Radiometer, Crookes type

06676.00

Operating Instructions

1 PURPOSE AND DESCRIPTION

The Crookes radiometer 06676.00 (Fig.) serves to detect radiation in the infrared and visible regions of the spectruml. The explanation of its mode of action can be taken as confirmation of basic concepts of gas kinetics.

The Crookes radiometer consists of a glass vessel containing a fused-in winged cross with four mica plates, each blackened on one side (radiometer system) on a rotating shaft. All blackened surfaces point in the same direction of rotation. As the gas pressure inside the vessel is adjusted to about 10^{-2} mbar, the free path length of the gas molecules is of the order of (λ) = 1 cm.

2 MODE OF ACTION (EXPERIMENT)

We will first consider only the events occurring for a single wing of the radiometer. On average, just as many gas molecules impinge on its blackened surface as on its unblackened surface.

1. When the winged cross is illuminated with daylight, with a light-bulb, an Hg high pressure lamp or with a heat radiator, e.g. 04036.93, the blackened surfaces of the wings are warmed up more strongly than the unblackened surfaces, because of their higher absorption. A temperature drop within the wings, from the blackened to the unblackened side, therefore results. Because of this, the gas molecules which strike the blackened (warmer) surface will be reflected with greater speed (energy) than the molecules which strike the unblackened (colder) surface. As „action and reaction are equal“, the gas molecules exert a larger recoil effect on the blackened surface than on the unblackened surface. The sum of all the individual recoils generates the radiometer force. The direction of this force coincides with the direction of the temperature drop which is generated in the wings. The force exerted force causes the winged cross to be kept in continual rotation.

2. The significance of the temperature drop within the wings for the movement of the winged cross can be shown in the following way:
   Direct a convergent bundle of light from an Hg high pressure lamp onto the winged cross of the radiometers, so that in each case only an unblackened area of a wing is focussed on by the condensor.
   As scattered light at first causes a sufficient warming of the blackened areas, the winged cross initially rotates in the same direction as in the previous experiment.
   After a sufficient period of irradiation, however, the temperature of the blackened areas which are warmed by the scattered light, and the temperature of the directly illuminated, unblackened areas, become comparable and the rotation slows down.
   Now remove the source of radiation. The direction of rotation reverses. Not only the absorption, but also the emission of the blackened surfaces is greater than that of the unblackened surfaces (Kirchhoff's Law). The blackened surfaces therefore cool down more quickly, and a temperature drop from the unblackened to the blackened surfaces results. According to the observations made in the preliminary experiment, the direction of rotation must also therefore reverse. The movement is then again in the direction of the drop in temperature.

3 The reversal in the direction of rotation of the winged cross can also be attained by an intensive irradiation of the blackened areas. It only occurs, however, some time after the source of radiation has been removed.
   The higher emission of the blackened areas must again be used to explain this occurrence. It results in a quicker cooling down of the blackened areas and so generates a temperature drop in the reverse direction.

3 LIST OF EQUIPMENT

Lamp for 50 W Hg high pressure lamp	08144.00
Power supply for Hg CS/50 W lamp	13661.93
Infrared lamp, 220 V	04036.93
Lamp socket, E 27, mains connection	06751.00