZE NEW DATA

Picking the *TRY AGAIN button allows the user to enter another label. the *ABORT button will terminate IPAP. *ANALYZE NEW DATA will transfer control to the Ship Selection Frame to allow analysis of data from card input.

The light buttons displayed when a valid curve is displayed perform the following functions:

*ERASE AXES AND CURVES - This light button removes from display all curves, labels and parameter names. If another curve is subsequently displayed, scaling on both axes will be as determined by the new curve.

*ERASE ALL CURVES - All displayed curves and their axes will be removed from display. Axis parameter names and scaling from the removed curves will be retained for subsequent curves.

*ERASE A CURVE - Selected curves and their labels may be removed from display with this light button. The following message and light button are displayed:

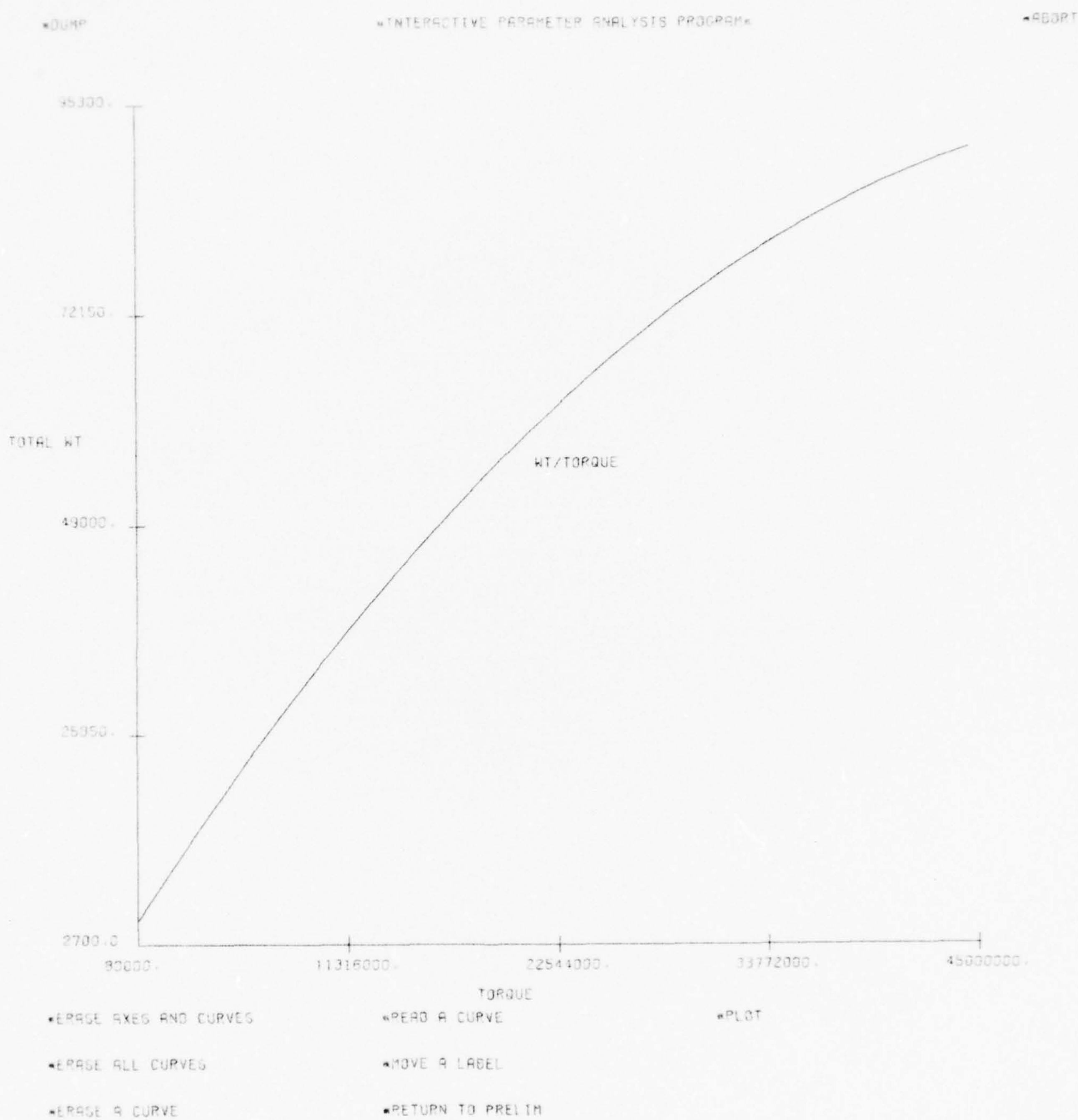

*DUMP
INTERACTIVE PARAMETER ANALYSIS PROGRAM
*ABORT
95300.
72150.
TOTAL WT
WT/TORQUE
49000.
25850.
2700.0
80000.
11316000.
22544000.
33772000.
45000000.
TORQUE
*ERASE AXES AND CURVES
*READ A CURVE
*PLOT
*ERASE ALL CURVES
*MOVE A LABEL
*ERASE A CURVE
*RETURN TO PRELIM

FIGURE 11

PICK CURVE(S)
OR
*DONE

The user then picks one or more curves with the light pen, and picks *DONE when he has removed the desired curve(s).

*READ A CURVE - This button is not displayed if the maximum seven curves are already in display. When this button is picked the user will be prompted to type the label of another curve to be added to the display. If the axis parameter names of the new curve are identical with those of curve(s) currently displayed, the new curve will be superimposed on the existing display at the same scale as the other curve(s). If the axis parameter names of the new and old curves are not identical, the following message and light buttons are displayed:

NEW $\begin{pmatrix}X\\Y\end{pmatrix}$ DIFFERS FROM OLD $\begin{pmatrix}X\\Y\end{pmatrix}$

NEW $\begin{pmatrix}X\\Y\end{pmatrix}$ AXIS LABEL IS parameter name

*READ A CURVE

*ERASE AXES AND CURVES

*DISPLAY ANYWAY

When the *READ A CURVE button is picked, the user is indicating he will abandon display of the curve, and wants to name another curve for display. The *ERASE AXES AND CURVES will remove all existing curves and display the new curve with its parameters as if it were the first curve to be displayed. By picking the *DISPLAY ANYWAY button the user forces superposition of the new curve in spite of the difference of axis parameter names, and he must accept responsibility for integrity of the composite display. When this override option is exercised, the new curve is assumed to represent the same units on the respective axes as the existing curves, and is scaled accordingly.

