MEMORANDUM REPORT ARBRL-MR-03303

COMPUTER AIDED DESIGN OF POLYHEDRON SOLIDS TO MODEL AIR IN COM-GEOM DESCRIPTIONS

James E. Shiells

August 1983

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**Title:** Computer Aided Design of Polyhedron Solids to Model Air in COM-GEOM Descriptions

**Authors:** James E. Shiells

**Abstract:**
Certain target vulnerability analysis performed at BRL require (COM-GEOM) simulations which include internal air in the description. This report describes an interactive program which aids the user in describing such internal air. A simple example is included in this report in which the procedure is described in a step-by-step fashion.
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### APPENDIX A

| A-1     | Intersection (+), Subtraction (-), Union (OR) of Solids                    | 31   |
Vulnerability/lethality analyses performed at the Ballistic Research Laboratory (BRL) generally require a computer description of the target under investigation. The target simulation is most often accomplished through a method known as combinatorial geometry (COM-GEOM). The resulting target descriptions are commonly referred to as COM-GEOM descriptions. The COM-GEOM technique for target descriptions employs a variety of basic geometric solids in order to model all of the components of the target. The BRL tank vulnerability program is routinely used to estimate the vulnerability of many armored targets. In particular, this program requires the COM-GEOM target descriptions to include internal air modeled in the description.

This report describes the interactive program CADAIR which aids the user in describing internal air for COM-GEOM descriptions. The program is useful during the creation phase of a COM-GEOM description or in modifying an earlier COM-GEOM description which lacked internal air. In addition, various other capabilities of the CADAIR program are discussed.

II. BACKGROUND

The BRL tank vulnerability computer program (VAMP) is based on the "compartment model" of vehicle vulnerability. In this lethality model, damage correlations for entire compartments are considered in order to arrive at final kill probabilities for the target. Usually the vehicle is divided into two compartments: the engine compartment and the crew compartment. It has been found convenient to identify "compartments" by describing the compartment air in the COM-GEOM description. The target description air is merely coded in order to distinguish the crew compartment (02) from the engine compartment (05). Special other compartments may similarly be identified by this technique.

---

III. TARGET DESCRIPTION

A brief summary of the COM-GEOM technique is presented in Appendix A. The descriptions utilize a variety of basic geometric solids for describing the actual target. The solid types currently available for building COM-GEOM descriptions are listed in Table A-1. These solids, with the exception of the ARS, are fundamentally simple geometric shapes. The ARS (triangular surfaced polyhedral solid) may be used to model extremely complex shapes. Figure 1 illustrates the essential characteristics of the ARS solid.

![Basic ARS Solid](image)

**SPECIFY:** The X, Y, Z coordinate values of the vertices of the concave or convex polyhedron. Either 1) order and record the vertices by the number of curves (M) and number of points per curve (N) system or 2) order and record the vertices by the scheme associated with the SHOT GENERATOR Code and specify the number of recorded points (ND).

**Figure 1. Basic ARS Solid**

Both the number of curves and number of points per curve may vary considerably from that shown in Figure 1. An example of the possible complexity of the ARS solid is shown in Figure 2 which depicts an entire surface of a tank turret. The versatility of the ARS solid makes it ideally suited for describing interior air in target descriptions.

In order to avoid errors, the user must exercise caution when modeling air in the COM-GEOM description. Figure 3 shows a cross section of a tank turret which has two types of errors that may occur if the internal air is modeled incorrectly. If the internal air (bounded by solid line) does not "fill up" the interior compartment volume or if it "spills over" the exterior surface of the compartment, then errors will occur during further computer processing. An acceptable modeling technique for internal air is illustrated in Figure 4. Note in this figure that the boundary of the internal air is defined within the shell wall which identifies the compartmentalized volume.

In view of these constraints and the previously noted versatility of the ARS solid, it therefore is apparent that this solid type is well suited...
Figure 2. Example of Large ARS Solid
Figure 3. Example of Air Modeling Errors in COM-GEOM Description

Figure 4. Example of Acceptable Modeling of Air in a COM-GEOM Description
Figure 5. Inverted Tumbler Cross-Cuts
for modeling internal air. The purpose of the CADAIR program is to aid the user in constructing an ARS solid which will conform to the aforementioned requirements.

IV. CADAIR PROGRAM OVERVIEW

CADAIR is an interactive graphics program for use with a TEKTRONIX \textsuperscript{R} terminal operating within the NOS (version 1.4) environment. The Network Operating System (NOS) controls the operation of CDC CYBER 170 series, CDC CYBER 70, Models 71, 72, 73, and 74, and CDC 6000 series computer systems. CADAIR is a FORTRAN program which requires the library software package DISSIP\textsuperscript{R} which is a proprietary product of ISSCO\textsuperscript{R}. The program CADAIR listed in Appendix B is currently used at BRL in conjunction with a TEKTRONIX\textsuperscript{R} model 4010 terminal operating at 9600 baud.

