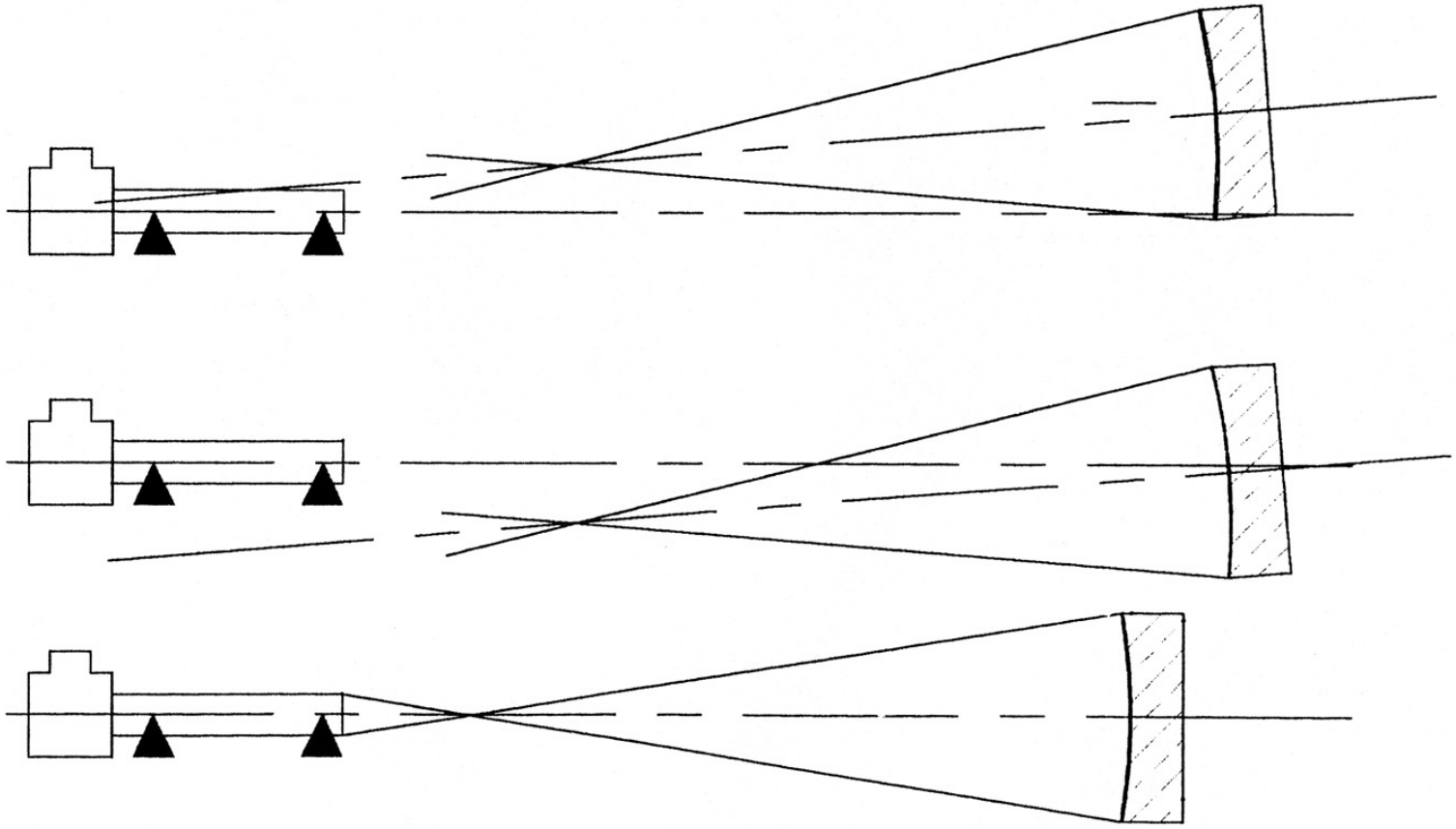
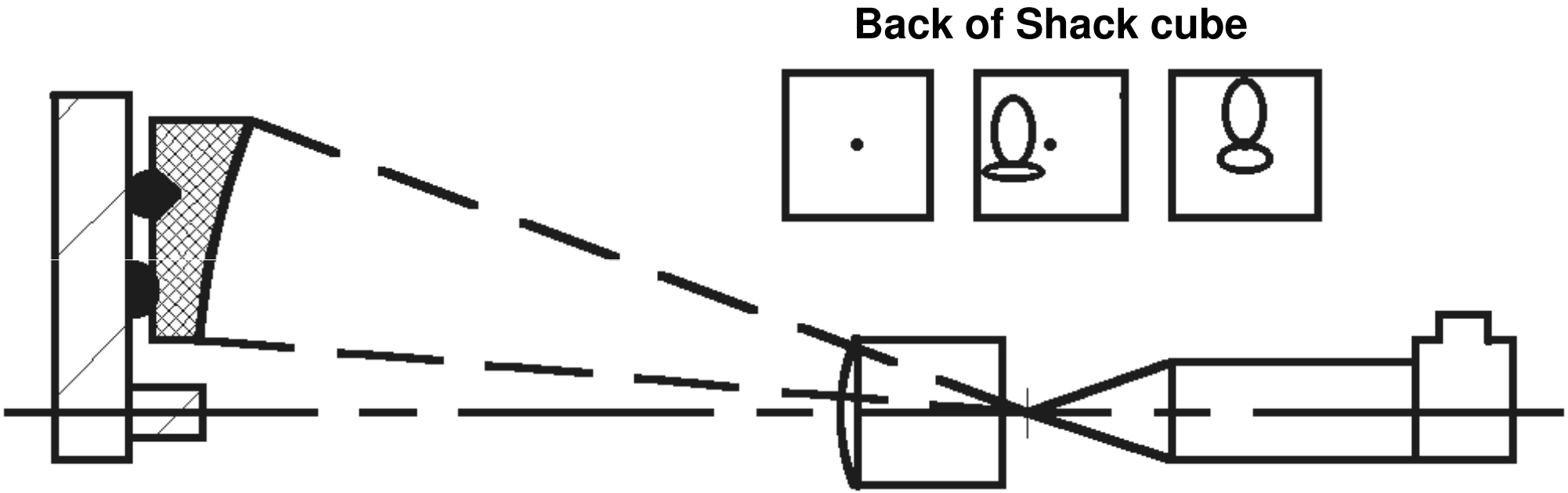
Alignment of a Single Surface

This procedure will be used (w/some variations) to align *any* off-axis aspheric surface to an established optical axis.



