FINAL REPORT

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TITLE

Data Management and Language Enhancement for
Generalized Set Theory Computer Language for
Operation of Large Relational Databases

ABSTRACT

This report covers the study of the relational database
implementation in the NASCAD computer program system. The
existing system is primarily used for computer aided design.
Attention is also directed to a hidden-surface algorithm for
final drawing output.

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INTRODUCTION

The overall objective of this study is the description of the development of an interactive computer language to handle operations on large relational databases. The language contains features applicable to computer graphics and computer aided design. Additionally, this language is extended to contain commands reflecting the operators of relational algebra to manipulate relational databases.

At the inception of this study, the existing system at NASA, called NASCAD, was complete for primitive graphic commands, for numeric data, and for macros to create more complex graphics. Some work was also complete for creating the relational database. This study, therefore, extends the relational system with additional manipulation commands.

Initial proposals also investigated alternate data structures -- especially some hierarchical structure such as the B-tree. The existing data structure, a roving first fit, was considered adequate in the virtual memory environment; it remained undisturbed.

This report also addresses a hidden-surface algorithm to manipulate the final output of a graphic system -- the drawing. The hidden-surface algorithm has as its objective the removal (from the picture) of surfaces that are not visible when viewed from the planned perspective.
Relational Systems

The relational database system derives its theory from the mathematical theory of relations (relational algebra and relational calculus). The term relation is derived as follows. Given the sets $D_1, D_2, ..., D_n$ (not mutually distinct), $R$ is a relation on these sets if it is a set of ordered $n$-tuples $<d_1, d_2, ..., d_n>$ such that $d_1$ belongs to $D_1$, $d_2$ belongs to $D_2$, ..., and $d_n$ belongs to $D_n$, where the sets $D_1, D_2, ..., D_n$ are called the domains of $R$. $R$ then is considered a relation of degree $n$.

In a practical sense, a relational database may be pictured as interrelated flat files or tables. These files can be easily represented by the existing notation available in most current higher level languages, namely, the representation of a 2-dimensional array with rows and columns. Each row is considered a tuple and each column represents a domain. Restrictive properties of a relation are: no two rows (tuple) can be identical; and the order of the rows or columns is not significant.

An example used in standard information processing follows. This example represents a file of students where each row (tuple) represents information about a single student, and each column (domain) represents a particular item of information.
STUDENT RELATION

<table>
<thead>
<tr>
<th>SS</th>
<th>NAME</th>
<th>ADDR</th>
<th>ZIP</th>
<th>MAJOR</th>
</tr>
</thead>
<tbody>
<tr>
<td>542</td>
<td>Adams</td>
<td>125 A St</td>
<td>20005</td>
<td>EE</td>
</tr>
<tr>
<td>543</td>
<td>Jones</td>
<td>136 J St</td>
<td>20003</td>
<td>CE</td>
</tr>
<tr>
<td>546</td>
<td>Smith</td>
<td>146 K St</td>
<td>20001</td>
<td>CS</td>
</tr>
</tbody>
</table>

The following example would apply to describing a primitive function in a graphic system.

PRIMITIVE RELATION

<table>
<thead>
<tr>
<th>OPERATION</th>
<th>VERTEX1 (V1)</th>
<th>VERTEX2 (V2)</th>
<th>COLOR</th>
</tr>
</thead>
<tbody>
<tr>
<td>Line</td>
<td>X1</td>
<td>X2</td>
<td>Red</td>
</tr>
<tr>
<td>Line</td>
<td>X11</td>
<td>X22</td>
<td>Blue</td>
</tr>
<tr>
<td>Line</td>
<td>X13</td>
<td>X23</td>
<td>Red</td>
</tr>
<tr>
<td>Line</td>
<td>X1</td>
<td>X23</td>
<td>Green</td>
</tr>
</tbody>
</table>

Relational algebra is a collection of operations on relations. The select, project, and join operators, along with others not mentioned here, constitute the relational algebra. Each operator takes one or two relations as operands and produces another relation.

The select operator takes an existing relation as an input and produces a horizontal subset of that relation - namely that subset of tuples (rows) that satisfy a particular condition specified in the operator statement. That particular condition may be a single attribute or a comparison of attributes within a domain (column). For example: Select lines (defined in tuples)
whose color attribute (defined in the domain, Color) is red. This yields a relation that is a collection of lines whose color attribute is red.

The project operator takes an existing relation as an input and produces, by contrast, a vertical subset of that relation—namely the subset of attributes (columns) specified in a particular order and having any duplicate tuples within the attribute removed. For example: Consider the previous example and lines expressed as vertices V1, V2. After the select produces a relation of red lines, then a project operations over V1 yields a relation showing unique start vertices for all red lines.

The join operator is basically a combination of two relations over a common domain to yield a new relation, generally a wider table containing domains of both predecessor relations with the common domain eliminated. For example: Noting the previous example, consider a join of two relations over the V1 domain. This would yield a relation showing all lines and their attributes emanating from the same starting vertex (regardless of other attributes - color, etc.).

Relational Implementation

Modifications were made to the existing NASA program, NASCAD, to add the commands for the relational operations, project and join. Initial commands for creating and displaying relations as well as SELECT for manipulation of tuples were already
in the system.

The project command (PRJCT) manipulates domains yielding all specified domains in the resulting new relation. Conversely, the command, UNPRJCT, yields all unspecified domains in the resulting new relation. UNPRJCT is desirable when a relatively small number of domains are deleted. The user may specify the domain by name or by number. Domains in the resulting relation are ordered as they were specified in the command string. Thus, PRJCT may be used to reorder domains.

The join command (JOIN) merges two relations over a specified domain. The command string provides for definition of the following: two input relations; a domain (by name or number) in each input relation; and the resulting relation. Theoretically the name of the key domain in each input relation should be the same. However, for flexibility, provision is made for a different "name" to belong to "logically" identical key domains that exist in different relations. (Note that an alias type command could also handle this kind of flexibility.) The key domain may be referred to by name or by number. JOIN provides for operators other than equal such as: greater than and not equal thus allowing the effect of expanded relational operations. The key domain is removed in the resulting relation; this is consistent with traditional join operations.

Each command follows the accepted rules for relational algebra. General command syntax by keyword follows the standard NASCADC form. Identifier names for relations and domains also
follow NASCAD conventions.

At the inception of the study, the NASCAD system, implemented at NASA on a VAX 11/780 Digital Equipment Corporation computer (written in FORTRAN 77) was already in place. The system consists of four basic parts: the command language interpreter, macro interpreter, the editor, and database management system. The command language consists of operating system commands, macro commands, data handling commands, and edit commands. The data base management system is broken into three logical units handling data separately for graphic, numeric, and macro types. The initial commands to create the relational database and the select operator were also in place at that time. These commands as well as additional commands are implemented as macro commands.

In order to provide for change with minimal disruption of existing programs, any modifications are modular -- made as independent segments of existing programs or as separate subroutines. The following program modules are affected by the change: DEFTBL, DEFTAB (with entry points CPYCOL and ADJTAB), and SYSTBL. All work was done from a remote terminal at the university linked to the Vax 11/780 computer at the NASA facility. Testing included runs of expected command variations as well as error conditions. Program listings are filed at NASA.

The following table lists and describes the relational commands.
RELATIONAL COMMANDS

Notation:
R relation by name
D domain or column by name or by number
T tuple of row
d data in domain or column according to specified format
EQ, NE, GT standard logical operations equal, not equal, greater

Relational Commands Existing Prior to Study
ATTACH R retrieves R
SETTABL R retrieves R
DEFTBL number of D, R by name defines new R
DEFCOL col number Di, D by name, format for di defines column or domain of R
DEFROW d1, d2, ...dn defines data in each tuple or row
DSPTBL displays current R
SELECT Di, logical operator, constant performs select operation

Relational Commands Implemented in Study
PRJCT D1, D2, ...,Dn project operation over D
UNPRJCT D1, D2, ..., Dn converse of project; D represents deleted domains
JOIN R1, R2, D1, logical operator, D2, R3 performs join operation over R1 and R2 according to the logical operation with D1 and D2 to yield R3. Normally D1 and D2 are the same key domain. D1 is in R1 and D2 is in R2.