*MOVE LABELS - This light button allows the user to reposition labels in the display. The following message and light button are displayed:

PICK LABEL
OR
*DONE

The user picks a label with the light pen, and the tracking cross will appear in front of that label and a new light button *ACC will appear at the bottom of the screen. With the light pen the user must "drag" the tracking cross to the new location, then pick *ACC, at which time the label will be redisplayed alongside the tracking cross. In a like manner other labels may be repositioned. The user must pick *DONE when all desired labels have been adjusted.

*PLOT - Picking this button will produce a CALCOMP plot of the current display, except that all light buttons will be edited out of the plot.

IV. USE OF IPAP FOR GENERAL DATA DISPLAY AND CURVE FITTING

IPAP has been developed toward the primary goal of analyzing parametric design data taken from a group of ships. However, its data point display and curve fitting capabilities have been productively used for other applications. Such "off-design" use of the program requires of the user a better understanding of the data used by IPAP, that he interpret the corresponding terminology (ship name, parameter name) used in this user's manual, and that he use some creativity and insight in setting up his application of the program.

Appendix D gives two examples which demonstrate use of the program for applications other than ship parameter analysis.

V. FUTURE ENHANCEMENTS

The IPAP program shows promise of being useful in a variety of design problems involving the plotting of data and the fitting of curves. It has already been used in perhaps half a dozen pilot problems of diverse nature, which have identified additional capabilities which would make IPAP more useful. Some of the possible future capabilities are described below:

- The X and Y axes may be designated to represent algebraic functions of data parameters.
- The program would report to the user a parameter indicative of the "goodness of fit" of fitted curves.
- The user may input descriptive titles for curves, which would be sorted with the curve for future display and editing.
- The operation of IPAP on minicomputer and storage tubes will be investigated.
- Stored curve labels could be displayed, and curves might be displayed when labels are picked with the light pen.

```
   JOB CARD (CM75000)
   CHARGE CARD
1  REQUEST,TAPE30,*PF.
2  ATTACH,TEMP,olddatafilename,ID=userid.
2  COPYCF(TEMP,TAPE30,1)
2  REWIND,TAPE30.
   ATTACH,DIXON,CADXNAVISK,ID=CADX.
   COPYCR,INPUT,TAPE31.
   REWIND,TAPE31.
   DIXON.

   EXIT(U)
   CATALOG,TAPE30,olddatafilename,ID=userid,AC=accountnumber.
2  PURGE(TEMP)
   REWIND,TAPE30.                  {OPTIONAL TO PRINT CONTENTS
   COPYSBF(TAPE30,OUTPUT)          {OF OLDDATAFILE
   ROUTE,PLOT,DC=PT.
   7/8/9

   SHIP PARAMETER DATA

   7/8/9

   AUXILIARY DATA

   6/7/8/9
```

1 = THIS CARD IS REQUIRED IF A NEW OLDDATAFILE IS TO BE CREATED WITH THE RUN

2 = THESE CARDS ARE REQUIRED IF AN EXISTING OLDDATAFILE IS TO BE USED WITH THE RUN

Figure A-1 IPAP Control Cards for Hardcopy Plots on NAVSEC's CALCOMP Plotter

```
    JOB CARD (CM75000)
    CHARGE CARD
    PURGE,DUMA,CADXPLT,ID=CADX.
1   REQUEST,TAPE30,*PF.
    REQUEST,TAPE10,*PF.
2   ATTACH,TEMP,olddatafilename,ID=userid.
2   COPYCF(TEMP,TAPE30,1)
2   REWIND,TAPE30.
    ATTACH,DIXON,CADXIPAPTSK,ID=CADX.
    COPYCR,INPUT,TAPE31.
    REWIND,TAPE31.
    DIXON.
    EXIT(U)
    CATALOG,TAPE30,olddatafilename,ID=userid,AC=accountnumber.
    PURGE(TEMP)
    REWIND,TAPE30.
    COPYSBF(TAPE30,OUTPUT)
    REWIND,TAPE10.
    CATALOG,TAPE10,CADXPLT,ID=CADX,AC=accountnumber.
    ROUTE,PLOT,DC9
    7/8/9

     SHIP PARAMETER DATA

    7/8/9

     AUXILIARY DATA

    6/7/8/9
```

1 = THIS CARD IS REQUIRED IF NEW OLDDATAFILE IS TO BE CREATED.

2 = THESE CARDS ARE REQUIRED IF AN EXISTING OLDDATAFILE IS TO BE USED WITH THE RUN.

Figure A-2 IPAP Control Cards Which Produce Cataloged Plot File to be Plotted at DTNSRDC