Procedure: Off-axis alignment



Summary of procedure

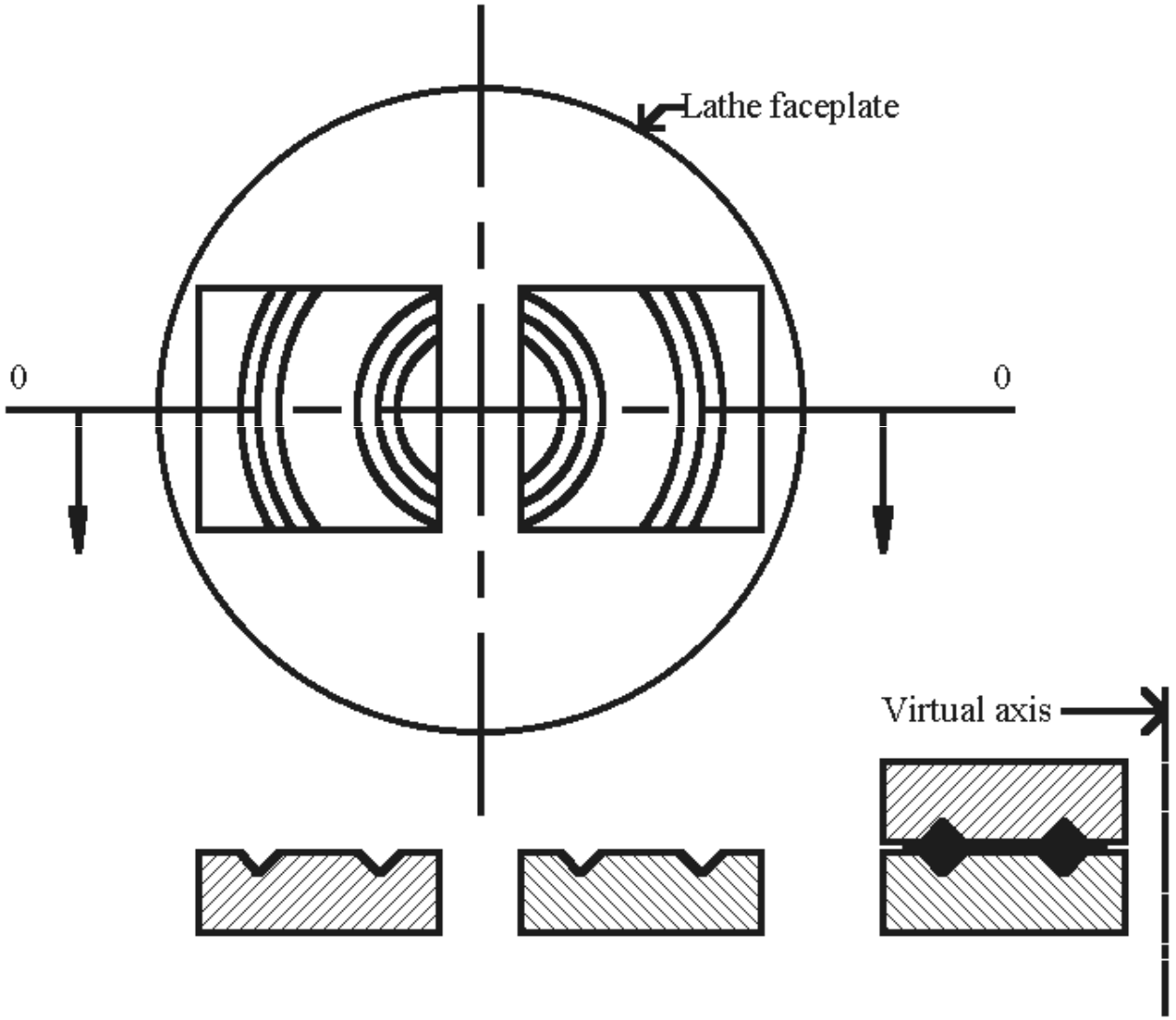
- Establish optical axis w/alignment telescope
- Assemble vertex jig/mirror – fixes rotation
- Focus AT on VG, remove X,Y decenter
- Place LACI cube near CC – anywhere w/in the axial caustic of the section
- Use AT to center reference spot/LACI cube
- Look for figure 8 image on back of cube
- Tilt/tip mirror until ‘8” is centered on spot

The Mirror Mount

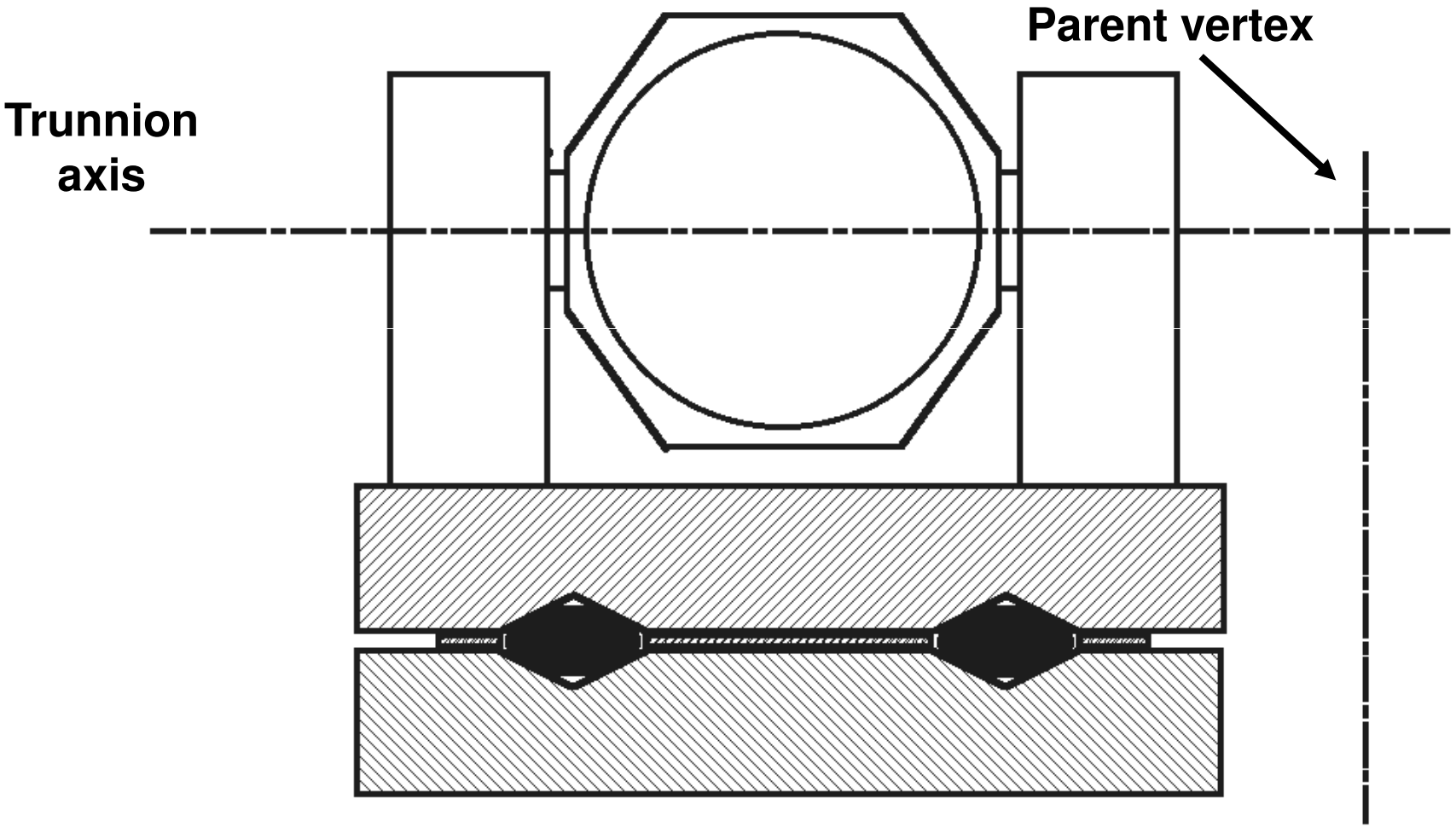
Thoughts on how to design something that works.

Note: To reduce the weight of flight hardware, this stuff could be designed to be removed before flight.

Making of an Off-axis mount



Essence of an off-axis mount



Actual Mirror Mount Implementation

Closing remarks

- What we discussed were straightforward solutions to a challenging problem
- There now, wasn't that easy?