General comments and restrictions:
- Commas in above command strings are for clarity in this text; NASCAD uses blanks as delimiters in command strings.
- Domains may not be referenced both by name and number in the same command string.
Hidden-line/surface Algorithms

One end product of a graphic system is obviously the final drawing. With engineering applications, the drawing of a three dimensional object is made up of precise points, lines, and curved surfaces (represented in this application as flat polygon patches) that are stored in the drawing database to be displayed on a particular graphic device. This drawing is considered viewed from a certain perspective and the (three dimensional) x-y coordinates are projected onto (two dimensional) screen coordinates with the z coordinate representing depth. With the figure completely outlined on the screen (wire frame) all lines and surfaces are shown. The object of hidden-line/surface algorithms is to remove those lines/surfaces from the displayed drawing that are not visible when viewed from the planned perspective. The hidden-line algorithm outlines only the visible lines. The hidden-surface problem renders all visible surfaces on the screen; shading and coloring of the object are considered part of the problem.

The hidden-line/surface problem is one of the oldest in the graphic field. Many algorithms have been developed over the years. All algorithms share one common fault; they are very time consuming. To some extent, the algorithms are suitable for one graphic device versus another. A color raster graphics terminal is the chosen device for this project. For this reason
and because it had been proven effective, the Watkins scan-line algorithm was chosen as the initial algorithm to solve the problem. [Newman & Sproull, 1st edition]

The Watkins algorithm is similar to other scan line algorithms. It operates in image space on the basis of a raster of scan lines. As an image space algorithm, it seeks to compute what the image will be only at each of the resolvable dots on the display screen. The scan lines are assumed to be horizontal-parallel to the x-axis of the image plane coordinate system. The process has few basic steps. The drawing is scanned from the bottom up. Therefore edges are sorted by Y so that only those intersecting the current scan line need be examined. Appropriate sample spans are chosen across the scan-line; this involves a form of X sort. An elimination process of sample spans occurs. Lastly, the segments are searched for visibility - a Z search. The process is repeated at each scan-line.

Implementation and Testing

The program system implements the Watkins hidden-surface algorithm for display of the graphic solids that will be generated by the, NASA based, NASCAD computer aided design system.

Preliminary data processing takes the output from the NASCAD system that represents the three-dimensional object as flat polygon patches projected onto the plane of the screen(x-y coordinates) with the Z coordinate representing depth. The
figure is displayed in outline form on the screen with all parts showing. The algorithm proceeds to scan the figure from bottom to top, one line at a time. Those edges that intersect the current Y scan line are examined for X intersection and lastly for visibility by level of Z depth. The visible components of the figure are filled in at each Y line. The process repeats itself until the top of the screen is reached.

The algorithm as described in the reference [Newman & Sproull, 1st edition] was written in SAIL, a higher level programming language. The implementation is written in FORTRAN IV and is run on the Dec 2060 (Digital Equipment Corporation) computer. Graphic output was produced on the Tektronics 4027 color terminal. Program documentation was completed in a report by Peter A. Brown, a university student, dated March 23, 1981. Test data of scenes typically used in graphic reference materials were produced by NASCAD and used for initial testing.

Final test data generated by NASCAD were figures of the space shuttle pallet and the pallet with the more complex telescope mounted. Tests were successful except those where the telescope was incorporated into the drawing. The point of concern was a center point where multiple lines joined. The figures were broken into individual components and various component combinations to speed test time (the entire figure took 26 minutes to draw on the screen). The case of selected intersecting (or penetrating) planes was the broader problem with the Watkins algorithm itself. [Newman & Sproull, 2nd edition]
A tripod mounted, 35 mm camera was used to present test results as color photographic slides taken of the computer terminal screen at various stages of solution. Extensions were made to provide hard copy visual output on a black and white graphics device. This was done by creating patterns in black and white to represent any of eight colors used simultaneously. This technique was effective where figures had relatively large surface areas. Details were not clearly seen in the black and white pattern, even when patterns were carefully chosen to match the smallest surface area with the smallest pattern.
APPENDIX

COMPUTER CODE FOR HIDDEN-SURFACE ALGORITHM

This program is written in the FORTRAN IV programming language for the DEC 2060 computer (Digital Equipment Corporation). The graphic output devices that are supported are:

- Tektronix 4027 Color Terminal
- Tektronix 4013/4015 Series Black And White Terminal
- RAMTEC Terminal (Unimplemented)
C THIS DOCUMENTATION SPECIFIES ALL SUBROUTINES USED
C IN THE WATKINS HIDDEN SURFACE ALGORITHM. IN ADDITION
C A BRIEF DESCRIPTION IS GIVEN OF THE SUBROUTINES
C MENTIONED.
C*****************************************************************************
C SUBROUTINE DESCRIPTION
C LOADBX
C
C THIS ROUTINE TAKES THE PRESENT SEGMENT, AND LOA
C LOADS IT INTO THE BOX. THE EXTREMITIES OF THE
C SEGMENT ARE REMEMBERED AS THE EXTREMITIES
C OF THE BOX.

C XPANBX
C
C THE PRESENT SEGMENT IS ADDED TO THE BOX, IF
C NECESSARY, THE EXTREMITIES OF THE BOX ARE
C EXPANDED TO ENCLOSE THE NEW SEGMENT.

C (FUNCTION)
C BZINT
C
C IF ONLY ONE SEGMENT IS IN THE BOX, WE MAY
C HAVE A DESIRE TO COMPUTE THE 'DEPTH' OF
C THAT SEGMENT AT SEVERAL POINTS. THE BZINT
C FUNCTION DOES THIS, GIVEN AN XS
C CO-ORDINATE AS ARGUMENT.

C (FUNCTION)
C ZINT
C
C THIS FUNCTION COMPUTES THE DEPTH OF THE
C SEGMENT BEING LOOKED AT, GIVEN AN XS
C COORDINATE AS ARGUMENT.

C RMXSRT
C
C THIS ROUTINE REMOVES A SEGMENT FROM THE
C XSORTLIST.

C RETBLK
C
C RETURN A SEGMENT BLOCK TO FREE STORAGE.

C GETBLK
C
C GETS A BLOCK FROM FREE STORAGE AND INITIALIZE
C YLEFT AND TRIGHT ENTRIES TO ZERO.

C FIXSRT
C
C THIS ROUTINE PUTS THE SEGMENT AT THE HEAD
C OF XSORT LIST.

C SHWCLS
C
C CALL SHWCLS, CALL EFRAME TO END THE FRAME
C AND PUT IT UP ON THE SCREEN.

C STOPIC
C
C STOPIC TAKES TWO ARGUMENTS: THE XS POSITION
C AT WHICH THE SEGMENT STARTS AND THE INDEX
C OF THE VISIBLE SEGMENT. IF THIS INDEX IS
C ZERO, THEN THIS SECTION OF THE SCAN-LINE
C IS BLANK. STOPIC RECORDS A COLLECTION OF
C PAIRS X1, X2, X3 THESE ARE USED, AT THE END
C OF THE SCAN-LINE TO CREATE SHADING
C COMMANDS FOR THIS SCAN-LINE.

C RECSAM
C
C THE RECORD SAMPLE ROUTINE IS CONCERNED WITH
C THE COLLECTION OF SAMPLE POINTS FOR THE
C TRAVERSE OF THE NEXT SCAN-LINE. A SAMPLE POINT
C IS RETAINED IF A SPAN EDGE CORRESPONDS TO THE
C ENTRY IN THE LIST, SAMFLST TO THE FIRST
C SAMPLE POINT.

C PUTSAM
C
C PUT A SAMPLE IN THE SAMPLE LIST FOR NEXT SCAN-
LINE. GET A FREE SAMPLE BLOCK AND FIX UP FREE STORAGE. ALSO IT RECORDS X POSITION OF SAMPLE POINT.