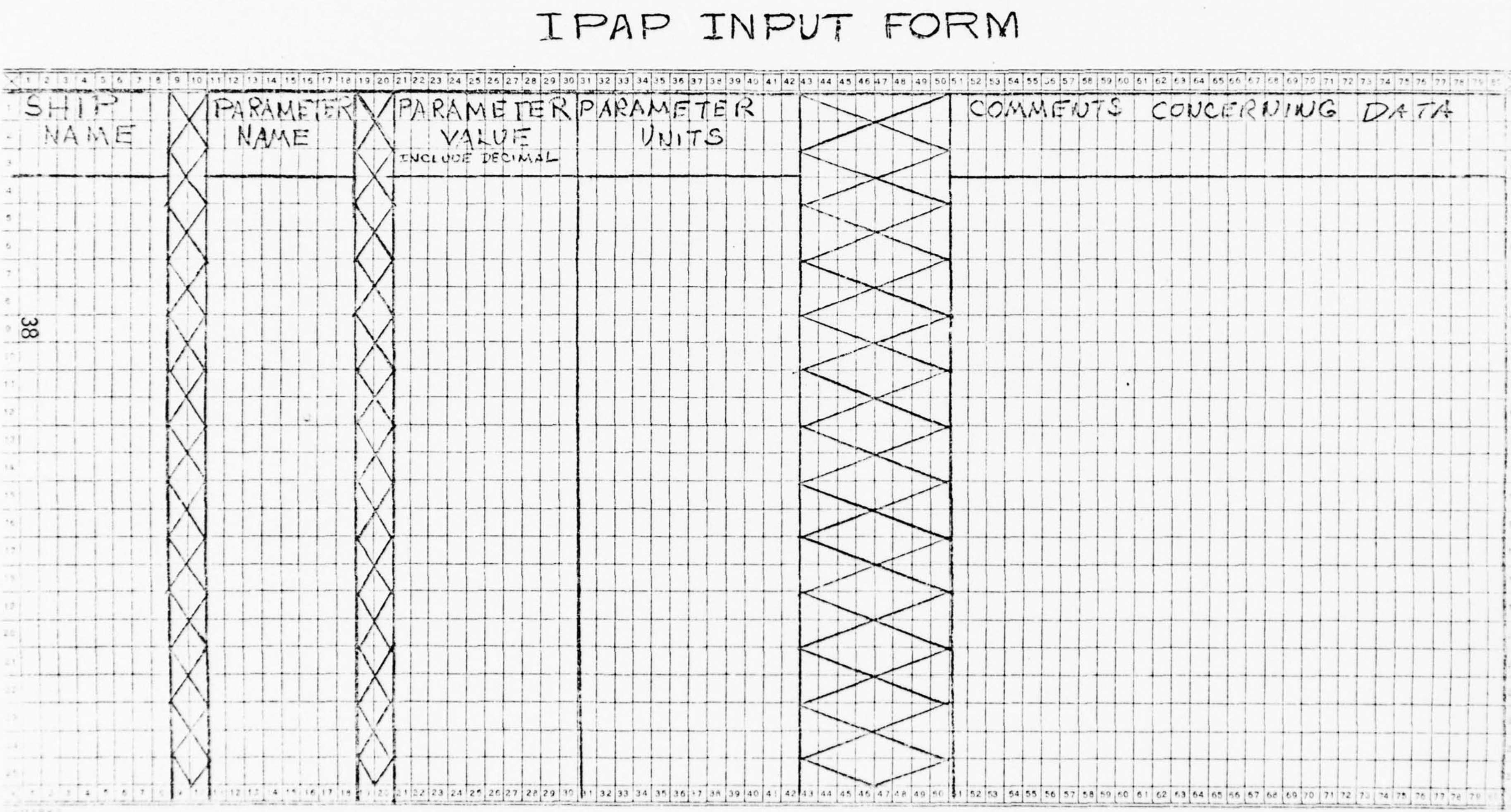
APPENDIX A

```
JOB CARD    (CM6000,MT1)
CHARGE CARD
VSN,TAPE11=SLOT27=CADX27.
REQUEST,TAPE11,HI.      SLOT27/CADX27/RING)
ATTACH,CADXPLT,ID=CADX.
COPYBF(CADXPLT,TAPE11,5)
REWIND,TAPE11.
6/7/8/9/
```

Batch Control Cards to Plot Cataloged
Plot File at DTNSRDC

FIGURE A-3

APPENDIX B


IPAP INPUT FORM
SHIP NAME
PARAMETER NAME
PARAMETER VALUE
INCLUDE DECIMAL
PARAMETER UNITS
COMMENTS CONCERNING DATA

APPENDIX C - Sample Ship Parameter Printout

INTERACTIVE PARAMETER ANALYSIS PROGRAM

INPUT AS READ

SHIP NAME	PARAMETER NAME	PARAMETER VALUE	PARAMETER UNITS	ENGINEERING COMMENTS
AD-36	YEAR	1945.00		HYDE WINDLASS
AD-36	CONFIG	2.00SEPERATE		
AD-36	TYPE	1.00RAPSON		
AD-36	NO RDORS	1.00		
AD-36	PRESSURE	1500.00		
AD-36	TORQUE	3125000.00		CAL PRES TILLER
AD-36	RATE	2.33		
AD-36	HARDOVER	35.00		
AD-36	CU STOP	35.95		
AD-36	HARDSTOP	37.00		
AD-36	NPWRUNIT	2.00		
AD-36	HP	40.00		WESTINGHOUSE
AD-36	OVERLOAD	150.00		
AD-36	NO CYL.	4.00		
AD-36	DIA	9.00		
AD-36	STROKE	37.68		
AD-36	PUMP CAP	57.50		600RPM WATERBURY SIZE 5
AD-36	TILLER R	25.00		
AD-36	XRAMS	12.92		
AD-36	YRAMS	8.35		
AD-36	ZRAMS	2.75		
AD-36	ARAMS	107.91		
AD-36	VRAMS	296.75		
AD-36	XPWRUNIT	5.82		
AD-36	YPWRUNIT	10.85		
AD-36	ZPWRUNIT	6.58		TANK ABOVE
AD-36	APWRUNIT	63.15		
AD-36	VPWRUNIT	415.51		
AD-36	TOT AREA	171.06		
AD-36	TOT VOL	712.26		
AD-36	REF	15.00		TECH MAN NAVSHIPS 3220093
AFS-1	YEAR	1963.00		BALDWIN-LIMA-HAMILTON
AFS-1	CONFIG	2.00SEPERATE		
AFS-1	TYPE	1.00RAPSON		
AFS-1	NO RDORS	1.00		
AFS-1	PRESSURE	1600.00		
AFS-1	TORQUE	12000000.00		
AFS-1	RATE	2.33		
AFS-1	HARDOVER	35.00		
AFS-1	CU STOP	37.00		
AFS-1	HARDSTOP	38.00		
AFS-1	NPWRUNIT	2.00		
AFS-1	HP	75.00		RELIANCE
AFS-1	OVERLOAD	150.00		
AFS-1	NO CYL.	4.00		
AFS-1	DIA	11.50		
AFS-1	STROKE	23.44		
AFS-1	PUMP CAP	95.00		DENISON SERIES 40
AFS-1	TILLER R	30.00		
AFS-1	XRAMS	8.46		

APPENDIX C - Sample Ship Parameter Printout (Continued)