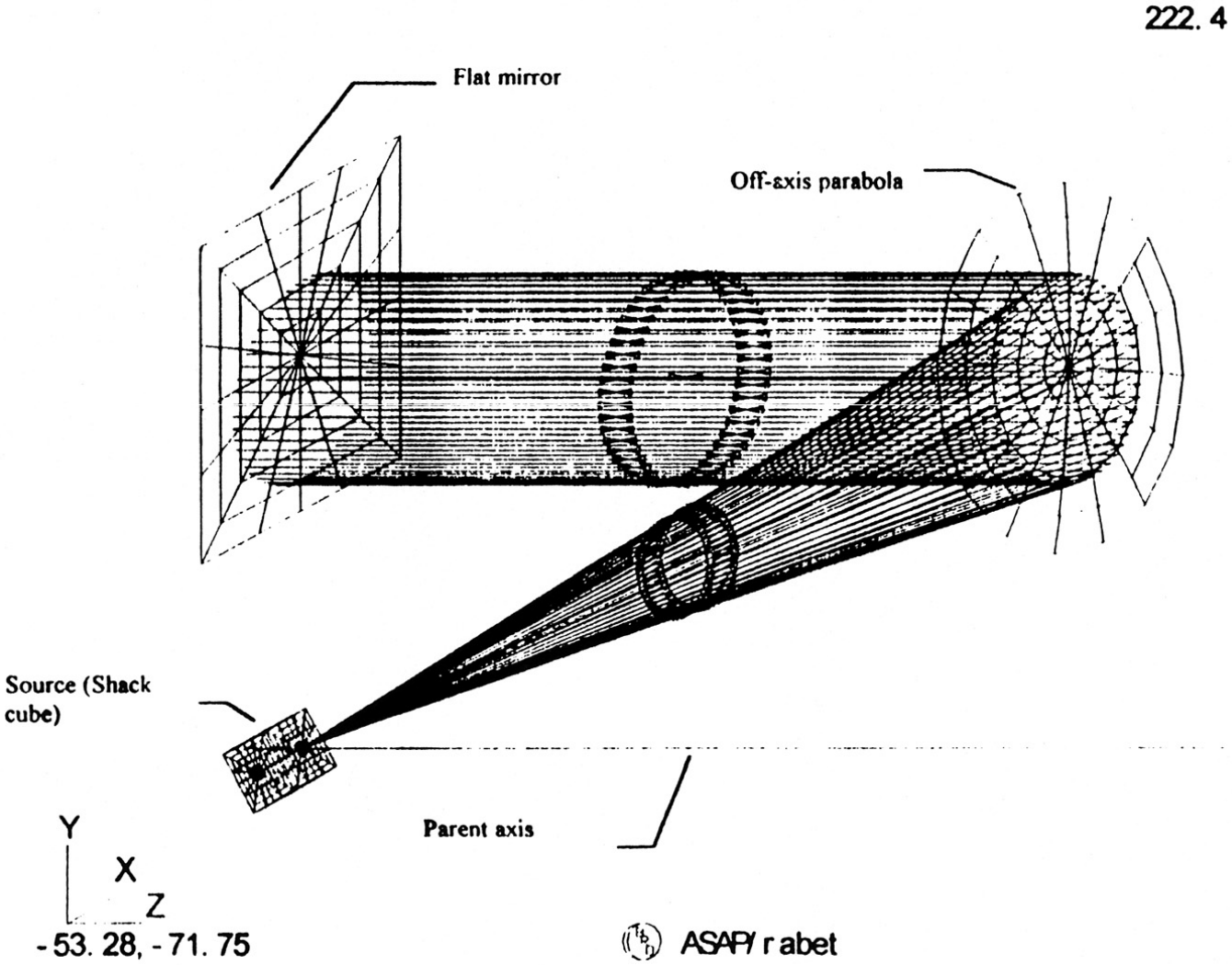
The Next Technique...

- A parabola, fabricated as a stand-alone optic, having its optical axis accessible
  - Very common situation
  - We will use logic, based on how the return image changes as the knobs are tweaked, to figure out what we're doing.
  - There are numerous starting points to this problem. We will choose one for this example.

Alignment of Off-axis Parabolas Using the Boresight/Coma Method

This was discussed earlier. Two knobs are adjusted simultaneously. As one keeps the image in place, the other alters the coma until the image is acceptable.

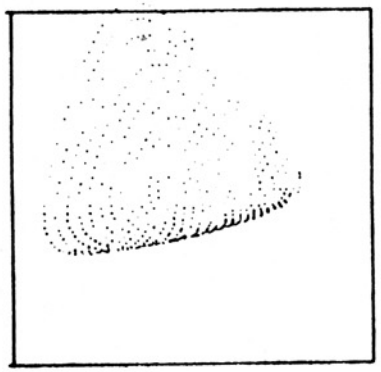
OAP Alignment with Single-pass Flat



Single-pass Test - Alignment Using Star Image

- Single pass alignment
  - Decenter OAP (x,y)
  - Tilt flat to superimpose return image
  - Observe return

Single-pass Test - Alignment Using Star Image



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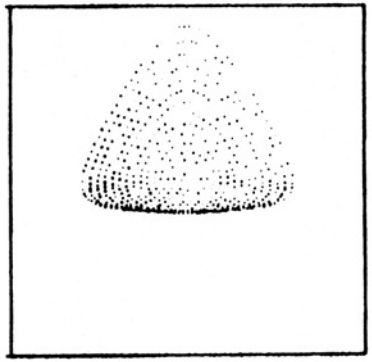

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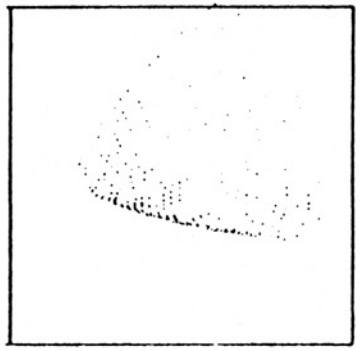

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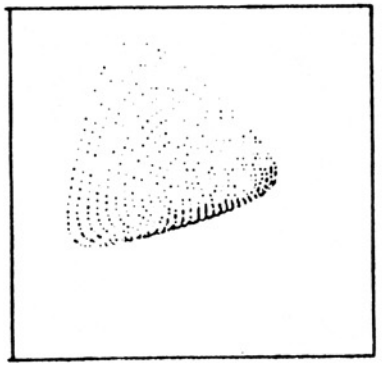

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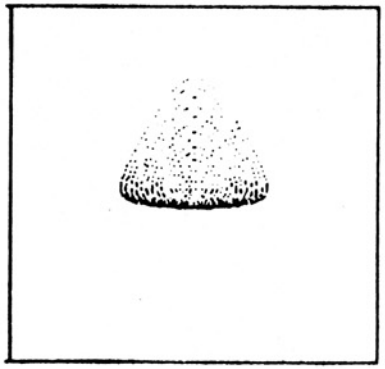

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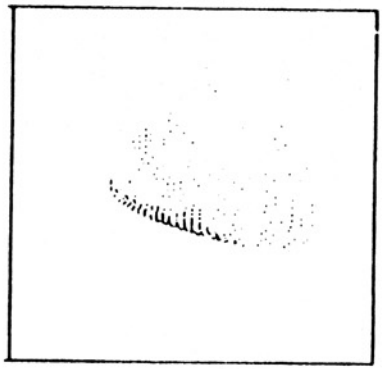
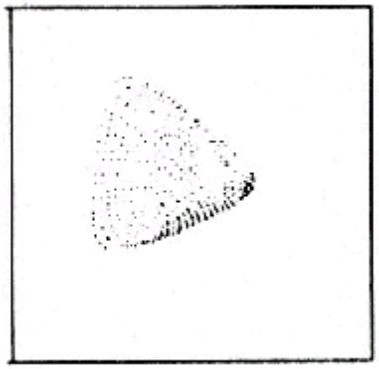


y = -0.3
x = +0.3

Single-pass Test - Alignment Using Star Image



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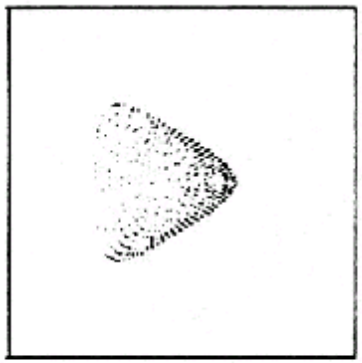

