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GIG - A FORTRAN IV GEOMETRY INPUT GENERATOR PROGRAM FOR A FINITE-ELEMENT HEAT-TRANSFER CODE

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SUMMARY

The GIG program was developed to fulfill the need for a generalized program to generate geometrical data required as input to a heat-transfer code. GIG is presently designed to be used in conjunction with a transient or steady-state (TOSS) code which computes transient or steady-state temperature distributions for general heat-transfer problems.

With a minimum of input information, GIG will generate and punch data cards in the TOSS format for any two-dimensional geometric configuration defined by straight line segments. Adaptability, accuracy of results, and ease of use are the prime considerations of this program.

INTRODUCTION

One drawback to using general finite-element heat-transfer programs is the time consuming and tedious work involved in preparing the voluminous input data which are required to describe the body geometry. To alleviate this problem, a computer program, GIG, was written in FORTRAN IV version 13. GIG is designed for use with the TOSS code (ref. 1) which solves heat-transfer problems for irregularly shaped bodies. GIG will generate the geometrical two-dimensional information that is required as input to TOSS for any body whose configuration consists of straight line segments.

Although the output of GIG is currently structured for direct use with TOSS, future versions will supply geometry information for direct use with other heat-transfer codes such as CINDA (ref. 2).

Programming features of GIG provide

(1) Time saving - Data preparation time is drastically reduced. The number of man hours saved varies with the geometry's complexity: the greater the complexity, the greater the saving.

(2) Accuracy - Computer calculated results obtained from equations of analytical geometry are substantially more accurate than scaled measurements.

(3) Error reduction - The program eliminates human error inherent in the preparation of large amounts of data.

(4) More useful TOSS program - The usefulness of TOSS itself is enhanced in that it can be used for design purposes because changes in geometry features no longer require lengthy hand calculations and preparation of input data.

To use TOSS, the body under consideration must be divided by a grid system into finite volume elements called nodes. For a two-dimensional problem, unit depth is generally specified to satisfy the input requirements. This constant depth dimension is punched on the GIG output, TOSS input cards.

In addition to volume, each element has a number of heat conduction path lengths and areas associated with it. The exact number depends on the geometry of the individual element. GIG will generate this information and use it to tie each node to its neighboring nodes in a heat conduction network. GIG was written to handle two-dimensional problems only. In the discussion that follows, then, volume elements are treated as area elements and heat-transfer areas are treated as lengths of line segments.

DESCRIPTION OF PROCEDURE

Let it be required to generate the geometrical input data for TOSS for the configuration of figure 1 which consists of a solid-body region R_1 with a cut-out region R_2. Assume that the body (fig. 1) lies in the first quadrant of the rectangular coordinate system with origin (0). Either a square or rectangular grid may be superimposed on the configuration. Figure 1 shows a square grid laid over a portion of quadrant I. Grid lines are marked off in the positive X and Y directions beginning at the origin.

Every closed cell formed by the grid is referred to as a node box. Node boxes are numbered sequentially from left to right in each row from bottom to top. GIG uses this convention in numbering all boxes of the entire (20 by 20) mesh as shown in figure 2. Any portion of R_1 that falls within a node box is called an interior node. The centroid of an interior node is called a node point. Figure 3 shows the node, node point, and node boundaries of node box 2.

INDIVIDUAL NODE INFORMATION

TOSS requires certain data pertaining to each node as input information. GIG calculates the area and centroid of a node. Next, the perpendicular length from the centroid to each boundary segment (called a face) is computed along with the length of each face. These perpendiculars and faces are labeled for node 2 (fig. 4). The first subscript digit is the face or perpendicular number, and the second is the node number.

CONNECTOR INFORMATION

TOSS requires that all nodes be tied together in a connector network using the information obtained for individual nodes. A connector is a path between two node points along which heat can flow. There are three classes of connectors generated by GIG.

Internal-to-internal connectors are connectors between two interior node points. Figure 5 shows node boxes 2 and 3 as they appear in figure 2 with pertinent labeling. It can be seen that the connector between node points 2 and 3 is made up of perpendiculars P_{12} and P_{13}.

Internal-to-surface connectors are connectors between interior node points and surface nodes. Let N be a general node number. Then a surface node N is defined as the intersection point of the perpendicular from internal node point N to the R_1 boundary line in node box N. The perpendicular is an internal-to-surface connector. Figure 5 shows surface nodes 2 and 3 and internal-to-surface connectors P_{32} and P_{33}.

Surface-to-boundary connectors are connectors between surface nodes and boundary nodes. Boundary nodes are points representing the temperatures of the boundary region surrounding the physical body. Each surface node is tied to a boundary node through the heat-transfer area associated with the surface node. Surface-to-boundary connectors are used to link the internal nodes (heat-capacity-bearing nodes) to the boundary temperature nodes. Surface-to-boundary connectors 2 and 3 are represented by dashed lines 2 and 3 in figure 5.

PROGRAM REQUIREMENTS

Input

The input to GIG is subdivided into groups of data. These groups are listed in the following sections with a description of information required within each group. Each unit of information within a group has been named so that specific pieces of input data may be referenced accurately.

Description. - (1) Identification: The first card contains a descriptive heading which appears in the output to aid in the identification of the cases.

(2) General data: This card specifies (a) SUBTOT, the total number of regions in the configuration; (b) DELTAX, the grid spacing in the X-direction (in inches); (c) DELTAY, the grid spacing in the Y-direction (in inches); and (d) UNIT, the thickness (depth) of the configuration material (in inches).

(3) Region data: This card contains (a) XCLUDE, a parameter that specifies which side of a region boundary line the material lies on and (b) CORNOR, a code that identifies the kind of corner that begins a region.

(4) Line data: For each line of a region there must be one card specifying (a) ENDX, the X-coordinate of the end of the line (in inches) and (b) ENDY, the Y-coordinate of the end of the line (in inches).

(5) End: The line information for each region must end with a card bearing the number 1000.

Definitions. - This section defines the regional input parameters. Both parameters pertain only to line 1 of a region.

(1) XCLUDE: Enter the value 1.0 if the material lies above a horizontal line, above a sloped line, or to the right of a vertical line. Otherwise, enter the value 0.

In all figures, the shaded area represents the material of the bodies displayed. In figure 6, XCLUDE has the value 1.0 if line A, B, or C is chosen as line 1 of R_2. In figure 7, XCLUDE has the value 0.0 if line A, B, or C is chosen as line 1 of R.

(2) CORNOR: This parameter is associated with the beginning corner point of a region. Enter the value 1.0 if the beginning corner is an internal corner; enter 0.0 if it is an external corner. An internal corner is defined as one whose angular measurement through the material is less than 180°; an external corner is one whose angular measurement through the material is greater than 180°.

Figure 8 shows examples of internal and external corners. Corners at points A and E are external; all others are internal. References will be made about two consecutive internal corners and two consecutive external corners in a node box. Figures 9 and 10 give general form examples of these types.

Procedure. - The region with which to begin the input should be arbitrarily chosen. The following conventions should be followed to insure proper recognition of input information in the program:

(1) Choose a beginning point for this region. All lines are numbered in consecutive order (beginning with line 1) moving in a clockwise direction around the region. This order is followed when entering line input data. Figure 11 shows line labeling for both regions of figure 1 after the beginning point of each region is chosen.

(2) When line information is entered, the coordinates given are those of the end point of the line.

(3) Once the beginning point is chosen, line 1 is automatically set by item (1). The beginning point is legitimate only if one of the following three situations is satisfied:

(a) The beginning segment of line 1 lies in a node box with no more than one other line segment of the same region. This is the normal beginning situation and should be chosen in preference to the other two whenever possible.

(b) The beginning point is one of the two corner points in a node box containing two consecutive internal corners. In this situation, use the line leaving the node box (in the clockwise sense) as line 1.