CADAIR requires input which is generated from the GIFT\textsuperscript{2} code under option XSECT. This option produces plot files which define cross-sectional views of the COM-GEOM description. Reference 2 is recommended for the reader unfamiliar with the XSECT option of the GIFT code. An example of this type of plot for the case of a simple inverted tumbler is illustrated in Figure 5.

The use of the CADAIR program for describing air within the inverted tumbler (Figure 5) will serve as an example in the following section. The user is free to select any number and location of cross-cuts when using the XSECT option of the GIFT code. The judicial selection of cutting planes which reflect "moderate" changes between succeeding cross-cut shapes is recommended. In the normal use of the XSECT option, there is no information relating to the position of the cutting plane (Z value) available in the plot file output. This third coordinate information (Z values) is clearly vital for describing an ARS solid in three dimensional space. However, a simple method for accomplishing this is readily available. The regular XSECT plot title may be replaced with the number of cutting planes and their respective locations (Z values). Figure 6 shows the prescribed format to be used for replacing the TITLE card for the XSECT option of the GIFT code.

<table>
<thead>
<tr>
<th>I5</th>
<th>F5.0</th>
<th>F5.0</th>
<th>F5.0</th>
<th>...</th>
<th>...</th>
<th>F5.0</th>
</tr>
</thead>
<tbody>
<tr>
<td>NUM</td>
<td>Z1</td>
<td>Z2</td>
<td>Z3</td>
<td>...</td>
<td>...</td>
<td>Zn</td>
</tr>
</tbody>
</table>

NUM- Total number of cross-cuts in plot file (not to exceed 20)
Zi- Cutting plane position (Z-value)
for i th cross cut in the COM-GEOM coordinate system

Figure 6. Title Replacement Format for XSECT Input

\textsuperscript{4}Integrated Software Systems Corporation, ISSCO\textsuperscript{R}, San Diego, CA 92121
The CADAIR graphics program displays each of the cross-sectional plots on the graphics screen and prompts the user to select points for each ARS curve. The user inputs the \((X, Y)\) values for these points by manipulating the position of the cross hairs that appear on the graphics screen. Advantage from visual feedback thereby aids the user in fitting the ARS curve entirely within the shell wall boundary around the internal compartment. The user may save the ARS data file (punch) thus created at the conclusion of the point selection procedure from each cross-cut plot. This file is appropriately formatted for use in a COM-GEOM description.

V. CADAIR PROGRAM USER GUIDE

The CADAIR program currently in use at BRL is accessed by entering the commands that are listed in Figure 7 on a TEKTRONIX® 4010.

```
GET, TAPE12=PLTFILE/UN=SHIELLS
ATTACH, DISSPLA/UN=DISSPLA
LIBRARY, DISSPLA
GET, GOX/UN=SHIELLS
GOX
```

Figure 7. MFB Commands to Access CADAIR Program at BRL

In Figure 7, PLTFILE is the plot file output from the XSECT option of the GIFT code that was discussed in the previous section. File DISSPLA is the proprietary graphics software product of ISSCO. In Figure 7, GOX is the binary file which contains the compiled CADAIR program.

When the last command in Figure 7 is entered on the terminal keyboard, the screen is cleared and the MENU is displayed.

Figure 8 shows a copy of the MENU which appears on the graphics terminal. The terminal cross hairs also become visible at this time. A keyboard response from the terminal user is required whenever the cross hairs become visible.

The required response generally requires the user to change the location of the cross hairs and then push any punctuation key on the keyboard instead of the carriage return (CR). The position of the cross hairs is changed by two dials (horizontal and vertical) available to the user near the terminal keyboard.
The MENU lists several different procedures available to the user. The user may optionally select any procedure by merely positioning the horizontal cross hair over the name of the procedure and then pressing any punctuation key. When the procedure is completed the MENU will reappear on the screen.

The explanation of each procedure (MENU item), supplemented with illustrations, follows:

REWIND This MENU entry permits the terminal user to rewind the entire plot file. This is a minor procedure that helps the user when previewing the various cross-cuts plots on PLOTFILE.

BACKTRACK This MENU entry permits the user to back up the plot file (PLOTFILE) in order to preview the previous cross-sectional plot.

