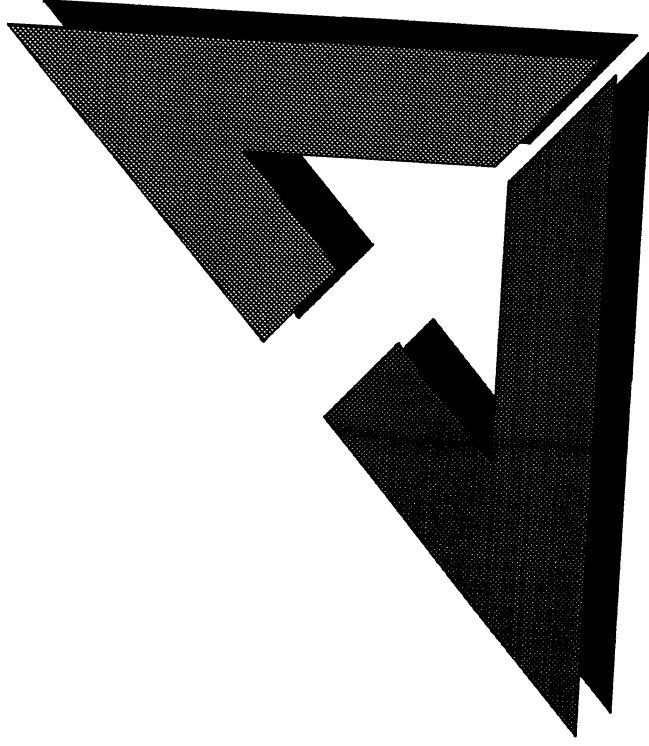




Simplifying Cam Design through the Use of ADAMS/View

*Karl Bangert
Application Engineer*

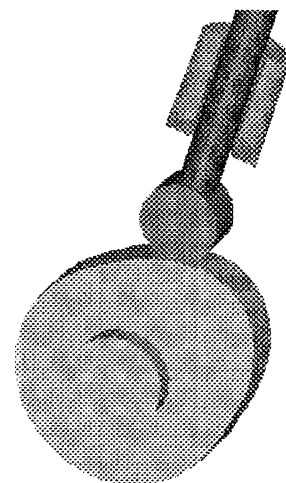
*Ann Arbor, MI
May 25, 1994*

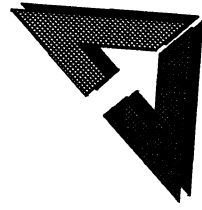
International ADAMS Users' Conference

ADAMS

SIMPLIFYING CAM DESIGN THROUGH THE USE OF ADAMS/VIEW

The design of cam driven devices has typically been a time consuming process requiring the interaction of many disparate softwares to perform numerous tasks. Such efforts involve input/output function definition, mechanism analysis, and export of geometry data to machine tool systems. The flexibility to analyze both an existing cam or design a new cam, given a desired output function, is also an important consideration. This paper presents several advanced ADAMS/View capabilities which simplify and couple these tasks. The cam synthesis methodology described here uses ADAMS/View as a seamless cam design tool.