INTERACTIVE PARAMETER ANALYSIS PROGRA

INPUT SORTED BY SHIP BY PARAMETER

SHIP NAME	PARAMETER NAME	PARAMETER VALUE	PARAMETER UNITS	ENGINEERING COMMENTS
AD-36	APWRUNIT	63.15		
AD-36	ARAMS	107.91		
AD-36	CONFIG	2.00	SEPERATE	
AD-36	CU STOP	35.95		
AD-36	DIA	9.00		
AD-36	HARDOVER	35.00		
AD-36	HARDSTOP	37.00		
AD-36	HP	40.00		WESTINGHOUSE
AD-36	NO CYL.	4.00		
AD-36	NO RODRS	1.00		
AD-36	NPWRUNIT	2.00		
AD-36	OVERLOAD	150.00		
AD-36	PRESSURE	1500.00		
AD-36	PUMP CAP	57.50		600RPM WATERBURY SIZE 5
AD-36	RATE	2.33		
AD-36	REF	15.00		TECH MAN NAVSHIPS 322009
AD-36	STROKE	37.68		
AD-36	TILLER R	25.00		
AD-36	TORQUE	3125000.00		CAL PRES TILLER
AD-36	TOT AREA	171.06		
AD-36	TOT VOL	712.26		
AD-36	TYPE	1.00	RAPSON	
AD-36	VPWRUNIT	415.51		
AD-36	VRAMS	296.75		
AD-36	XPWRUNIT	5.82		
AD-36	XRAMS	12.02		
AD-36	YEAR	1945.00		HYDE WINDLASS
AD-36	YPWRUNIT	10.85		
AD-36	YRAMS	8.35		
AD-36	ZPWRUNIT	6.58		TANK ABOVE
AD-36	ZRAMS	2.75		
AFS-1	APWRUNIT	51.95		
AFS-1	ARAMS	136.80		
AFS-1	CONFIG	2.00	SEPERATE	
AFS-1	CU STOP	37.00		
AFS-1	DIA	11.50		
AFS-1	HARDOVER	35.00		
AFS-1	HARDSTOP	38.00		
AFS-1	HP	75.00		RELIANCE
AFS-1	NO CYL.	4.00		
AFS-1	NO RODRS	1.00		
AFS-1	NPWRUNIT	2.00		
AFS-1	OVERLOAD	150.00		
AFS-1	PRESSURE	1500.00		
AFS-1	PUMP CAP	86.00		DENISON SERIES 40
AFS-1	PWRUNTWT	14500.00		WET
AFS-1	RATE	2.33		
AFS-1	REF	11.00		TECH MAN NAVSHIPS 322037
AFS-1	RN&LK WT	29950.00		WET
AFS-1	STROKE	23.44		

APPENDIX C - Sample Ship Parameter Printout (Continued)

INTERACTIVE PARAMETER ANALYSIS PROGRAM

INPUT SORTED BY PARAMETER BY SHIP

SHIP NAME	PARAMETER NAME	PARAMETER VALUE	PARAMETER UNITS	ENGINEERING COMMENTS
AD-36	APWRUNIT	63.15		
AFS-1	APWRUNIT	51.95		
CGN-9	APWRUNIT	79.62		
CVAN-65	APWRUNIT	75.03		TOTAL NEEDED FOR 1 ROOR
CVAN-68	APWRUNIT	133.00		EST.X
CVA-67	APWRUNIT	160.88		
CV-63	APWRUNIT	157.92		
DD-945	APWRUNIT	82.18		
DD-963	APWRUNIT	46.82		
DE-1040	APWRUNIT	25.13		
DE-1052	APWRUNIT	47.86		
DE-1072	APWRUNIT	48.39		
DLGN-35	APWRUNIT	61.17		
DLGN-38	APWRUNIT	61.56		
DLG-16	APWRUNIT	69.14		
DLG-26	APWRUNIT	69.14		
DLG-9	APWRUNIT	86.45		
LPD-4	APWRUNIT	42.25		
LSD-28	APWRUNIT	40.23		
MSC-198	APWRUNIT	4.49		
MSO-427	APWRUNIT	13.25		
AD-36	ARAMS	107.91		
AFS-1	ARAMS	136.80		
CGN-9	ARAMS	140.61		
CVAN-65	ARAMS	238.08		
CVAN-68	ARAMS	250.50		
CVA-67	ARAMS	225.40		
CV-63	ARAMS	238.49		
DD-945	ARAMS	109.15		
DD-963	ARAMS	86.19		
DE-1040	ARAMS	116.89		
DE-1052	ARAMS	98.99		
DE-1072	ARAMS	123.30		
DLGN-35	ARAMS	157.74		
DLGN-38	ARAMS	172.26		
DLG-16	ARAMS	124.78		
DLG-26	ARAMS	124.78		
DLG-9	ARAMS	186.87		
LPD-4	ARAMS	179.62		
LSD-28	ARAMS	121.15		
MSC-198	ARAMS	30.49		
MSO-427	ARAMS	30.33		
AD-36	CONFIG	2.00SEPERATE		
AFS-1	CONFIG	2.00SEPERATE		
AOE-1	CONFIG	1.00UNITIZED		
AOE-2	CONFIG	1.00UNITIZED		
AOE-4	CONFIG	1.00UNITIZED		
AOR-1	CONFIG	2.00SEPERATE		
CGN-9	CONFIG	2.00SEPERATE		
CVAN-65	CONFIG	2.00SEPERATE		

APPENDIX D

USE OF IPAP FOR GENERAL DATA DISPLAY AND CURVE FITTING

Figures D-1, D-2 and D-3 present, respectively, a problem formulation, the corresponding IPAP input data and the resulting plot in which IPAP was used to fit a polynomial curve to a series of points in two dimensions. Note that each data point is "named" not as a ship, but with a unique point identifier; the names selected may be any eight-or-less character IDs, but each point must have a unique name. Note that there are two data cards for each point, both of which reflect the point name, and each with a corresponding parameter name and parameter value.

In a separate atypical application,* IPAP was effectively used to compute the polynomial coefficients for a family of Bonjean curves, representing sectional areas on twenty-five offset stations of three related hullforms. Furthermore, unusual requirements of the user demanded:

- that there be two Bonjeans for each station - one above the design waterline and one below,
- that these curves be transformed to define sectional area as a function of distance from the design waterline instead of from the baseline, and
- that the curves be normalized with respect to the maximum section area and to the design draft.

The computation, transformation, and normalization of the curves was performed prior to preparing IPAP data.

*See "LX Synthesis Model Hullform Development", TM-185-76-11, by O. Stephans and B. Thomson, DTNSRDC, February 1976.

GIVEN: Table of values for variables A and B shown below:

Data Point #	1	2	3	4	5	6	7	8
A	5.	20.	40.	60.	62.	79.	95.	96.
B	50.	32.	63.	102.	146.	193.	275.	328.

