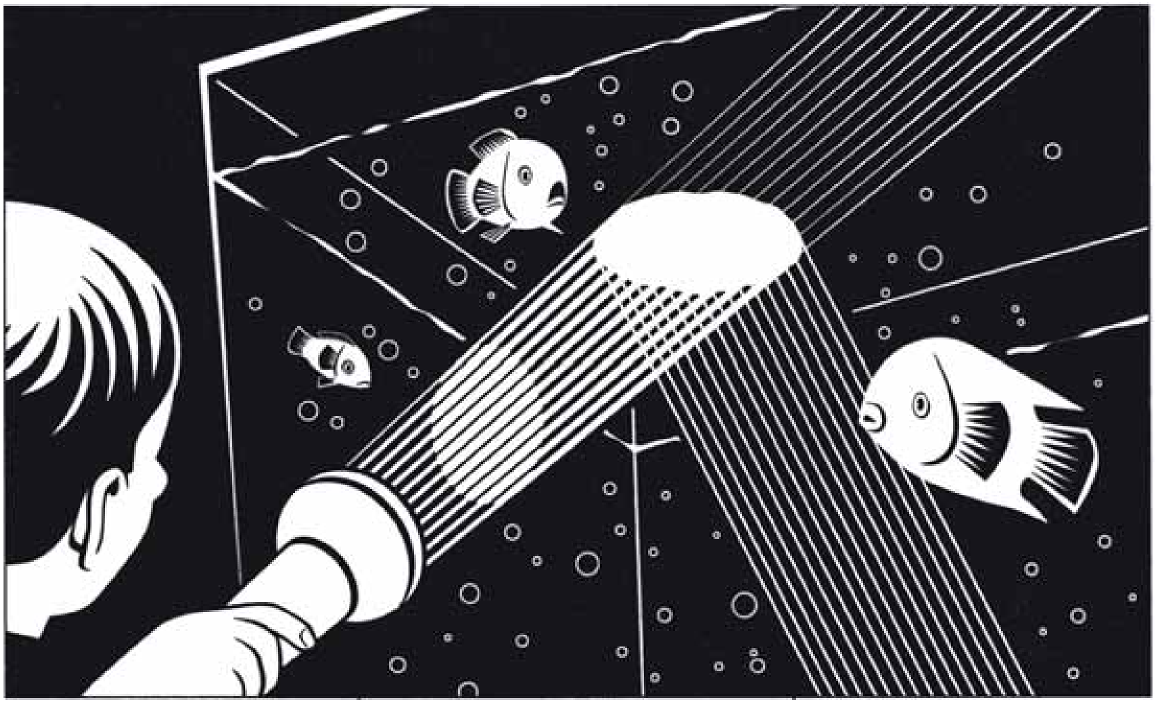
Speaking with Light

Understanding Optical Fiber



Materials

Rectangular aquarium
Water
Milk
Chalk (dust)
Large stirring rod
Flashlight

Assembly

Fill the aquarium with water. Add the milk a drop at a time, stirring after each drop, until you can see the light beam pass through the water.

Activity

Direct the light upward through the water either from the sidewall or from underneath the transparent bottom, so that the beam hits the surface of the water from underneath. Dimming the lights will make the beam more visible.

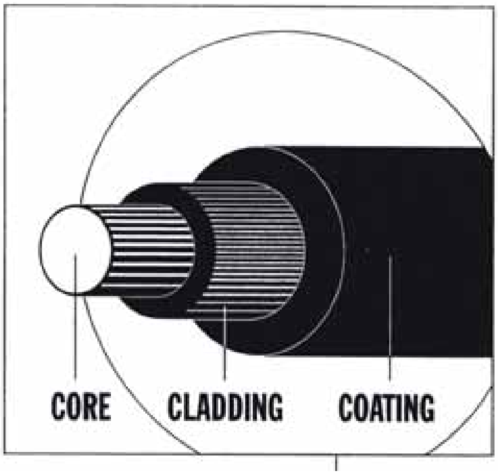
Point the beam so that it hits the surface of the water at about a right angle. You will be able to see both the reflected beam, which bounces back into the water, and the refracted beam, which comes out of the water and into the air. Adding chalk dust to the air above the aquarium will aid in seeing the refracted beam. By slowly decreasing the angle at which the beam of light hits the surface of the water, you will notice an angle for which no light is transmitted into the air and all of the light is reflected into the aquarium. This is the demonstration of total internal reflection, and the angle for which this occurs is called the critical angle.