DISPLAY This procedure displays the current cross-section plot in PLOTFILE on the graphics terminal. Figure 9 illustrates a typical example of a cross-sectional view of a tank turret. Successive use of this procedure allows the user to preview each cross-sectional plot in the plot file (PLOTFILE). This procedure may also be applied to plot files generated by the PICTUR option of the GIFT code if one condition is satisfied. The title card (Figure 6) used for the PICTUR run should be blank. Effectively the plot file output from PICTUR could be edited to accomplish the same thing. Figure 10 illustrates a typical perspective view of a tank which was produced by the PICTUR option of the GIFT code.
Figure 10. DISPLAY Perspective View Example
This procedure encompasses the overall purpose of the CADAIR program. When this procedure is initiated, the plotfile is automatically rewound. Figure 11 shows the first cross section (with prompts) which is displayed for the example of the inverted tumbler. A requirement for the ARS solid is that the first and last curves degenerate around a single point. Therefore, the user is prompted by the message "SELECT FIRST ARS POINT/CURVE." The user is expected to position the terminal cross hairs so that they intersect within the shell wall boundary of the displayed cross section. The user then presses any punctuation key to send the cross hair X and Y positional information to the host computer. The program resumes by clearing the screen, displaying the same cross section and prompting the user with the message "SELECT POINT FOR ARS CURVE." A second requirement for describing ARS solids is that all the intermediate curves (not first or last curve) be closed curves. This means that the first and last point of a curve have the same position. The user is thus free to select points that describe a curve which satisfy any arbitrary shape requirement. In the case of describing internal air, the curve would be confined to the shell surrounding the internal compartment. Figure 12 shows the example of the internal air boundary curve for the inverted tumbler. Line segments with arrowheads are displayed on the screen to aid the user while the ARS curve is being constructed. The ARS Curve point selection mode terminates automatically when the user closes the curve (i.e., the last point matches the first point). When the user closes the ARS curve, the message "END OF CURVE" is displayed on the screen. Figure 13 illustrates this for the example of the inverted tumbler. The program resumes when the user presses the carriage return (CR) key. Consideration need be directed to two further requirements for describing the ARS solid. Each curve of the ARS solid must have the same number of points. This number (not to exceed 19) is automatically set by the user depending on the number of points needed to define the first closed curve. Therefore, each subsequent curve must have the same number of points as the first curve. Additionally, the consecutive points in adjacent ARS curves should retain a "reasonable" degree of cadence or correspondence. Figure 14 illustrates the display on the screen which aids the user in dealing with the two additional ARS requirements outlined above. This display includes a "star" along with the usual cross section and related prompting messages. The star-like guide is centered at the lateral position of the first degenerate ARS curve which was user defined. Each radial arrow in the star points to the user selected points of the preceding curve of the ARS.
Figure 11. Inverted Tumbler - First Display

Figure 12. Inverted Tumbler - Second Display
Figure 13. Inverted Tumbler - Second Display - End

Figure 14. Inverted Tumbler - Third Display - Start
Figure 15. Inverted Tumbler - Third Display - Midway

Figure 16. Perspective View of Completed ARS Solid
The purposes of star guide are twofold: It helps the user to keep track of the number of points that now must be used in defining the curve, and it aids the user in selecting points in the vicinity of the same angular zone to maintain the cadence mentioned above. Figure 15 illustrates this by showing the user defined third ARS curve partially completed. When the curve is completed, the message "END OF CURVE" is displayed. The user presses the carriage return key and the process described above repeats for all of the remaining ARS curves. In order to save this file the user should enter the command SAVE,PUNCH after returning to the operating system. Figure 16 illustrates a perspective view of the ARS solid which was described in this example. To exit prematurely from this procedure, the user need only move the horizontal cross-hair below the plot axis while selecting points. The screen will be cleared and the menu displayed again.

This function, as the name implies, permits the user to optionally expand a small region of the displayed plot for convenient viewing. Initially the current cross-section plot in PLOTFILE is displayed on the graphics screen. Figure 17 illustrates an example with a cross-sectional view of a tank cupola. The user is required to press a punctuation key to continue this procedure. The prompting message "SELECT LOWER LEFT CORNER" instructs the user to define the lower left corner of a "window" which will later be expanded to fill up the whole plot area. The "window" definition operation is performed by the user through the usual use of the cross hairs and punctuation key. The user then responds similarly to the next prompting message "SELECT UPPER RIGHT CORNER." The user defined window area is then magnified and displayed on the graphics screen. Figure 18 illustrates the enlarged view of the window area shown in Figure 17. This procedure will also function on plot files created by PICTUR provided that the title card is modified as discussed for the DISPLAY procedure.

This menu entry allows the user to return to the network operating system (NOS) to perform other computer operations possibly unrelated to CADAIR.
Figure 17. ZOOM Example - Start

Figure 18. ZOOM Example - Result
VI. ARS COORDINATE TRANSLATION

The ARS solid described by the preceding technique may need to undergo a coordinate translation before it is used in the COM-GEOM description. This is necessary because the XSECT option of the GIFT code changes the coordinate system of the COM-GEOM description as it creates the cross-section plot file. The amount of coordinate change depends on how the XSECT option was set up to run. Figure 19 illustrates the input required by the XSECT option which defines the boundary of the cross-section plot.