SUBROUTINES WHICH ARE INVOKED BY THE THINKER

STOPIC
RECSAM
PUTSAM
STOPIC
PIXSRT
GETBLK

SUBROUTINES WHICH ARE INVOKED BY THE LOOKER

LOADBX
XPANBX
BZINT
ZINT

SUBROUTINES WHICH ARE INVOKED BY THE CONTROLLER

RMXSRT
RETBK
GETBLK
PIXSRT
LOOKER
THINK
SHOW
SHWCLS
THE FOLLOWING IS A GROUP OF *.CMN

C USED BY CONTROLLER, GETBLK, RETBLK
INTEGER FRELST
COMMON/BLK/FRELST

C COMMON BLOCKS USED FOR INPUT DATA
COMMON /VERTEX/ XS(MAXPNT),YS(MAXPNT),ZS(MAXPNT)
INTEGER P1,P2,V1,V2,ENTLST
INTEGER EDGLST
INTEGER XRES,YRES
COMMON/EDG/P1(MAXEDG),P2(MAXEDG),V1(MAXEDG),V2(MAXEDG),
  1 ENTLST(MAXEDG),EDGLST,EDGLST
INTEGER SHAD
COMMON/COLOR/ SHAD(MAXPLY)
COMMON/DEV/IDEV,XRES,YRES
C*****k*****X************X**X***kX************END OF INPUT.WN******

C BOX BLOCK USED BY LOOKER & SUBROUTINES
C
INTEGER BOXCNT,BOXTYP,BFULL,BSEG1,BSEG2,SFULL,SEG
COMMON/LOKBX1/ BOXCNT,BOXTYP,BFULL,BSEG1,BSEG2,
  1 BXLEFT,BXRGHT,BZLEFT,BZRGHT,
  2 BZMIN,BZMAX,DIV,SFULL,SEG
COMMON/LOKBX2/ SDIV,SXLEFT,SXRGHT,SZLEFT,SZRIGHT

C POLYGON DATA BLOCKS
INTEGER CHNGNG,SEGLST
COMMON/POLYGON/ CHNGNG(MAXPLY),SEGLST(MAXPLY)

C SEGMENT DATA BLOCKS
INTEGER POLYGN,PLYSEG,XSRTLT,XSRTRT,ACTIVE,YLEFT,YRIGHT
COMMON/SEG1PK1/ POLYGN(MAXSEG),PLYSEG(MAXSEG),
  1 ACTIVE(MAXSEG),
  2 XSRTLT(MAXSEG),XSRTRT(MAXSEG),
  3 YLEFT(MAXSEG),YRIGHT(MAXSEG)

C
COMMON/SEG1PK2/ XLEFT(MAXSEG),DXLEFT(MAXSEG),
  1 ZLEFT(MAXSEG),DZLEFT(MAXSEG),
  2 XRIGHT(MAXSEG),DXRGHT(MAXSEG),
  3 ZRIGHT(MAXSEG),DZRGHT(MAXSEG)
C***************************************************************
C MISCELLANEOUS COMMON ROUTINE 9
INTEGER VISPOS,VISSEG
COMMON/MISC1/ VISPOS(MAXSEG),VISSEG(MAXSEG)

C
INTEGER SAMLNK,SAMX
COMMON/SAM/ SAMLNK(IMAX),SAMX(IMAX)

C USED BY CONTROLLER, STOPIC
INTEGER SEGCNT
COMMON/PIC/LASSEG,SEGCNT

C SINGLE VARIABLES USED BY THINKER, CONTROLLER
C RRECSAM, PSMPLE
INTEGER SAMFST,SAMFRE,SAMLST
COMMON/SAMIN/ SAMFST,SAMFRE,SAMLST

C USED BY LOOKER, THINKER, CONTROLLER, RRECSAM
COMMON/SPAN/ SPANRT,SPANLT,IMPLFT

C USED IN CONTROLLER, PIXSRT,RMXSRT
INTEGER SEGFST
COMMON /SRT/ SEGFST

C USED BY CONTROLLER, ,THINKER
INTEGER PREV

COMMON/THK/ IMPLST,MPLST2,PREV
C MODULE USED BY LOOKER.
C**********************************************************************
C FILE NAME SUB4.FOR
C FUNCTION NAME 'BZINT';
C THE BZINT FUNCTION IS DESIGNED TO COMPUTE THE
C 'DEPTH' OF A SEGMENT AT SEVERAL POINTS. GIVEN
C AN XS ARGUMENT.
C**********************************************************************

FUNCTION BZINT (X)
INCLUDE 'MAIN.PAR'
INCLUDE 'LOOKBX.CMN'
IF(BXRGHT .EQ. BXLEFT) GO TO 10
   BZINT = BZLEFT + (BXRGHT - BXLEFT)
1   *(X -BXLEFT)/(BXRGHT-BXLEFT)
RETURN
10  BZINT = BZLEFT
RETURN
END
SUBROUTINE CONT

C BEGIN ELIMINATE
INCLUD 'MAIN.PAR'
INCLUD 'MAIN.CMN'
INCLUD 'INPUT.CMN'
INCLUD 'BLK.CMN'
INCLUD 'SRT.CMN'
INCLUD 'SAMSIN.CMN'
INCLUD 'SPAN.CMN'
INCLUD 'THK.CMN'
INCLUD 'LOOKBX.CMN'
INCLUD 'PIC.CMN'
INTEGER YENTER(IYRESB)
INTEGER GETBLK
REAL LSTUSE, ZFIRST, XSLOPE, RELDLY, ZSLOPE,
1 XFIRST
INTEGER CHANGE, SEGLO, CURSEG, SEG1, YLAST,
1 K, PTR, SEGOUT, Y2, TE1, NEXT, Y1, Y,
2 YFIRST, P, J, TE2, MX, VV1, DELY, PCHLST,
3 SEGACT, ITH, IX, SAMPLE, ITEM,TE
4 MXSG, VV2, I
DO 10 I = 1, MXSG
ACTIVE(I) = I+1
CONTINUE
FRELST = 1
MXSG = MAXSEG * 2 - 1
DO 20 I = 1, MXSG
SAMLNK(I) = I + 1
CONTINUE
C BEGIN HIDDEN-LINE INITIALIZATION
IMPLST = 0
MPLST2 = 0
SEGFLST = 0
PTR = EDGLST
10 IF(PTR .EQ. 0) GO TO 60
NEXT = ENTLST(PTR)
IF (((P1(PTR).NE.0).AND.(SHAD(P1(PTR)).NE.
1 0)).OR.((P2(PTR).NE.0).AND.(SHAD(P2(PTR))
1 .NE.0))).EQ.0) GO TO 50
J = V1(PTR)
K = V2(PTR)
IF(YS(J).LE.YS(K)) GO TO 30
ITEM = V1(PTR)
V1(PTR) = V2(PTR)
V2(PTR) = ITEM
J = K
30 I=YS(J) +.999999
IF((I.LT.1).OR.(YRES.LT.I)) GO TO 40
ENTLST(PTR) = YENTER(I)
YENTER(I) = PTR
GO TO 50
40 WRITE(5,1000)
1000 FORMAT(1X,'EDGE OUT OF BOUNDS')
STOP
50 PTR = NEXT
GO TO 25
C******************************************************************************************
60 CONTINUE
CALL SHWINT
C END HIDDEN_LINE_INITIALIZATION

C DISPLAY GENERATION

DO 730 Y = 1, YRES
    WRITE(5,789)Y
789 FORMAT(1X,'Y= ',I4)

