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R. W. Colsher

R. A. Leemhuis

W. Soedel

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MOTION SIMULATION OF WANKEL-TYPE COMPRESSORS
BY COMPUTER GRAPHICS

Robert W. Colsher, Graduate Teaching Assistant
Richard S. Leemhuis, Graduate Teaching Assistant
Dr. Werner Soedel, Professor
School of Mechanical Engineering
Purdue University

The motion picture accompanying this presentation was prepared for use in the kinematics course of Purdue University. Its purpose in that course is to demonstrate the transition from a mathematical description to an operating graphical model.

Using the equations for the apex point of a Wankel rotor, given the crank angle, viz.,

$$\theta_7 = \tan^{-1} \left\{ \frac{\sin\theta_2 + \frac{r_5}{r_2} \sin \left[\pi + \theta_2 \left(1 - \frac{r_5}{r_3} \right) - \alpha \right]}{\cos\theta_2 + \frac{r_5}{r_2} \cos \left[\pi + \theta_2 \left(1 - \frac{r_5}{r_3} \right) - \alpha \right]} \right\}$$

$$r_7 = \sqrt{\left\{ \cos\theta_2 + \frac{r_5}{r_2} \cos \left[\pi + \theta_2 \left(1 - \frac{r_5}{r_3} \right) - \alpha \right] \right\}^2 + \left\{ \sin\theta_2 + \frac{r_5}{r_2} \sin \left[\pi + \theta_2 \left(1 - \frac{r_5}{r_3} \right) - \alpha \right] \right\}^2}$$

where, $r_2 = \frac{r_3}{N}$ [1]
 $r_5 = r_3 \left(1 - \frac{1}{N} \right)$
 $\alpha = \frac{\pi}{N}$
 $N = \text{number of apex points on rotor} = \text{number of lobes} + 1,$

a program was written to calculate an array of values for a sequence of crank angles. This array describes the shape of the compressor bore.

Noting that adjacent apex points of the rotor are identical with the primary apex point when the crank has completed one 360° rotation, it is possible to construct an outline for the rotor. The curvature of the rotor edges is determined by choosing a point on the perpendicular bisector of the line segment connecting the two adjacent apex points and constructing a circular arc through the apex points with the center of curvature being the chosen point on the perpendicular bisector. By using successive crank angles in the above construction procedure, the rotor can be drawn in an approx-

imation of smooth motion.

Making use of the refresh graphics display system in the Mechanical Engineering School's Computer Aided Design and Graphics Laboratory [2], the bore outline and the sun-gear and rotor were drawn in a sequence of positions. This display was then recorded on film for classroom presentation.

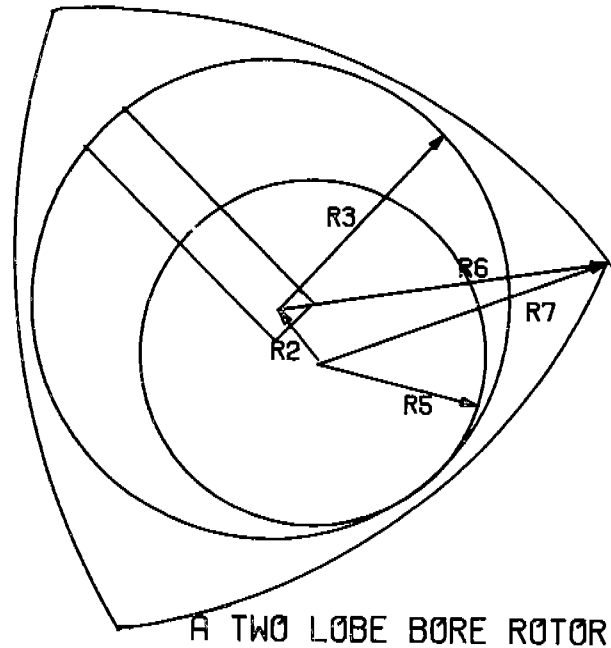


Figure 1.