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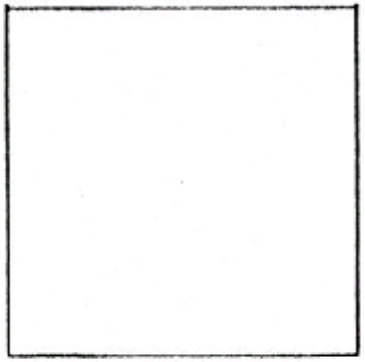

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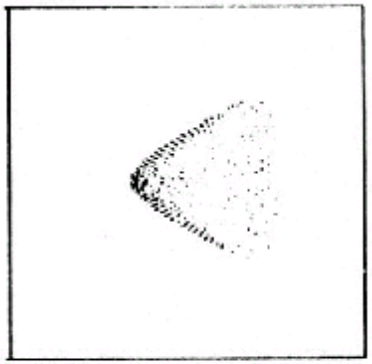
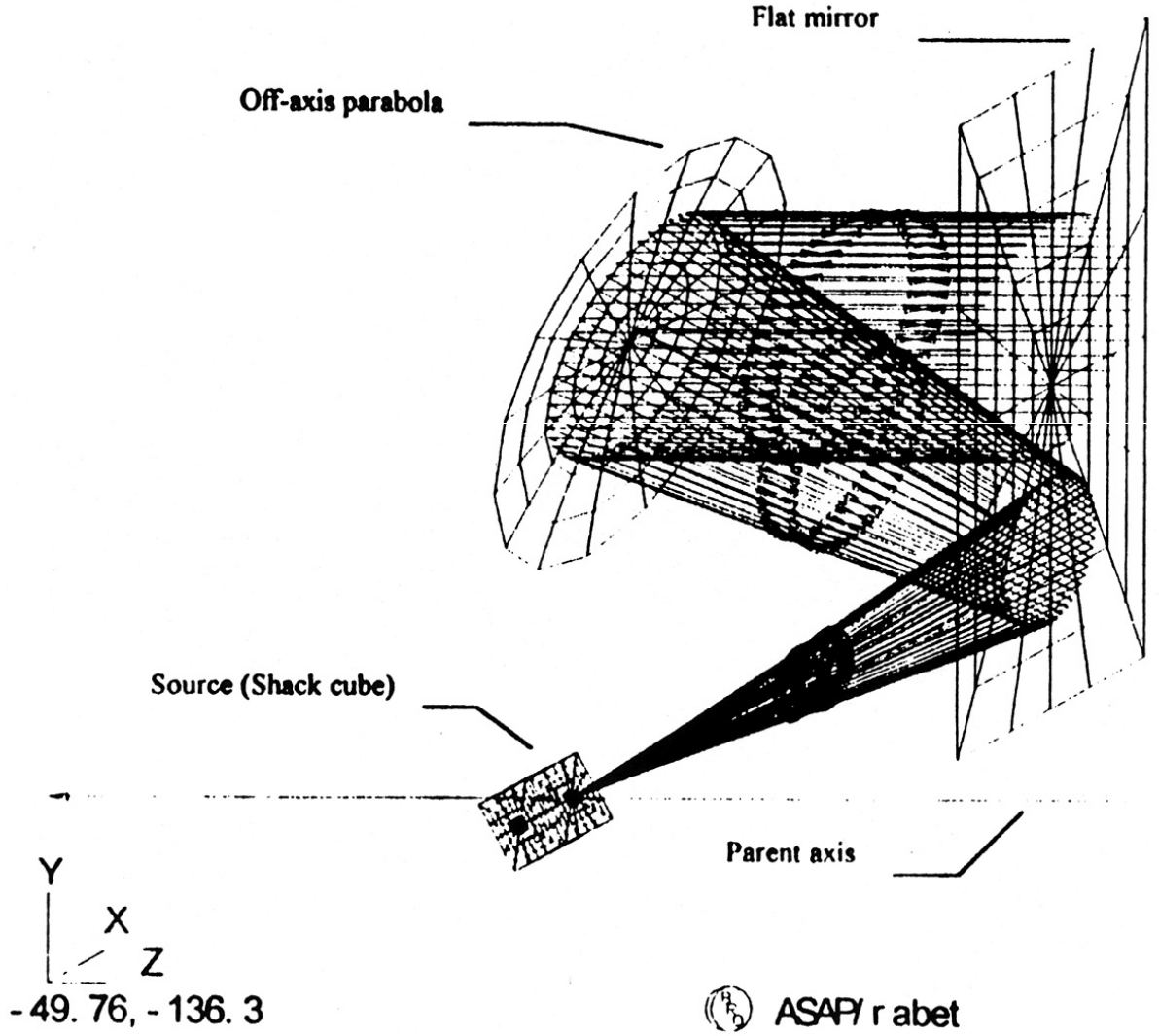
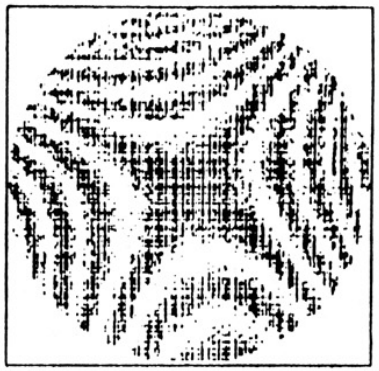


y = 0
x = +0.3

OAP Alignment
Using Triple=pass Flat and Source at Vertex



Triple-pass Test - Alignment Using Interferogram



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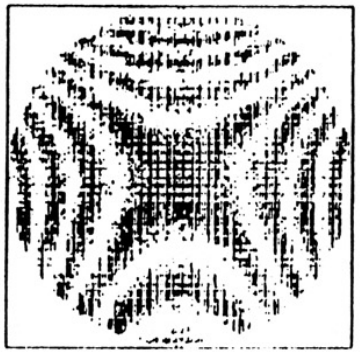

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y = 0.45
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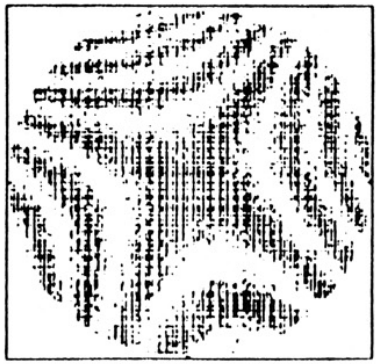

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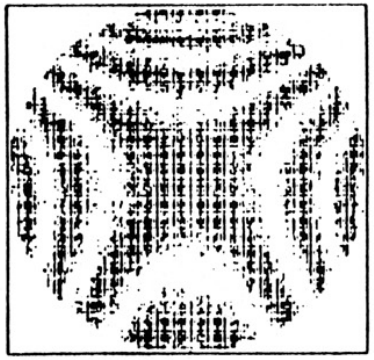