C BEGIN PROCESSING BEFORE STEPPING ACROSS SCAN-LINE
    PCHLST = -1
    SEG = SEGFST
70   IF(SEG .EQ. 0) GO TO 100
        XLEFT(SEG) = XLEFT(SEG) + DXLEFT(SEG)
        XRIGHT(SEG) = XRIGHT(SEG) + DXRIGHT(SEG)
        ZLEFT(SEG) = ZLEFT(SEG) + DZLEFT(SEG)
        ZRIGHT(SEG) = ZRIGHT(SEG) + DZRIGHT(SEG)
        Y1 = YLEFT(SEG) + 1
        YLEFT(SEG) = YLEFT(SEG) + 1
        Y2 = YRIGHT(SEG) + 1
        YRIGHT(SEG) = YRIGHT(SEG) + 1
        IF((Y1.NE. 0).AND.(Y2.NE.0)) GO TO 90
    PTR = POLYGN(SEG)
    IF(PTR.NE. 0) GO TO 80
C*********************************************
C*********************************************
C*********************************************
    CALL RMXSRT(SEG)
C*********************************************
    CALL RETBLK(SEG)
C*********************************************
    GO TO 90
80   IF(CHNGNG(PTR).NE.0) GO TO 90
    CHNGNG(PTR) = PCHLST
    PCHLST = PTR
90   SEG = XSRTSEG(SEG)
    GO TO 70
100  PTR = YENTER(Y)
110  IF(PTR .EQ. 0) GO TO 260

C BEGIN ENTERING EDGES
    VV1 = V1(PTR)
    VV2 = V2(PTR)
    YFIRST = YS(VV1)
    YLAST = YS(VV2)
    DELY = YFIRST - YLAST
    RELDLY = YS(VV2) - YS(VV1)
    IF(DELY.GE.0) GO TO 255

C--BEGIN MAKE SEGMENTS FOR THIS EDGE
    XSLOPE = (XS(VV2)-XS(VV1))/RELDLY
    XFIRST = XS(VV1) + XSLOPE * (Y-YS(VV1))
    ZSLOPE = (ZS(VV2)-ZS(VV1))/RELDLY
    ZFIRST = ZS(VV1) + ZSLOPE * (Y-YS(VV1))
    DO 250 P = PI(PTR),P2(PTR)

C--BEGIN LOOK AT BOTH POLYGONS BORDERING THIS EDGE
    IF(P.EQ.0) GO TO 250
C--BEGIN A REAL POLYGON
    IF(CHNGNG(P).NE. 0 ) GO TO 120
    CHNGNG(P) = PCHLST
    PCHLST = P
120 SEG = SEGLST(P)  
PREV = 0  
J = 3  
130 IF(SEG.EQ.0) GO TO 190  
C--BEGIN LOOK AT SEGMENTS

    T1 = (XFIRST.LT.XLEFT(SEG)).OR.(XFIRST.EQ.XLEFT(SEG))  
        .AND.XSLOPE.LT.DXLEFT(SEG))  
    T2 = (XFIRST.LT.XRIGHT(SEG)).OR.(XFIRST.EQ.XRIGHT(SEG))  
        .AND.XSLOPE.LT.DXRIGHT(SEG))  
    Y1 = (YLEFT(SEG).LT.0)  
    Y2 = (YRIGHT(SEG).LT.0)  
    I = -(T1*8)-(T2*4)-(Y1*2)-(Y2)  
    IF((I.LT.0).OR.(I.GT.15))GO TO 170  
    IF(I.NE.11)GO TO 140  
J = 0  
GO TO 180  
140 IF((I.LT.13).AND.((I.NE.5).AND.(I.NE.10)))GO TO 150  
J = 1  
GO TO 180  
150 IF(I.NE.7) GO TO 160  
J = 2  
GO TO 180  
160 J = 3  
GO TO 180  
170 WRITE(5,1010)  
1010 FORMAT(1X,'CASE I ERROR IN CONTROLLER')  
STOP  
180 IF(J.NE.3) GO TO 190  
PREV = SEG  
SEG = PLYSEG(SEG)  
GO TO 130  
C--END LOOK AT SEGMENTS  
190 IF((J.NE.1).AND.(J.NE.3)) GO TO 220  
C--BEGIN INSERT NEW SEGMENT BETWEEN PREV AND SEG

    DUMMY = 0  
    SEG1 = GETBLK(DUMMY)  
    POLYGN(SEG1) = P  
    XLEFT(SEG1) = XFIRST  
    DXLEFT(SEG1) = XSLOPE  
    ZLEFT(SEG1) = ZFIRST  
    DZLEFT(SEG1) = ZSLOPE  
    YLEFT(SEG1) = DELY  

C**************************************************************************  
CALL PIXSRT(SEG1)  
C**************************************************************************

    IF(PREV.EQ.0) GO TO 200  
    PLYSEG(PREV) = SEG1  
    GO TO 210  
200 SEGLST(P) = SEG1  
210 PLYSEG(SEG1) = SEG  
GO TO 250  
C--BEGIN SPLIT THE SEGMENT

    DUMMY = 0  
220 SEG1 = GETBLK(DUMMY)  
    POLYGN(SEG1) = P  
    XLEFT(SEG1) = XLEFT(SEG)  
    DXLEFT(SEG1) = DXLEFT(SEG)  
    ZLEFT(SEG1) = ZLEFT(SEG)
```fortran
DZLEFT(SEG1) = DZLEFT(SEG)
YLEFT(SEG1)=YLEFT(SEG)
YLEFT(SEG) = 0
XRIGHT(SEG1) = XFIRST
DXRIGHT(SEG1) = XSLOPE
ZRIGHT(SEG1) = ZFIRST
DZRIGHT(SEG1) = ZSLOPE
YRIGHT(SEG1) = DELY

CALL PIXSRT(SEG1)

CALL RMXSRT(SEG)
```