Included in the film are rotation simulations of:

1. Two separate two-lobed compressors
 - a. $r_3=6.$ $r_6=11.$ $\text{prc}=0.8$ Fig.2
 - b. $r_3=6.$ $r_6=12.$ $\text{prc}=0.9$
2. A single lobed Wankel compressor
 - $r_3=3.$ $r_6=12.$ $\text{prc}=0.9$

- 3. A three lobed compressor
 $r_3=6.$ $r_6=12.$ $prc=0.9^*$
- 4. A four lobed compressor
 $r_3=6.$ $r_6=14.5$ $prc=0.8$
- 5. A five lobed compressor
 $r_3=4.$ $r_6=14.$ $prc=0.8$ **Fig.3**
- 6. Two eight lobed Wankel compressors
 a. $r_3=4.$ $r_6=15.$ $prc=0.5$ **Fig.4**
 b. $r_3=8.$ $r_6=11.$ $prc=0.9$ **Fig.5**
- and, 7. Two more four lobed compressors
 a. $r_3=6.$ $r_6=10.$ $prc=0.3$ **Fig.6**
 b. $r_3=6.$ $r_6=14.5$ $prc=-15.$ **Fig.7**

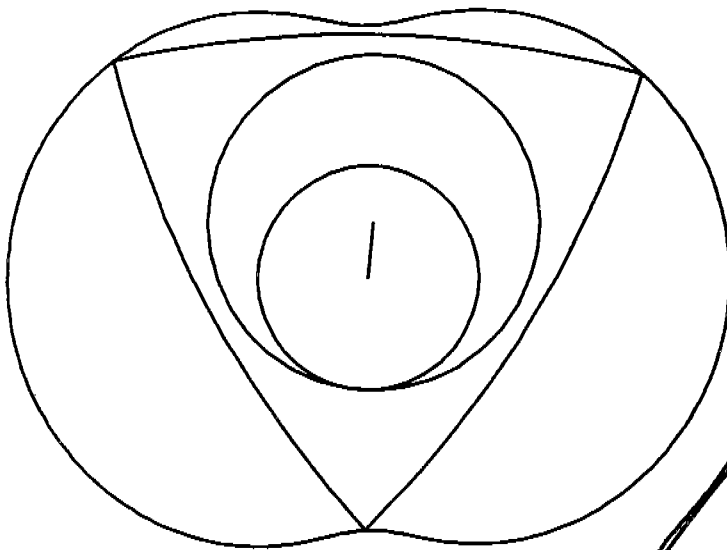


Figure 2.