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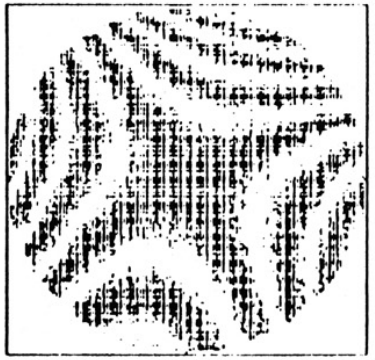
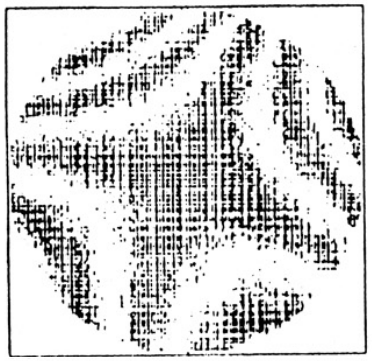


y = -0.3
x = 0.15

Triple-pass Test - Alignment Using Interferogram



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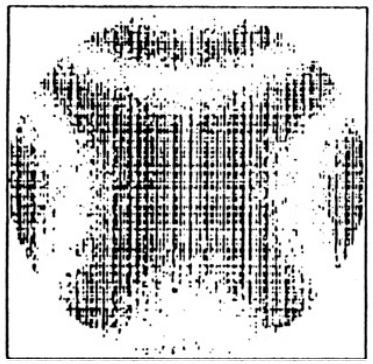

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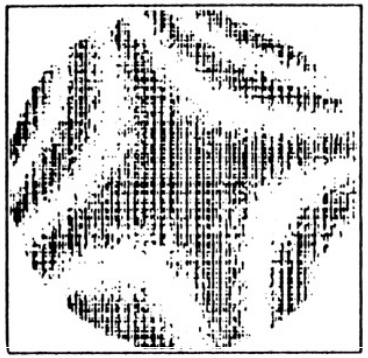

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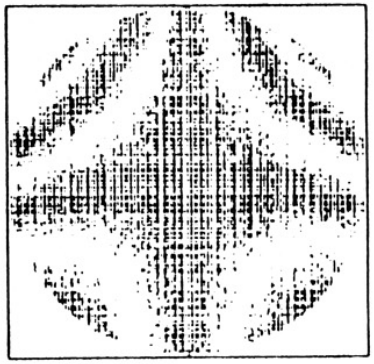

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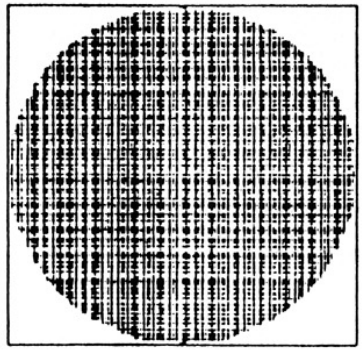

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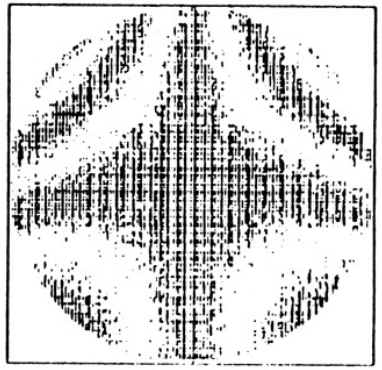
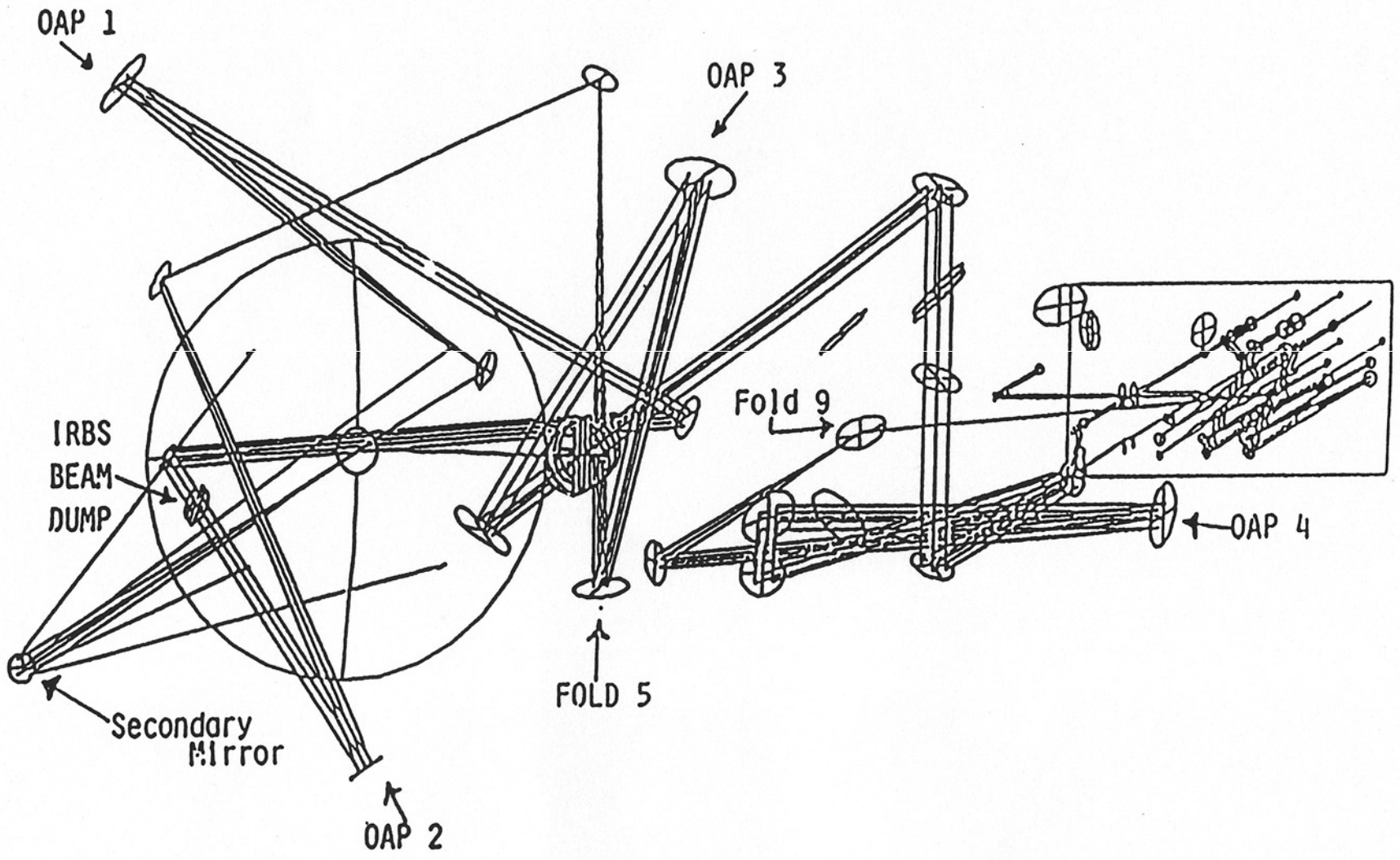


