**Westinghouse
Astronuclear
Laboratory**

WANL-TME-2724
AUGUST 1970

**LOBO - A COMPUTER PROGRAM
TO AZIMUTHALLY MESH (FROM
AN EXTERNAL ORIGIN) AND
APPROXIMATE CIRCLES,
ANNULI, AND PARTIAL ANNULI**

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1.0 INTRODUCTION

In the nuclear rocket engine, the level of neutron generation is determined by cylindrical control drums, which are covered by a neutron "poison" on one side for high neutron absorption. As these absorbing sides are rotated inward, neutrons, which ordinarily would be reflected back into the core, are absorbed by the poison. In this way, the number of free neutrons and, hence, the reactor power is controlled. The poisonous regions of these control drums are frequently called control vanes.

Computer codes, such as DOT, are able to predict neutron fluxes in the various regions of the reactor; however, the codes need a geometrical finite mesh cell approximation of the different materials in the reactor as input. The approximation is made with mesh cells of the shape of an annular sector.

Previously, the (r, θ) mesh lines, which form the mesh cells, were chosen manually. A better solution to the problem is to accurately represent an area of the reactor containing a distinct material using small annular sectors. The approximation must be continuous (corner to corner or common point continuity), have good total area agreement, and adequately reflect the shape of the material region, i.e. good local area agreement. The approach is to define methodically a mesh which might best accomplish the area agreement with the fewest possible mesh cells, and select those cells in such a manner that the continuity of the approximation will be insured.

The following program (LOBO) description is concerned primarily with the meshed model of a control drum vane. The generation of a mesh by the program is restricted to the case of a control vane, since the meshing is dependent on the narrow width of the vane. Therefore, if an approximation

of a cylindrical annulus (ring) is desired and its inner radius is significantly less than its outer radius, then the mesh must be input and the annular sector must be increased to 360° . By reducing the inner radius of a cylindrical annulus to near zero and inputting a mesh, the program can choose an approximation for a cylinder.

2.0 PROGRAM DESCRIPTION

This program (LOBO) can receive an input of an (r, θ) mesh or create its own azimuthal mesh, do all the necessary area calculations, and select an (r, θ) mesh cell approximation of azimuthal area elements.

2.1 THE GENERATION OF A MESH

A desirable mesh approximation of the control vane is one that not only has a total area which is in good agreement with that of the vane, but also one which reflects the position and shape of the vane accurately with the fewest possible cells. Other considerations are important, e.g. the approximation, when used in other codes such as DOT⁽¹⁾, should be of mesh cells which have distances between opposing sides that are nearly equal. The proper (r, θ) mesh can greatly improve the chances for a good approximation.

The mesh is constructed on the premise that at certain locations of the vane a coarse mesh would give adequate local area agreement (Figure 2-1) for an approximation of a single strand of mesh cells. The coarser mesh should

Figure 2-1. A Coarse Mesh Cell Region

be located in the regions determined by the circles of radii BKP1 and BKP2 of Figure 2-2. BKP1 and BKP2 are determined by first constructing 45° angles to the $\theta = \text{constant}$ ray which passes through the center of the cylinder, and then calculating BKP1 and BKP2 by the formulas

$$\text{BKP1} = \left[\left(R1 - \frac{R3}{\sqrt{2}} \right)^2 + \frac{R3^2}{2} \right]^{\frac{1}{2}}$$

$$\text{BKP2} = \left[\left(R1 + \frac{R3}{\sqrt{2}} \right)^2 + \frac{R3^2}{2} \right]^{\frac{1}{2}}$$

