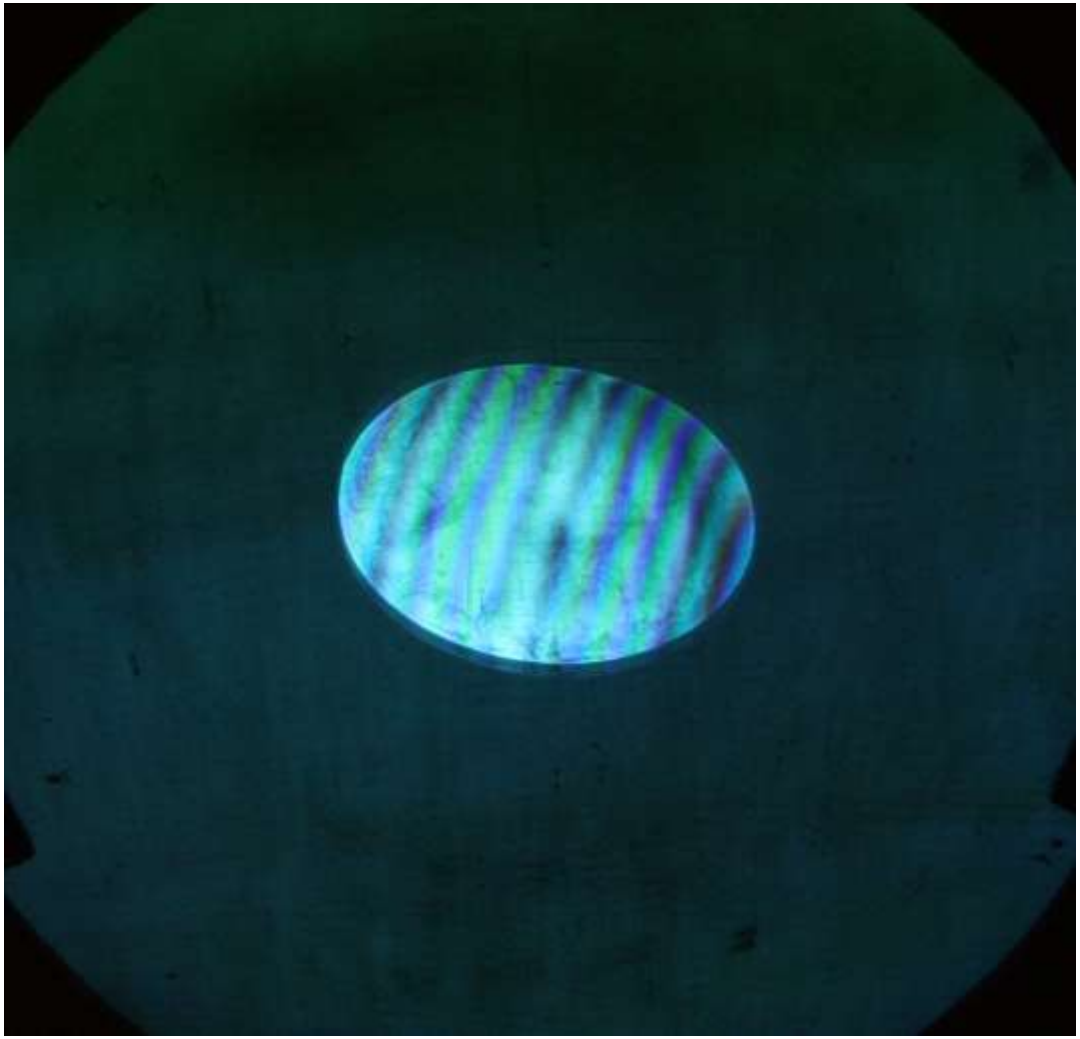
# The Raleigh Water test



# Optical Tests for flats

- Testing against a spherical mirror
- 3 mirror test
- Contact interference testing against master flat
- Raleigh water test