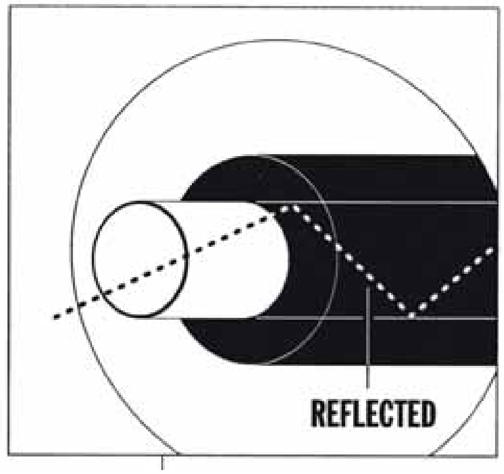
Discussion

We think we know glass pretty well - we know that it is transparent, and if stressed, it breaks. But, both of these facts are only partly true.

A window pane two meters thick will only transmit 1% of the light shining on it. Scientists at Corning Incorporated, however, learned how to make glass so transparent that light could shine through a very long optical fiber, equivalent to a pane of glass 200 km thick.

Besides the transparency of glass optical fiber, flexibility of optical fiber makes it successful in guiding signals of light, which carry voice and data information. You can bend





optical fiber, tie it in a knot, and light is still transmitted through it.

Although fiber can be bent, we think of light beams traveling in straight lines. Let's understand how light is kept in optical fiber.

An optical fiber consists of two different types of glass - one makes up the core, and the other the cladding. The core is the light guiding region of the fiber, while the cladding ensures that the light pulses remain within the core.

Light is contained within the core glass because the core and cladding glasses have different indices of refraction. That difference causes the light signal to be reflected when it strikes the interfaces (boundary) between the core and the cladding, which allows the light signal to be carried along the fiber's length. This is called total internal reflection. It is better than any mirror we could possibly imagine.

Total internal reflection helps transmit phone messages along optical fibers. Any light at less than the critical angle, that is not aligned parallel to the axis of the fiber hits the core/cladding interface and is reflected back inward. This helps prevent the light signal from weakening too rapidly over long distances, or from leaking out when the fiber goes around a curve.

Optical fiber is also surrounded by a protective polymer coating which serves as a barrier to protect the fiber from dust and scratches, which affects a fiber's strength.

Amazing Science

The diameter of a coated fiber is about 250 microns and is stronger than a steel wire. In case you didn't know, a strand of hair is about 125 microns. Just one strand of fiber provides the ability to transmit nearly 100 million telephone calls.

Credits

This activity was written exclusively for National Engineers Week by Corning Incorporated, Corning, N.Y., and by the Science and Discovery Center, Horseheads, N.Y., at the request of the National Academy of Engineering (NAE).

Each year the NAE presents the Charles Stark Draper Prize to individuals whose outstanding engineering achievements have significantly impacted society by improving the quality of life, providing the ability to live freely and comfortably, and permitting the access to information. During National Engineers Week 2000, Dr. Charles Kao, Dr. Robert Maurer, and Dr. John MacChesney shared the $500,000 prize for their separate contributions that led to the development and manufacturing of fiber optics. Fiber optics revolutionized global communications by providing the "concrete" of the information superhighway. Optical fibers replaced copper wiring, reduced manufacturing costs and relayed vastly larger amounts of information. You can learn more at www.nae.edulawards.