To have local area agreement, the distance between radii and azimuthal lines should be approximately the square root of two times the thickness of the control vane near the radii BKP1 and BKP2. The distance between the radii and azimuthal lines should be equal to the thickness of the control vane at the innermost radii (R(1) and R(2) of Figure 2-2), the outermost radii (Figure 2-2), and at the center of the control drum (R1 of Figure 2-2). In Figure 2-3, the radii have been generated out to the center of the control vane. In the region between R(1) and BKP1, the distance between successive radii (R(I) and R(I+1)) are determined by

$$(1) \quad \text{DX}(I) = \text{THK} + (\sqrt{2} - 1) \text{THK} \frac{(R(I) + 0.6 \text{THK}) - R(1)}{\text{BKP1} - R(1)}$$

where THK is the thickness of control vane. Formula (1) is designed such that, when the 0.6 THK term is neglected, DX(I) linearly increases from THK when $R(I) = R(1)$, to 2 THK when $R(I) = \text{BKP1}$. The 0.6 THK term is added to R(I) so that DX(I) is calculated on the basis of an average radius between R(I) and R(I+1). The constant .6 is used, since it approximately represents $\frac{1}{2}$ of the average distance between successive radii, i.e. $0.6 \text{THK} \sim \frac{1}{2} \left(\frac{\text{THK} + 1.414 \text{THK}}{2} \right)$. Between BKP1 and R1 the difference is linearly decreased, i.e.,

$$DX(I) = THK \sqrt{2} - (\sqrt{2} - 1) THK \frac{(R(I) + 0.6 THK) - BKP1}{R1 - BKP1}$$

Similarly between R1 and BKP2,

$$DX(I) = THK + (\sqrt{2} - 1) THK \frac{(R(I) + 0.6 THK) - R1}{BKP2 - R1}$$

and between BKP2 and R1 + R3.

$$DX(I) = THK \sqrt{2} - (\sqrt{2} - 1) THK \frac{(R(I) + 0.6 THK) - BKP2}{R1 + R3 - BKP2}$$

After the radii have been constructed, the problem becomes one of choosing the azimuthal lines to overlay the radii. Wherever possible, on the inner side of the control drum, an attempt is made to center a mesh cell on the control vane. This is done in the following way. Azimuthal lines (ϕ in Figure 2-4) from the center of the reactor are defined by the intersections of the generated radii with a circle of radius $\frac{R2 + R3}{2}$ in the control drum. The ϕ_i 's are used if the $r_i \Delta \phi_i > \Delta r_i$, i.e., if the arc length between the azimuthal lines is at least as great as the distance between the radii at that place.

In Figure 2-4, the azimuthal spacing between $\phi(5)$ and $\phi(6)$ is the last interval where the azimuthal spacing is greater than the radial spacing. The number of azimuthal lines which are created between THETA(2) (in Figure 2-5) and $\phi(6)$ (in Figure 2-4) is determined by the number of times the angle subtended by the thickness of control vane (THETA(2) - THETA(1)) integrally divides into $\phi(6) - THETA(2)$ (in Figure 2-6 this is seen to be 5 times). $\phi(1)$ through $\phi(6)$ will be used as azimuthal lines, but now additional lines must be inserted between them to make $r_i \Delta \theta_i$ as nearly equal to Δr_i as possible. In Figure 2-7, no additional azimuthal lines are inserted between $\phi(5)$ and $\phi(6)$ or between $\phi(4)$ and $\phi(5)$. It can be seen, however, that the interval between

Figure 2-2. Determination of Coarse Mesh Cell Regions

Figure 2-3. The Radial Lines Generated to the Center of the Control Drum

Figure 2-4. The Radial Lines and the ϕ Angles
Determined by the Generated Radii

Figure 2-5. The Most Basic Azimuthal Lines

Figure 2-6. The Azimuthal Intervals Between $THETA(2)$ and $\varphi(6)$

Figure 2-7. Azimuthal Spacing Between $\phi(6)$ and $\phi(3)$

Figure 2-8. The Azimuthal Meshing of Half of the Control Vane

Figure 2-9. The Completed Mesh

$\phi(3)$ and $\phi(4)$ is split by an azimuthal line. In Figure 2-8, the $\phi(2)$ and $\phi(3)$ interval is trisected, and the $\phi(1)$ and $\phi(2)$ interval is divided into four equal intervals. The number of THETA intervals that the ϕ intervals are divided into is determined by the rounded off value of $\frac{r_i \Delta \phi_i}{\Delta r_i}$. After the THETA's have been generated to the center line of the control drum, the THETA's are reflected about the center line, and the mesh of the control drum is complete (Figure 2-9). The next step is the selection of the subset of this mesh which just encompasses the control vane. It is only after this that the area calculations are made.