# Testing against a spherical mirror

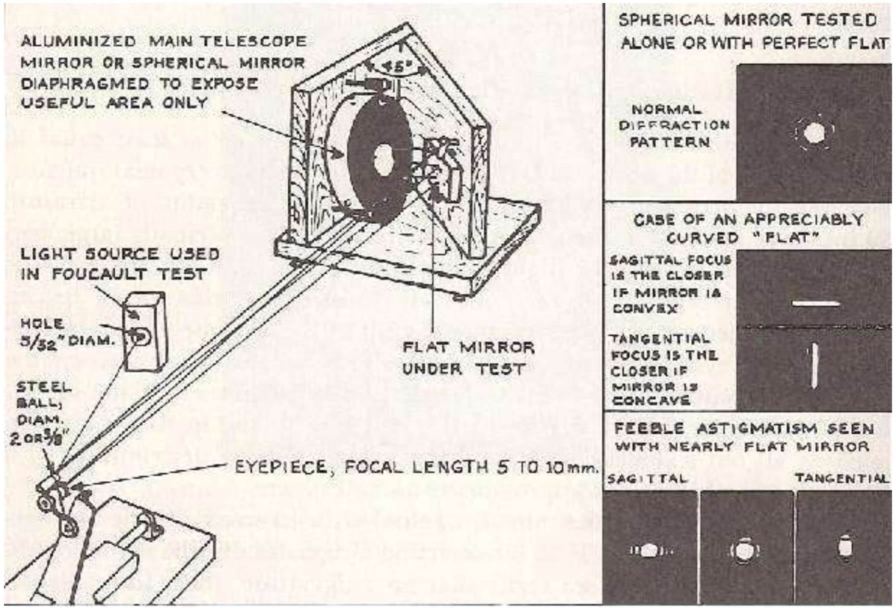
• Described in Texereau’s book

• Uses a spherical mirror in the layout below.  Measures the astigmatism in the sagittal and tangential plane.

• Good for testing spherical power but not great for localized areas

• Needs a good spherical mirror.

• Could be fooled by a toroid.



# 3 Flat Method

- You must make 3 flats but doesn't require a master flat.
- You test A&B, B&C and A&C by the contact method
- Flatness is determined by solving 3 simultaneous equations

A on B

+

B on C

-

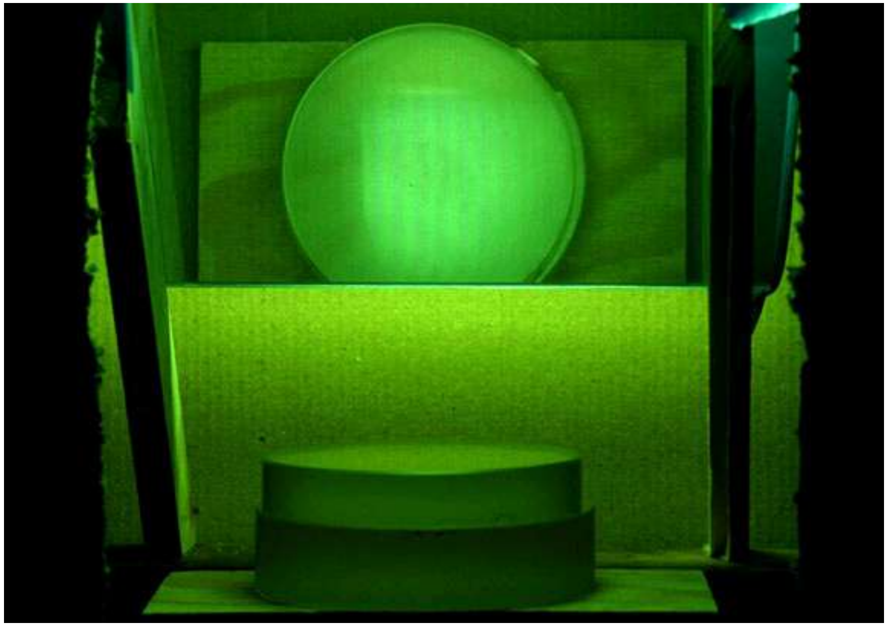
C on A

-

# Contact interference testing

- Most convenient test but requires a master flat
- Need to be careful to view fringes correctly (not too close)
- Low contract on aluminized mirrors
- Can scratch your part if you aren’t careful
- Master flats are expensive to buy