REQUIRED: Fit a parabola to the above data and determine the coefficients C_o, C_1, and C_2 of the equation:

$$B=C_o+C_1A+C_2A^2$$

Figure D-1 Problem Statement for Simple 2-D Curve Fit

CC 1	11	21	31
POINT1	A	5.	FT
POINT2	A	20.	FT
POINT3	A	40.	FT
POINT4	A	60.	FT
POINT5	A	62.	FT
POINT6	A	79.	FT
POINT7	A	95.	FT
POINT8	A	96.	FT
POINT1	B	50.	LBS
POINT2	B	32.	LBS
POINT3	B	63.	LBS
POINT4	B	102.	LBS
POINT5	B	146.	LBS
POINT6	B	193.	LBS
POINT7	B	275.	LBS
POINT8	B	328.	LBS

Figure D-2 Input Data for Polynomial Curve Example

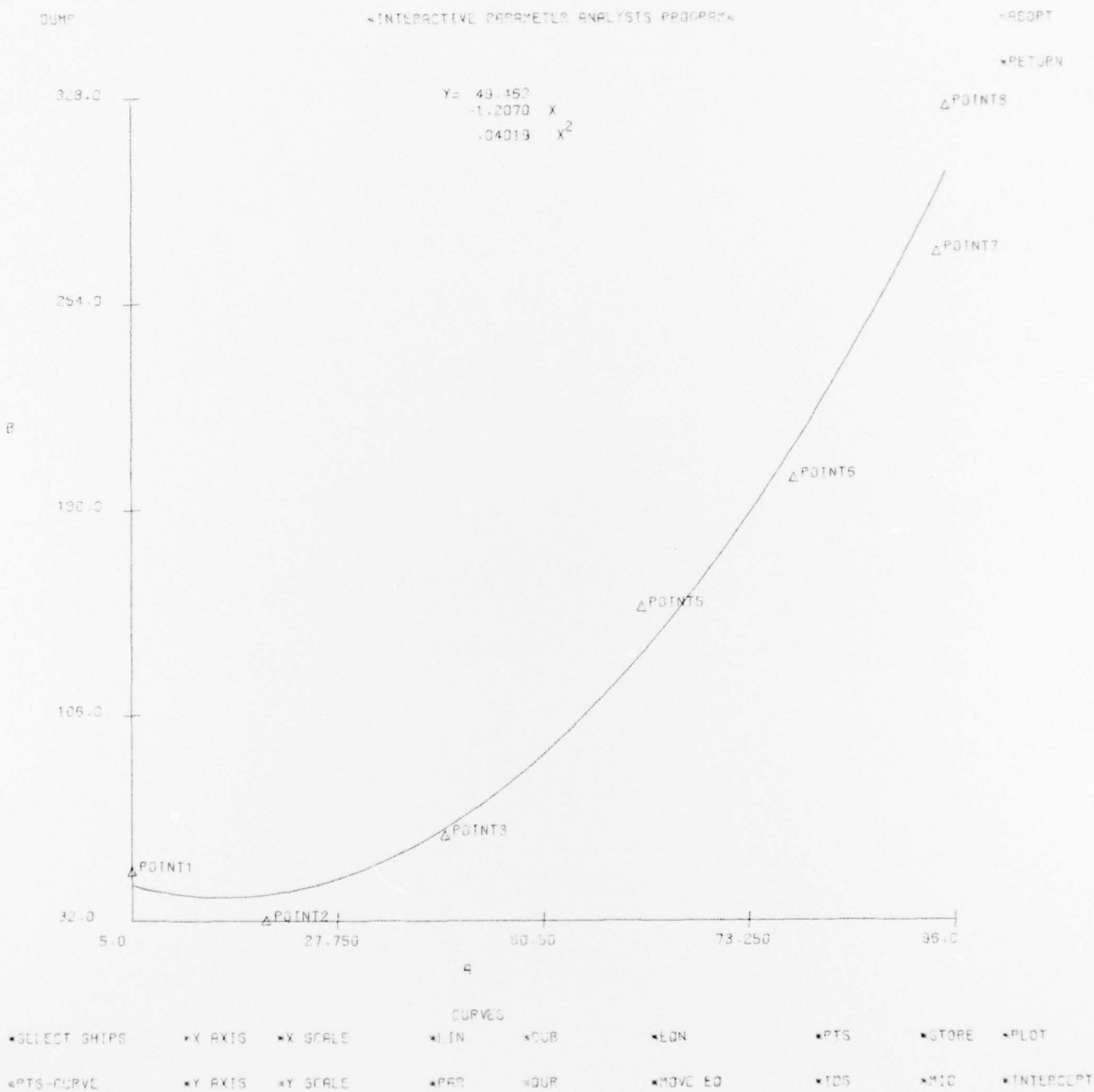


Figure D-3 Fitted Parabolic Curve for Polynomial Curve Example

Each of the three ships was represented by fifty curves (upper and lower curves on each of 25 stations), and each curve contained approximately ten data points.

The IPAP "ship names" and parameter names were selected to reflect the various stations, the separate upper and lower curves on each station, and the data points at particular waterlines on each curve. Since each data point on a Bonjean curve represents a sectional area (in this case a transformed and normalized sectional area) at a particular waterline, the "ship names" were defined to reflect those waterlines at which the area data was computed (See Figures D-4 through D-9).

Since the user required polynomial coefficients of area as a function of waterline height, and since IPAP fits polynomials in the form of Y (vertical axis) as a function of X (horizontal axis), it was necessary to transpose axes from those of the conventional Bonjean plots where waterlines appear on the vertical axis and areas on the horizontal. The horizontal IPAP axis parameter names were therefore defined to represent the normalized distance of the data point from the design waterline, and also to distinquish between upper and lower curves. Two parameters, ZU and ZL, were defined to be plotted along the X axis. The upper bon jean curve for each station was represented by ZU and the lower curve by ZL. Parameter values for both ZU and ZL were computed and input to represent the desired transformed and normalized values of these parameters at the various waterlines.

The values to be scaled along the Y axis were of course the transformed, normalized values for sectional area. The Y axis parameter names do not in fact reflect the "area" measure, but are used instead to identify both the hull (LX1, LX2, LX3) and the station number which correspond to the area represented by the particular parameter value. For instance, the parameter name "LX2 15.0" corresponds to the normalized, transformed sectional area value on the second hull at station 15. (See Figure D-5).