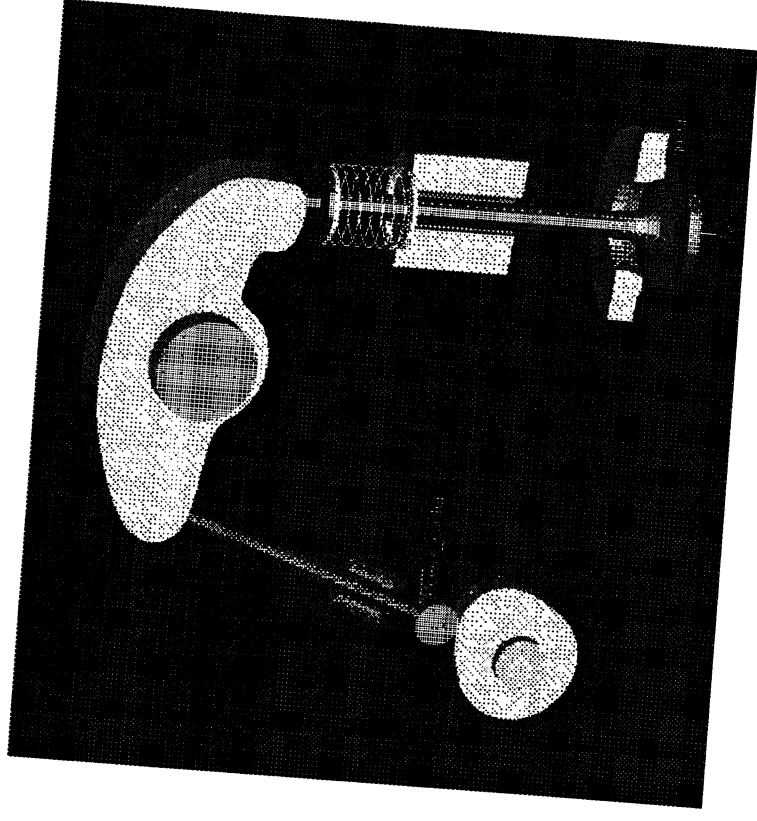


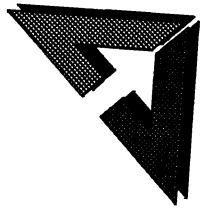


Cam Design with ADAMS/View

Motivation - ADAMS 7.0 Themes

- ▶ ***Improved Cam Modeling***
- ▶ ***ADAMS/View Macro Language***
- ▶ ***Higher-Pair Constraint Icons***

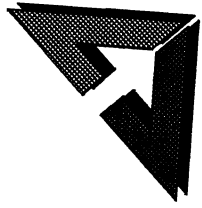




Cam Design with ADAMS/View

Cam Design Overview

- ▶ ***System Setup***
- ▶ ***ADAMS Analysis***
- ▶ ***Cam Generation***
- ▶ ***Cam Verification***



Cam Design with ADAMS/View

System Setup

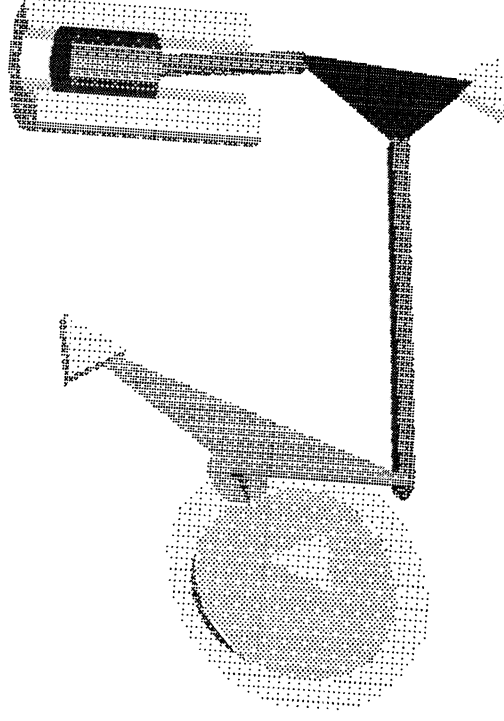
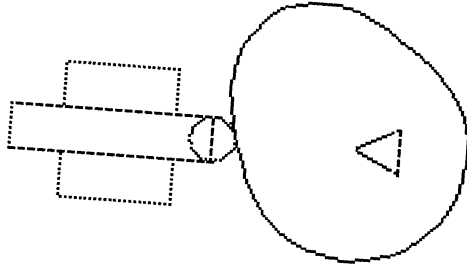
Kinematic Mechanism