(c) The beginning point is one of the two corner points in a node box containing two consecutive external corners. Both corner points must lie either inside the node box or on the same grid line. If line 1 is not the line leaving the node box (in the clockwise sense), redefine it to be so.

If (a), (b), or (c) cannot be satisfied, redefine the mesh.

Order. - An example of the order of input cards to GIG for a configuration of one region is

(1) Identification card
(2) General card
(3) Region card for region 1
(4) All line cards for region 1
(5) End card

The order for any number of regions is obtained by adding cards analogous to those of (3), (4), and (5) for each additional region to the cards above. This was done to get cards (6), (7), and (8) for a configuration of two regions:

(1) Identification card
(2) General card
(3) Region card for region 1
(4) All line cards for region 1
(5) End card
(6) Region card for region 2
(7) All line cards for region 2
(8) End card

Formats. - The format diagram graphically expresses the order of cards and the card columns allotted for each field of information. Parameter names used in the diagram were defined in the description section.

Identification card:

1 80
ALL 80 COLUMNS OF THIS IDENTIFICATION CARD MAY BE USED FOR A DESCRIPTIVE HEADING

General data card:

1 7	8 14	15 21	22 28	80
SUBTOT	DELTAX	DELTAY	UNIT	
XXX . XXX	XXX . XXX	XXX . XXX	XXX . XXX	

Regional data card:

XCLUDE	CORNOR			
XXX XXX	XXX . XXX			

Line data cards:

ENDX	ENDY			
XXX . XXX	XXX . XXX			

End card:

END				
1000. 00				

PROBLEM LIMITS

Because a single node box can contain innumerable geometries, a limit is placed on the types GIG will consider. Those programmed are sufficient to generate information for the bulk of practical applications. Should a situation arise where GIG responds improperly, it is only necessary to redefine the grid. This will break down extremely complicated node box geometries into types readily handled by GIG.

Guideline Statement

GIG will respond properly only when the user works within the general guideline statement, "a node box cannot have more than two cuts;" where a cut is defined as

(1) an internal corner in the node box

(2) an external corner in the node box

(3) a line segment in the node box which is independent of any corner in the box.

The cuts can be the same or any combination of (1), (2), and (3). The single exception under the general guideline statement is a node box containing two separated external corners. Figure 12 shows the general form of this type which is excluded. If this form is encountered by the program, a message will print identifying the node box as an illegitimate type.

Node box geometries. - The user need not be overly concerned about node box geometries. Should a box appear to be cut too often, reference to (1), (2), and (3) below will fortell which box GIG considers any line segment or corner to lie in. With that information, one can determine if the congested box is acceptable from the general guideline statement.

(1) Line segment - lies in the node box if the line segment intersects any two boundaries of the box; lies in the box containing the material if the line segment lies on a grid line. In figure 13, segment EF lies in box 22.

(2) Internal corner - lies in the box if each of the two line segments forming the corner lies in the box; otherwise, the corner is considered not to be in any box.

(3) External corner - lies in the box if each of the two line segments forming the corner lies in the box. This is true regardless of where the corner point lies. However, if both line segments of the corner are not in the same box, then the position of the corner point determines which box the corner is in. If the corner point lies

(a) on a grid intersection, the corner is considered not to be in any box.

(b) on a grid line, the corner is considered not to be in any box unless one of the two lines forming the corner also lies on a grid line. In this case, the corner lies in the box that contains the largest portion of the external angle.

Examples are given in figures 14 and 15. Corner A lies in box 21 and corner B in box 1. Figure 16 shows how this type can enter into an illegitimate node box. Both internal corners A and B lie in node box 22. Corner C is also determined to be in box 22 making it a three-corner box which is an excluded type.

Limits. - The following is a table of limits for GIG:

Node boxes (X-direction)	20
Node boxes (Y-direction)	20
Regions	Unlimited
Lines (each region)	100

Output

Printed output. - The printed output is completely labeled and consists of (1) the input, (2) the internal-to-internal node connectors, (3) the internal-to-surface node connectors, (4) the surface-to-boundary node connectors, (5) the individual node information, and (6) the correspondence between original node box numbers and nodes added to a box.

Punched output. - The punched output cards are in the correct format for entry into TOSS. Each card is labeled consistent with nomenclature used in TOSS and consists of

(1) Internal-to-internal connector cards - labeled ICONN
(2) Internal-to-surface connector cards - labeled ICONN
(3) Surface-to-boundary connector cards - labeled BCONN
(4) Individual node cards - labeled INODE.

Split node boxes. - The output will have node numbers for corresponding node boxes that are not cut by the configuration. This results from one node box being split into two or three nodes which is necessary to insure that the centroid of each node lies within its material.

These added nodes are assigned numbers of uncut boxes and the correspondence between them and the split box appears in the printed output. To match these assigned numbers with the nodes of a split box correctly, refer to the area of each node and its internal node connectors. These connectors indicate which neighboring nodes each split node is linked to.

When a node box is cut by an external corner, the box is split by extending one of the two lines forming the corner, normally the first line into the node box in the clockwise sense. Figure 17 shows an example of how GIG would break a configuration into nodes.

Node box 23 is cut by an external corner. The incoming line to box 23 (line 2 of R_2) is extended to split it into two distinct nodes. The first of these nodes (again, in the clockwise sense of R_2) is given an uncut box number (76), and the second retains the original box number (23).

Node boxes 62 and 75 are examples of extending the second line of the external corner (line 3 of R_1) to obtain a split. It is not practical to give the criterion to determine which line is extended under all circumstances. The node box correspondence numbers, node areas, internal connectors, and knowledge that one of the two lines of the external corner was extended is sufficient to determine how a box was split and the split nodes numbered. A more detailed example of how GIG handles split node boxes is given in the appendix.

GENERAL REMARKS

Order of output. - All data pertaining to a node box need not appear consecutively in the output. Some node information may appear in two places within the output of two regions. All internal-to-internal connectors are shown in a section separate from region output.

Node numbering. - Output node numbers reflect certain ranges required by TOSS. These ranges are

$$0 < \text{internal} \leq 400$$

$$1000 < \text{surface} \leq 1200$$

$$2000 < \text{boundary} \leq 2220$$

Configurations should always be placed in the lower left corner section of the first quadrant because of the node number range imposed by TOSS. This requires internal nodes to be numbered from 1 to 400. Placing the geometry in the position described will result in a lower maximum node number.

Lewis Research Center,
National Aeronautics and Space Administration,
Cleveland, Ohio, November 6, 1970,
129-04.

APPENDIX - SAMPLE PROBLEM

This section provides a sample problem which demonstrates the procedure, input, and output for the GIG program.

Procedure

Figure 18 shows the sample configuration. It has four regions: the main body region R_1 and three cut-out regions R_2, R_3, and R_4. In figure 19, the body has been placed in the first quadrant of a rectangular coordinate system and has a 1-inch (2.54 cm) square grid superimposed on it. The grid shown is a partition of the 20 by 20 mesh that GIG works with. Node boxes have been labeled in the manner prescribed in the section DESCRIPTION OF PROCEDURE.

In figure 20, line 1 of each region has been chosen and other lines of each region have been numbered consecutively moving in the clockwise direction around the region from line 1. Figure 21 shows how GIG broke up and numbered split node boxes. Node numbering has replaced node box numbering and all output pertains to this configuration.

Node box 67 was cut by an external corner. The incoming line to box 67 (line 1 of R_4) was extended to split it into two nodes. The first of these nodes (in the clockwise sense of R_4) was given an uncut box number (120), and the second node retains the original box number (67). This matching is readily verified from the printed output which shows the area of node 120 to be 0. 5 square inch (3.23 cm^2). Further, reference to the internal connector output shows node 120 to be connected to nodes 47 and 87, and 67 to nodes 47 and 66.

Box 62 was cut by two consecutive external corners. Again, the first line of each corner was extended to split the box into three nodes. Node boxes 4 and 113 are examples of extending the second line of the external corner to obtain a split.