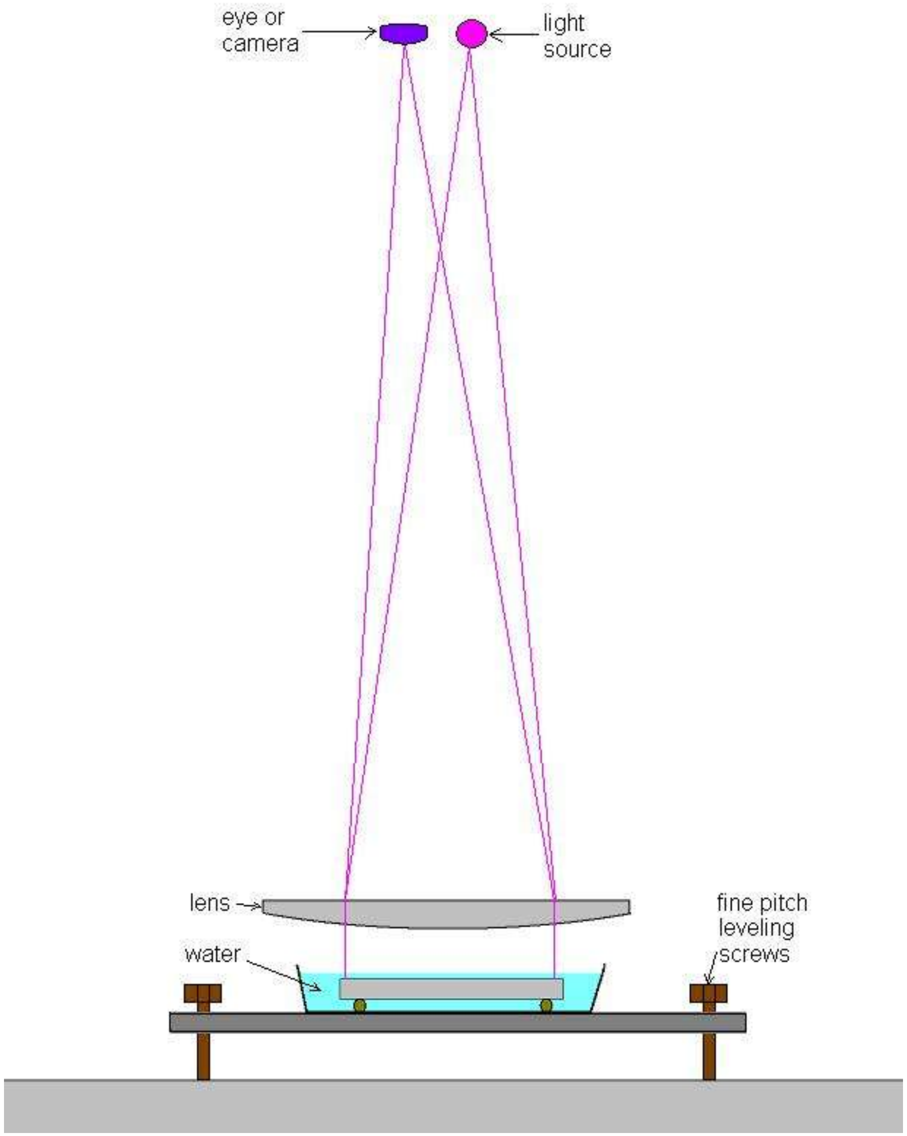
Typical light box
for contact testing



# Raleigh Water Test

- An old test but workable
- Uses the earth's surface as a reference
- Flat to 1/100 wave on a 20 inch flat
- More sensitive than contact testing (33%)
- **Requires** a collimating lens
- Contrast is low (5.6 to1) but useable
- Affected by vibrations (somewhat)
- A bit tricky to learn to do