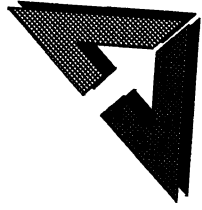


Simple



Complex

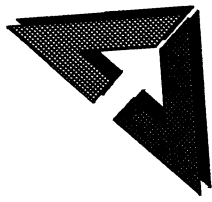




Cam Design with ADAMS/View

System Setup

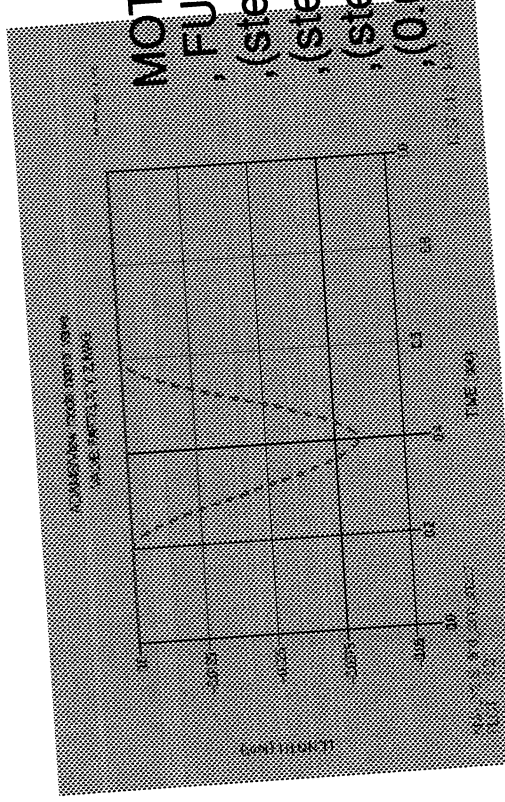
- End Effector Control
- MOTION definition
 - $x = f(TIME)$
 - ,DISPLACEMENT
 - ,VELOCITY
 - ,ACCELERATION



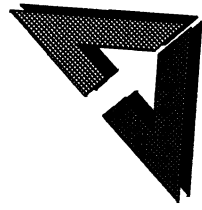
Cam Design with ADAMS/View

System Setup

- ▶ End Effector Control - *MOTION*
- ▶ Nested *FUNCTION* expressions



```
MOTION/1, TRANSLATIONAL, JOINT = 1
, FUNCTION = step(time,0,0,0.2,
, (step(time,0.2,(0.0/12),0.4,
, (step(time,0.4,(0.0/12+0.5/12),0.6,
, (step(time,0.6,(0.0/12+0.5/12+-0.5/12),1.0,
, (0.0/12+0.5/12+-0.5/12+0.0/12)))))))))
```



Cam Design with ADAMS/View

System Setup

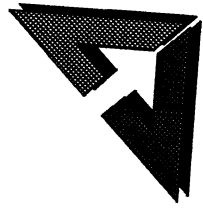
➤ End Effector Control - *MOTION*

➤ *FUNCTION* expressions

STEP(*TIME*, *x0*, *h0*, *x1*, *h1*)

POLY(*x*, *x0*, *a0*, *a1*, ..., *a30*)

SHF(*x*, *x0*, *a*, ω , ϕ , *b*)



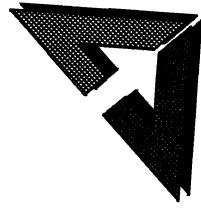
Cam Design with ADAMS/View

System Setup

▲ End Effector Control - MOTION

▲ Customized ADAMS/View Macro

```
constraint modify motion &  
motion_name=$motion_name &  
type=translation &  
function= &  
"step(time,0,0,$t1," , &  
"(step(time,$t1,($m1/12),$t2," , &  
"(step(time,$t2,($m1/12+$m2/12),$t3," , &  
"(step(time,$t3,($m1/12+$m2/12+$m3/12),$t4," , &  
"($m1/12+$m2/12+$m3/12+$m4/12))))))"
```