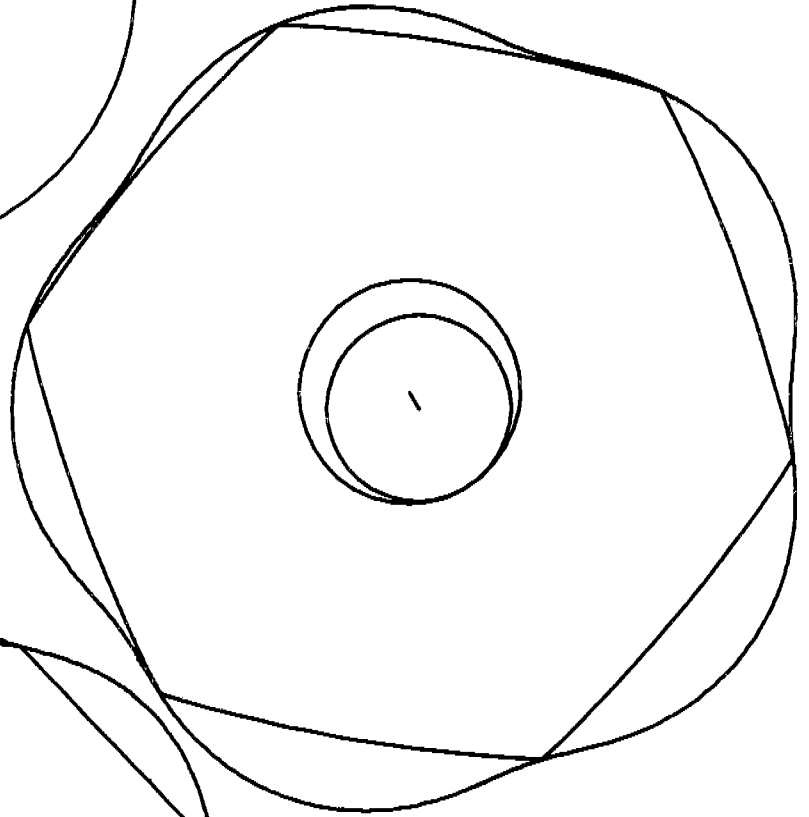


Figure 3

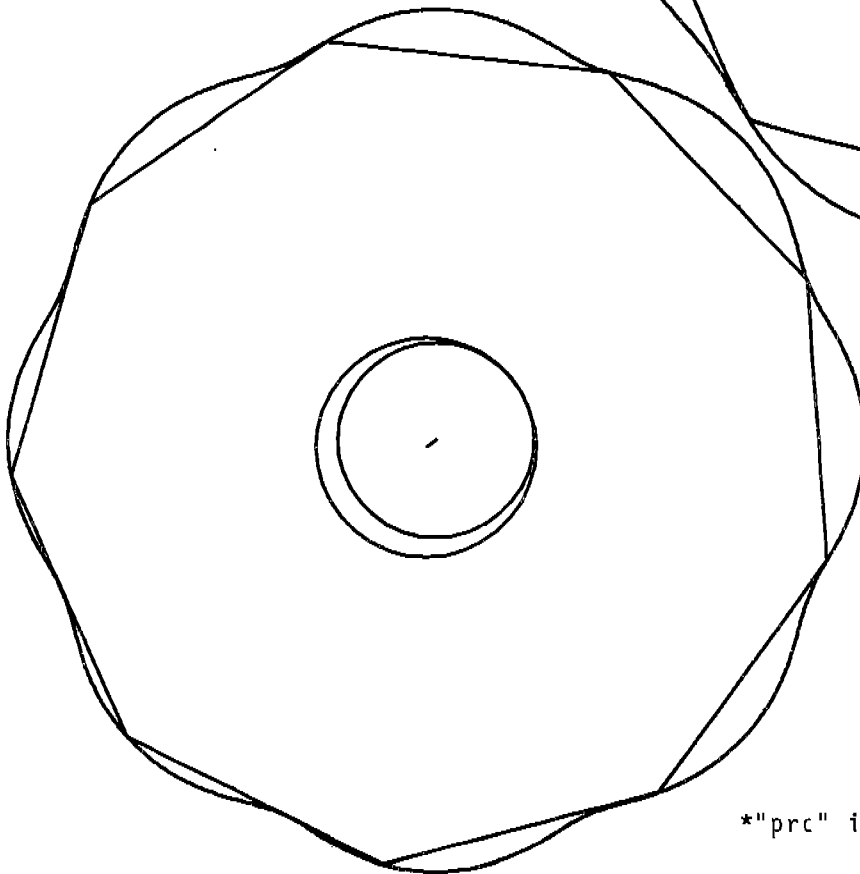


Figure 4

*"prc" is a parametrized relative curvature

The first eight of these simulations were chosen with rotors of maximal volumes since it is for these that it is most difficult to visualize the rotation. The ninth simulation is an example of a rotor with smaller volume and the last is an example of a mathematically derivable, yet physically impossible, rotor. It is interesting to note that although a smaller rotor allows larger volumes to be compressed, the compression ratio for such a rotor is significantly less than that for a larger rotor.