Input

The input to GIG, consistant with figure 21 and labeled with the input parameter names defined in the input description section is

Sample Problem (I. D. Card)

SUBTOT	4.	DELTAX	1. } general data card
DELTAY	1.	UNIT	1. }
XCLUDE	0.	CORNOR	1. (region 1)
ENDX	3.	ENDY	6. (line 1)
ENDX	7.	ENDY	6. (line 2)
ENDX	7.	ENDY	1. (line 3)
ENDX	5.	ENDY	1.5 (line 4)
ENDX	5.	ENDY	.75 (line 5)
ENDX	3.5	ENDY	.75 (line 6)
ENDX	3.25	ENDY	.5 (line 7)
ENDX	.5	ENDY	2.5 (line 8)
ENDX	.5	ENDY	4.75 (line 9)
1000.		(end card)	
XCLUDE	1.	CORNOR	0. (region 2)
ENDX	3.5	ENDY	3.75 (line 1)
ENDX	3.5	ENDY	3.125 (line 2)
ENDX	1.5	ENDY	3.125 (line 3)
ENDX	1.5	ENDY	3.75 (line 4)
1000.		(end card)	
XCLUDE	0.	CORNOR	0. (region 3)
ENDX	4.	ENDY	2. (line 1)
ENDX	4.	ENDY	3. (line 2)
ENDX	5.	ENDY	3. (line 3)
ENDX	5.	ENDY	2. (line 4)
1000.		(end card)	
XCLUDE	1.	CORNOR	0. (region 4)
ENDX	6.5	ENDY	3.25 (line 1)
ENDX	5.	ENDY	4.75 (line 2)
ENDX	6.5	ENDY	5.5 (line 3)
1000.		(end card)	

Punched output. - Punched output is not displayed. It would consist of all INODE, ICONN, and BCONN cards as shown in the printed output sections.

Printed output. - The input of the previous section fully labeled along with all required geometry information is listed under appropriate headings.

SAMPLE PROBLEM

TOTAL NUMBER OF REGIONS 4
GRID SPACING IN X-DIRECTION(INCHES) 1.000
GRID SPACING IN Y-DIRECTION(INCHES) 1.000
THICKNESS OF MATERIAL(INCHES) 1.000

OUTPUT FOR ALL REGIONS CONTAINS

INTERNAL-TO-SURFACE CONNECTORS (LABELED ICONN)
SURFACE-TO-BOUNDARY CONNECTORS (LABELED BCONN)
INDIVIDUAL NODE INFORMATION (LABELED INODE)
INTERNAL-TO-INTERNAL CONNECTORS WITHIN SPLIT-NODE BOXES (ALSO LABELED ICONN)

EACH OF THE 4 TYPES ABOVE IS PRINTED WITHOUT SPECIFIC LABELING. THE FOLLOWING GIVES THE GENERAL LABELING FORM FOR EACH FIELD OF DATA FOR EACH OF THE 4 TYPES---

(1) ICONN
INTERNAL NODE I, SURFACE NODE J, CONNECTOR LENGTH IN I, BLANK FIELD, SURFACE LENGTH, DEPTH

(2) BCONN
SURFACE NODE I, BOUNDARY NODE J, SURFACE LENGTH, DEPTH

(3) INODE
INTERNAL NODE, BLANK FIELD, NODE AREA, THE CONSTANT 1., DEPTH

(4) ICONN(FOR SPLIT-NODE BOXES ONLY)
INTERNAL NODE I, INTERNAL NODE J, CONNECTOR LENGTH IN I, CONNECTOR LENGTH IN J, COMMON INTERFACE LENGTH, DEPTH

REGION 1	XCLUDE	0.	CORNOR	1.
LINE 1	ENDX	3.000	ENDY	6.000
LINE 2	ENDX	7.000	ENDY	6.000
LINE 3	ENDX	7.000	ENDY	1.000
LINE 4	ENDX	5.000	ENDY	1.500
LINE 5	ENDX	5.000	ENDY	0.750
LINE 6	ENDX	3.500	ENDY	0.750
LINE 7	ENDX	3.250	ENDY	0.500
LINE 8	ENDX	0.500	ENDY	2.500
LINE 9	ENDX	0.500	ENDY	4.750

102	1001	0.1491		1.1180	1.0000	ICONN
1001	2001	1.1180	1.0000			BCONN
102		0.2500	1.0000	1.0000		INODE
103	1002	0.3478		1.1180	1.0000	ICONN
1002	2002	1.1180	1.0000			BCONN
103		0.7500	1.0000	1.0000		INODE
104	1003	0.5000		1.0000	1.0000	ICONN
1003	2003	1.0000	1.0000			BCONN
104		1.0000	1.0000	1.0000		INODE
105	1004	0.5000		1.0000	1.0000	ICONN
1004	2004	1.0000	1.0000			BCONN
105		1.0000	1.0000	1.0000		INODE
106	1005	0.4722		1.0000	1.0000	ICONN
1005	2005	1.0000	1.0000			BCONN
106		0.9375	1.0000	1.0000		INODE
113	1006	0.2500		0.5000	1.0000	ICONN
1006	2006	0.5000	1.0000			BCONN
113	1007	0.5000		0.5000	1.0000	ICONN
1007	2007	0.5000	1.0000			BCONN
113	1008	0.2500		1.0000	1.0000	ICONN
1008	2008	1.0000	1.0000			BCONN
113		0.5000	1.0000	1.0000		INODE
87	1009	0.2500		1.0000	1.0000	ICONN
1009	2009	1.0000	1.0000			BCONN
87		0.5000	1.0000	1.0000		INODE
47	1010	0.5000		1.0000	1.0000	ICONN
1010	2010	1.0000	1.0000			BCONN
47		1.0000	1.0000	1.0000		INODE
27	1011	0.4762		1.0000	1.0000	ICONN

1011	2011	1.0000	1.0000			BCONN
27	1012	0.4273		1.0308	1.0000	ICONN
1012	2012	1.0308	1.0000			BCONN
27		0.8750	1.0000	1.0000		INODE
26	1013	0.3072		1.0308	1.0000	ICONN
1013	2013	1.0308	1.0000			BCONN
26		0.6250	1.0000	1.0000		INODE
25	1014	0.5000		0.5000	1.0000	ICONN
1014	2014	0.5000	1.0000			BCONN
25		1.0000	1.0000	1.0000		INODE
5	1015	0.5000		0.2500	1.0000	ICONN
1015	2015	0.2500	1.0000			BCONN
5	1016	0.1250		1.0000	1.0000	ICONN
1016	2016	1.0000	1.0000			BCONN
5		0.2500	1.0000	1.0000		INODE
114	1017	0.2778		0.3091	1.0000	ICONN
1017	2017	0.3091	1.0000			BCONN
114	1018	0.1946		0.3536	1.0000	ICONN
1018	2018	0.3536	1.0000			BCONN
114		0.2273	1.0000	1.0000		INODE
4	114	0.1375	0.1946	0.3536	1.0000	ICONN
4	1019	0.1111		0.5000	1.0000	ICONN
1019	2019	0.5000	1.0000			BCONN
4		0.0937	1.0000	1.0000		INODE
3	1020	0.0858		0.5410	1.0000	ICONN
1020	2020	0.5410	1.0000			BCONN
3		0.0696	1.0000	1.0000		INODE
23	1021	0.4297		0.6955	1.0000	ICONN
1021	2021	0.6955	1.0000			BCONN
23		0.8849	1.0000	1.0000		INODE
22	1022	0.1593		1.0047	1.0000	ICONN
1022	2022	1.0047	1.0000			BCONN
22		0.2401	1.0000	1.0000		INODE
42	1023	0.5963		0.2318	1.0000	ICONN
1023	2023	0.2318	1.0000			BCONN
42		0.9872	1.0000	1.0000		INODE
41	1024	0.2822		0.6182	1.0000	ICONN
1024	2024	0.6182	1.0000			BCONN
41	1025	0.2722		0.5000	1.0000	ICONN
1025	2025	0.5000	1.0000			BCONN
41		0.3409	1.0000	1.0000		INODE
61	1026	0.2500		1.0000	1.0000	ICONN
1026	2026	1.0000	1.0000			BCONN
61		0.5000	1.0000	1.0000		INODE
81	1027	0.2619		0.7500	1.0000	ICONN
1027	2027	0.7500	1.0000			BCONN
81	1028	0.3940		0.5590	1.0000	ICONN
1028	2028	0.5590	1.0000			BCONN
81		0.4375	1.0000	1.0000		INODE

```
REGION  2         XCLUDE   1.       CORNOR   0.
 LINE  1       ENDX     3.500      ENDY     3.750
 LINE  2       ENDX     3.500      ENDY     3.125
 LINE  3       ENDX     1.500      ENDY     3.125
 LINE  4       ENDX     1.500      ENDY     3.750
```