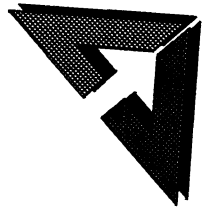


Cam Design with ADAMS/View

System Setup

- ▶ *End Effector Control - MOTION*
- ▶ *Customized ADAMS/View Macro
(aview/examples)*

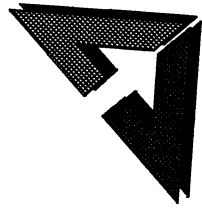
GLOBAL	UNIT/DEG	MODE/NAME	VELOCITY	UNIT
From TIME_0 to TIME_1=	0.2	move	0.0	inches
From TIME_1 to TIME_2=	0.4	move	0.5	inches
From TIME_2 to TIME_3=	0.6	move	-0.5	inches
From TIME_3 to TIME_4=	1.0	move	0.0	inches



Cam Design with ADAMS/View

System Setup for Analysis

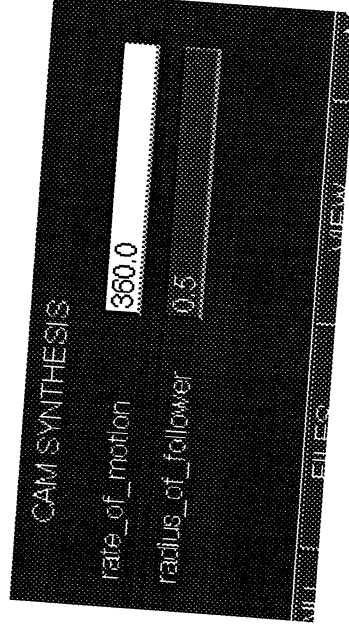
- ▶ **Cam Part**
- ▶ **REV JOINT + MOTION**
- ▶ **REQUEST Definition**
 - i =follower center**
 - j =cam center**
 - rm =cam center**