2.2 THE AREA CALCULATIONS

The exact area calculations are done within two subroutines: one for defining the figures formed by the intersection of a sector of an annulus by a straight line (WOKEE) and the other for defining the figures formed by the intersection of any figure by a circle (DIRAH, an altered version of HOLE)^{*(2)}. First the mesh cell (a sector of an annulus) is tested for intersections by one of the straight line boundaries of the vane. If there are intersections, then two new figures are defined but only the intersection of the mesh cell with the poisonous figure is stored. If the straight line boundary ends within the mesh cell, it is arbitrarily extended in order that a temporary, closed figure (Figure 2-10) can be stored. The stored figure, which still may be the original sector of an annulus if there were no previous intersections, is tested for intersections by a circle having a radius equal to the outer radius of the vane.

* These intersections of figures are mathematically defined by straight line and circular arc segments which form the boundary of the area to be calculated. The exact method of description is given in WANL-TME-2721.

Figure 2-10. Figure Defined by the Straight Line
Side of the Control Vane

Figure 2-11. Figure Defined Further by the Outer Radius
of the Control Vane (Cross-Hatched)

**Figure 2-12. Final Figure Defined by the Inner
Radius of the Control Vane**

If there are intersections, the poisonous figure within the circle (Figure 2-11) which is part of the vane is retained and stored. Finally this last stored figure is tested for intersections by a circle of the radius of the inner arc boundary of the vane. The figure outside the circle (Figure 2-12) that is now defined after this last test is stored and its exact area is computed (CNTRD)⁽²⁾.

2.3 THE SELECTION OF AN APPROXIMATION

The selection of a mesh cell approximation is based on the percentage of the area of a mesh cell that is a part of the vane. From the area calculations, the percentage is known for each mesh cell, and the mesh cell numbers are ordered in terms of increasing percentage of enclosed vane area to total mesh cell area. A low arbitrary acceptance percentage is established, e.g., 25%, to insure initial continuity of the approximation. The continuity that is referred to is point continuity, i.e., at least, corner to corner. The initial approximation is invariably too large so the mesh cell number whose percentage area is equal to 25% or just above 25% is found, and this mesh cell is checked to see if its removal would destroy the continuity of the approximation. If its removal would make the approximation discontinuous, the cell is not removed and the mesh cell of the next higher percentage is examined. If the approximation is not discontinuous, and the area of the resulting approximation is in better agreement than before, then the total area is subtracted and the approximation is reduced by one mesh cell. The procedure is repeated until the area agreement cannot be further improved.

If the approximation is a control vane, a subroutine (REZEENA) will compute the "rubber band perimeter" of the approximation and compare it with

the actual arc length of the vane. The "rubber band perimeter" may be expected to be slightly under the value of the arc length since it is just the sum of the distances between the farthest corners from the center of the drum of select, radially prominent mesh cells. This perimeter does not include the additional side of the two end mesh cells.

Figure 2-13. An Example of the Mesh Cells
Selected in an Approximation

3.0 INPUT INSTRUCTIONS

Card No. 1

Column	Format	Variable Name	
1-6	I6	INPT	0 = mesh to be created 1 = mesh to be inputted
7-12	I6	MATI	material number of the approximated figure
13-18	I6	MATO	material number of surrounding area
19-24	I6	ISTART	row number of lower azimuthal line
25-30	I6	JSTART	column number of inner radius
31-36	6X		
37-48	F12.5	RRF	outer radius of reflector region (for plotting purposes)
49-60	F12.5	RRE	outer radius of reactor core (RRF > RRE) (for plotting purposes)

If INPT = 0, the next card should be omitted.

Optional Card

Column	Format	Variable Name	
1-6	I6	MAX	number of arcs to be inputted (radii)
7-12	I6	INDC	number of radii to be inputted (azimuthal lines)

If INPT = 0, the next group of cards should be omitted.