INPUT SORTED BY PARAMETER BY SHIP

SHIP NAME	PARAMETER NAME	PARAMETER VALUE	PARAMETER UNITS	ENGINEERING COMMENTS
WL 22.0	ZU	0.0000000	NON DIML	LX2
WL 24.0	ZU	.0620155	NON DIML	LX2
WL 26.0	ZU	.1240310	NON DIML	LX2
WL 30.0	ZU	.2480620	NON DIML	LX2
WL 34.0	ZU	.3720930	NON DIML	LX2
WL 38.0	ZU	.4961240	NON DIML	LX2
WL 42.0	ZU	.6201550	NON DIML	LX2
WL 46.0	ZU	.7441860	NON DIML	LX2
WL 50.0	ZU	.8682171	NON DIML	LX2
WL 54.0	ZU	.9922481	NON DIML	LX2
WL 54.2	ZU	1.000	NON DIML	LX2 MN.DK.ST9
WL 54.3	ZU	1.0015	NON DIML	LX2 MN.DK.ST7
WL 54.4	ZU	1.0031	NON DIML	LX2 MN.DK.ST6
WL 54.8	ZU	1.0155	NON DIML	LX2 MN.DK.ST5
WL 55.4	ZU	1.0372	NON DIML	LX2 MN.DK.ST4
WL 56.5	ZU	1.0694	NON DIML	LX2 MN.DK.ST3
WL 57.9	ZU	1.1119	NON DIML	LX2 MN.DK.ST2
WL 58.6	ZU	1.1348	NON DIML	LX2 MN.DK.ST1.5
WL 59.7	ZU	1.1680	NON DIML	LX2 MN.DK.ST1
WL 60.7	ZU	1.200	NON DIML	LX2 MN.DK.ST0.5
WL 61.9	ZU	1.2368	NON DIML	LX2 MN.DK.ST0
WL 0.0	LX2 0.0	.0114	NON DIML	LX2
WL 1.0	LX2 0.0	.0111590	NON DIML	LX2
WL 2.0	LX2 0.0	.0105731	NON DIML	LX2
WL 4.0	LX2 0.0	.0086045	NON DIML	LX2
WL 8.0	LX2 0.0	.0048251	NON DIML	LX2
WL 12.0	LX2 0.0	.0020560	NON DIML	LX2
WL 16.0	LX2 0.0	.0008346	NON DIML	LX2
WL 18.0	LX2 0.0	.0005803	NON DIML	LX2
WL 20.0	LX2 0.0	.0003482	NON DIML	LX2
WL 22.0	LX2 0.0	0.0000000	NON DIML	LX2
WL 24.0	LX2 0.0	.0003506	NON DIML	LX2
WL 26.0	LX2 0.0	.0008295	NON DIML	LX2
WL 30.0	LX2 0.0	.0022698	NON DIML	LX2
WL 34.0	LX2 0.0	.0046828	NON DIML	LX2
WL 38.0	LX2 0.0	.0086153	NON DIML	LX2
WL 42.0	LX2 0.0	.0148099	NON DIML	LX2
WL 46.0	LX2 0.0	.0242057	NON DIML	LX2
WL 50.0	LX2 0.0	.0379788	NON DIML	LX2
WL 54.0	LX2 0.0	.0568456	NON DIML	LX2
WL 61.9	LX2 0.0	.1097	NON DIML	LX2
WL 0.0	LX2 .5	.0443	NON DIML	LX2
WL 1.0	LX2 .5	.043	NON DIML	LX2
WL 2.0	LX2 .5	.042	NON DIML	LX2

Figure D-4 Portion of LX2 IPAP Input Data

SHIP NAME	PARAMETER NAME	PARAMETER VALUE	PARAMETER UNITS	ENGINEERING COMMENTS
INPUT SORTED BY PARAMETER BY SHIP				
WL 26.0	LX2 14.0	.1206513	NON DIML	LX2
WL 30.0	LX2 14.0	.2423608	NON DIML	LX2
WL 34.0	LX2 14.0	.3651925	NON DIML	LX2
WL 38.0	LX2 14.0	.4890733	NON DIML	LX2
WL 42.0	LX2 14.0	.6140433	NON DIML	LX2
WL 46.0	LX2 14.0	.7400145	NON DIML	LX2
WL 50.0	LX2 14.0	.8661931	NON DIML	LX2
WL 54.0	LX2 14.0	.9923755	NON DIML	LX2
WL 54.2	LX2 14.0	1.0005	NON DIML	LX2
WL 0.0	LX2 15.0	.6892326	NON DIML	LX2
WL 1.0	LX2 15.0	.6892326	NON DIML	LX2
WL 2.0	LX2 15.0	.6781289	NON DIML	LX2
WL 4.0	LX2 15.0	.6426567	NON DIML	LX2
WL 8.0	LX2 15.0	.5356541	NON DIML	LX2
WL 12.0	LX2 15.0	.4002538	NON DIML	LX2
WL 16.0	LX2 15.0	.2484826	NON DIML	LX2
WL 18.0	LX2 15.0	.1681532	NON DIML	LX2
WL 20.0	LX2 15.0	.0852373	NON DIML	LX2
WL 22.0	LX2 15.0	0.0000000	NON DIML	LX2
WL 24.0	LX2 15.0	.0598513	NON DIML	LX2
WL 26.0	LX2 15.0	.1184582	NON DIML	LX2
WL 30.0	LX2 15.0	.2383918	NON DIML	LX2
WL 34.0	LX2 15.0	.3597745	NON DIML	LX2
WL 38.0	LX2 15.0	.4826083	NON DIML	LX2
WL 42.0	LX2 15.0	.6069023	NON DIML	LX2
WL 46.0	LX2 15.0	.7325455	NON DIML	LX2
WL 50.0	LX2 15.0	.8584752	NON DIML	LX2
WL 54.0	LX2 15.0	.9844050	NON DIML	LX2
WL 54.2	LX2 15.0	.9925	NON DIML	LX2
WL 0.0	LX2 16.0	.5751831	NON DIML	LX2
WL 1.0	LX2 16.0	.5751831	NON DIML	LX2
WL 2.0	LX2 16.0	.5701094	NON DIML	LX2
WL 4.0	LX2 16.0	.5495268	NON DIML	LX2
WL 8.0	LX2 16.0	.4753269	NON DIML	LX2
WL 12.0	LX2 16.0	.3677661	NON DIML	LX2
WL 16.0	LX2 16.0	.2349535	NON DIML	LX2
WL 18.0	LX2 16.0	.1608139	NON DIML	LX2
WL 20.0	LX2 16.0	.0822582	NON DIML	LX2
WL 22.0	LX2 16.0	0.0000000	NON DIML	LX2
WL 24.0	LX2 16.0	.0574112	NON DIML	LX2
WL 26.0	LX2 16.0	.1152408	NON DIML	LX2
WL 30.0	LX2 16.0	.2321733	NON DIML	LX2
WL 34.0	LX2 16.0	.3508049	NON DIML	LX2
WL 38.0	LX2 16.0	.4711243	NON DIML	LX2