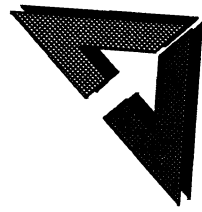


Cam Design with ADAMS/View

ADAMS Analysis

- ▶ Kinematic Analysis***
- ▶ ADAMS/View Macro
Automatic Submit
Results Read***





Cam Design with ADAMS/View

ADAMS Analysis

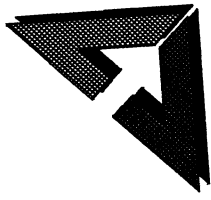
▲ ***ADAMS/View Design Studies***

▲ ***Design Variables:***

Link Lengths

Follower Radius

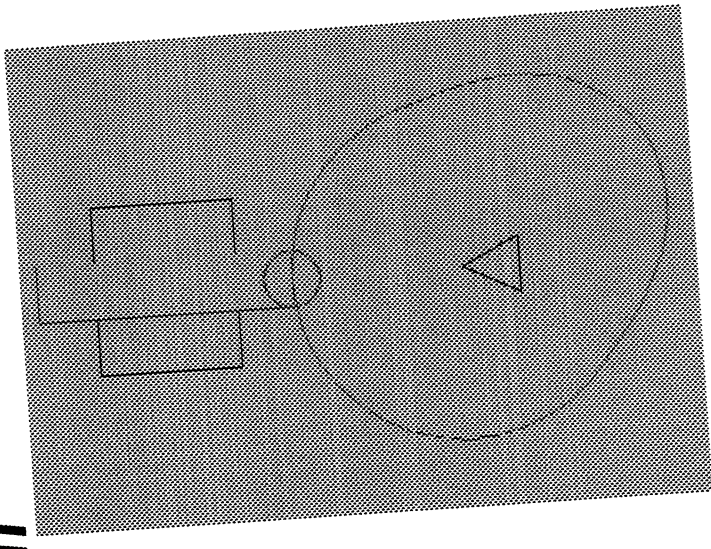
Cam Rotational Velocity

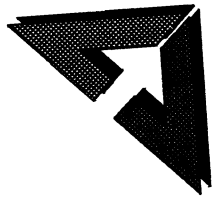


Cam Design with ADAMS/View

Cam Generation

- Cam Profile Computation
- Offset Pitch Curve by Follower Radius





Cam Design with ADAMS/View

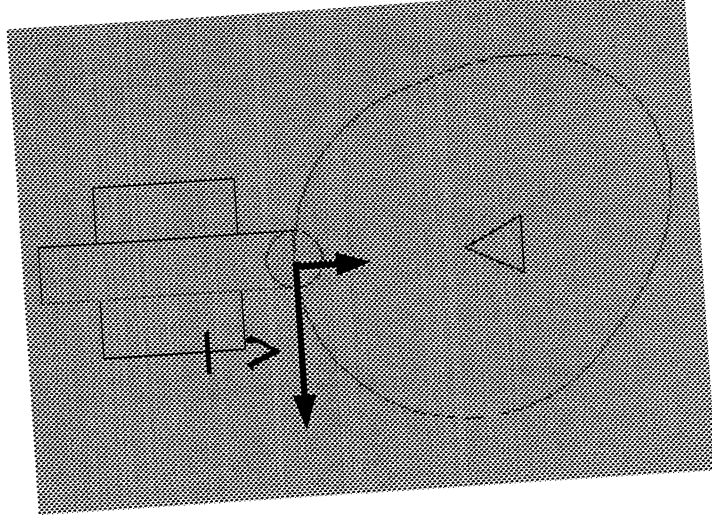
Cam Generation

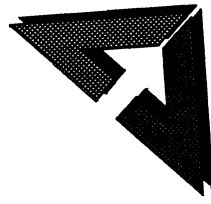
- Offset Pitch Curve by Follower Radius
- Numerical Results Processing

$$x(t) = x_0 + r\hat{x}$$

$$y(t) = y_0 + r\hat{y}$$

$$\hat{\hat{x}}, \hat{\hat{y}} = \frac{(\dot{y}(t), -\dot{x}(t))}{\sqrt{\dot{x}(t)^2 + \dot{y}(t)^2}}$$