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C******************************************************************************
C******************************************************************************
C******************************************************************************
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C******************************************************************************
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C******************************************************************************
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C******************************************************************************
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C******************************************************************************
C******************************************************************************
C******************************************************************************
```
CALL RETBLK(SEG)
SEG = I
GO TO 360

C******************************************************************************
310 IF((Y1.NE.0).OR.(Y2.GE.0)) GO TO 320
C--BEGIN MOVE RIGHT TO LEFT
   YLEFT(SEG) = YRIGHT(SEG)
   YRIGHT(SEG) = 0
   XLEFT(SEG) = XRIGHT(SEG)
   DXLEFT(SEG) = DXRIGHT(SEG)
   ZLEFT(SEG) = ZRIGHT(SEG)
   DZLEFT(SEG) = DZRIGHT(SEG)
GO TO 360

C--BEGIN RIGHT SIDE IS EMPTY—LOOK AT NEXT SEGMENT

320  NEXT = PLYSEG(SEG)
    IF(NEXT.NE.0) GO TO 330
    WRITE(5,1020)
1020  FORMAT(1X,'NEXT ERROR')
    STOP
330  IF(YLEFT(NEXT).GE.0) GO TO 340

C--BEGIN MOVE NEXT'S LEFT TO MY RIGHT

340  IF(YRIGHT(NEXT).GE.0) GO TO 350

C--BEGIN MOVE NEXT'S RIGHT TO MY RIGHT'

350   PLYSEG(SEG) = PLYSEG(NEXT)
C******************************************************************************
   CALL RMXSRT (NEXT)
C******************************************************************************
   CALL RETBLK(NEXT)
C******************************************************************************

C--END RIGHTSIDE IS EMPTY—LOOK AT NEXT SEGMENT

360  GO TO 270
C--END TRANSFORM THE LIST
370  GO TO 260
C--END PROCESS A CHANGING POLYGON
GO TO 385
IF(CHANGE .EQ.O) GO TO 430
CONTINUE

C--BEGIN SORT THE XSORTLIST

CHANGE = 0
SEG = SEGFST
IF(SEG .EQ.0) GO TO 425

C--BEGIN RAMBLE DOWN LIST

I = XSRTRT(SEG)
IF(I .EQ. 0) GO TO 425
IF(XLEFT(SEG).LE. XLEFT(I))GO TO 420

C--BEGIN SWAP

CHANGE = -1
IF(XSRTLT(SEG).EQ. 0) GO TO 400
K = XSRTLT(SEG)
XSRTRT(K) = I
K = XSRTLT(SEG)
XSRTLT(I) = K
XSRTLT(SEG) = I
IF(XSRTRT(I) .EQ. 0) GO TO 410
K = XSRTRT(I)
XSRTLT(K) = SEG
K = XSRTRT(I)
XSRTLT(SEG) = K
XSRTRT(I) = SEG
IF(SEGFST.EQ.SEGR) SEGFST = I
GO TO 425

C--END SWAP

SEG = XSRTRT(SEG)
GO TO 390
CONTINUE
GO TO 380

C--END RAMBLE DOWN LIST
C--END SORT THE LIST
C-- END PROCESSING BEFORE STEPPING ACROSS SCAN-LINE

SEGACT = 0
SEGCNT = 0
IF(IMPLST.EQ.0) GO TO 450
MPLST = XSRTRT(IMPLST)
J = IMPLST
CALL RETBLK(J)

GO TO 440
IMPLST = MPLST2
MPLST2 = 0
CURSEG = SEGFST
SPANRT = 0
SAMPLE = SAMFST
SAMSLST = 0
LSTUSE = 0
GO TO 465
IF(SANRT .EQ. XRES) GO TO 700
CONTINUE
C--BEGIN ACROSS THE SCAN LINE

SPANLT = SPANRT + 1
IF(SPNLT .LE. LSTUSE) GO TO 490

C--BEGIN MOVED TO RIGHT OF LAST SAMPLE SPAN

IF(SAMPLE .EQ. 0) GO TO 470

C--BEGIN MORE SAMPLES LEFT

SPANRT = SAMX(SAMPLE)
IX = SAMPLE
SAMPLE = SAMLNK(SAMPLE)
SAMLNK(IX) = SAMFRE
SAMFRE = IX
LSTUSE = SPANRT
GO TO 480

470 SPANRT = XRES
480 GO TO 500
490 SPANRT = LSTUSE
500 IMLFLT = 0

C--WHILE STATEMENT SIMULATION UNTIL STMT #670
C--WHEN THINKER IS TRUE, THIS WHILE BLOCK WILL

C--BE LEFT.

510 CONTINUE
BOXCNT = 0
SEGOUT = 0
PREV = 0
SEG = SEGACT

520 IF(SEG .EQ. 0) GO TO 590

C--BEGIN ACTIVE SEGMENTS

NEXT = ACTIVE(SEG)
IF(XRIGHT(SEG).GE.SPANRT + 1) GO TO 560

C--BEGIN IT ENDS IN THIS SPAN

IF(PREV.EQ. 0) GO TO 530
ACTIVE(PREV) = NEXT
GO TO 540

530 SEGACT = NEXT
540 ACTIVE(SEG) = SEGOUT
IF(SEGOUT.EQ. 0) SEGLO = SEG
SEGOUT = SEG
IF(XRIGHT(SEG).LT.SPANLT) GO TO 550
CALL LOOKER
C*****************************************************************************
CALL LOOKER

C--END IT ENDS IN THIS SPAN

550 GO TO 580
560 IF(XLEFT(SEG).GT.SPANRT) GO TO 570
CALL LOOKER
C-- BEGIN IMPLIED EDGE BLOCK

IF(.NOT.((L.LE.XLEFT(SEG)).AND.(XLEFT(SEG)
    1 .LE. XRES)).AND.((PLYSEG(SEG)/10000).EQ.
    1 LASSEG)) GO TO 600

C BEGIN OK TO KEEP IMPLIED EDGE

IMPLFT = SEG
GO TO 630

C BEGIN THROW OUT IMPLIED EDGE

C-- END IMPLIED EDGE BLOCK

GO TO 630

C--BEGIN REAL EDGE BLOCK

605 IF(XLEFT(SEG)+1.GE.XRIGHT(SEG))GO TO 630
IF(XRIGHT(SEG).GE.SPANRT+1) GO TO 610
ACTIVE(SEG) = SEGOUT
IF(SEGOUT.EQ. 0) SEGLO = SEG
SEGOUT = SEG
GO TO 620

610 ACTIVE(SEG) = SEGACT
SEGACT = SEG

C--BEGIN DIVIDE AT MID POINT

I = DIV
IF(I .LT. SPANRT) GO TO 660

C--BEGIN DIVIDE AT MID POINT

I = (SPANLT + SPANRT)/2
SPANRT = I
GO TO 670
660 SPANRT = I
670 GO TO 510

C--END SUBDIVIDE SAMPLE SPACE

680 IF(IMPLFT .EQ. 0) GO TO 690
C*******************************************************
CALL RMXSRT(IMPLFT)
CALL RETBLK(IMPLFT)
C*******************************************************
C END SAMPLE ACROSS THE SCAN LINE

690 GO TO 460
700 IF(SAMLST.EQ.0) GO TO 710
SAMLNK(SAMLST) = 0
GO TO 720
710 SAMFST = 0
C*******************************************************
720 CONTINUE
    IB = Y
    CALL SHOW(IB)
C*******************************************************
730 CONTINUE
C END DISPLAY GENERATION
    CALL SHWCLS
C END ELIMINATE
RETURN
END
C   MISCELLANEOUS PROCEDURE.
C******************************************************************************
C FUNCTION NAME GETBLK.
C THIS FUNCTION GETS A BLOCK FROM FREE STORAGE
C AND INITIALIZE YLEFT AND YRIGHT ENTRIES TO ZERO.
C******************************************************************************

INTEGER FUNCTION GETBLK(DUMMY)
INCLUDE 'MAIN.PAR'
INCLUDE 'MAIN.CMN'
INCLUDE 'BLK.CMN'
I = FRELST
IF(I .NE. 0) GO TO 20
WRITE(5,4)
4 FORMAT(3X,'NO MORE FREE STORAGE')
STOP
20 YLEFT(I) = 0
YRIGHT(I) = 0
FRELST = ACTIVE(I)
GETBLK = I
RETURN
END
SUBROUTINE LOADBX
INCLUDE 'MAIN.PAR'
INCLUDE 'LOOKBX.CMN'
BOXCNT = 1
BOXTYP = 0
BXLEFT = SXLEFT
BXRGT = SXRGT
BZLEFT = SZLEFT
BZRGT = SZRGT
BSEG1 = SEG
BZMIN = BZLEFT
BZMAX = BZRGT
IF(BZMIN.LE.BZMAX) GO TO 10
CALL SWAP(BZMIN,BZMAX)
10 DIV = SDIV
BFULL = SFULL
RETURN
END
THE LOOKER IS A SUBROUTINE WHICH EXAMINES THE SEGMENT INDEXED BY 'SEG', AND ADDS IT TO THE PRESENT BOX, ETC.

VARIABLES USED BY THE LOOKER:

- BXLEFT, BXRIGHT: LEFT AND RIGHT EDGES OF BOX.
- BZMIN, BZMAX: NEAR AND FAR EDGES OF THE BOX.
- BZLEFT, BZRIGHT: WHEN ONLY ONE SEGMENT IS IN THE BOX, THESE CONTAIN THE ZS COORDINATES OF THE LEFT AND RIGHT ENDS OF THAT SEGMENT.
- BOXCNT: COUNT OF NUMBER OF SEGMENTS IN THE BOX.
- BOXTYPE: 1 IF WE HAVE COMPUTED THE INTERSECTION OF TWO PENETRATING SEGMENTS (IMPLIED EDGE)
- DIV: THE PLACE TO SUBDIVIDE THE SPAN IF NEEDED.
- BSEG1: IF THE ONE SEGMENT IN THE BOX IS A SPANNER.
- BSEG2: THE INDEX OF THE SECOND SEGMENT IN THE BOX
- BSEG: THE INDEX OF THE FIRST SEGMENT IN THE BOX.
- SXLEFT, SXRIGHT: XS COORDINATES OF LEFT AND RIGHT ENDS OF THE SEGMENT BEING EXAMINED.
- SZLEFT, SZRIGHT: SAME FOR ZS COORDINATES.
- SFULL: TRUE IF SEGMENT BEING LOOKED AT IS A SPANNER.

SUBROUTINES CREATED FOR USE BY THE LOOKER.

- SUBROUTINE XPANBOX: THE PRESENT SEGMENT IS ADDED TO THE BOX IF NEEDED, THE EXTREMITIES OF THE BOX ARE EXPANDED TO ENCLOSURE THE NEW SEGMENT.
- SUBROUTINE BZINT: IF ONLY ONE SEGMENT IS IN THE BOX, WE MAY HAVE A DESIRE TO COMPUTE THE DEPTH OF THAT SEGMENT AT SEVERAL POINTS. THE BZINT FCT DOES THIS, GIVEN AN XS COORDINATE AS ARGUMENT.
- SUBROUTINE ZINT: THIS FUNCTION COMPUTES THE DEPTH OF THE SEGMENT BEING LOOKED AT, GIVEN AN XS COORDINATE AS ARGUMENT.

SUBROUTINE LOOKER

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SUBROUTINE LOOKER
INCLUDE 'MAIN.PAR'
INCLUDE 'MAIN.CMN'
INCLUDE 'LOOKBX.CMN'
INCLUDE 'SPAN.CMN'
SXLEFT = XLEFT(SEG)
SZLEFT = ZLEFT(SEG)
SXRIGHT = XRIGHT(SEG)
SZRIGHT = ZRIGHT(SEG)
SFULL = -1
IF(SXLEFT .GT. SPANLT) GO TO 10
SZLEFT = ZINT(SPANLT)
SXLEFT = SPANLT
GO TO 15
10 SFULL = 0
15 IF(SXRIGHT .LT. SPANRT) GO TO 20
SZRIGHT = ZINT(SPANRT)
SXRIGHT = SPANRT
```
GO TO 21
SFULL = 0
IF(SXLEFT .LE. SPANLT) GO TO 22
SDIV = SXLEFT
GO TO 23
SDIV = SXRGHT
IF(BOXCNT .EQ. 0) GO TO 1000
IF(BOXCNT .EQ. 1) GO TO 25
IF((SXLEFT .LE. BXLEFT).AND.(SXRGHT .GE. BXRGHT)
    .AND.(SZLEFT .LE. BZMIN).AND.(SZRGHT .GE. BZMIN))
    GO TO 1000
IF((BXLEFT .LE. SXLEFT).AND.(BXRGHT .GE. SXRGHT)
    .AND.(BZMAX .LE. SZLEFT).AND.(BZMAX .LE. SZRGHT))
    RETURN
C******************************************************************************
C******************************************************************************
CALL XPANBX
C******************************************************************************
RETURN
25
IF((BXLEFT .LE. SXLEFT).AND.(BXRGHT .GE. SXRGHT)
    .AND.(BZINT(SXLEFT) .LE. SZLEFT).AND.
    (BZINT(SXRGHT) .GE. SZRGHT))RETURN
IF((SXLEFT .LE. BXLEFT).AND.(SXRGHT .GE. BXRGHT)
    .AND.(BZINT(BXLEFT) .LE. BZLEFT).AND.
    (BZINT(BXRGHT) .GE. BZRGHT))GO TO 1000
IF((SFULL .NE. 0) .AND. (BFULL .NE. 0)) GO TO 29
C******************************************************************************
C******************************************************************************
CALL XPANBX
C******************************************************************************
RETURN
29
TEMP = BXLEFT + (SXRGHT - BXLEFT) *
    (SZLEFT - BZLEFT) / (BZRGHT - BZLEFT
    - SZRGHT + SZLEFT)
C******************************************************************************
C******************************************************************************
CALL XPANBX
C******************************************************************************
BOXTPY = i
DIV = TEMP
IF(BZLEFT .LT. SZLEFT)CALL SWAP(BSEG1,BSEG2)
RETURN
1000 CALL LOADBX
9999 RETURN
END
C MAIN CONTROL PROGRAM