<table>
<thead>
<tr>
<th>1-8</th>
<th>9-16</th>
<th>17-24</th>
<th>25-32</th>
<th>33-40</th>
<th>41-48</th>
<th>49-56</th>
<th>57-64</th>
<th>65-72</th>
<th>73-80</th>
</tr>
</thead>
</table>

FORMAT (9F8.0)

- **P(1-3)** - Specify the x, y, and z coordinate of the point in the upper left corner on plotter of cross section.
- **P(4-6)** - Specify the x, y, and z coordinate of the point in the lower left corner on plotter of cross section.
- **P(7-9)** - Specify the x, y, and z coordinate of the point in the lower right corner on plotter of cross section.

Figure 19. Plane Card for XSECT Option

Figure 20 shows a cross-sectional plot of a target with the parameters of Figure 19 indicated on the drawing. The coordinates of the points of the XSECT output file include no negative values. Table I summarizes the required translation of the ARS solid in order that it be compatible with the associated COM-GEOM description. Additionally, in case 2 the Y and Z coordinate values must be exchanged. In case 3 both the X and Z values and then the Y and Z coordinate values need be exchanged, respectively.
Table 1. Coordinate Transformation Formulae

CASE 1: Z-Plane XSECT Plots (P3 = P6 = P9)
Translating ARS solid X values by minimum of P1, P4 or P7.
Translating ARS solid Y values by minimum of P2, P5 or P8.

CASE 2: Y-Plane XSECT Plots (P2 = P5 = P8)
Translating ARS solid X values by minimum of P1, P4 or P7.
Translating ARS solid Y values by minimum of P3, P6 or P9.
Exchange the Z and Y values of the ARS solid.

CASE 3: X-Plane XSECT Plots (P1 = P4 = P7)
Translating ARS solid Y values by minimum of P2, P5 or P8.
Translating ARS solid Z values by minimum of P3, P6 or P9.
Exchange the X and Z values of the ARS solid; then exchange the Y and Z values of the ARS solid.

VII. DISCUSSION

The preceding description of the CADAIR program was largely concerned with its single utility for describing internal air in COM-GEOM descriptions. There are, however, several other possible uses for the CADAIR program. COM-GEOM descriptions of armored vehicles are often required to include many small "boxes" (i.e., radio, control panels, etc.) that may be attached to the vehicle main armor. In the regular process of modeling these boxes, there are often problems with the boxes overlapping the armor or each other in the COM-GEOM description. The CADAIR program may be used for modeling these small boxes with simple (4 pts/curve) ARS solids. The advantage is clear for the user being able to see where the "boxes" are placed in relation to other target components to avoid overlaps. The problem of "overlaps" in COM-GEOM descriptions has incurred many delays and cost increases for doing target descriptions.

It is occasionally desired to quantitatively determine the protection afforded an armored vehicle through the addition of a ballistic liner. For the case of curved tank turrets, it can prove troublesome to modify COM-GEOM descriptions to include a liner. In these situations, advantage may be realized through the use of the CADAIR program. The XSECT output file may be simulated by other means in order to utilize the CADAIR program to construct original COM-GEOM descriptions. Figure 2 illustrates such an example for the M60A1 turret which was created through use of the CADAIR program. In this case, the tank manufacturer made available a series of drawings which showed "cross-cut" sections of the turret casting. Measurements were taken from these drawings in order to build a plot file (XSECT equivalent output file) suitable as input for the CADAIR program. Figure 21 illustrates a typical ARS curve made during this particular exercise of the CADAIR program. The ARS solids which describe the M60A1 turret exterior surface are shown in Figure 2.
Figure 21. Turret Cross-Cut
APPENDIX A

Combinatorial Geometry Background
Combinatorial Geometry Background

The GIFT computer code requires a combinatorial geometry (COM-GEOM) target description as input data. Familiarization with the COM-GEOM technique and terminology is required to understand the target description. The following is a brief introduction to the COM-GEOM technique of target description. Reference 1 gives a more detailed account of the COM-GEOM method as required for input to the GIFT code.

Engineering drawings, manuals, photographs or other descriptive material are required to produce a COM-GEOM description. The COM-GEOM technique utilizes twelve basic geometric solids (see Table A-1) combined under three set-theory (BOOLEAN) type operations to define the shape and location of each component of a target. A complete COM-GEOM description contains the three distinct parts: a solid table, a region table and a region identification table.

A solid is defined as one of the twelve geometric shapes available for COM-GEOM descriptions. The parameters of a solid give its location, size and orientation within the coordinate system established for the target. Each solid is uniquely numbered and its parameters listed in the solid table.

A region is the space occupied by a single solid or combination of solids. Solids are combined using the three operations: intersection (+), union (OR) and difference (-). The intersection (+) of two solids is defined as the space in common with both solids. The union (OR) of two solids is defined as the space in both of the solids. The difference (-) of two solids is defined as the space in the first solid minus the space of the second solid. Figure A-1 is a graphic illustration of these three operations. Any number of solids from the solid table may be used to define a region. Each region is uniquely numbered and its defined combination of solids is listed in the region table.