115	1029	0.1250		1.0000	1.0000	ICONN
1029	2029	1.0000	1.0000			BCONN
115		0.2500	1.0000	1.0000		INODE
116	1030	0.1250		0.5000	1.0000	ICONN
1030	2030	0.5000	1.0000			BCONN
116		0.2500	1.0000	1.0000		INODE
117	116	0.3750	0.1250	0.5000	1.0000	ICONN
117	1031	0.2500		0.6250	1.0000	ICONN
1031	2031	0.6250	1.0000			BCONN
117		0.3750	1.0000	1.0000		INODE
64	117	0.2500	0.2500	0.1250	1.0000	ICONN
64	1032	0.0625		0.5000	1.0000	ICONN
1032	2032	0.5000	1.0000			BCONN
64		0.0625	1.0000	1.0000		INODE
63	1033	0.0625		1.0000	1.0000	ICONN
1033	2033	1.0000	1.0000			BCONN
63		0.1250	1.0000	1.0000		INODE
118	1034	0.0625		0.5000	1.0000	ICONN
1034	2034	0.5000	1.0000			BCONN
118		0.1250	1.0000	1.0000		INODE
119	118	0.4375	0.0625	0.5000	1.0000	ICONN
119	1035	0.2500		0.6250	1.0000	ICONN
1035	2035	0.6250	1.0000			BCONN
119		0.4375	1.0000	1.0000		INODE
62	119	0.2500	0.2500	0.2500	1.0000	ICONN
62	1036	0.1250		0.5000	1.0000	ICONN
1036	2036	0.5000	1.0000			BCONN
62		0.1250	1.0000	1.0000		INODE

REGION 3	XCLUDE	0.	CORNOR	0.
LINE 1	ENDX	4.000	ENDY	2.000
LINE 2	ENDX	4.000	ENDY	3.000
LINE 3	ENDX	5.000	ENDY	3.000
LINE 4	ENDX	5.000	ENDY	2.000

25	1037	0.5000		1.0000	1.0000	ICONN
1037	2037	1.0000	1.0000			BCONN
44	1038	0.5000		1.0000	1.0000	ICONN
1038	2038	1.0000	1.0000			BCONN
44		1.0000	1.0000	1.0000		INODE
65	1039	0.5000		1.0000	1.0000	ICONN
1039	2039	1.0000	1.0000			BCONN
65		1.0000	1.0000	1.0000		INODE
46	1040	0.5000		1.0000	1.0000	ICONN
1040	2040	1.0000	1.0000			BCONN
46		1.0000	1.0000	1.0000		INODE

REGION 4	XCLUDE	1.	CORNOR	0.
LINE 1	ENDX	6.500	ENDY	3.250
LINE 2	ENDX	5.000	ENDY	4.750
LINE 3	ENDX	6.500	ENDY	5.500

87	1041	0.2500		1.0000	1.0000	ICONN
1041	2041	1.0000	1.0000			BCONN
120	1042	0.2500		0.7500	1.0000	ICONN
1042	2042	0.7500	1.0000			BCONN
120		0.5000	1.0000	1.0000		INODE
67	120	0.2917	0.2500	0.2500	1.0000	ICONN
67	1043	0.1915		0.7071	1.0000	ICONN
1043	2043	0.7071	1.0000			BCONN
67		0.2500	1.0000	1.0000		INODE
120	1044	0.2500		1.0000	1.0000	ICONN
1044	2044	1.0000	1.0000			BCONN
66	1045	0.5493		0.3536	1.0000	ICONN
1045	2045	0.3536	1.0000			BCONN
66		0.9688	1.0000	1.0000		INODE
121	1046	0.1768		1.0607	1.0000	ICONN
1046	2046	1.0607	1.0000			BCONN
121		0.2813	1.0000	1.0000		INODE
86	1047	0.0745		0.5590	1.0000	ICONN
1047	2047	0.5590	1.0000			BCONN
86		0.0625	1.0000	1.0000		INODE
106	1048	0.4820		0.5590	1.0000	ICONN
1048	2048	0.5590	1.0000			BCONN
107	1049	0.2832		0.5590	1.0000	ICONN
1049	2049	0.5590	1.0000			BCONN
107	1050	0.3167		0.5000	1.0000	ICONN
1050	2050	0.5000	1.0000			BCONN
107	113	0.2667	0.2500	0.5000	1.0000	ICONN
107		0.3125	1.0000	1.0000		INODE

GENERAL INTERNAL NODES

NODE	NODE AREA	CONSTANT	DEPTH	
24	1.0000	1.0000	1.0000	INODE
43	1.0000	1.0000	1.0000	INODE
82	1.0000	1.0000	1.0000	INODE
83	1.0000	1.0000	1.0000	INODE
84	1.0000	1.0000	1.0000	INODE
85	1.0000	1.0000	1.0000	INODE

CORRESPONDENCE BETWEEN ORIGINAL NODE BOX NUMBERS AND NODES ADDED TO THESE BOXES

ORIGINAL NODE	ADDITIONAL NODE
4	114
62	119
62	118
63	115
64	117
64	116
67	120
86	121
107	113

INTERNAL NODE CONNECTORS

Y-DIRECTION CONNECTORS

NODE	NODE	CONNECTOR LENGTH IN I	CONNECTOR LENGTH IN J	COMMON INTERFACE LENGTH	DEPTH	
3	23	0.1061	0.5473	0.4375	1.0000	ICONN
4	24	0.1389	0.5000	0.2500	1.C000	ICONN
114	24	0.1852	0.5000	0.7500	1.0000	ICONN
5	25	0.1250	0.5000	1.0000	1.C000	ICONN
22	42	0.1970	0.5059	0.8125	1.0000	ICONN
23	43	0.4527	0.5000	1.0000	1.0000	ICONN
24	44	0.5000	0.5000	1.0000	1.0000	ICONN
26	46	0.3167	0.5000	1.0000	1.0000	ICONN
27	47	0.4405	0.5000	1.0000	1.0000	ICONN
41	61	0.3490	0.5000	0.5000	1.0000	ICONN
42	118	0.4941	0.0625	1.0000	1.0000	ICONN
43	63	0.5000	0.0625	1.0000	1.0000	ICONN
44	64	0.5000	0.0625	0.5000	1.C000	ICONN
44	117	0.5000	0.3750	0.5000	1.0000	ICONN
46	66	0.5000	0.4866	1.0000	1.0000	ICONN
47	67	0.5000	0.2708	0.5000	1.0000	ICONN
47	120	0.5000	0.5000	0.5000	1.0000	ICONN
61	81	0.5000	0.4405	0.5000	1.0000	ICONN
62	82	0.1250	0.5000	0.5000	1.0000	ICONN
119	82	0.4375	0.5000	0.5000	1.0000	ICONN
115	83	0.1250	0.5000	1.0000	1.0000	ICONN
116	84	0.1250	0.5000	1.0000	1.0000	ICONN
65	85	0.5000	0.5000	1.0000	1.C000	ICONN
66	121	0.5134	0.2500	0.7500	1.0000	ICONN
120	87	0.5000	0.5000	0.5000	1.0000	ICONN
82	102	0.5000	0.1667	1.0000	1.0000	ICONN
83	103	0.5000	0.3889	1.0000	1.0000	ICONN
84	104	0.5000	0.5000	1.0000	1.0000	ICONN
85	105	0.5000	0.5000	1.0000	1.0000	ICONN
86	106	0.0833	0.5278	0.5000	1.0000	ICONN
87	113	0.5000	0.5000	0.5000	1.0000	ICONN