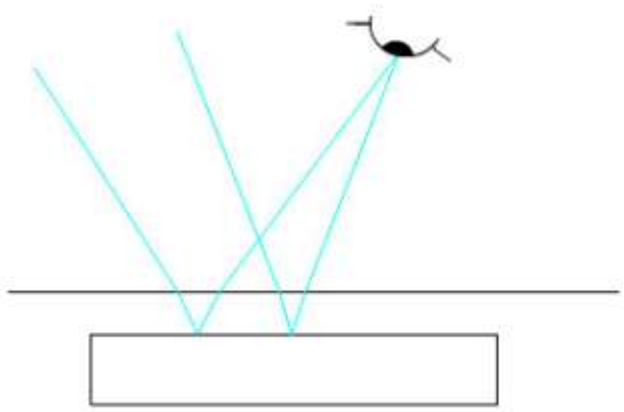
# Raleigh Water Test



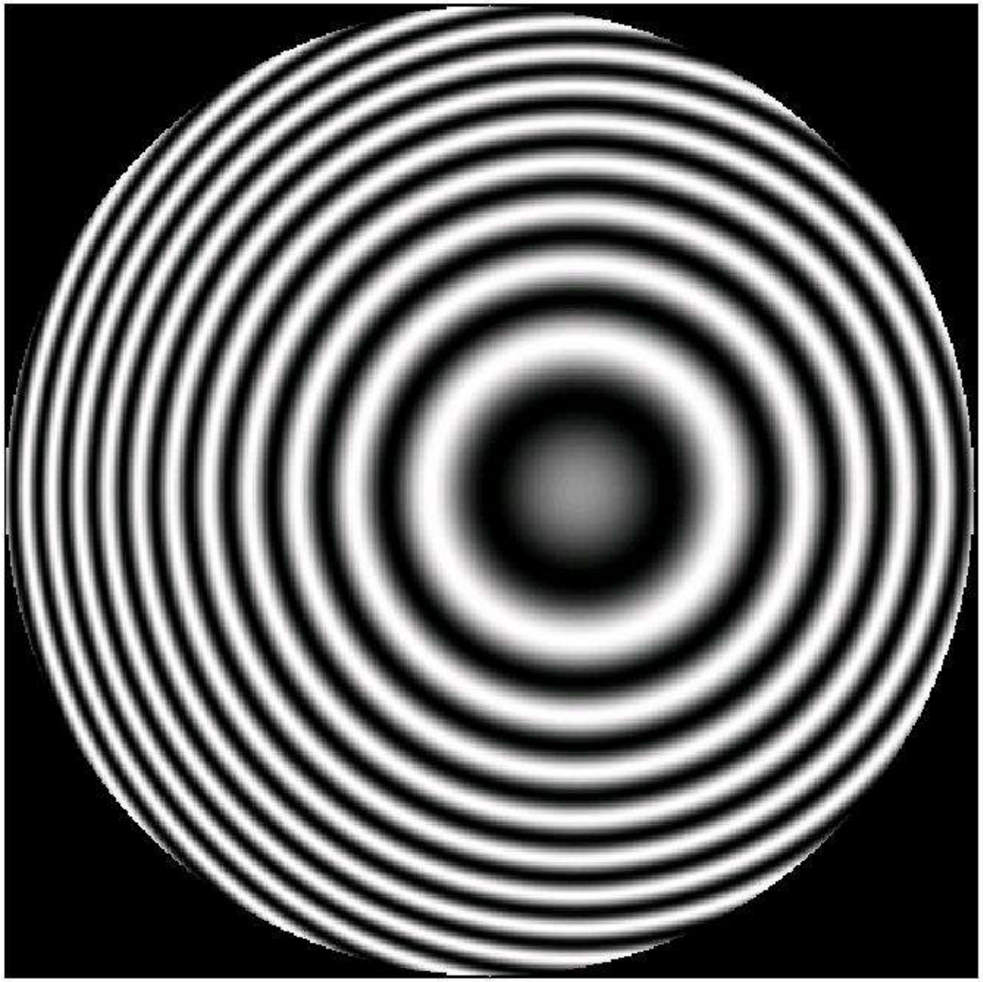
# Why do you need a collimator?

When you do contact testing the optical path length (distance between the master and part) is only a dozen wavelengths of light perhaps.