Optional Card Group

Column	Format	Variable Name	
1-72	6E12.5	R(I)	the distance from the center of the reactor to the arcs (the number of them is equal to MAX, and they should be in increasing order)

Column	Format	Variable Name	
1-72	6E12.5	THETA(I)	the angles in degrees made by the radii of the mesh and the base line of a side of the reactor sector (the number of them is equal to INDC, and they should be in increasing order) and begin on a new card

Card No. 2

Column	Format	Variable Name	
1-12	E12.5	P(1); R1	the distance between the center of the reactor and the center of the control drum
13-24	E12.5	P(2); R2	the distance between the center of the control drum and the inner arc boundary of the control vane
25-36	E12.5	P(3); R3	the distance between the center of the control drum and the outer arc boundary of the control vane
37-48	E12.5	P(4); ALPHA	the clockwise angular rotation in degrees of the "midpoint" of the control vane from the closed position in which the vane is on the inner side of the drum.
49-60	E12.5	P(5); BETA	the angular span in degrees of the control vane
61-72	E12.5	P(6); GAMMA	the azimuthal displacement in degrees of the center of the control drum from the base line of the side of the reactor sector

Figure 3-1. Sector Showing the Input Variables

[illegible]

4.0 OUTPUT DESCRIPTION

The printed output consists of the parameters of the vane which fix its location, the initial mesh (either by input or creation), the final mesh about the control vane, the distances between radii, and the angular separation between azimuthal lines. The angles, $\text{THETA}(I)$, which define the azimuthal lines are printed in radians.

Next, the lower azimuthal line number and inner radius number are printed. The row (azimuthal line) and column (radii) numbers of all cells which contain any of the control vane are printed with their total area (TAREA), the intersection area (EAREA) that is common to both the mesh cell and the control vane, the fraction of the area of the mesh cell that is also a part of the control vane ($\text{PAREA}=\text{EAREA}/\text{TAREA}$), and the material number (Z) that is assigned to each mesh cell by the approximation technique.

Finally, the area agreement is printed, and the mesh that is punched is printed. Punched output for DOT consists of R_i ($R(I)$) in centimeters in 6E12.5 format and θ_j ($\text{THETA}(I)$) in revolutions in 6E12.5. M_{ij} in 6I12 is the material number of the mesh cell bounded by R_i , R_{i+1} , θ_j , and θ_{j+1} . They are punched with the i index varying more rapidly, and a new card is started with each new j . Punched output for EXTERMINATOR-2 consists of the definition of the approximation by the rectangular blocking of mesh cells that are included in the approximation by determining the azimuthal line numbers and radii numbers which bound the rectangular block of cells. The blocks are arranged along a common column or radii. The first of the five numbers is the material number of the approximated region, then the top line number, the bottom line number, the left line number, and the right line number.

4.1 PLOTTING

MESHED MODEL FOR CONTROL VANE

RADIAL DISPLACEMENT	0.56832E+02
INNER RADIUS	0.46990E+01
OUTER RADIUS	0.49530E+01
ANGULAR DISPLACEMENT	0.
TOTAL ANGULAR COVERAGE	0.12000E+03
AZIMUTHAL DISPLACEMENT	0.15000E+02
LOWER AZIMUTHAL LINE NO.	1
INNER RADIUS NO.	1
AREA OF VANE	0.25673E+01
AREA OF MESHED VANE	0.25714E+01
PERCENT ERROR	0.16006E+00

Figure 4-1. First Frame of the Plotted Output
(Input Variables, Reference Lines, and
Results of the Approximation)

Figure 4-2. Second Frame of the Plotted Output
(Relative Orientation of the Control Vane)

Figure 4-3. Third Frame of the Plotted Output
(The Selected Approximation)

4.2 PRINTED OUTPUT

MESHED MODEL FOR CONTROL VANE

RADIAL DISPLACEMENT= 56.83250 INNER RADIUS= 4.69900 OUTER RADIUS= 4.95300
ANGULAR DISPLACEMENT= 0.00 TOTAL ANGULAR COVERAGE=120.00 AZIMUTHAL DISPLACEMENT= 15.00