X-DIRECTION CONNECTORS

NODE	NODE	CONNECTOR LENGTH IN I	CONNECTOR LENGTH IN J	COMMON INTERFACE LENGTH	DEPTH	
3	114	0.1458	0.2896	0.3182	1.C000	ICONN
4	5	0.1944	0.5000	0.2500	1.C000	ICONN
22	23	0.2708	0.5406	0.5909	1.0000	ICONN
23	24	0.4594	0.5000	1.0000	1.C000	ICONN
24	25	0.5000	0.5000	1.0000	1.0000	ICONN
25	26	0.5000	0.5333	0.5000	1.0000	ICONN
26	27	0.4667	0.5238	0.7500	1.0000	ICONN
41	42	0.2278	0.5057	0.8636	1.0000	ICONN
42	43	0.4943	0.5000	1.0000	1.0000	ICONN
43	44	0.5000	0.5000	1.0000	1.C000	ICONN
46	47	0.5000	0.5000	1.0000	1.0000	ICONN
61	118	0.2500	0.5000	0.1250	1.0000	ICONN
61	119	0.2500	0.2500	0.8750	1.C000	ICONN
118	63	0.5000	0.5000	0.1250	1.0000	ICONN
62	115	0.2500	0.5000	0.2500	1.0000	ICONN
63	64	0.5000	0.2500	0.1250	1.0000	ICONN
115	116	0.5000	0.5000	0.2500	1.C000	ICONN
117	65	0.2500	0.5000	0.7500	1.C000	ICONN
116	65	0.5000	0.5000	0.2500	1.0000	ICONN
65	66	0.5000	0.4866	1.0000	1.0000	ICONN
66	67	0.5134	0.2083	0.7500	1.C000	ICONN
81	82	0.2381	0.5000	1.0000	1.0000	ICONN
82	83	0.5000	0.5000	1.0000	1.0000	ICONN
83	84	0.5000	0.5000	1.0000	1.0000	ICONN
84	85	0.5000	0.5000	1.0000	1.0000	ICONN
85	86	0.5000	0.1667	0.2500	1.0000	ICONN
85	121	0.5000	0.2500	0.7500	1.0000	ICONN
102	103	0.3333	0.5556	0.5000	1.0000	ICONN
103	104	0.4444	0.5000	1.0000	1.C000	ICONN
104	105	0.5000	0.5000	1.0000	1.0000	ICONN
105	106	0.5000	0.4778	1.0000	1.0000	ICONN
106	107	0.5222	0.2333	0.7500	1.0000	ICONN

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2. Lewis, D. R.; Gaski, J. D.; and Thomson, L. R.: Chrysler Improved Numerical Differencing Analyzer for Third Generation Computers. Rep. TN-AP-67-287, Chrysler Corp., Space Division, Oct. 20, 1967.

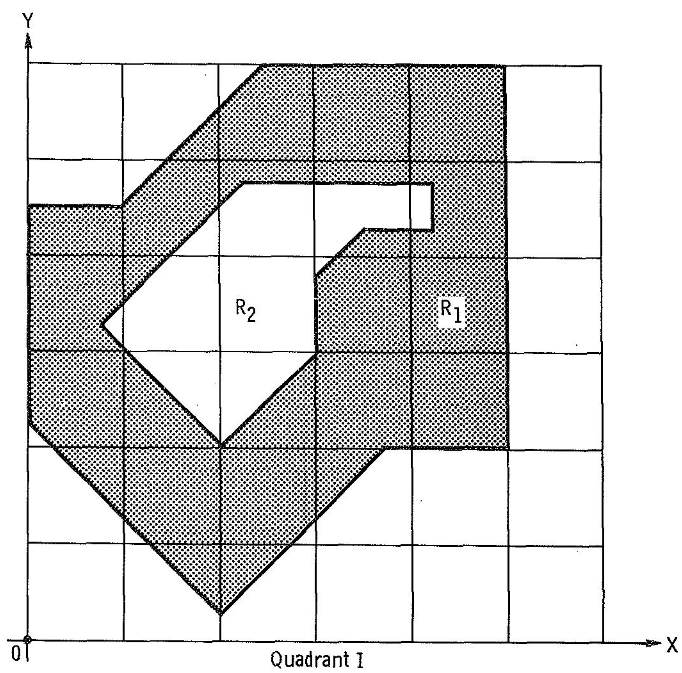

Figure 1. - Procedure example configuration.

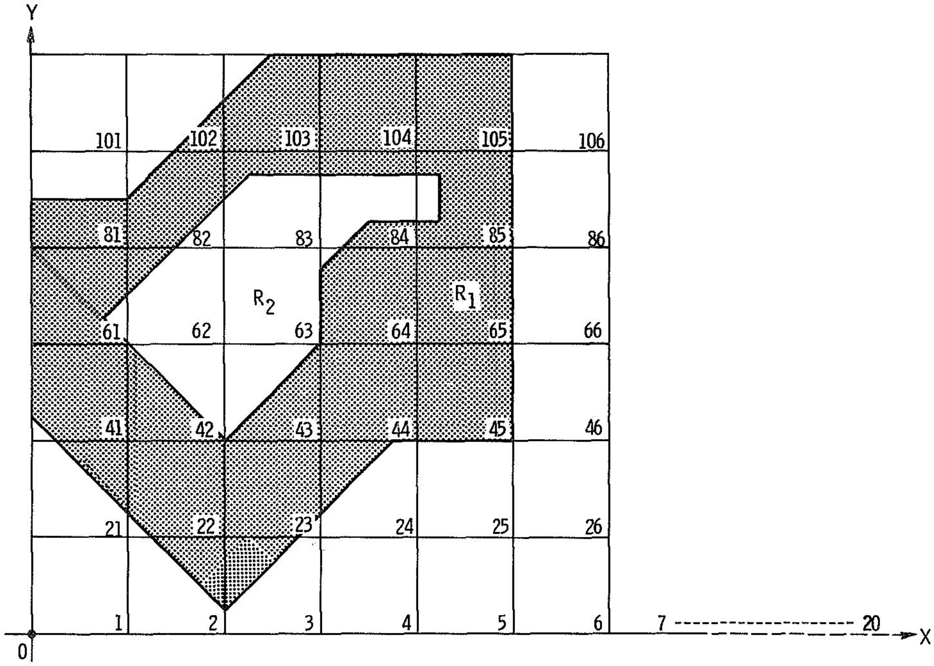

Figure 2. - Node box numbering.

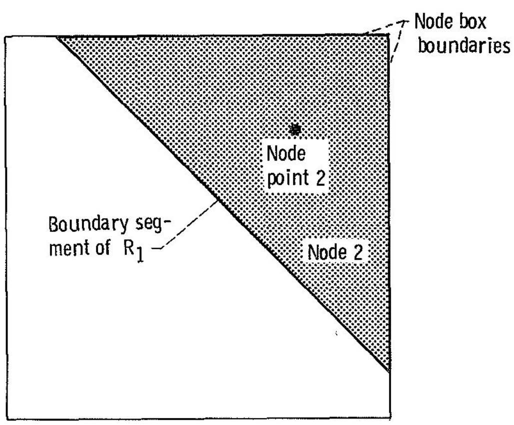

Figure 3. - Node and boundaries in node box 2.