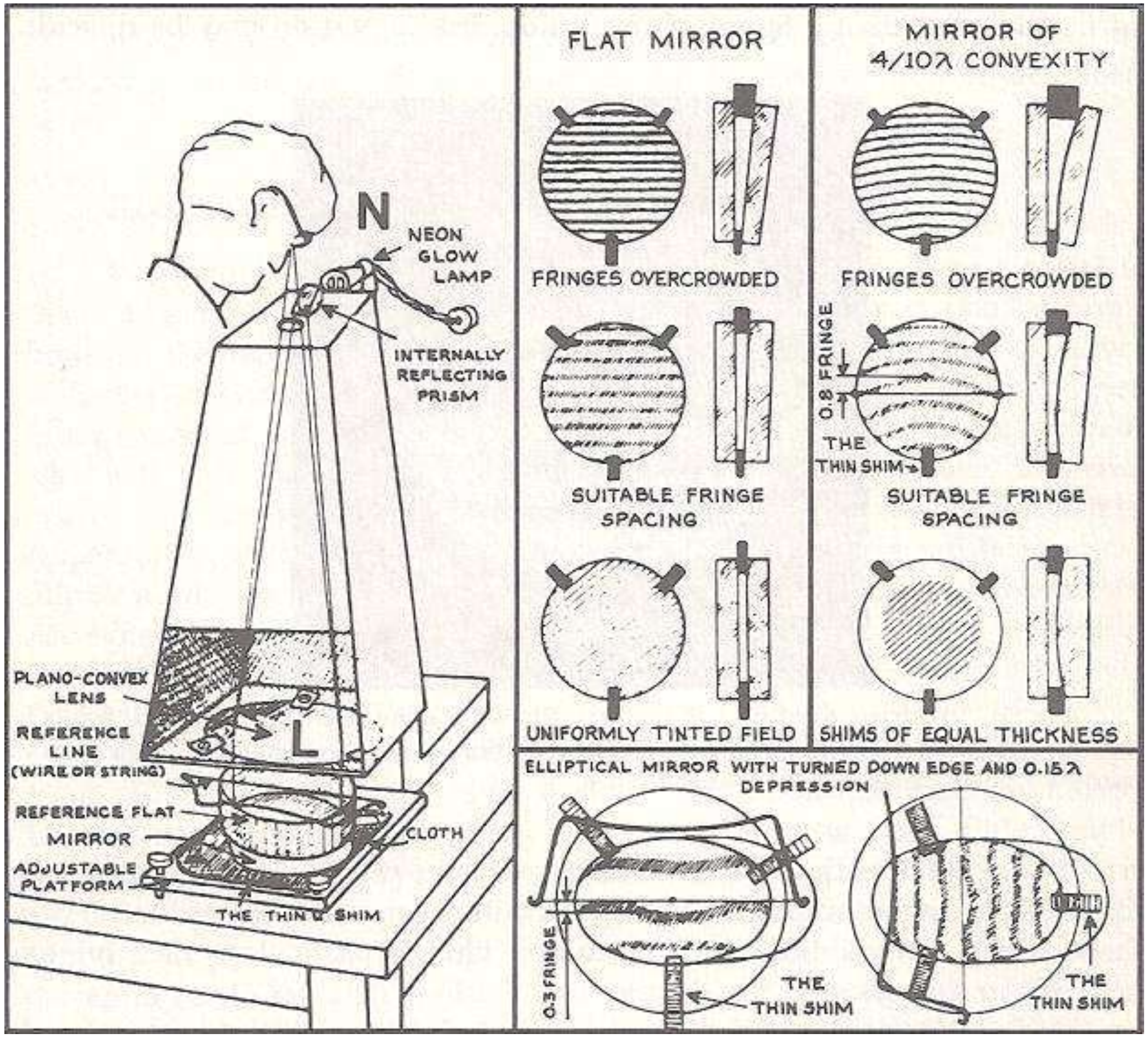
However in the water test with 1 millimeter of water over the flat the number of wavelengths in the optical path is 4587. Without a collimator when you look at different areas of the flat the light travels through different angles and different path lengths. This *cosine error* causes you to see fringe rings that would make you believe that your flat wasn't flat. Also the closer you get the more rings you will see. This problem occurs in contact testing but is many orders of magnitude smaller.



