Radiometer

Introduction

Demonstrate motion caused by infrared radiation.

Materials

Radiometer

Light source, incandescent and fluorescent

Safety Precautions

The radiometer is fragile. Take care not to damage or drop it. Since the radiometer contains a vacuum, it can implode like a lightbulb.

Procedure

1. Place a radiometer in a brightly lit area, but not in direct sunlight. Describe the rotation of the paddle wheel.
2. Move the radiometer into bright sunlight. Describe the rotation of the paddle wheel.
3. Place the radiometer near a bright incandescent lightbulb. Describe the rotation of the paddle wheel.
4. Place the radiometer near a bright fluorescent lightbulb. Describe the rotation of the paddle wheel.
5. Try other sources of light to see their effects on the rotating paddle wheel.
   a. Summarize the types of light that work well with the radiometer and the types that do not work well.
   b. What are the differences between these types of light and their sources?

Discussion

The radiometer was invented by Sir William Crookes in 1874 as a result of his studies on weighing objects in an evacuated balance chamber.

The radiometer consists of an evacuated glass globe with a pivoted paddle wheel which is free to rotate about a vertical axis. The fins or vanes of the paddle wheel are blackened on one side and polished, silvered, or painted white on the other side. When the radiometer is exposed to sunlight, or other types of radiation, the paddle wheel rotates. The brighter the light, the more rapid the rate of rotation.

The direction of the rotation is such that the blackened surfaces of the paddle wheel move away from the source of radiation. This makes it appear that the radiation is pushing the paddle wheel and, to Crookes, that appeared to be the explanation and proof that light consisted of particles.

The way the radiometer actually works is that the globe does not contain perfect vacuum and there are residual air molecules left inside. When radiation falls on the light surface of the vanes, it is reflected and when it falls on the dark side, it is absorbed. This creates a difference in temperature between the two sides and the air on the darkened side is heated, causing its molecules to move about more rapidly. These rapid moving molecules collide with the vanes and bounce off with greater energy than the molecules colliding with the light-colored side, thus causing the paddle wheel to turn. The radiometer, therefore, really demonstrates the molecular theory of gases.

If the globe contained a perfect vacuum, would the radiometer still work? Theoretically, yes, but the vanes would rotate in the opposite direction. This is due to the conservation of momentum of the light particles. The black side absorbs the momentum of light (and the energy) and the white or silver side reflects the momentum of light (and the energy). Due to the conservation of momentum, this would cause the white or silver side to move away from the radiation source, if the energy was high enough to overcome the friction of the axle of the paddle wheel. This does not occur in a partial vacuum because the energy of the moving air molecules striking the black side is much higher than the conservation of momentum affect from the light particles.

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The *Radiometer* is available from Flinn Scientific, Inc.

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AP1948	Radiometer

Consult your *Flinn Scientific Catalog/Reference Manual* for current prices.