In the region identification table, each region is assigned an identification code number. These code numbers either identify each specific region as a component of the target or as an air space. Space not described as a region is assigned the air space code "01" by the GIFT code. It is not necessary to describe the inside air of a target, in which case both inside and outside air will be identified by the 01 space code. However, in many targets, it is important to distinguish between inside and outside air. For these targets, all interior space is described as a region and identified as inside air, leaving the 01 space code for outside air only. The RAYAIR subroutine of the GIFT code allows any region identified with a space code to overlap any region identified with an item code or the same space code. However, regions with different code numbers cannot overlap.
Table A-1. Geometric Solids Used in COM-GEOM Descriptions

<table>
<thead>
<tr>
<th>SYMBOL</th>
<th>SOLID NAME</th>
</tr>
</thead>
<tbody>
<tr>
<td>RPP</td>
<td>Rectangular Parallelepiped</td>
</tr>
<tr>
<td>BOX</td>
<td>Box</td>
</tr>
<tr>
<td>RAW</td>
<td>Right Angle Wedge</td>
</tr>
<tr>
<td>ARB</td>
<td>Arbitrary Convex Polyhedron</td>
</tr>
<tr>
<td>ARS</td>
<td>Triangular Surfaced Polyhedron</td>
</tr>
<tr>
<td>ELL</td>
<td>Ellipsoid of Revolution</td>
</tr>
<tr>
<td>SPH</td>
<td>Sphere</td>
</tr>
<tr>
<td>RCC</td>
<td>Right Circular Cylinder</td>
</tr>
<tr>
<td>REC</td>
<td>Right Elliptical Cylinder</td>
</tr>
<tr>
<td>TRC</td>
<td>Truncated Right Angle Cone</td>
</tr>
<tr>
<td>TEC</td>
<td>Truncated Elliptic Cone</td>
</tr>
<tr>
<td>TOR</td>
<td>Torus</td>
</tr>
</tbody>
</table>

The region identification table also allows 40 alphanumeric characteristics of descriptive data per region. The analyst needs to know the type and percentage of material making up each region. The percentage value is used to produce an equivalent line-of-sight thickness of the material type. This information is included in the 40 characters of descriptive data in the region identification table.

The three tables described above constitute a complete COM-GEOM target description as required for input to the GIFT computer code.
Figure A-1. Intersection (+), Subtraction (-), Union (OR) of Solids
APPENDIX B

CADAIR Program Listing
PROGRAM CADAIR (INPUT, OUTPUT, PUNCH, TAPE6, TAPE7, TAPE10
tape8=PUNCH, TAPE12)

'CADAIR' is an interactive graphics program which aids the user
in constructing ACS' solids for COM-GEOM descriptions. This
version of 'CADAIR' initiates communications with the Tektronics
model 4010 graphics terminal at 9600 baud. Subroutines identified
below make extensive use of the 'DISPLA' library which is the
proprietary product of ISSCO, Inc.

*** Menu definitions ***

REWIND - Rewind TAPE12 (Plotfile) to beginning of tape
BACKSPACE - Rewind TAPE12 (Plotfile) to start of previous plot
DISPLAY - Display current plot on graphics screen
BUILD ARS - Assist user in constructing an ARS SOLID
ZOOM - 'Zoom in' on displayed plot
EXIT - Return to operating system (NOS)

COMMON /ZAP/ ICONT

CALL TK4010 (9600)
CALL SETDEV (6, 6)
CALL CLEAR
CALL CURSOR (CX, CY)
CALL ENUR (0)
CALL CLEAR
PRINT *, CX, CY

IF (CY.LT.686.0, AND CY.GT.655.) CALL REDO
IF (CY.LT.655.0, AND CY.GT.624.) CALL BACKUP
IF (CY.LT.624.0, AND CY.GT.593.) CALL PICT
IF (CY.LT.593.0, AND CY.GT.562.) CALL DRAW
IF (CY.LT.562.0, AND CY.GT.531.) CALL ZOOM
IF (CY.LT.531.0, AND CY.GT.500.) CALL OUT

GO TO 1
END
SUBROUTINE CLEAR

SUBROUTINE CLEAR Erases the graphics screen

IRACE=00074035403340140000B
CALL CONN (10)
WRITE (10) IRACE
CALL DISCON (10)
RETURN
END

SUBROUTINE MENU

SUBROUTINE MENU Displays the menu procedures on the screen

CALL PAGE (8, 1315, 6, 2)
CALL PHYSOR (0, 63, 0, 59)
CALL TITLE ('REWIND', 'BACKSPACE', 'DISPLAY', 'BUILD ARS', 'ZOOM', 'EXIT')
CALL FRAME
CALL MESSAG ('REWIND', 'BACKSPACE', 'DISPLAY')
CALL MESSAG ('BUILD ARS', 'ZOOM', 'EXIT')