INCLUDE 'MAIN.PAR'
INCLUDE 'INPUT.CMN'

WRITE(5,9)
FORMAT(2X,'OPTIONS:'//,3X,'1-4027'//,3X,'2-4013/16'//,3X,
1'3-RAMTEC',//)
READ(5,*)IDIV
GOTO(4,6,8),IDIV

WRITE(5,19)
FORMAT(1X, 'SWITCH IS NOT AVILABLE .')
STOP

XRES=IXRES1
YRES=IYRES1
GO TO 10

XRES=IXRES2
YRES=IYRES2

CALL READIN
CALL CONT
STOP
END
C SUBROUTINE PIXSRT
C THIS SUBROUTINE PUT THE GIVEN SEGMENT AT THE
C HEAD OF THE XSORT LIST.
C**************************************************************************

SUBROUTINE PIXSRT(SEG)
INCLUDE 'MAIN.PAR'
INCLUDE 'MAIN.CMN'
INCLUDE 'SRT.CMN'
INTEGER SEG
IF(SEGFST .EQ. 0) GO TO 20
XSRTLT(SEGFST) = SEG
XSRTLT(SEG) = 0
XSRTRT(SEG) = SEGFST
SEGFST = SEG
RETURN
END
SUBROUTINE PSMPLE(X)
INCLUDE 'MAIN.PAR'
INCLUDE 'MAIN.CMN'
INCLUDE 'SAMSIN.CMN'
I = SAMFRE
SAMFRE = SAMLNK(I)
IF(SAMLST .EQ. 0) GO TO 10
SAMLNK(SAMLST) = I
GO TO 15
10 SAMFST = I
15 SAMLST = I
SAMX(I) = X
RETURN
END
SUBROUTINE READ2
C MAIN READIN ROUTINE
INCLUDE 'MAIN.PAR'
INCLUDE 'INPUT.CMN'
INTEGER PLYPTR(MAXPLY), PLYEDG(MAXPLY)
WRITE(5,988)
988 FORMAT(1X,'INPUT SIZE: ')
READ(5,*), SIZE
C CLEAR P1, P2
DO 10 I = 1, MAXEDG
P1(I) = 0
P2(I) = 0
10 CONTINUE
READ(22,1000) NPTS, NEDGE, NPOLY
1000 FORMAT (3I4)
IF (NPTS.GT.MAXPNT.OR.NEDGE.GT.MAXEDG.OR.
NPOLY .GT. MAXPLY) GO TO 888
C READ VERTICES
C
WRITE(5,97)
97 FORMAT(1X,' X,Y,Z ')
DO 20 I = 1, NPTS
READ (22,2000) XS(I), YS(I), ZS(I)
WRITE(5,*), XS(I), YS(I), ZS(I)
20 CONTINUE
C ADJUST SCREEN SIZE
C
XS(I) = XS(I)/SIZE
YS(I) = YS(I)/SIZE
20 CONTINUE
EDGLST = NEDGE
WRITE(5,876)
876 FORMAT(1X,' NEXT POSITION')
DO 30 I = 1, NEDGE
ENTLST (I) = I-1
READ (22,1000) V1(I), V2(I), LINKED(I)
WRITE(5,*), V1(I), V2(I), LINKED(I)
30 CONTINUE
C LINKED NOT USED HERE BUT PUT TO BE COMPATABLE WITH CADCOM INPUT
30 CONTINUE
C FORMAT DOES NOT AGREE WITH BRAKE, TAKEN EXACTLY FROM WATKINS
C ON TEXT -- SIMPLE PROGRAM TO GENERATE THIS FORMAT FROM BRAKE
C ONCE FINAL FORMAT IS ESTABLISHED.
DO 50 I = 1, NPOLY
READ (22,1000) PLYPTR(I), SHAD(I), PLYEDG(I)
J = PLYEDG(I)
DO 40 L = 1, J
C C GET EDGE NUMBER FOR EDGE
C DETERMINE WHAT POLYGON/S BORDER EACH EDGE
READ (22,1000) K
IF(P1(K).EQ.0) GO TO 35
P2(K) = I
GO TO 40
35 P1(K) = I
40 CONTINUE
50 CONTINUE
C TO INITIALIZE SCREEN
C CALL INITSR
CONTINUE
WRITE(5,7000)

