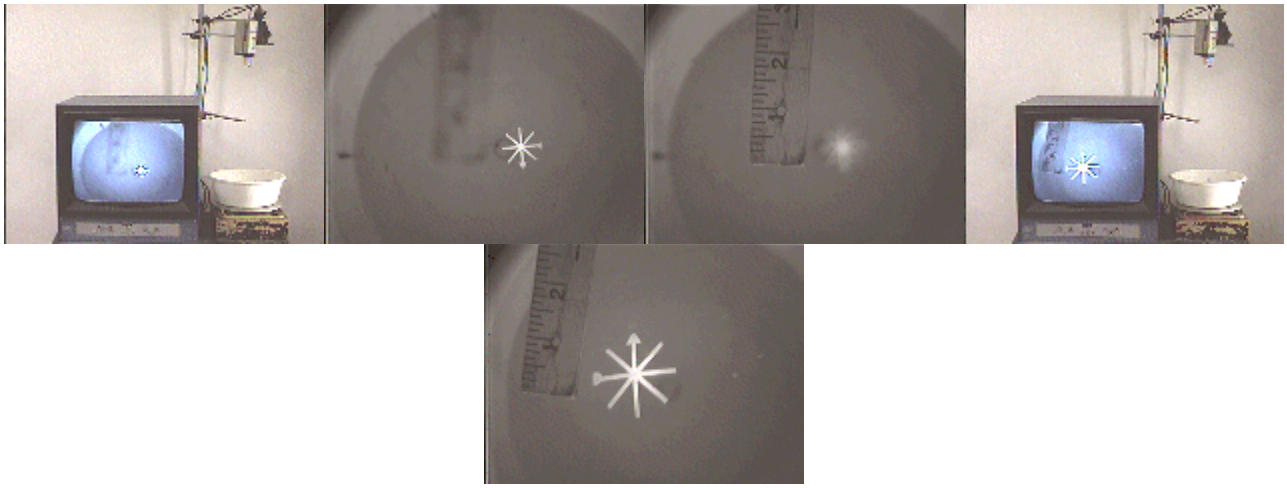
Answer #211

The answer is (a): the image created by the parabolic concave mirror formed by the liquid surface when the liquid container is rotated is real and inverted. The image is located at the position of the ruler (32 cm from the liquid surface) less than twice the focal distance from the mirror when the object is at a distance greater than twice the focal distance of the mirror, about 22 cm for a rotational speed of 45 revolutions per minute. The image is inverted, as can be seen. The image is actually smaller in the case when the liquid is rotating: although it appears bigger in the photograph because it is closer to the camera. In reality the image is 70 cm from the mirror when the surface is flat, and only 32 cm from the mirror when the liquid surface forms a parabolic concave mirror.

The series of photographs below illustrate the situation. The photograph at the left shows the setup with the rotator at rest, the photograph at the left center shows the camera focusing on the image, 70cm below the surface of the liquid, so the ruler is out of focus, and the photograph at the center shows the camera focused on the ruler, so the image (70 cm below the liquid surface) is out of focus. The photograph at the right center shows the seup with the rotator in motion at 45 revolutions per minute, and the photograph at the right is a close-up showing that the ruler and the image are both in focus at the same point. Notice the orientations of the images in both cases.



We provide three mpeg videos showing the transitions between the flat mirror and the concave mirror situation.

- Case 1: Full video, showing the surface of the liquid at rest, rotating the liquid to obtain the parabolic concave mirror, then letting it stop to return to the original condition.
- Case 2: Video showing only the first part, in which the liquid surface begins at rest and is rotated to obtain the parabolic concave mirror.
- Case 3: Video showing only the second part, in which the liquid surface begins in motion with the parabolic concave mirror and is allowed to stop, producing the flat mirror.

As the liquid begins its rotation, the focus of the camera is slowly changed from its original position on the flat mirror image to the position of the image of the parabolic concave mirror.

As the liquid ceases its rotation, the focus of the camera is slowly changed from the position of the image of the concave mirror to the position of the image of the flat mirror.

Many modern telescope mirrors up to 25 feet in diameter are constructed using this technique, called "spin-casting." A container of molten glass is rotated as it cools, forming a nearly perfect parabolic mirror, the surface of which is then ground to eliminate small errors and coated with a reflecting material.

A nice article discussing the features of this device and developing the applicable equations will be found in the American Journal of Physics: Richard E. Berg, *Rotating Liquid Mirror*, AJP 58, 280-281, (1990).

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