MESH CREATED FOR DRUM

ARCS (RADII)

0.51879E+02	0.52133E+02	0.52411E+02	0.52703E+02	0.53013E+02	0.53340E+02
0.53685E+02	0.54018E+02	0.54342E+02	0.54657E+02	0.54964E+02	0.55263E+02
0.55555E+02	0.55838E+02	0.56114E+02	0.56383E+02	0.56645E+02	0.56832E+02
0.57090E+02	0.57354E+02	0.57625E+02	0.57902E+02	0.58186E+02	0.58478E+02
0.58776E+02	0.59082E+02	0.59395E+02	0.59716E+02	0.60045E+02	0.60382E+02
0.60727E+02	0.61034E+02	0.61316E+02	0.61531E+02	0.61785E+02	

RADII (AZIMUTHAL LINES) IN RADIANS

0.17487E+00	0.17931E+00	0.18480E+00	0.19030E+00	0.19580E+00	0.20130E+00
0.20806E+00	0.21615E+00	0.22126E+00	0.22638E+00	0.23145E+00	0.23652E+00
0.24159E+00	0.24664E+00	0.25170E+00	0.25675E+00	0.26180E+00	0.26685E+00
0.27190E+00	0.27695E+00	0.28201E+00	0.28708E+00	0.29215E+00	0.29722E+00
0.30234E+00	0.30745E+00	0.31254E+00	0.31760E+00	0.32270E+00	0.32780E+00
0.33879E+00	0.34429E+00	0.34973E+00			

FINAL MESH

NUMBER OF ARCS = 10 NUMBER OF RADII = 31

ARCS (RADII)					
0.51879E+02	0.52133E+02	0.52411E+02	0.52703E+02	0.53013E+02	0.53340E+02
0.53685E+02	0.54018E+02	0.54342E+02	0.54657E+02		

DISTANCES BETWEEN ARCS (RADII)					
0.25400E+00	0.27708E+00	0.29281E+00	0.30944E+00	0.32701E+00	0.34558E+00
0.33259E+00	0.32386E+00	0.31536E+00			

RADII (AZIMUTHAL LINES) IN RADIAN					
0.17931E+00	0.18480E+00	0.19030E+00	0.19580E+00	0.20130E+00	0.20680E+00
0.21615E+00	0.22126E+00	0.22638E+00	0.23145E+00	0.23652E+00	0.24159E+00
0.24664E+00	0.25170E+00	0.25675E+00	0.26180E+00	0.26685E+00	0.27190E+00
0.27695E+00	0.28201E+00	0.28708E+00	0.29215E+00	0.29722E+00	0.30234E+00
0.30745E+00	0.31554E+00	0.32230E+00	0.32780E+00	0.33330E+00	0.33879E+00
0.34429E+00					

ANGLES BETWEEN THE RADII (AZIMUTHAL LINES) IN RADIAN					
0.54991E-02	0.54991E-02	0.54991E-02	0.54991E-02	0.67534E-02	0.80947E-02
0.51140E-02	0.51140E-02	0.50718E-02	0.50718E-02	0.50718E-02	0.50516E-02
0.50516E-02	0.50516E-02	0.50516E-02	0.50516E-02	0.50516E-02	0.50516E-02
0.50516E-02	0.50718E-02	0.50718E-02	0.50718E-02	0.51140E-02	0.51140E-02
0.80947E-02	0.67534E-02	0.54991E-02	0.54991E-02	0.54991E-02	0.54991E-02