Cam Design with ADAMS/View

Cam Generation

➤ Create Cam Graphics

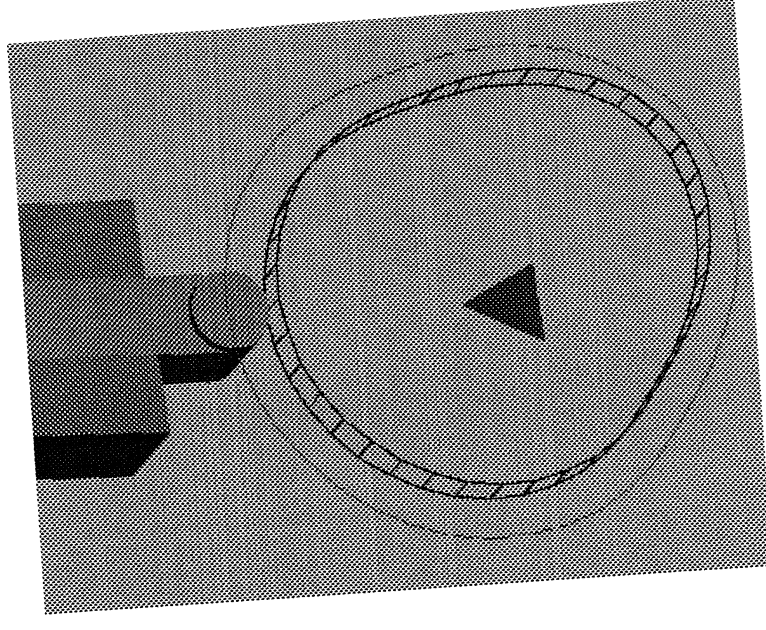
➤ Results Set

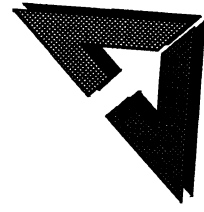
↳ MATRIX

↳ CURVE

↳ curve GFX

↳ extrusion





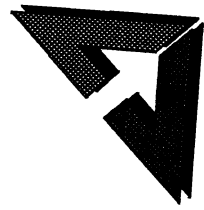
Cam Design with ADAMS/View

Cam Generation

▲ ADAMS/View Macro Automation

***Results Read
Numerical Processing
Graphics Creation***

***▲ Example: build_cam.mac
(Appendix A)***

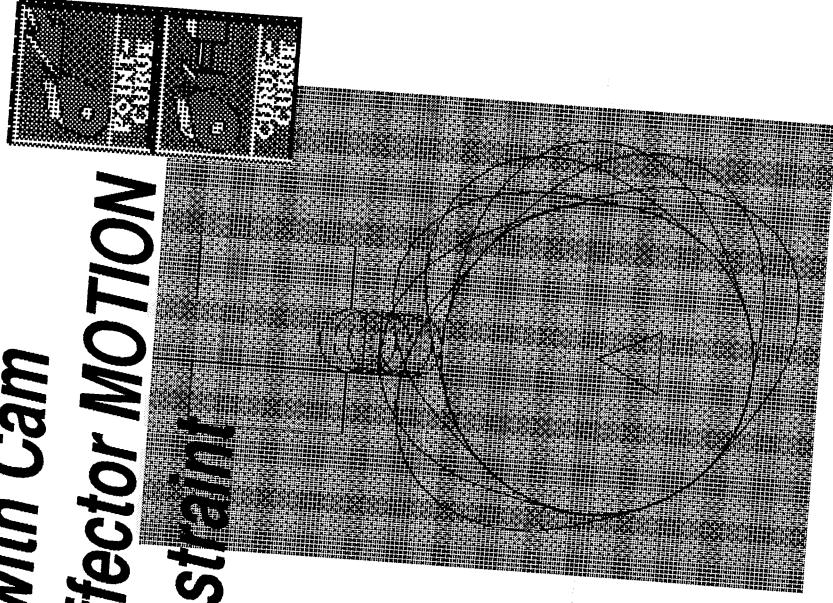