30
CALL MESSAG (*DISPLAY',7,0.2,4.25)
CALL MESSAG (*BUILD ARS',9,0.2,4.0)
CALL MESSAG (*ZOOM',4,0.2,3.75)
CALL MESSAG (*EXIT',4,0.2,3.5)
RETURN
END
SUBROUTINE CURSOR (CX,CY)

SUBROUTINE CURSOR TURNS ON THE TERMINAL CROSS-HAIRS AND FACILATES USER SELECTED SCREEN COORDINATE DATA TRANSFER TO THE HOST COMPUTER

DIMENSION IHY(2)

ITRAN=0006001200150000 00008
ITURN=0 00740354033403200008
MHX=000000000000000000008
MLX=00000000000000000000B
MHy=000000000000000000008
MLY=000000000000000000008
CALL TSEND
CALL CONNEC (10)
WRITE (10) ITRAN,ITURN BUFFER IN( 10.1) (IHY(1),IHY(2)) CALL DISCON (10)
JHX=ANO(IHY(1),MHX)
JLX =AND(IHY(1),MLX)
JHY=ANO(IHY(1),MHy)
JLY=AND(IHY(2),MLY)
KHX=SHIFT(JHX,-19)
KLX=SHIFT(JLX,-12)
KHY=SHIFT(JHY,5)
KLY=SHIFT(JLY,-48)
LX=OR(KHX,KLX)
LY=OR(KHY,KLY)
CX=FLOAT(LX)
CY=FLOAT(LY)
RETURN
END
SUBROUTINE REDO

SUBROUTINE REDO

REWIND INITIATES THE PROCEDURE FOR THE MENU ENTRY

COMMON /ZAP/ ICONT
REWIND GRAPHICS FILE ATTACHED TO TAPE12
REWIND 12 ICONT=0 RETURN END
SUBROUTINE BACKUP

SUBROUTINE BACKUP INITIATES THE PROCEDURE FOR THE MENU ENTRY 'BACKSPACE'

COMMON /ZAP/ ICONT
BACKUP THE GRAPHICS FILE TO BEGINNING OF PREVIOUS PLOT IF (ICONT.EQ.0) RETURN REWIND 12 ICONT=ICONT+1 CALL SKIPFE (12,ICONT,0) RETURN END
SUBROUTINE PICT

SUBROUTINE PICT INITIATES THE PROCEDURE FOR THE MENU ENTRY 'DISPLAY'

* 101* PICT 2 PICT 3 PICT 4
C

DIMENSION X(300), Y(300), FIL(999)
COMMON /ZAP/ ICONT
COMMON /ZIP/ ZZ(30), HOR, VET, NC
COMMON /ZOP/ HAR, VAT
IF (ICONT.EQ.0) IEND=100
IF (ICONT.LT.1) REWIND 12
IF (ICONT.LT.IEND) RETURN
1 READ (12,7) NC, (ZZ(I), I=1,30)
IF (EOF(12)) 1,2
2 IF (NC.EQ.1) READ (12,8) A, B, HOR, VET
IF (NC.NE.1) READ (12,8) A, B, C, HOR, VET
CALL PHYSOR (3,0,0.59)
CALL TITLE (DISPLAY 1.0, 1.5, 0.5, 0.5)
CALL GRAF (0,0,HOR,HOR.0,0,VET,VET)
3 READ (12,9) N
IF (N.EQ.1) READ (12,5) HO, VE
IF (N.EQ.2) GD TO 3
IF (N.EQ.2) READ (12,5) (FIL(IJ), IJ=1,NF)
IF (N.EQ.2) GD TO 4
READ (12,10) (X(I), Y(I), I=1,N)
CALL CURVE (X,Y,N,0)
GO TO 3
4 CONTINUE
CALL CURSOR (CX,CY)
CALL ENDDR (0)
CALL RESET (PHYSOR)
ICONT=ICONT+1
HAR=HOH
VAT=VET
IEND=NC
RETURN
5 FORMAT (2F12.4)
6 FORMAT (11.10)
7 FORMAT (15.20F1.1)
8 FORMAT (6F12.4)
9 FORMAT (11.10)
10 FORMAT (6F12.4)
END
SUBROUTINE DRAW
C SUBROUTINE DRAW INITIATES THE PROCEDURE FOR THE ENTRY
C 'BUILD ARS'