y = 0.0
x = +0.15

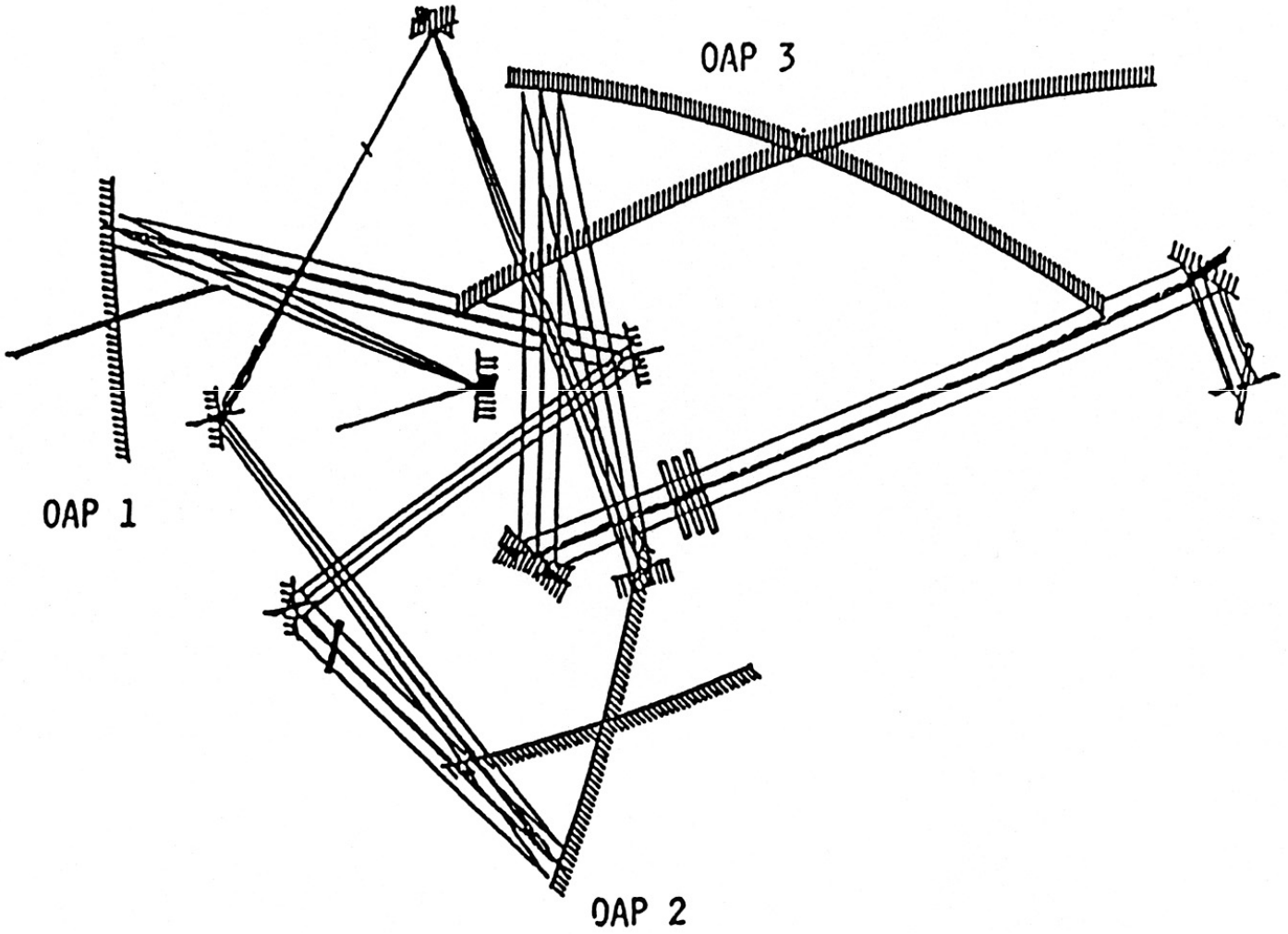
A parabola, fabricated as a stand-alone optic, not having its optical axis accessible

- This requires some effort but clearly with the right forethought it is still a straightforward task.