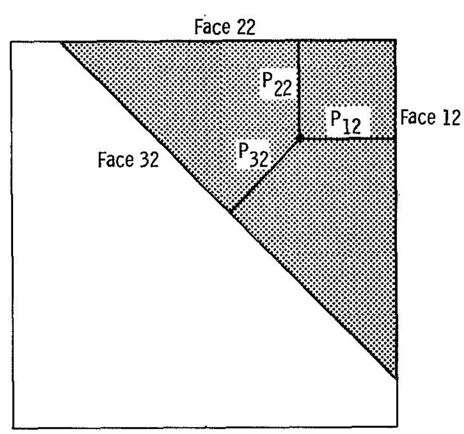

Figure 4. - Perpendiculars and faces in node box 2.

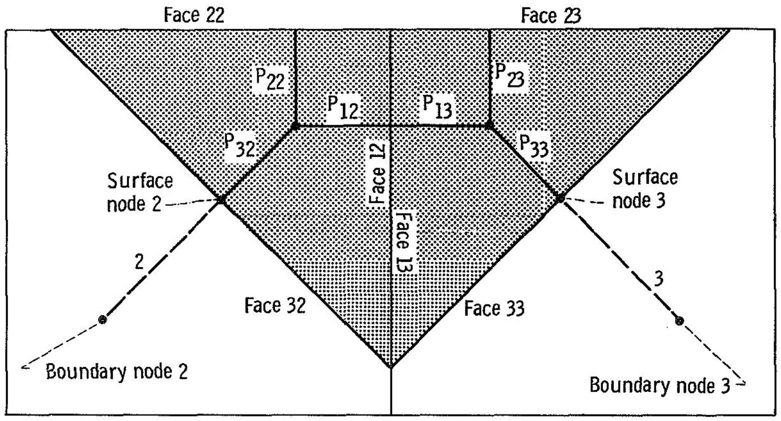

Figure 5. - Connectors pertaining to node boxes 2 and 3.

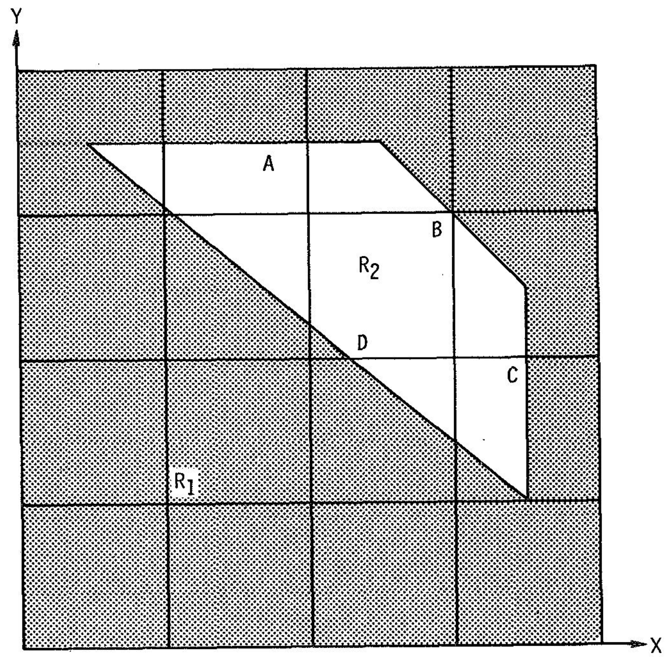

Figure 6. - Typical XCLUDE = 1 lines.

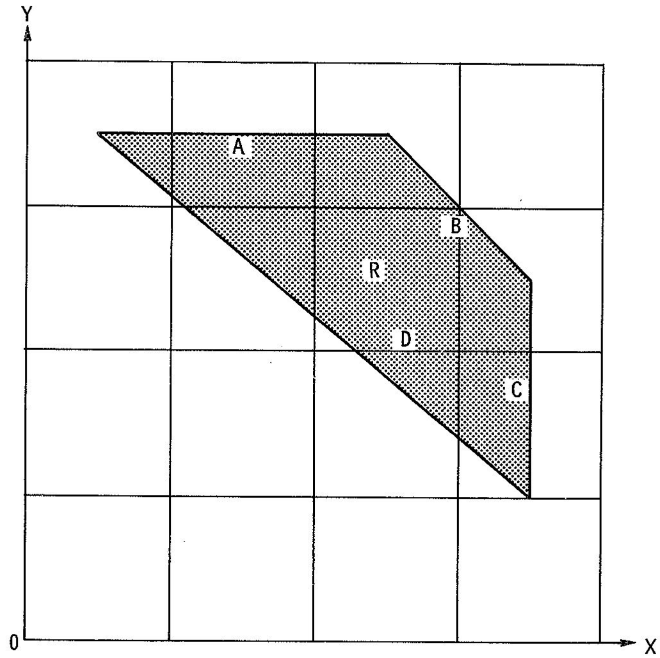

Figure 7. - Typical XCLUDE = 0 lines.

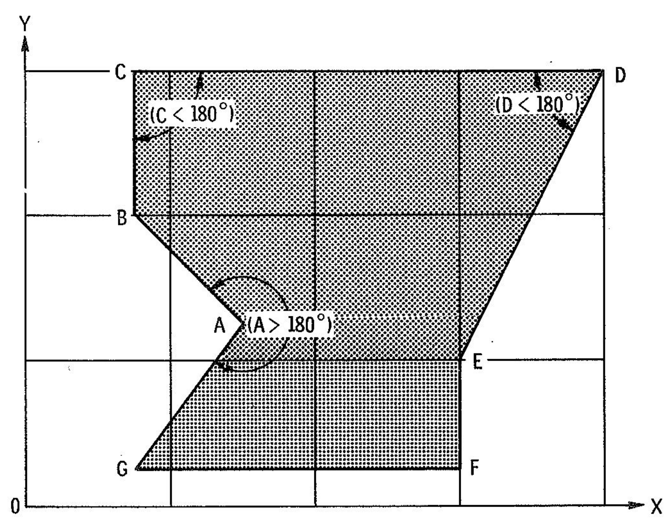

Figure 8. - Internal and external corners.

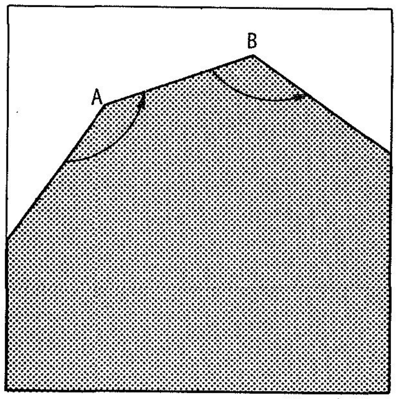

Figure 9. - Two consecutive internal corners.

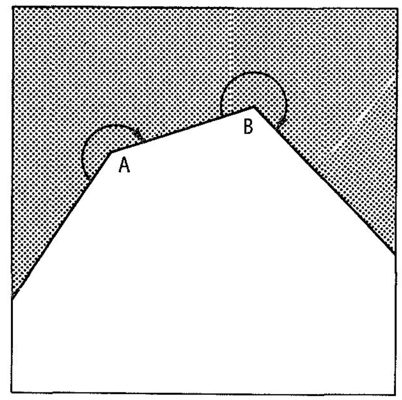

Figure 10. - Two consecutive external corners.