Figure D-5 Portion of LX2 IPAP Input Data

INPUT SORTED BY PARAMETER BY SHIP

	SHIP NAME	PARAMETER NAME	PARAMETER VALUE	PARAMETER UNITS	ENGINEERING COMMENTS
WL	4.0	LX2 19.5	.133	NON DIML	LX2
WL	8.0	LX2 19.5	.133	NON DIML	LX2
WL	12.0	LX2 19.5	.133	NON DIML	LX2
WL	16.0	LX2 19.5	.128	NON DIML	LX2
WL	18.0	LX2 19.5	.099	NON DIML	LX2
WL	20.0	LX2 19.5	.056	NON DIML	LX2
WL	22.0	LX2 19.5	.0	NON DIML	LX2
WL	24.0	LX2 19.5	.0452	NON DIML	LX2
WL	26.0	LX2 19.5	.0916	NON DIML	LX2
WL	30.0	LX2 19.5	.1859	NON DIML	LX2
WL	34.0	LX2 19.5	.2835	NON DIML	LX2
WL	38.0	LX2 19.5	.3819	NON DIML	LX2
WL	42.0	LX2 19.5	.4833	NON DIML	LX2
WL	46.0	LX2 19.5	.5866	NON DIML	LX2
WL	50.0	LX2 19.5	.6907	NON DIML	LX2
WL	54.0	LX2 19.5	.7944	NON DIML	LX2
WL	54.3	LX2 19.5	.8027	NON DIML	LX2
WL	0.0	LX2 20.0	.0904824	NON DIML	LX2
WL	1.0	LX2 20.0	.0904824	NON DIML	LX2
WL	2.0	LX2 20.0	.0904824	NON DIML	LX2
[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
WL	8.0	LX2 20.0	.0904824	NON DIML	LX2
WL	12.0	LX2 20.0	.0904824	NON DIML	LX2
WL	16.0	LX2 20.0	.0904824	NON DIML	LX2
WL	18.0	LX2 20.0	.0808046	NON DIML	LX2
WL	20.0	LX2 20.0	.0510971	NON DIML	LX2
WL	22.0	LX2 20.0	0.0000000	NON DIML	LX2
WL	24.0	LX2 20.0	.0430386	NON DIML	LX2
WL	26.0	LX2 20.0	.0867143	NON DIML	LX2
WL	30.0	LX2 20.0	.1759548	NON DIML	LX2
WL	34.0	LX2 20.0	.2677214	NON DIML	LX2
WL	38.0	LX2 20.0	.3520179	NON DIML	LX2
WL	42.0	LX2 20.0	.4585368	NON DIML	LX2
WL	46.0	LX2 20.0	.5580033	NON DIML	LX2
WL	50.0	LX2 20.0	.6576738	NON DIML	LX2
WL	54.0	LX2 20.0	.7573355	NON DIML	LX2
WL	54.3	LX2 20.0	.7658	NON DIML	LX2
WL	0.0	ZL	1.0000000	NON DIML	LX2
WL	1.0	ZL	.9545455	NON DIML	LX2
WL	2.0	ZL	.9090909	NON DIML	LX2
WL	4.0	ZL	.8181818	NON DIML	LX2
WL	8.0	ZL	.6363636	NON DIML	LX2
WL	12.0	ZL	.4545455	NON DIML	LX2
WL	16.0	ZL	.2727273	NON DIML	LX2

Figure D-6 Portion of LX2 IPAP Input Data

INTERACTIVE PARAMETER ANALYSIS PROGRAM

SHIP NAME	PARAMETER NAME	PARAMETER VALUE	PARAMETER UNITS	ENGINEERING COMMENTS
INPUT SORTED BY PARAMETER BY SHIP				
WL 18.0	ZL	.1818182	NON DIML	LX2
WL 20.0	ZL	.0909091	NON DIML	LX2
WL 22.0	ZL	0.0000000	NON DIML	LX2