7000 FORMAT (' !WOR 30/ !GRA 1,30/'
   1   ' !ERA G')
WRITE(5,931)

931 FORMAT(IX, ' HERE ARE THE SHADES')
DO 90 I=1,NPOLY
WRITE (5,4000) SHAD(I)
WRITE(5,*)SHAD(I)

4000 FORMAT (' !COL C',I1)
C ASSUME REPEATED EDGES
K=PLYPTR(I)
KK=K+PLYEDG(I)-1
DO 80 J=K,KK
IXS=XS(V1(J))
IYS=YS(V1(J))
IXS2=XS(V2(J))
IYS2=YS(V2(J))
WRITE (5,5000)IXS,IYS,IXS2,IYS2

5000 FORMAT (' !VEC',4I4)
80 CONTINUE
90 CONTINUE
C CALL CONT
GO TO 999

888 WRITE (5,8000)
8000 FORMAT (' TOO MUCH DATA')
999 RETURN
END
SUBROUTINE READIN

C MAIN READIN ROUTINE
INCLUDE 'MAIN.PAR'
INCLUDE 'INPUT.CMN'
INTEGER PLYPTR(MAXPLY),PLYEDG(MAXPLY)
WRITE(5,988)
988 FORMAT(1X,'INPUT SIZE: ')
READ(5,*)SIZE
C CLEAR P1, P2
DO 10 I=1,MAXEDG
   P1(I) = 0
   P2(I) = 0
10 CONTINUE
1000 FORMAT (3I4)
READ(22,1000) NPTS, NEDGE, NPOLY
1000 FORMAT (3I4)
IF (NPTS.GT.MAXPNT.OR.NEDGE.GT.MAXEDG.OR.
   1 NPOLY .GT. MAXPLY) GO TO 888
C READ VERTICES
C
DO 20 I = 1,NPTS
   READ (22,2000) XS(I),YS(I),ZS(I)
2000 FORMAT (3F4.0)
C
C ADJUST SCREEN SIZE
C
XS(I) = XS(I)/SIZE
YS(I) = YS(I)/SIZE
CONTINUE
EDGLST = NEDGE
DO 30 I = 1,NEDGE
   ENTLST (I) = I-1
   READ (22,1000) V1(I),V2(I),LINKED(I)
30 CONTINUE
C LINKED NOT USED HERE BUT PUT TO BE COMPATABLE WITH CADCOM INPUT
C
C FORMAT DOES NOT AGREE WITH BRAKE, TAKEN EXACTLY FROM WATKINS
C ON TEXT -- SIMPLE PROGRAM TO GENERATE THIS FORMAT FROM BRAKE
C ONCE FINAL FORMAT IS ESTABLISHED.
DO 50 I=1,NPOLY
C PLYPTR NOT USED FOR WATKINS, PLYEDG NOT NEEDED TO RETAIN
C
READ (22,1000) PLYPTR (I),SHAD(I),PLYEDG(I)
   J=PLYEDG(I)
DO 40 L=1,J
C
C GET EDGE NUMBER FOR EDGE
C DETERMINE WHAT POLYGON/S BORDER EACH EDGE
READ(22,1000) K
IF(P1(K).EQ.0) GO TO 35
   P2(K) =I
   GO TO 40
35 P1(K) = I
40 CONTINUE
50 CONTINUE
C TO INITIALIZE SCREEN
CALL SHWINT
77 CONTINUE
DO 90 I=1,NPOLY
   GOTO(100,110,120),IDEV
100 WRITE(100,110,120),SHAD(I)
4000 FORMAT ('!COL C',I1)
C ASSUME REPEATED EDGES
K = PLYPTR(I)

K = K + PLYEDG(I) - 1

DO 80 J = K, K

IXS = XS(V1(J))

IYS = YS(V1(J))

IXS2 = XS(V2(J))

IYS2 = YS(V2(J))

IF (IDEV .EQ. 1) GO TO 88

CALL MOVABS(IXS, IYS)

5000 FORMAT (' !VEC', 4I4)

CALL DRWABS(IXS2, IYS2)

GO TO 80

88 WRITE (5, 5000) IXS, IYS, IXS2, IYS2

80 CONTINUE

90 CONTINUE

C CALL CONT

GO TO 999

888 WRITE (5, 8000)

8000 FORMAT (' TOO MUCH DATA')

GO TO 999

120 WRITE (5, 130)

130 FORMAT (1X, ' SWITCH IS NOT AVAILABLE')

999 RETURN

END
SUBROUTINE RECSAM(SEG, LEFT, RIGHT)

INCLUDE 'MAIN.PAR'
INCLUDE 'MAIN.CMN'
INCLUDE 'SPAN.CMN'
INCLUDE 'SAMSIN.CMN'
INTEGER SEG, RIGHT
REAL LSAMP

IF (.NOT.((LEFT .NE. 0).AND.(IMPLFT .NE. 0).AND.(XLEFT(SEG) .NE. 0)
1 .LE.(SPANLT .NE. 0).AND.(SEG .NE. 0).EQ.MOD(PLYSEG(IMPLFT)
1,10000)))) GO TO 10
A = XLEFT(IMPLFT) + DXLEFT(IMPLFT)
CALL PSAMPLE(A)
IMPLFT = 0

10 IF (.NOT.((LEFT .NE. 0).AND.(YLEFT(SEG) .NE. 0)).LT.-1
1 .AND.(LEFT.EQ.-1.OR.(SPANLT-1.LT.XLEFT(SEG).AND.
XLEFT(SEG).LE.SPANLT))) GO TO 20
IF (.NOT.(SAMLST.EQ.0.OR.LSAMP.NE.SPANLT-1.OR.
1 LEFT.EQ.-1)) GO TO 20
B = (XLEFT(SEG) + DXLEFT(SEG))
CALL PSAMPLE(B)
LSAMP = SPANLT-1

20 IF (.NOT.((RIGHT .NE. 0).AND.YRIGHT(SEG) .LT.-1
1 .AND.(SPANRT.LE.XRIGHT(SEG).AND.XRIGHT(SEG).LT.
1 SPANRT+1))) GO TO 30
C = XRIGHT(SEG) + DXRIGHT(SEG)
CALL PSAMPLE(C)
LSAMP = SPANRT

30 CONTINUE
RETURN
END
C MISCELLANEOUS PROCEDURE.
C*******************************************************************************
C SUBROUTINE NAME RETBLK.
C THIS SUBROUTINE IS USED TO RETURN
C A SEGMENT BLOCK TO FREE STORAGE.
C*******************************************************************************

SUBROUTINE RETBLK(I)
INCLUDE 'MAIN.PAR'
INCLUDE 'MAIN.CMN'
INCLUDE 'BLK.CMN'
ACTIVE(I) = FRELST
FRELST = I
RETURN
END
SUBROUTINE RMXSRT(SEG)
INCLUDE 'MAIN.PAR'
INCLUDE 'MAIN.CMN'
INCLUDE 'SRT.CMN'
INTEGER SEG
IF(SEGFST .NE. SEG) GO TO 10
SEGFRST = XSRTRT(SEG)
10
I = XSRTRT(SEG)
IF( I .EQ. 0 ) GO TO 20
XSRTRT(I) = XSRTRT(SEG)
20
I = XSRTRT(SEG)
IF(I .EQ. 0) RETURN
XSRTRT(I) = XSRTRT(SEG)
RETURN
END
C DISPLAY SUBROUTINE