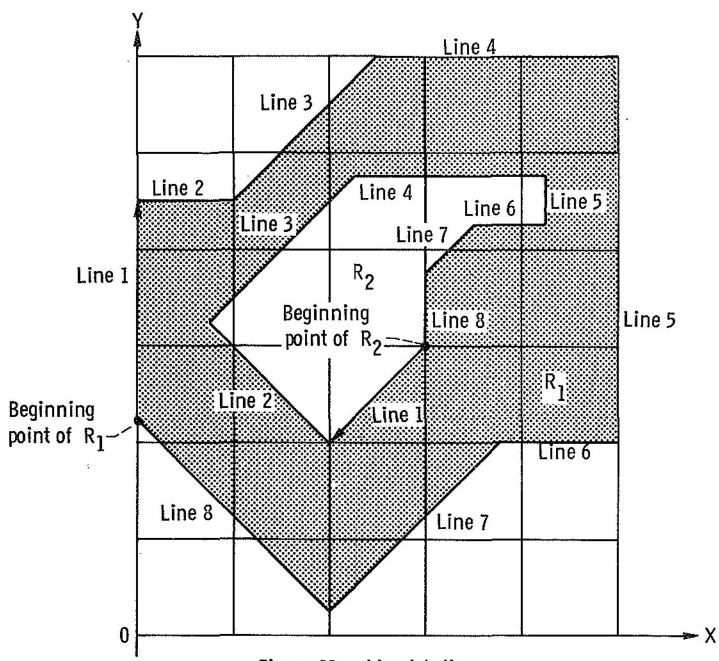

Figure 11. - Line labeling.

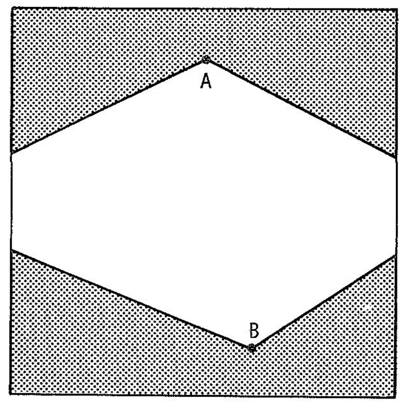

Figure 12. - Excluded type of node box.

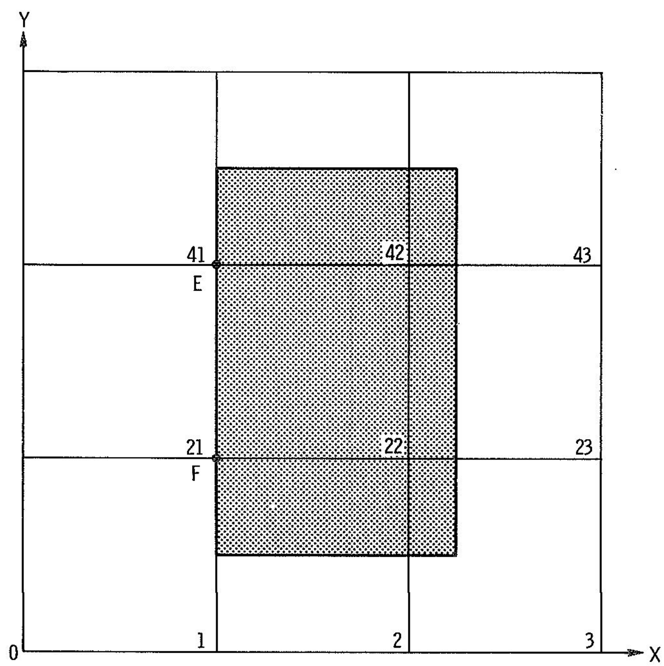

Figure 13. - Line segment in box 22.

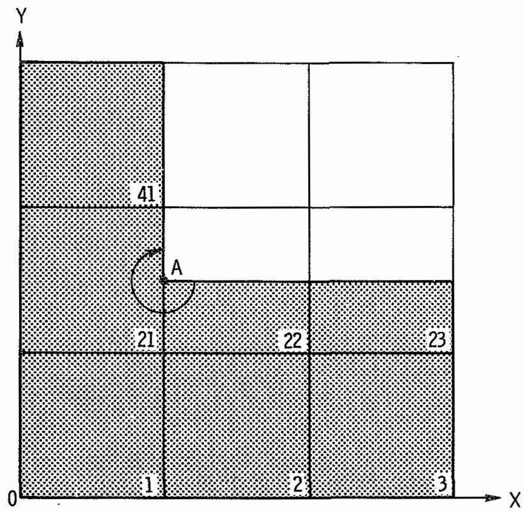

Figure 14. - External corner in box 21.

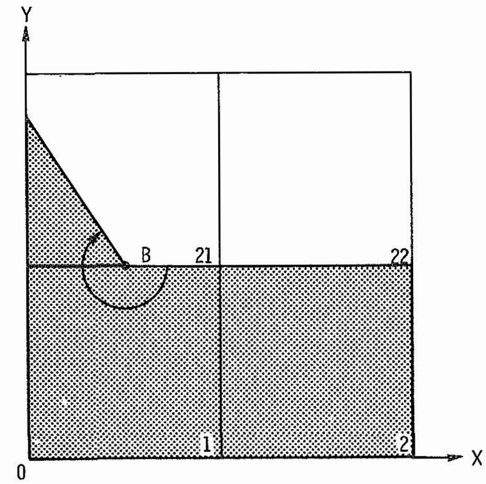

Figure 15. - External corner in box 1.

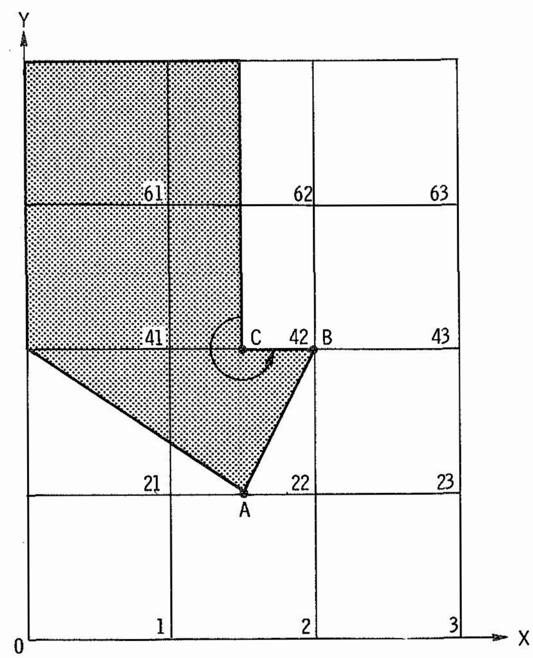

Figure 16. - Illegitimate node box (22).

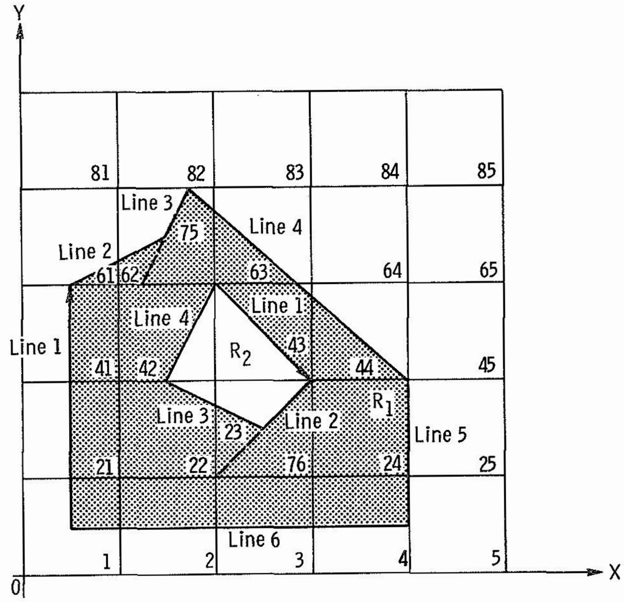

Figure 17. - Example of split nodes.