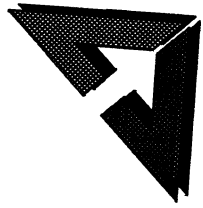
Cam Design with ADAMS/View

Cam Verification

- ▶ **Drive Simulation with Cam**
Remove end effector MOTION
Add CVCV Constraint

- ▶ **Compare Follower**
Displacement
Velocity
Acceleration

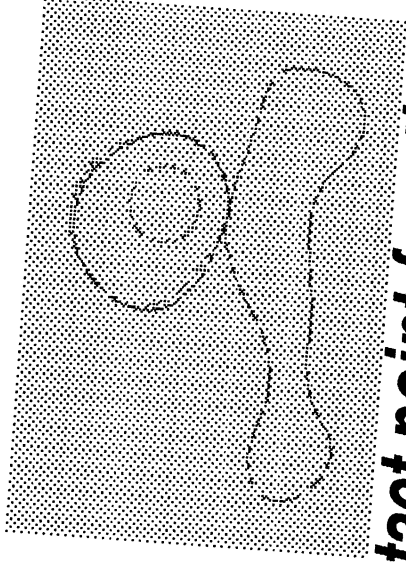




Cam Design with ADAMS/View

Special Case

▲ ***Non-Circular Follower***



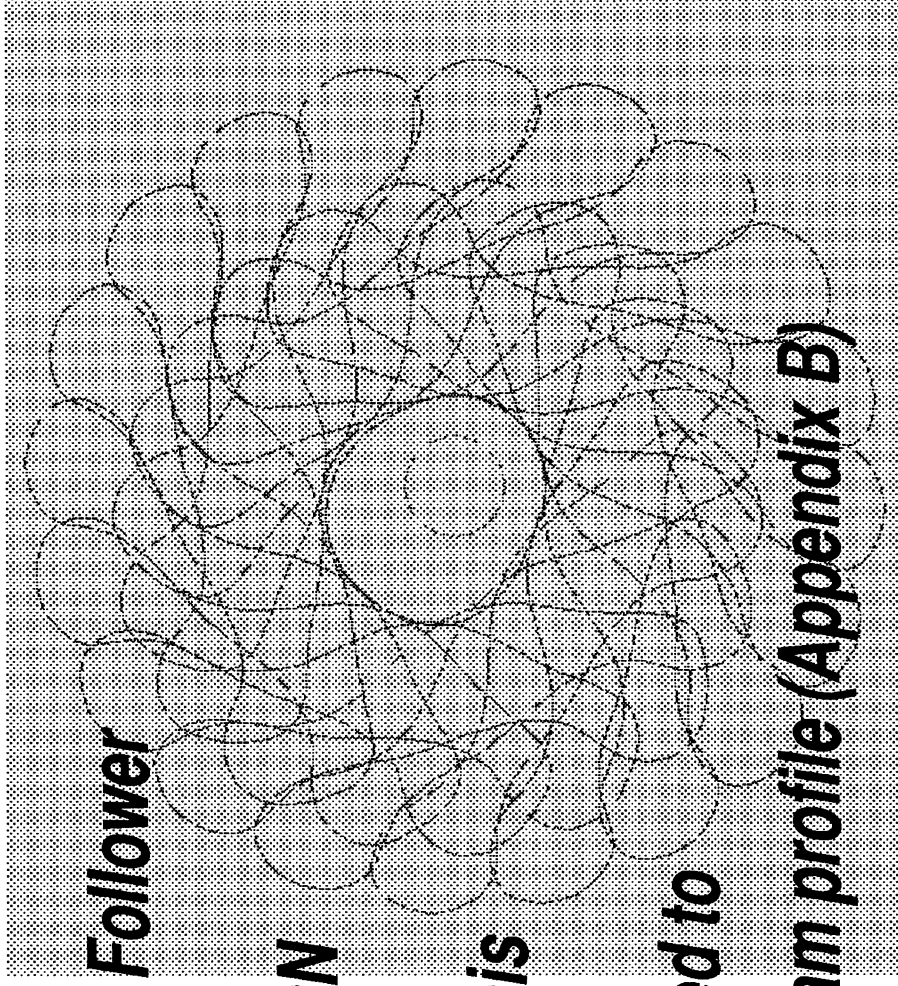
▲ ***Contact point function of
Curve Geometry
Relative Velocities***