THE INTERSECTED MESH CELLS

ROW
LOWER AZIMUTHAL LINE NO.= 1

COLUMN
INNER RADIUS NO.= 1

ROW	COLUMN	TAREA	EARFA	PARFA	Z
10	1	.06700	.00552	.08235	1
11	1	.06700	.02546	.38008	1
12	1	.06673	.04187	.62741	3
13	1	.06673	.05404	.80982	3
14	1	.06673	.06207	.93021	3
15	1	.06673	.06607	.99005	3
16	1	.06673	.06607	.99005	3
17	1	.06673	.06207	.93021	3
18	1	.06673	.05404	.80982	3
19	1	.06673	.04187	.62741	3
20	1	.06700	.02546	.38008	1
21	1	.06700	.00552	.08235	1
7	2	.07407	.00009	.00121	1
8	2	.07407	.02045	.27608	1
9	2	.07346	.05173	.70418	3
10	2	.07346	.06496	.88434	3
11	2	.07346	.04431	.60315	3
12	2	.07316	.02650	.36219	1
13	2	.07316	.01352	.18475	1
14	2	.07316	.00496	.06777	1
15	2	.07316	.00496	.06777	1
16	2	.07316	.00071	.00966	1
17	2	.07316	.00496	.06777	1
18	2	.07316	.01352	.18475	1
19	2	.07316	.02650	.36219	1
20	2	.07346	.04431	.60315	3
21	2	.07346	.06496	.88434	3
22	2	.07346	.05173	.70418	3
23	2	.07407	.02045	.27608	1
24	2	.07407	.00009	.00121	1
6	3	.12457	.01748	.14036	1
7	3	.07870	.06112	.77662	3
8	3	.07870	.05579	.70892	3
9	3	.07805	.02145	.27480	1
10	3	.07805	.00078	.01003	1

ROW	COLUMN	TAREA	FAREA	PAREA	/
21	3	.07805	.00078	.01003	1
22	3	.07805	.02145	.27480	1
23	3	.07870	.05579	.70892	3
24	3	.07870	.06112	.77662	3
25	3	.12457	.01748	.14036	1
5	4	.11046	.01628	.14735	1
6	4	.13240	.10008	.75589	3
7	4	.08365	.01816	.21706	1
24	4	.08365	.01816	.21706	1
25	4	.13240	.10008	.75589	3
26	4	.11046	.01628	.14735	1
4	5	.09562	.01538	.16709	1
5	5	.11744	.09032	.77418	3
6	5	.14076	.01667	.11840	1
25	5	.14076	.01667	.11840	1
26	5	.11744	.09032	.77418	3
27	5	.09562	.01538	.16709	1
3	6	.10169	.01914	.13818	1
4	6	.10169	.08222	.80855	3
5	6	.12489	.01630	.13050	1
26	6	.12489	.01630	.13050	1
27	6	.10169	.08222	.80855	3
28	6	.10169	.01914	.13818	1
2	7	.09849	.00957	.03716	1
3	7	.09849	.08116	.82404	3
4	7	.09849	.01412	.14238	1
27	7	.09849	.01412	.14238	1
28	7	.09849	.08116	.82404	3
29	7	.09849	.00957	.03716	1
1	8	.09649	.00001	.00011	1
2	8	.09649	.06788	.70346	3
3	8	.09649	.02840	.29430	1
22	8	.09649	.02840	.29430	1
29	8	.09649	.06788	.70346	3
30	8	.09649	.00001	.00011	1
1	9	.09451	.01141	.12068	1

ROW , COLUMN	TAREA	EAREA	PAREA	Z
2 , 9	.09451	.05662	.59905	3
29 , 9	.09451	.05662	.59905	3
30 , 9	.09451	.01141	.12068	1

AREA OF VANE=	2.567318	AREA OF MESHED VANE=	2.571427	PERCENT ERROR=	.160056
---------------	----------	----------------------	----------	----------------	---------

4-13

4U	0.51879E+02	0.52133E+02	0.52411E+02	0.52703E+02	0.53013E+02	0.53340E+02
0.53685E+02	0.54018E+02	0.54342E+02	0.54657E+02			
2U	0.28537E-01	0.29413E-01	0.30288E-01	0.31163E-01	0.32038E-01	0.33113E-01
0.34401E-01	0.35215E-01	0.36029E-01	0.36836E-01	0.37644E-01	0.38451E-01	
0.39255E-01	0.40059E-01	0.40863E-01	0.41667E-01	0.42471E-01	0.43275E-01	
0.44079E-01	0.44883E-01	0.45690E-01	0.46497E-01	0.47304E-01	0.48118E-01	
0.48932E-01	0.50220E-01	0.51295E-01	0.52170E-01	0.53046E-01	0.53921E-01	
0.54796E-01						