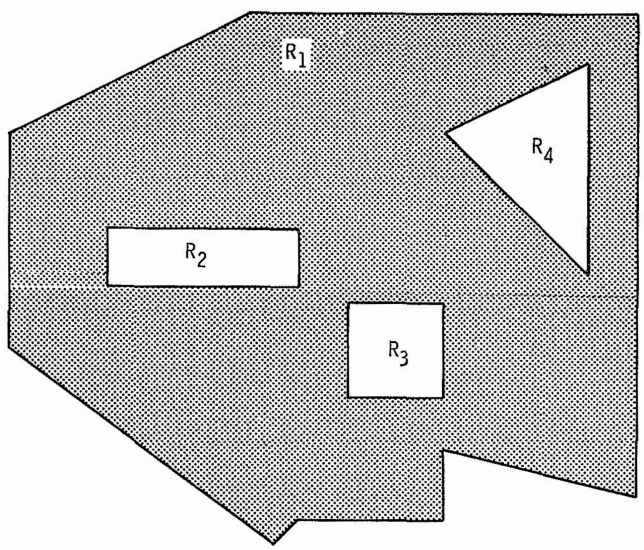

Figure 18. - Sample configuration.

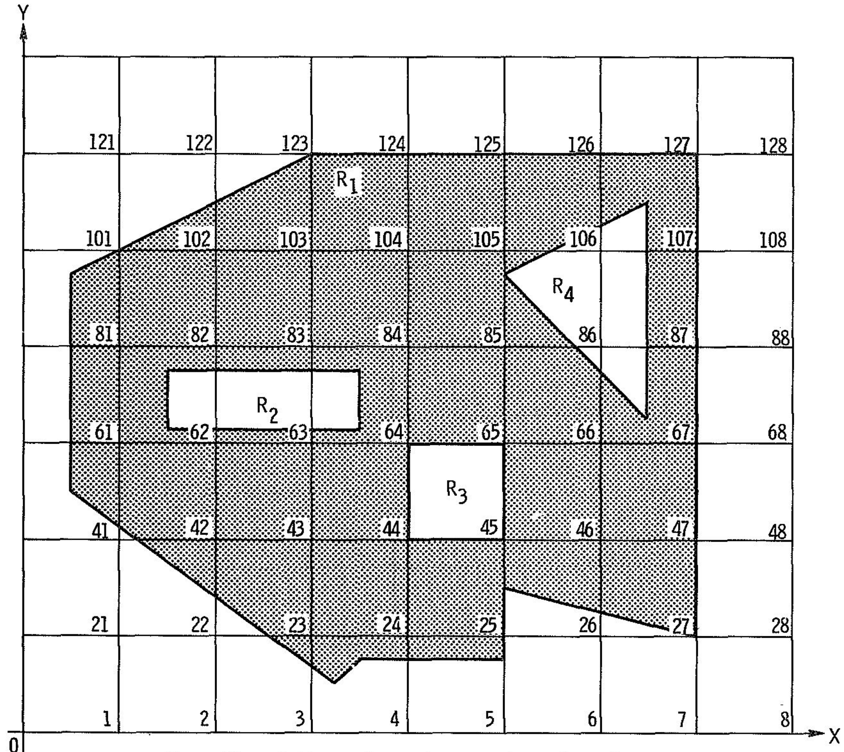

Figure 19. - Grid superimposed on sample configuration.

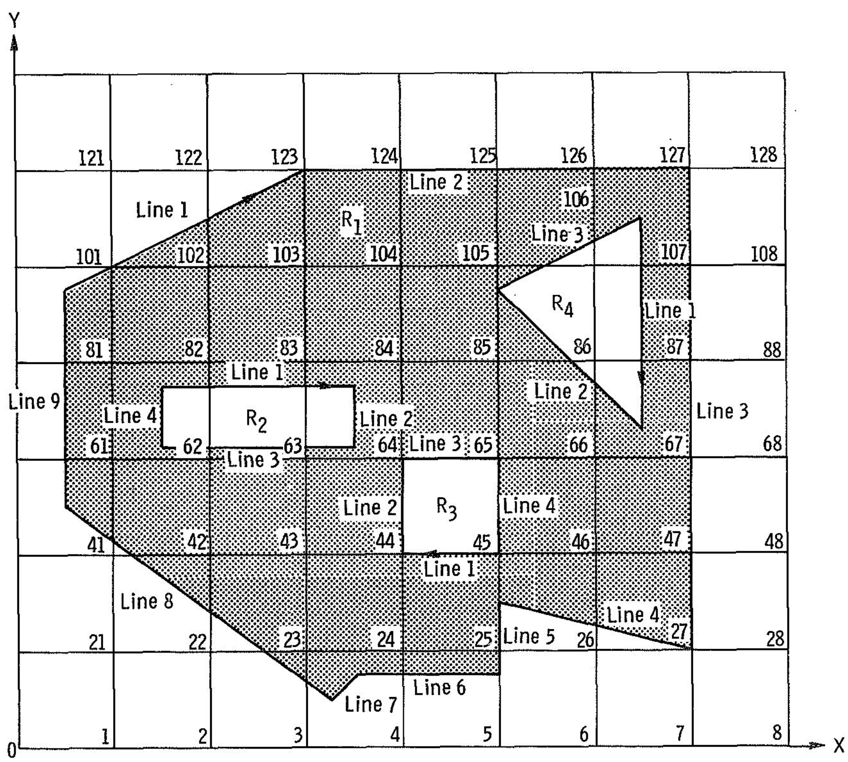

Figure 20. - Sample configuration fully labeled.

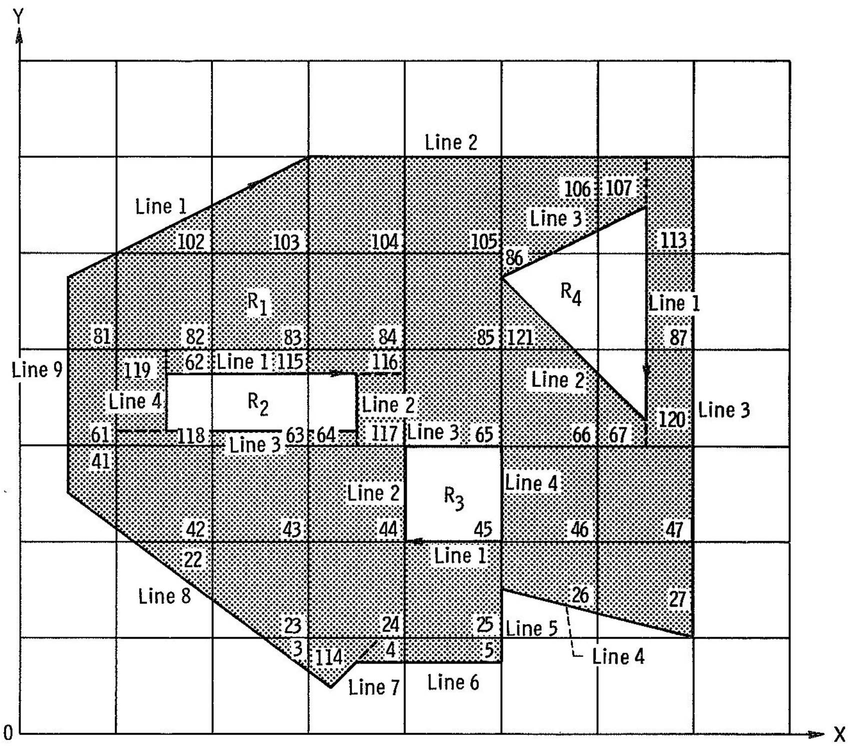

Figure 21. - How GIG split and labeled nodes.

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15. Supplementary Notes

16. Abstract

A computer program was written to generate geometrical data required as input to a finite-element heat-transfer code. With a minimum of input information, the program will generate data for any two-dimensional geometry configuration defined by straight line segments. Adaptability, accuracy of results, and ease of use are the prime considerations of the program.

17. Key Words (Suggested by Author(s))	18. Distribution Statement
Heat transfer; Node data generator; Finite element; Geometry data generator	Unclassified - unlimited

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