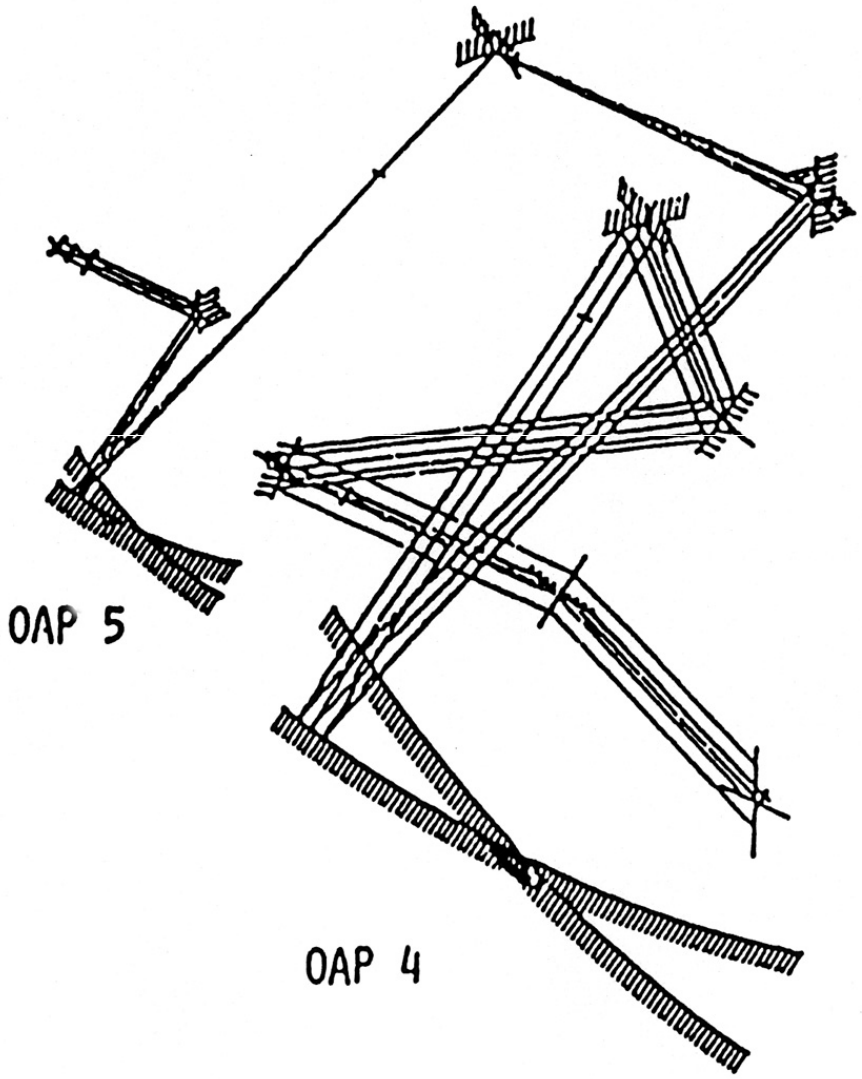
Modern Complex Optical System



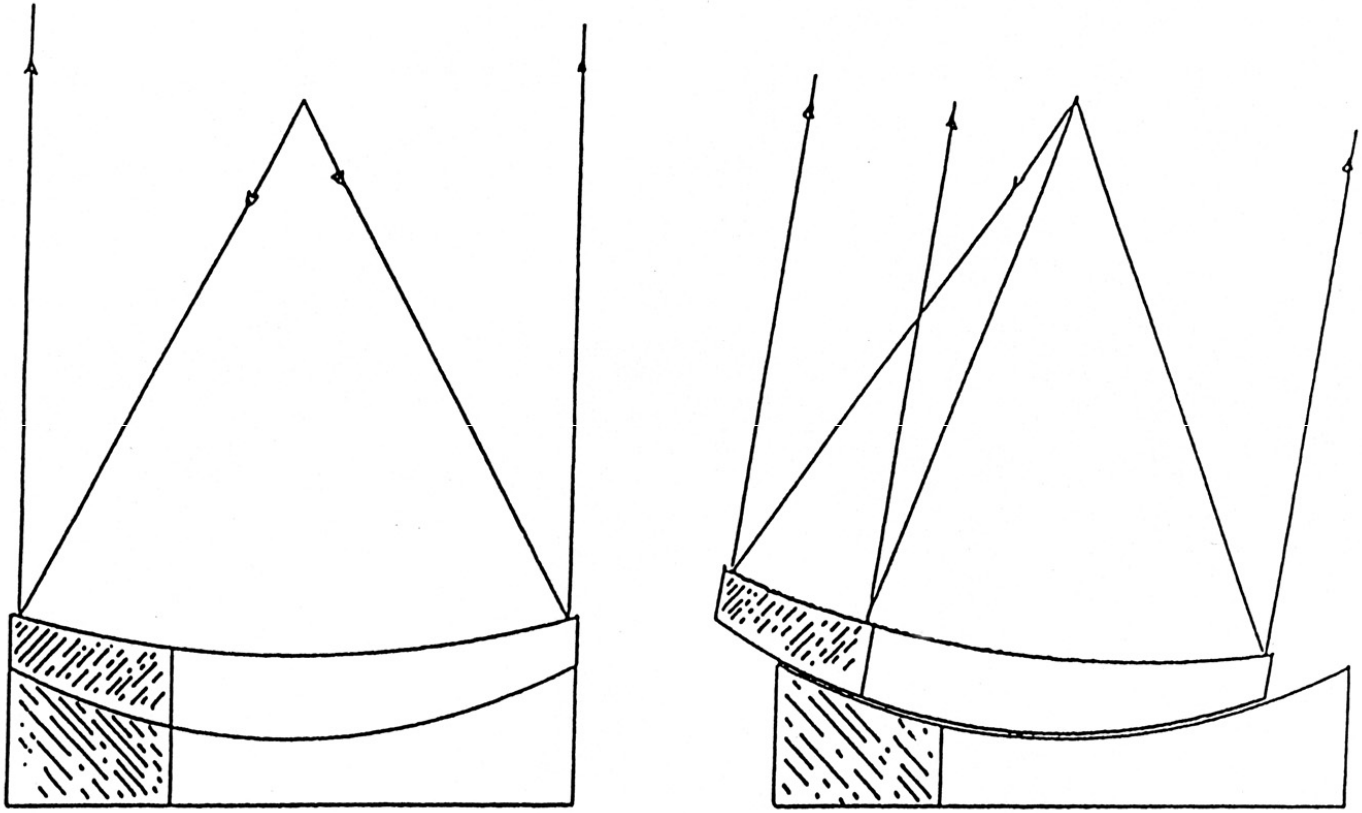
OAPM 1, 2, and 3



OAPM 4 and 5



Coincident Mount: Philosophy



With spherical mounting surface center of curvature coincident with OAP focus, motion, as shown, creates beam direction change with no aberration introduced

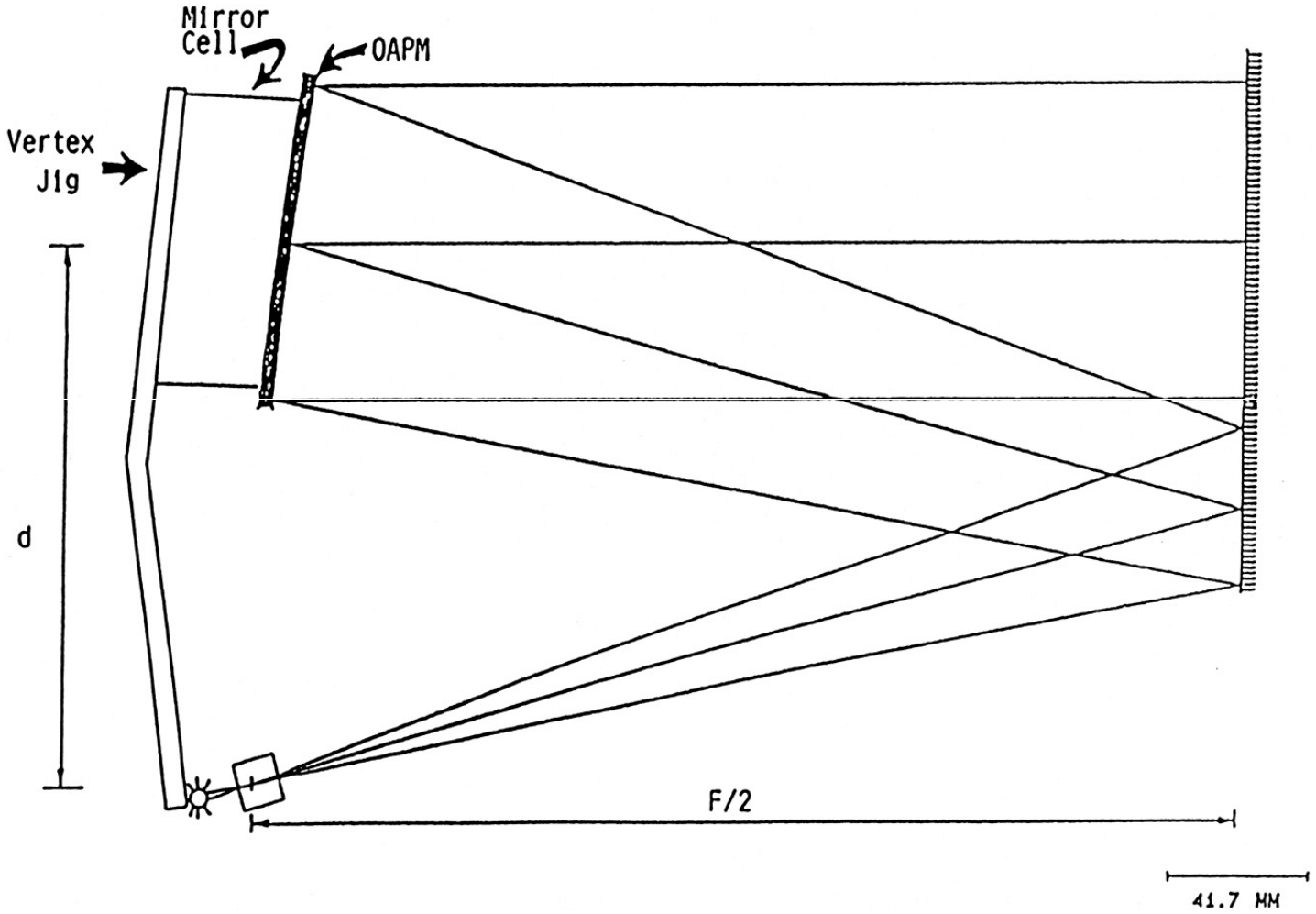
Coincident Mount: Discussion

- OAPs are sections of rotationally symmetric parabolas
- Alignment is usually accomplished with parent optical axis
- The coincident mount, by virtue of its "pre-alignment", eliminates the need to access the parent axis. Thus, alignment can proceed along the "gut ray"
- The mirror is correctly positioned in an aberration free position by moving the mount
- The mirror is correctly positioned in boresight by sliding the mirror along the concave surface

Alignment of a Single OAPM

1. Light source is placed at desired focal point location
2. Confocal mount is mounted on bench
3. Confocal mount is adjusted such that reflected light is focused back onto source
4. OAPM, with all attached, is mounted on confocal mount
5. OAPM is steered such that collimated beam points in the proper direction
6. Fold mirrors in collimated space are tipped/tilted to bring collimated beams into coincidence
7. Fold mirrors near focal points are translated to move OAP focal points to the desired locations