C

DIMENSION X(30,30), Y(30,30), Z(30,30), XC(2), YC(2)
COMMON /ZAP/ ICONT
COMMON /ZIP/ ZZ(30), HOR, VET, NC
CALL READ
AXS=365,05A5=63,0
CALL CLEAR
CALL PACT
IF (NC.EQ.1) CALL ENDPL (0)
IF (NC.EQ.1) RETURN
CALL HEIGHT (.07)
CALL MESSAG ('SELECT FIRST ARS POINT/CURVES', 0, 0, 0, 0, 0, 0)
CALL RESET ('HEIGHT')
CALL CURSOR (CX,CY)
IF (CX.LT.AXS OR CY.LT.AYS) CALL ENDPL (0)
IF (CX.LT.AXS OR CY.LT.AYS) RETURN
CALL HEIGHT (.07)
CALL MESSAG ('SELECT FIRST ARS POINT/CURVES', 100, 0, 0, 0, 0, 0)
CALL RESET ('HEIGHT')
CALL CURSOR (CX,CY)
IF (CX.LT.AXS OR CY.LT.AYS) CALL ENDPL (0)
IF (CX.LT.AXS OR CY.LT.AYS) RETURN
CX=(CX-(1024.0*3.0/8.1315))*HOR/(1024.0*5.0/8.1315)
CY=(CY-(780.0*0.59/6.2))*VET/(780.0*5.0/6.2)
CALL ENDDR (0)
DO 1 I=1,30
C
\[ X(I+1) = CX \times Y(I+1) = CY \times Z(I+1) = ZZ(I+1) \]

1. CONTINUE
2. CALL REDO
3. CALL CLEAR
4. CALL PACT
5. I=0$FLG=0.0$CX(I)=0.0
6. CALL HEIGHT (.07)
7. YPOS=5.0-125*FLOAT(I)
8. CALL MESSAG ('SELECT POINT FOR ARS CURVES',100*2.5,YPOS)
9. CALL RESET ('HEIGHT')
10. I=I+1
11. CALL CURSOR (CX,CY)
12. IF (I.EQ.1) BX=CX
13. IF (I.EQ.1) BY=CY
14. DEL=SQRT((BX-CX)**2)+ARS((BY-CY)**2)
15. IF (I.EQ.1) DEL=10.0
16. IF (DEL.LT.9.0) FLG=1.0
17. X(I,2)=(CX-(1024.0*3.0/8.1315))*HOR/(1024.0*5.0/8.1315)
18. Y(I,2)=(CY-(780.0*0.59/6.2))*VET/(780.0*5.0/6.2)
19. IF (CX.LT.AXS.OR.CY.LT.AYS) CALL ENDPD (0)
20. IF (CX.LT.AXS.OR.CY.LT.AYS) RETURN
21. Z(I,2)=Z2(I)
22. CALL RLVEC (XC(1),YC(1),XC(2),YC(2),1201)
23. XC(1)=XC(2)
24. YC(1)=YC(2)
25. CALL RLVEC (X(I,1),Y(I,1),X(K),Y(K),1201)
26. CONTINUE
27. NPP=NPP-1
28. DO 5 J=1,NPP
29. CALL HEIGHT (.07)
30. YPOS=5.0-125*FLOAT(J)
31. CALL MESSAG ('SELECT POINT FOR ARS CURVES',100*2.5,YPOS)
32. CALL CURSOR (CX,CY)
33. X(J,N)=(CX-(1024.0*3.0/8.1315))*HOR/(1024.0*5.0/8.1315)
34. Y(J,N)=(CY-(780.0*0.59/6.2))*VET/(780.0*5.0/6.2)
35. IF (CX.LT.AXS.OR.CY.LT.AYS) CALL ENDPD (0)
36. IF (CX.LT.AXS.OR.CY.LT.AYS) RETURN
37. NNN=N-1
38. Z(J,N)=Z2(NNN)
39. A=XC(1)
IF (A.EQ.0.0) X(1)=X(J,N)
IF (A.EQ.0.0) Y(1)=Y(J,N)
IF (A.EQ.0.0) 50 TO 5

XC(2)=X(J,N)
YC(2)=Y(J,N)
CALL RLVEC (XC(1), YC(1), XC(2), YC(2), 1201)
XC(1)=XC(2)
YC(1)=YC(2)

CONTINUE

X(NP,N)=X(1,N)
Y(NP,N)=Y(1,N)
Z(NP,N)=Z(1,N)
IF (N.LT.LIM) CALL MESSAG (13HEN0 OF CURVES, 100, 2, 2)
IF (N.LT.LIM) CALL ENDPL (0)
IF (N.LT.LIM) 30 TO 3

CALL MESSAG ('END OF CURVES', 100, 2, 2)
CALL ENDPL (0)
NT=NC*2
DO 6 I=1,NP
X(I,NT)=X(I,1)
Y(I,NT)=Y(I,1)
Z(I,NT)=Z(I,NC)
6 CONTINUE

