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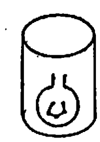
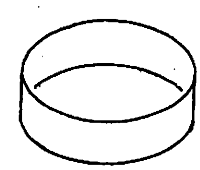
Reflection - a front surface, parabolic, water mirror. In the Nov. 21, 1995 NY Times, an article appeared, "Spun Mercury is Eye of New Telescopes" by Malcolm W. Browne, that got me thinking. A summary of the article follows:

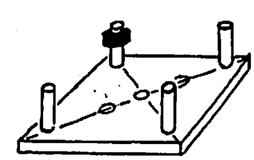
(a) They are limited to looking almost straight up like the 1000 ft dia. radio telescope at Arecibo, PR but can scan, especially for space debris a ½ inch in dia.
(b) They are simpler and much cheaper (1/100) to make than solid, alum.-coated glass mirrors and are more accurate (better image quality). Thus, they can easily be located almost anywhere on earth for specific studies.
(c) They utilize a 1/8 inch thickness of silvery liquid mercury which is spun on a smooth, compressed-air bearing (no vibration and a constant speed) in a precast plastic paraboloid shell (also spun in its manufacture). Presently, the mirror diameters vary from 59" (1.5m) to 118"(3m). A 104"(2.6m) mirror requires about 300 lbs of Hg.
(d) To start the mirror spinning, it must be turned by hand until the motor's speed is reached, and it takes over. Operators must wear gas masks during run-up to protect themselves against toxic mercury vapor. However, the stable spinning mirror surface is quickly oxidized by air contact and forms a barrier preventing the further escape of Hg vapor. The thin, oxidized layer is just as reflective as the bare metal.
(e) For more, see an article in Scientific American in 1994 by Dr. Ermanno F. Borra on spinning liquid mirrors.

I immediately wondered if I could construct a mini version using water rather than mercury and spinning it with an old record player. I reasoned that the front surface reflection of about 30% of the incident light on water would be enough to form a bright image. Since 8"dia. commercial telescopes are very popular, I looked for and found an 8"dia. tub to hold the water.* I would need to construct a "tub" holder and select a light source (the object). The tub had a strong cover that would support an old PSSC accelerometer. The arrangement of the items is illustrated at the right. The 8"sq. tub holder fits on the turntable and the tub with water fits in the holder. The object (light source) is some distance above the water's surface; the distance will vary as you perform the experiments.

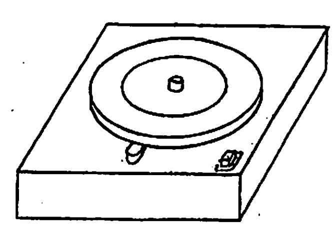


Preparation: The following directions correspond to the no. 3055 tub only; a different tub would probably require different dimensions.
(a) Making the tub holder requires an 8"sq. piece of ½" plywood. Locate its center. Using a compass, lay out a circle (8"dia.?) and locate the holes for the 3/8"dia. dowels, 3" long. Space the dowel holes slightly outside the circle; you will "adjust" (center) the tub by wrapping different thicknesses of masking tape around the dowels. Drill an ~ 9/32"dia. center hole for the spindle. If you find a better way to attach the tub to the turntable, use it.
(b) Attach the accelerometer securely (wing nuts and bolts?) to the tub's cover. (See illustration on next page.)
(c) For the object (light source), I chose a 60W clear, incandescent bulb with a pentagonal filament. Used as an "end window" device, the bright filament serves as an excellent object. You must find a way to suspend the bulb and socket (and any shielding) over the water mirror and be able to move it up and down freely.

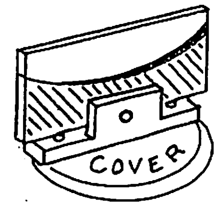




Presentation: (a) With everything aligned and plain water in the tub, snap on the tub's cover with the attached accelerometer. Start the turntable spinning at its lowest speed (rpm). Increase the speed to show the fluid's changing parabolic curve (and focal point). Review the math, centripetal acceleration (v^2/r), F_c , etc. Think of the parabolic curves in 3-D (as a bowl shape); the water in the tub will be parabolic like the curves.



* No. 3055, 2.4 qt, round, Rubbermaid, Servin' Saver, plastic container.



(b) Remove the cover with the accelerometer. With the light source overhead but slightly off-center, start with the 33.3 rpm speed, wait a moment for the water's surface to stabilize into a smooth parabolic "bowl", and move the light source up or down until a clear image appears on the ceiling. This is dramatic! Then change the speed to 45 rpm and predict the location of the focal point (length) and object (filament) distance to achieve another clear image on the ceiling. Adjust the bulb to clearly focus the image. Were the predictions correct? If possible, try the 78 rpm.

(c) Stop the turntable and let the water stabilize to "flat". Move the light source up and down to try to find an image on the ceiling. Ask why no image (real) can be found. Do the students now understand the difference between curved and flat (plane) mirrors?

(d) Place the light source near the ceiling (or high up) and the turntable with the water mirror on the floor, like a star and earth telescope. Make a white paper "screen" the size of a quarter and attach it to the end of a soda straw. Start the turntable at 33.3 rpm and with the "screen" as a probe, search for the image of the "star". Hint: look near the focal point. Why? When you find it, it will be <u>very</u> small and bright. The water mirror is acting as a light "catcher" and concentrator. How can you make the very small image larger? Do the students now understand the need for a telescope eyepiece (a magnifying lens)?

A lot of good introductory physics can be learned with this apparatus. The money, time, and effort to construct it would be well spent. Take note; I have not been successful using square containers for this demo. Stick with round tubs.

Addendum: When you are teaching the unit on sound, you might want to perform this demo. The grooves in an old phonograph record are waves (wavy), making the needle vibrate at right angles (transverse) as it "drags" through them. If you have an old (<u>not</u> choice) 78, 45, or 33.3 rpm record(s), you can show your students the simple ideas behind the first Victrolas or record players before electricity and electronics took over. Take a heavy piece of paper and roll it into a cone about 16" long, with a 7"dia. bell and a 3/8"dia. "needle" end. Push a thin sewing needle or straight pin through the two opposite sides near the "needle" end; let the sharp point extend only about 3/16". With the record on the moving turntable, carefully hold the cone over the record, parallel with the groove where the needle is making contact. With practice, you should be able to get an intelligible sound from the cone. The needle point vibrates, the needle vibrates in the cone, and the resulting vibrations (sound) move easily out into the air via the resonance and lowered impedance due to the shape of the cone. Another lesson; play a 33.3 rpm record at 45 rpm and a 45 rpm record at 33.3 rpm. What is going on here? All of this, of course, could be a nice way to introduce your students to the field of acoustics, the science of sound.