OAPM in Autocollimation Configuration



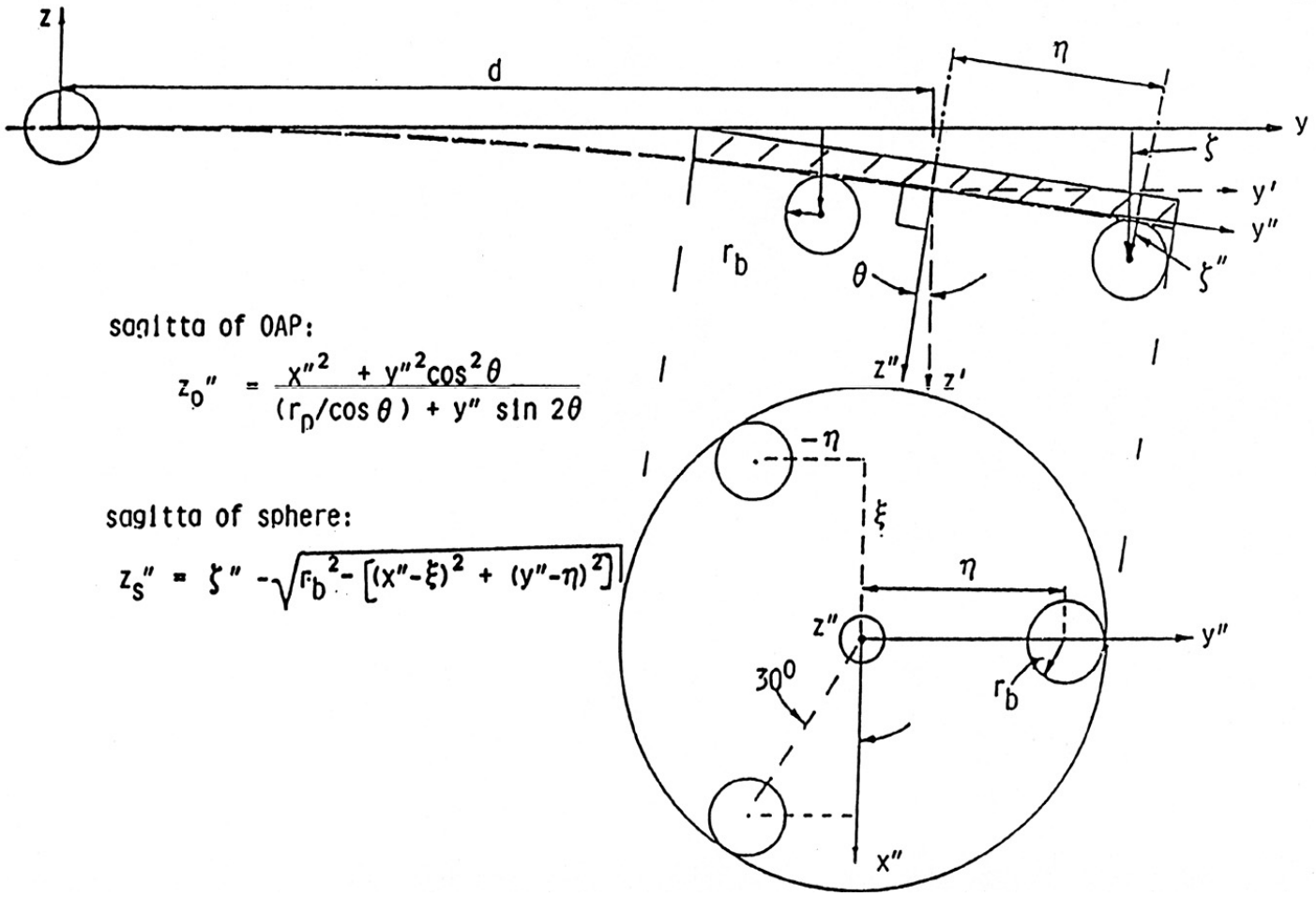
The Vertex Jig: Features

- Provides vital references for maintaining mirror parameters
  - (Decenter, rotation and focal length)
- Provides for a repeatable, easily alignable test set-up
- Used in pre-alignment process
- Acts as a temporary mirror mount
  - When used with the mirror cell, it also provides for a correctly supported mirror during testing

The Global Coordinate Tool: Features

- The Global Coordinate Tool acts as the reference for maintaining the correct orientation between the OAP surface and Vertex Jig
- 3 balls reference OAP surface
- 1 ball references Vertex
- All OAPs can be represented on one jig-bored plate

Global Coordinate Tool



sagitta of OAP:

$$z_o'' = \frac{x''^2 + y''^2 \cos^2\theta}{(r_p/\cos\theta) + y'' \sin 2\theta}$$

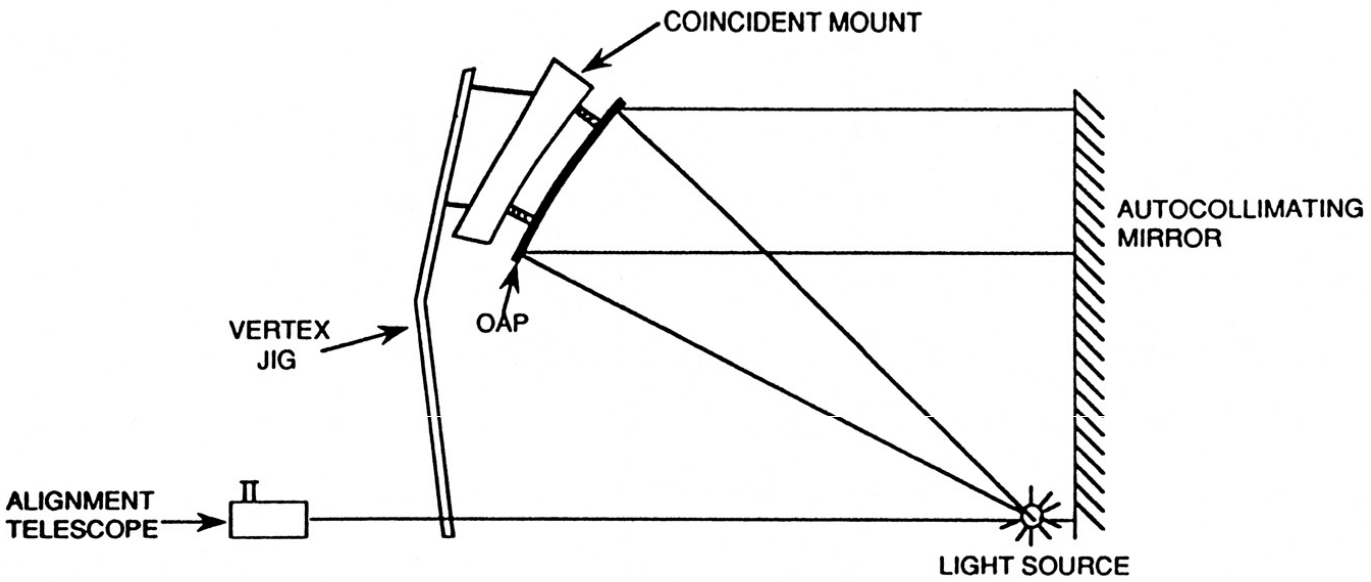
sagitta of sphere:

$$z_s'' = \zeta'' - \sqrt{r_b^2 - [(x''-\xi)^2 + (y''-\eta)^2]}$$

Concave Bearing Surface: Discussion

- Diamond-turning insures:
  - Reflecting optical surface for alignment purposes
  - Little or no polishing required
  - Relatively low cost
  - Excellent tolerances on radius of curvature (0.001%)
- INVAR cannot be diamond-turned
- Most probable candidate:
  - INVAR, electroless nickel plated and diamond turned. (Nickel is an excellent bearing surface)

Coincident Alignment Procedure for OAPs Made as Sections



1. Autocollimating mirror is made perpendicular to the AT
2. Light source is placed on AT axis
3. Coincident mount with vertex jig is mounted. AT axis should pass through parent axis on vertex jig
4. Coincident mount is adjusted so that reflected light is focused onto source
5. OAP is mounted
6. OAP is adjusted so that light reflected off autocollimating mirror is focused onto source
7. Interferometer may be used for fine adjustments

6.0 References

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