85

[illegible]

4-74

EXPERIMENT 2				EXPERIMENT 3				EXPERIMENT 4			
DATE	TIME	TEMP.	WIND	DATE	TIME	TEMP.	WIND	DATE	TIME	TEMP.	WIND
3 20 12	1 2	3 12	9 2 3	3 23 20	2 3	3 9 7	3 4				
3 25 23	3 4	3 7 6	4 5	3 26 25	4 5	3 6 5	5 6				
3 27 26	5 6	3 5 4	6 7	3 28 27	6 7	3 4 3	7 8				
3 29 28	7 8	3 3 2	8 9	3 30 29	8 9	3 3 2	9 10				
3 30 29	9 10										

ARCLNGTH= 10.373539 RUBBER BAND= 10.264068 PERCENT ERROR= -1.055294

11.16.45. GAMR232. ASP1110.GAMRIT.0060.1500 10.01.
 11.16.45. GAMR232. AS00254.
 11.16.45. GAMR232. RUN(S,,,,,,CR)
 11.17.09. GAMR232. LGO.
 11.17.12. GAMR232. MAXIMUM FL IF NO COMPILE **** 057000
 11.17.17. GAMR232. MAXIMUM FL IF NO COMPILE **** 130600
 11.17.30. GAMR232. MAXIMUM FL IF NO COMPILE **** 126500
 11.17.33. GAMR232. MAXIMUM FL IF NO COMPILE **** 117400
 11.17.39. GAMR232. RUN 2.3 PROGRAM... LINK 10
 11.17.50. GAMR232. SC-4020 FRAMES 0MF 4HC 030TH
 11.17.57. GAMR232. STOP
 11.17.58. GAMR232. CP 033.416 SEC.
 11.17.58. GAMR232. PP 051.415 SEC.
 11.28.57. 08/04/70 WEC SCOPE 3.2 SYSTEM (6416) 01/31/70

5.0 LIST OF ROUTINES

(LOBO,0,0)

LINK00

flow program

INTSCT

calculates the coordinates of the
intersections of every combination
of lines and arcs

INCRS

(LOBO,1,0)

LINK 10

coordinates input, mesh generation,
and area calculations

DYELAT

creates the mesh

BOND

reduces the mesh to around the
control drum

SLIM

reduces the mesh to around the
control vane

CELL

calculates the areas of the mesh cells

XTEND

extends the straight line boundaries
of the vane in mesh cells containing
its endpoints

HELO

controls area calculations

WOKEE

defines the figures in a mesh cell
intersected by a straight lineDIRAH
(modified
HOLE)defines the intersection of a figure
and a circle

CNTRD

calculates the area of any figure
with sides of arcs or straight lines

DNODE

determines the mesh cells that are
completely within the vane

(LOBO,2,0)

LINK 20	controls the mesh selection and output
PREBLEE	determines which cells are to be included in the approximation
PREEGOT	prepares the arrays for GRAFEK and plots the table on first plotting frame
GRAFEK	graphs any set of straight lines and arcs

(LOBO,3,0)

LINK 30	controls rubber band perimeter calculation
REZEENA	calculates the rubber band perimeter of the control vane approximation

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Astronuclear
Laboratory

TITLE LOBO - A Computer Program to Azimuthally Mesh From an External Origin) and Approximate Circles, Annuli and Partial Annuli	
DOCUMENT NO. WANL-TME-2724		DATE August 1970	
ABSTRACT This report describes a computer code which approximates by means of azimuthal mesh cells circles, annuli and angular portions of annuli. The output can be used in computer codes which predict neutron fluxes.			
DATA ITEM NO. N/A		SECURITY CLASSIFICATION OF DOCUMENT Unclassified	
CDRL LINE NO. N/A		TOTAL NO. OF PAGES 46	
KEY WORDS Azimuthal Meshing Circles, Annuli, Sectors			
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W Form 59943		DOCUMENT INFORMATION SUMMARY	

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