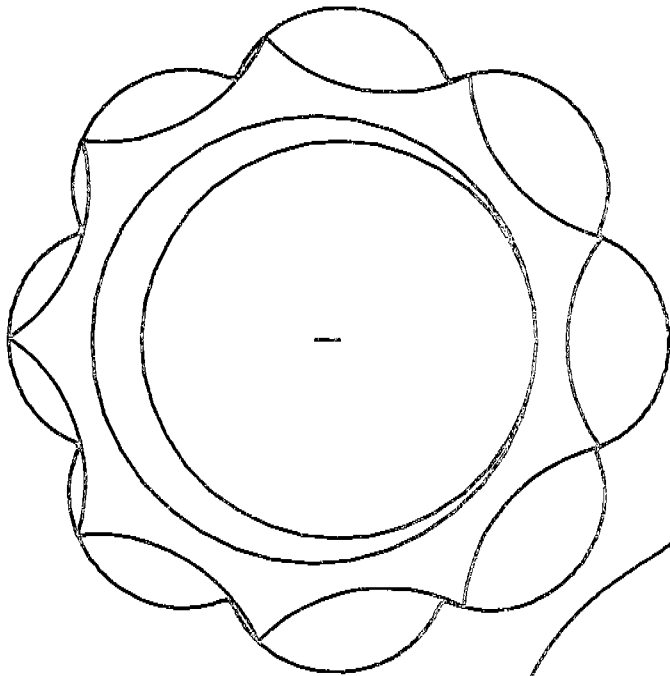


Figure 5

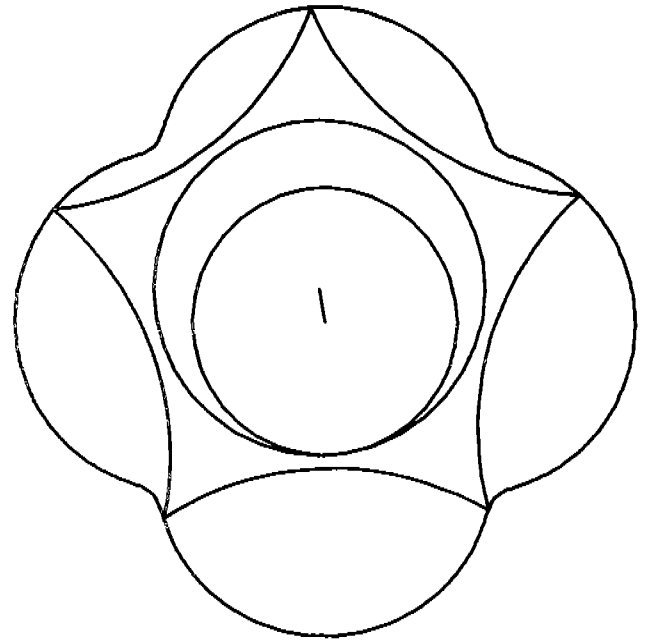


Figure 6

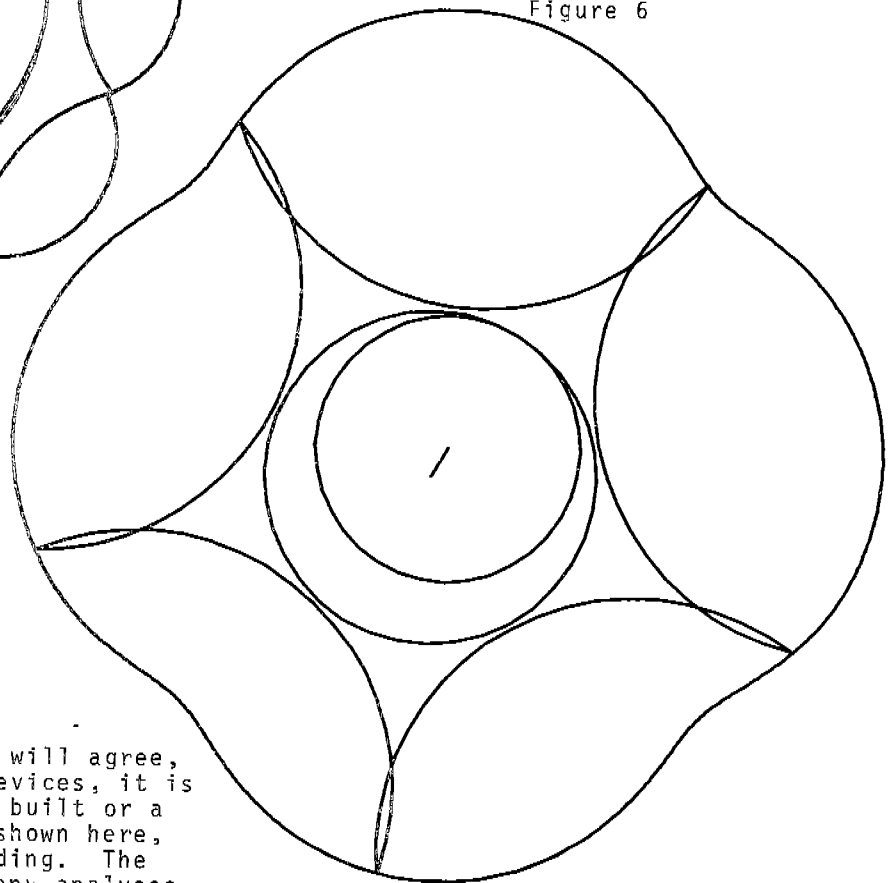


Figure 7

As the viewer of the movie will agree, for certain complex kinematic devices, it is essential that either models be built or a computer graphics approach, as shown here, is used to assist the understanding. The ability of the computer to do many analyses in a short period of time and to produce displays which can be filmed or plotted automatically increase the desirability of the computer graphics approach.

NOTES

1. R.S. Leemhuis and W. Soedel, "Kinematics of Wankel Compressors (or Engines) by way of Vector Loops", Proceedings of the 1976 Purdue Compressor Technology Conference.
2. D.C. Anderson and R.L. Belleville, "Two Approaches to On-Line Graphics Systems", Computers and Graphics, Pergamon Press, to be published, 1976.