SUBROUTINE SHOW(Y)
C

INCLUDE 'MAIN.PAR'
INCLUDE 'MAIN.CMN'
INCLUDE 'INPUT.CMN'
INCLUDE 'PIC.CMN'
INTEGER X,SEG,POLYG,SAMP,Y
DIMENSION IDASH(7),ICHECK(7),IREPT(7)
DATA IDASH/1,2,3,4,5,5,2/
DATA ICHECK/7*-1/
DATA IREPT/10,30,30,30,1,1,20/
DATA IFLAG/0/
SAMP=0
IF (SEGCNT.LE.1) GO TO 999
DO 30 I=1,SEGCNT
   SEG = VISSEG(I)
   X = VISPOS(I)
   IF (SEG.EQ.0) GO TO 20
   POLYG = POLYGN(SEG)
   GOTO(4,66),IDEV
66 ICOL=SHAD(POLYG)
   CALL PNTABS(SAMP,Y)
   CALL PNTABS(X,Y)
   IF(ICHECK(ICOL) .LT. 0)GO TO 5
   IDEL=ICHECK(ICOL)-SAMP
   IF(IDEL .EQ. 0)GO TO 6
   10 IF(MOD(ABS(IDEL),IREPT(ICOL)) .EQ. 0)GO TO 6
      SAMP=SAMP+1
      IF(SAMP .GE. X)GO TO 6
      IDEL=ICHECK(ICOL)-SAMP
      GO TO 10
   5 ICHECK(ICOL)=SAMP
   GOTO 6
4 WRITE(5,100) SHAD(POLYG)
100 FORMAT(‘icol’,I1)
   WRITE(5,200) SAMP,Y,X,Y
200 FORMAT(‘vec’,4I4)
   GO TO 20
6 IF(ICOL .NE. 6)GO TO 91
   IFLAG=IFLAG+1
   IF(MOD(IFLAG,5) .EQ. 0)GO TO 91
   GO TO 20
91 CALL MOVABS(SAMP,Y)
   CALL DSHABS(X,Y,IDASH(SHAD(POLYG)))
20 SAMP=X
30 CONTINUE
   GO TO 999
888 WRITE(5,300)
300 FORMAT(‘ SEGCNT =0,NO OUTPUT’)
999 RETURN
END
SUBROUTINE SHWCLS
CALL FINITT(0,0)
RETURN
END

C INITIALIZE SCREEN
SUBROUTINE SHWINT
INCLUDE 'MAIN.PAR'
INCLUDE 'INPUT.CMN'
GOTO(10,20,30), IDEV
10 WRITE(5,7000)
7000 FORMAT(1X,'!WOR 30'/!GRA 1,30'/! 'ERA G')
RETURN
20 CALL INITT(120)
RETURN
30 WRITE(5,8000)
8000 FORMAT(1X,' SWITCH IS NOT AVILABLE')
RETURN
END

SUBROUTINE STOPIC(X,SEGMEN)
INCLUDE 'MAIN.PAR'
INCLUDE 'MAIN.CMN'
INCLUDE 'PIC.CMN'
INTEGER SEGMEN
IF((SEGCNT .EQ. 0).OR.(SEGMEN.NE.LASSEG))GO TO 10
GO TO 15
10 SEGChT = SEGCNT + 1
LASSEG = SEGMEN
15 VISPOS(SEGCNT) = X
VISSEG(SEGCNT) = LASSEG
RETURN
END

C**********************************************
C FILE NAME 'SUB.FOR'.
C SUBROUTINE NAME 'SWAP'.
C THIS SUBROUTINE IS DESIGNED TO INTERCHANGE THE
C CONTENTS OF TWO VARIABLES.
C**********************************************
SUBROUTINE SWAP(X1,X2)
TEMP = X1
X1 = X2
X2 = TEMP
RETURN
END
SUBROUTINE THINK(Ith)
INCLUDE 'MAIN.PAR'
INCLUDE 'MAIN.CMN'
INCLUDE 'LOOKBX.CMN'
INCLUDE 'THK.CMN'
INCLUDE 'SPAN.CMN'
INCLUDE 'SAMSIN.CMN'
INTEGER SEGSAM
INTEGER GETBLK
INTEGER XRES
XRES = IXRES
C--BEGIN THINKER
IF (BOXCNT .NE. 0) GO TO 10
C--BEGIN NOTHING VISIBLE
CALL STOPIC(SPANRT,0)
ITH = -1
RETURN
C*********************************************************
10 IF (BOXCNT .NE. 1) GO TO 20
C--BEGIN ONLY ONE SEGMENT, DISPLAY DIRECTLY
IF (BXLEFT .NE. SPANLT) CALL STOPIC(BXLEFT,0)
CALL STOPIC(BXRGHT,BSEG1)
IF (BXRGHT .NE. SPANRT) CALL STOPIC(SPANRT,0)
CALL RECSAM(BSEG1,1,1)
ITH = -1
RETURN
C*********************************************************
20 IF (BOXTYP .NE. 1) GO TO 110
C--BEGIN INTERSECTING PLANES CASE
CALL STOPIC(DIV,BSEG1)
CALL RECSAM(BSEG1,1,0)
SEGSAM = BSEG1 * 10000 + BSEG2
SEG = IMPLST
PREV = 0
30 IF (SEG .EQ. 0) GO TO 40
IF (SEGSAM .EQ. PLYSEG(SEG)) GO TO 40
PREV = SEG
SEG = XSRTRT(SEG)
GO TO 30
40 IF (SEG .EQ. 0) GO TO 90
C--BEGIN FOUND A PREVIOUS ONE
IF (PREV .EQ. 0) GO TO 50
XSRTRT(PREV) = XSRTRT(SEG)
GO TO 60
50 CONTINUE
IMPLST = XSRTRT(SEG)
60 CONTINUE
DXLEFT(SEG) = DIV - XLEFT(SEG)
XLEFT(SEG) = DIV
IF (.NOT. (1.LE.XLEFT(SEG) + DXLEFT(SEG).AND.1 XLEFT(SEG) + DXLEFT(SEG).LE.XRES)) GO TO 70
C--BEGIN IMPLIED EDGE WILL BE WITHIN BOUNDS ON NEXT SCANLINE
CALL PIXSRT(SEG)
CALL RECSAM(SEG,-1,0)
GO TO 80
70 CALL RETBLK(SEG)
80 GO TO 100
C--BEGIN DETECTED NEW IMPLIED EDGE
J = GETBLK(J)
PLYSEG(J) = SEGSAM
I = YLEFT(BSEG1)
IF(I .LT. YRIGHT(BSEG1)) I = YRIGHT(BSEG1)
IF(I .LT. YLEFT(BSEG2)) I = YLEFT(BSEG2)
IF(I .LT. YRIGHT(BSEG2)) I = YRIGHT(BSEG2)
YLEFT(J) = I
POLYGN(J) = 0
XLEFT(J) = DIV
XSRTRT(J) = MPLST2
MPLST2 = J
100 CALL STOPIC(SPANRT, BSEG2)
CALL RECSAM(BSEG2, 0, 1)
ITH = -1
RETURN
C**********************************************************************************************
110 IF(SPANLT .NE. SPANRT) GO TO 120
C--BEGIN MUST NOT SUBDIVIDE FURTHER
ITH = -1
RETURN
C**********************************************************************************************
120 ITH = 0
RETURN
END
SUBROUTINE XPANBX
INCLUDE 'MAIN.PAR'
INCLUDE 'LOOKBX.CMN'
BSEG2 = BSEG1
BSEG1 = SEG
BOXTYP = 0
BOXCNT = BOXCNT + 1
IF(SDIV .LT. DIV)DIV= SDIV
IF(SXLEFT .LT. BXLEFT) BXLEFT=SXLEFT
IF(SXRGHT .GT. BXRGHT)BXRGHT = SXRGHT
IF(SZLEFT .LT. BZMIN) BZMIN = SZLEFT
IF(SZRGHT .LT.BZMIN) BZMIN = SZRGHT
IF(SZRIGHT .GT.BZMAX) BZMAX = SZLEFT
IF(SZRIGHT .GT.BZMAX) BZMAX = SZRIGHT
RETURN
END

FUNCTION ZINT(X)
INCLUDE 'MAIN.PAR'
INCLUDE 'LOOKBX.CMN'
IF(SXRGHT.EQ.SXLEFT) GO TO 10
ZINT=SZLEFT+(SZRGHT-SZLEFT)*(X-SXLEFT)
1 /(SXRGHT-SXLEFT)
RETURN
10 ZINT = SZLEFT
RETURN
END
BIBLIOGRAPHY