Figure D-7 Portion of LX2 IPAP Input Data

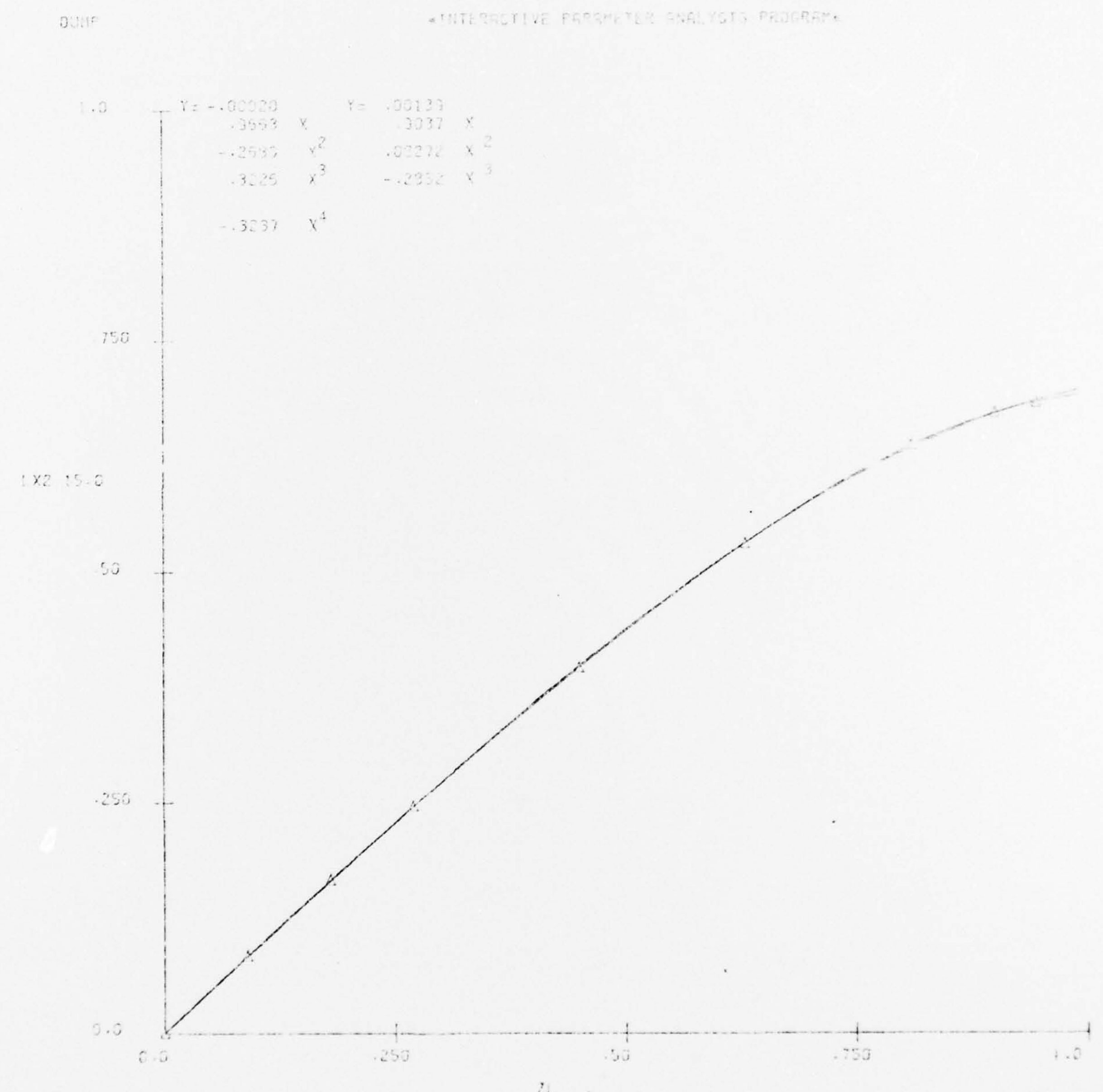


Figure D-8 Normalized Sectional Areas Below the DWL for Station 15 of the LX2 ($C_p = 0.60$)

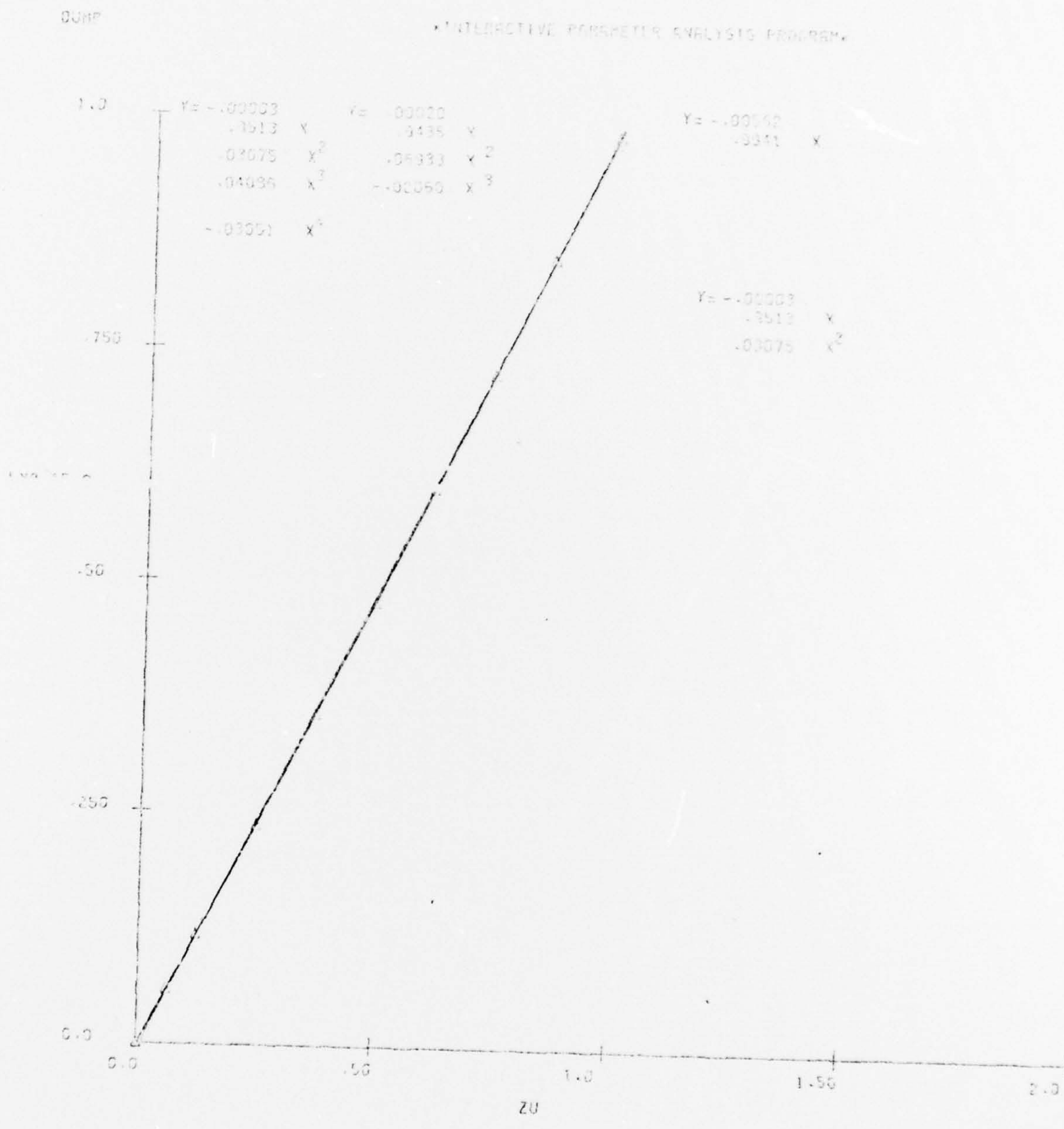


Figure D-9 Normalized Sectional Areas Above the DWL for Station 15 of the LX2 ($C_p = 0.60$)

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