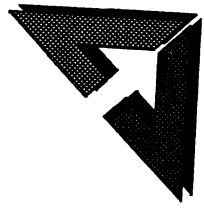


Cam Design with ADAMS/View

Special Case

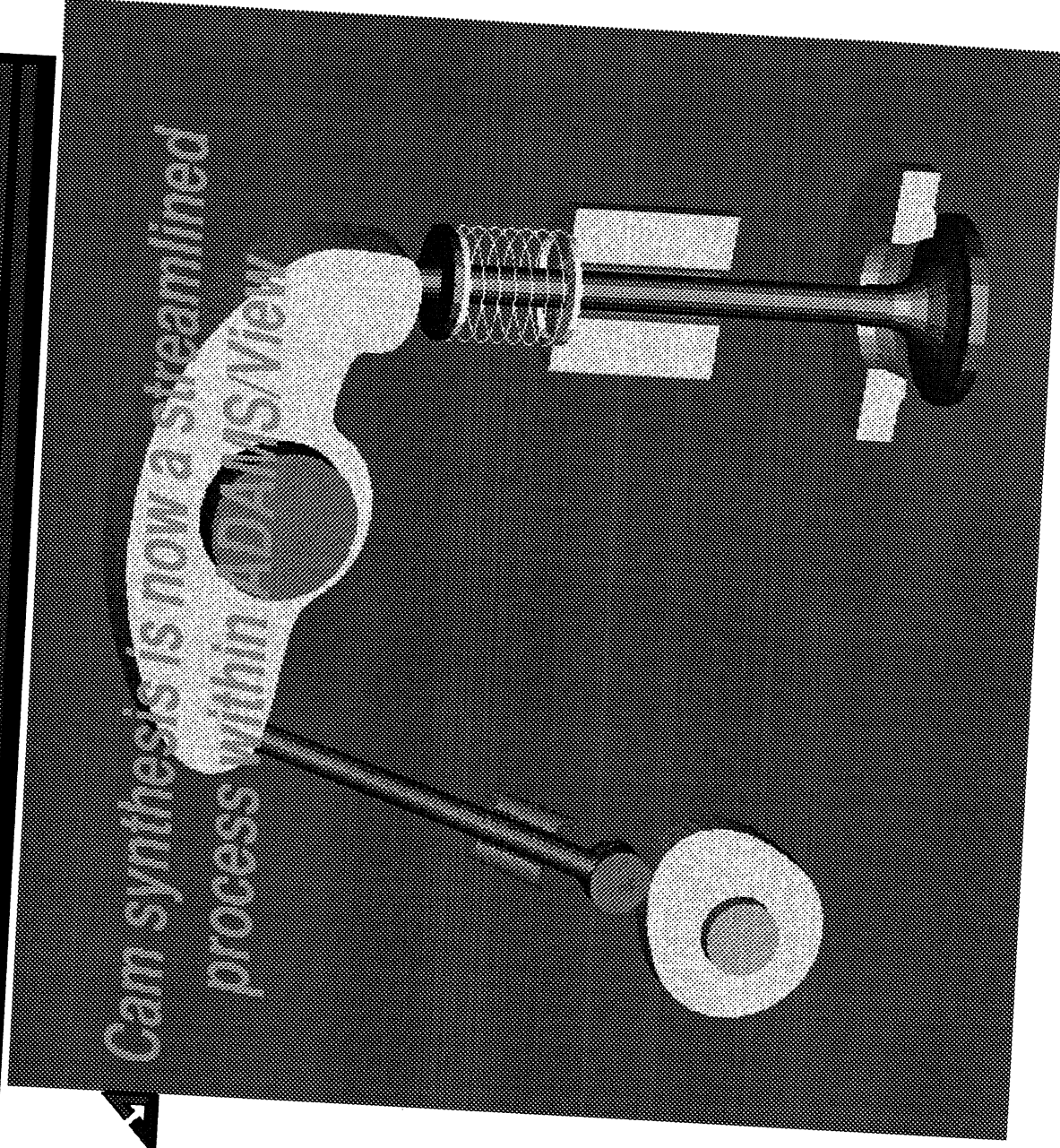
- ▲ *Non-Circular Follower*
- ▲ *Same MOTION*
- ▲ *Same Analysis*
- ▲ *REQSUB used to
compute cam profile (Appendix B)*

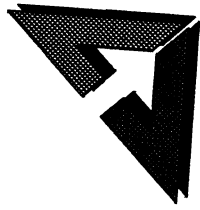




Cam Design with ADAMS/View

Summary





Cam Design with ADAMS/View

Acknowledgments

- ▲▲ Jon Thoreson, 3M***
- ▲▲ Dan Robertson, MDI***
- ▲▲ Bernd Ruschlau, MDI Germany***
- ▲▲ John Griffin, MDI***
- ▲▲ Andy Anderson, MDI***