PUNCH (8,8) NT,NP
DO 7 N=1,NT
PUNCH (8,9) X(I,N), Y(I,N), Z(I,N), X(I+1,N), Y(I+1,N), Z(I+1,N), I=1,
7 CONTINUE

RETURN

C

8 FORMAT (3X,3HARS,4X,2I10)
9 FORMAT (10X,6F10.4)

SUBROUTINE ZOOM

C

DIMENSION X(300), Y(300), FIL(999), ID1(3), ID2(3)
COMMON /ZIP/ ICONT
COMMON /ZOP/ HAR, VAT
DATA 101 /10HSELECT LOW, 10HER LEFT C, lOHORNFP
DATA 102 /10HSELECT UPP.
10HER RIGHT . 10HCORNEP
CALL BACKUP
CALL PICT
HOR=HAR
VET=VAT
CALL BACKUP
PRINT *, ID1
PRINT *, ID1
CALL CURSOR (CX,CY)
CX=(CX-(1024*0.3/8.1315))*HOR/(1024*0.5/8.1315)
CY=(CY-(780*0.59/6.2))*VET/(780*0.5/6.2)
XLL=CX SYLL=CY
PRINT *, ID2
PRINT *, ID2
CALL CURSOR (CX,CY)
CX=(CX-(1024*0.3/8.1315))*HOR/(1024*0.5/8.1315)
CY=(CY-(780*0.59/6.2))*VET/(780*0.5/6.2)
XUR=CY SYUR=CY
IF (XLL.GT.CX) XUR=XLL
IF (XLL.GT.CX) XLL=CY
IF (YLL.GT.CY) YUR=YLL
IF (YLL.GT.CY) YLL=CY
XOR=XLL$YOR=YLL
HOR=XUR-XLL$VET=YUR-YLL
CALL CLEAR
CALL PHYSOR (3.0,0.59)
CALL TITLE ('BUILD ARS',10.0,1.1,5.0,5.0)
XNEW=AMAX1(HOR,VET)
XNEW=10.0*FLOAT(IFIX(XNEW/10.0)+1)
HOR=XNEW
VET=XNEW
XOR=10.0*FLOAT(IFIX(XOR/10.0))
YOR=10.0*FLOAT(IFIX(YOR/10.0))
XUR=XOR*HOR
YUR=YOR*VET
CALL GRAF (XOH,HOR,XUR,YOR,VET,YUR)
READ (12,7) IDENT
IF (EOF(12)) 1,2
READ (12,8) A,B,C,HOR,VET
READ (12,9) N
IF (N.EQ.1) READ (12,6) HO,VE
IF (N.EQ.-2) READ (12,9) NF
IF (N.EQ.0) GO TO 5
READ (12,10) (X(I),Y(I),I=0,N)
IND=1
CONTINUE
3 4 I=1,N
IF (X(I),LT,XOR,OR,X(I),GT,XUR) GO TO 4
IF (Y(I),LT,YOR,OR,Y(I),GT,YUR) GO TO 4
X(IND)=X(I) Y(IND)=Y(I)
IND=IND+1
CONTINUE
N=IND-1
GO TO 3
CALL CURVE (X*,Y*,N+0)
GO TO 3
CALL CURSOR (CX,CY)
CALL ENQDR (0)
CALL RESET ('PHYSOR')
ICONT=ICONT+1
RETURN
C
6 FORMAT (2F12,4)
7 FORMAT (8A10)
8 FORMAT (6F12,4)
10 FORMAT (6F12,4)
END
SUBROUTINE OUT
C RETURN TO CYBER OPERATING SYSTEM
CALL CLEAR
STOP
END
SUBROUTINE PACT
DIMENSION X(300), Y(300), FIL(999)
COMMON /ZAP/ ICONT
COMMON /ZIP/ ZZ(300) HO, VET, NC
READ (12,5) NC, (ZZ(I),I=0,N)
IF (EOF(12)) 1,2
READ (12,6) A,B,C,HOR,VET
CALL PHYSOR (3.0,0.59)
CALL TITLE ('BUILD ARS',10.0,1.1,5.0,5.0)
CALL GRAF (X*,HOR,HOR,0,0,VET,VET)
READ (12,7) N
IF (N.EQ.0) GO TO 4
READ (12+i) (X(I),Y(I))=I=1,N
CALL CURVE (X,Y,N,O)
GO TO 3
4 CONTINUE
ICONT=ICONT+1
RETURN
5 FORMAT (I5,15F5.1)
6 FORMAT (6F12.4)
7 FORMAT (1110)
8 FORMAT (6F12.4)
END
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________________________________________________________________________

3. How, specifically, is the report being used? (Information source, design data or procedure, management procedure, source of ideas, etc.)

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4. Has the information in this report led to any quantitative savings as far as man-hours/contract dollars saved, operating costs avoided, efficiencies achieved, etc.? If so, please elaborate.

________________________________________________________________________

5. General Comments (Indicate what you think should be changed to make this report and future reports of this type more responsive to your needs, more usable, improve readability, etc.)

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6. If you would like to be contacted by the personnel who prepared this report to raise specific questions or discuss the topic, please fill in the following information.

   Name: ____________________________________________

   Telephone Number: ________________________________

   Organization Address: ______________________________

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