8 inch flat viewed at 48 inches away



Even if you have a master flat if you use shims to avoid scratching you'll need a collimator



# Are vibrations a serious problem? - Not really

- If the water thickness is fairly thick the water vibrations are not dampened and are a problem. (bounce freely around pan)
- When you decrease the water thickness above the test part the vibrations (waves) are retarded at shorter and shorter wavelengths, (like ocean waves entering shallow water).
- As the water layer gets thinner the time required to reach equilibrium increases. It can run into many minutes depending on size of part!
- There is an optimum thickness however where the vibrations are inhibited and the equilibration time is not terribly long (~15 seconds).
- This is a water thickness of about 1 mm.

# Is contrast a problem? - Only for aluminized parts

- Reflectivity of water = 2% $(1.333-1)^2/(1.333+1)^2$
- Reflectivity of glass in water is .35% $(1.5-1.333)^2/(1.5+1.333)^2$
- Contrast is reduced but easily seen (5.6 to 1)
- However aluminum in water is very difficult to see ( (43 to1)

Solution:

- You can add a dye to the water or cerium oxide to reduce the reflection off the aluminum and increase the contrast of the fringes. A diluted cerium oxide mixture sprayed with a spray bottle works best. Reapply if you need more attenuation.

# What you will need

Monochromatic light source such as:

a. clear mercury lamp with green filter

b. F412P blacklight bulb with green filter

c. low pressure sodium lamp

d. energy saver lamp

e. neon lamp

Pan to hold the mirror covered with water preferably black, 1 to 2 inches larger than your mirror

Leveling board with fine adjustment levelers

Collimating lens as large as your part, not too fast, and a mount not resting on leveling board.  Some Fresnels works fine

Laser pointer

Weak mixture of cerium oxide for reflective parts

Syringe or some way to remove water from the pan

Good environment: concrete floor, no breeze, no foot traffic

1 mm ball bearing or water thickness tester

# Procedure

1 Place part in leveling pan and cover with room-temperature water. Pan must be 1 inch larger than part and black. If not black use a piece of black plastic garbage bag under the part. Avoid bubbles.

2 Use a laser pointer to bounce off the part under water Bring both reflections close together using leveling screws. Hold the laser pointer as close to vertical as possible.

3 Remove excess water with a turkey baster, syringe or anything to leave about 1 mm of water above the part. A water thickness tester is handy. Lacking that a 1 mm wide glass ball or ball bearing might help.

4 If the part is not aluminized then bring both reflections accurately together into one spot. [If the part is aluminized then you will see a dim reflection off the water and a bright reflection from the aluminum. Pour a dye solution (food coloring) or better yet a weak mixture of cerium oxide evenly over the mirror. Try to dim the bright reflection off the aluminum to be as bright as the water reflection. Now bring both reflections together.]

*5 Without the collimating lens in place look for the fringes using monochromatic light. They will probably be closely spaced. If necessary try using a magnifying glass to look at the surface of the part but always try to look normal (vertical) to the surface. If you absolutely don't see fringes go back and re-check that your laser dots are overlapped accurately.

6 Adjust the leveling screw that is most perpendicular to the fringes a fraction of a turn. If the fringes get even closer then you went the wrong direction. The goal is to open up the fringes to get them as widely spaced as possible. They will look like a bulls-eye when fully opened. The leveling screws should be very fine pitch (80tpi).

7 Place the collimating lens in place and move the light source to the lens focus and view from there. (A long focal length lens is preferable)

8 The fringes will look a lot different but continue by adjusting the adjusting screw most perpendicular to the fringes until you have only 5 or 6 fringes left.

Interpretation: Is it convex or concave? - Turn the screw closest you clockwise (when it is perpendicular to the fringes). If the fringes get more open then continue. If you turn the screw clockwise and the fringes become closer then they represent a cross-section of the part measured in fringes. Remember that 1 fringe =3/8 wave.