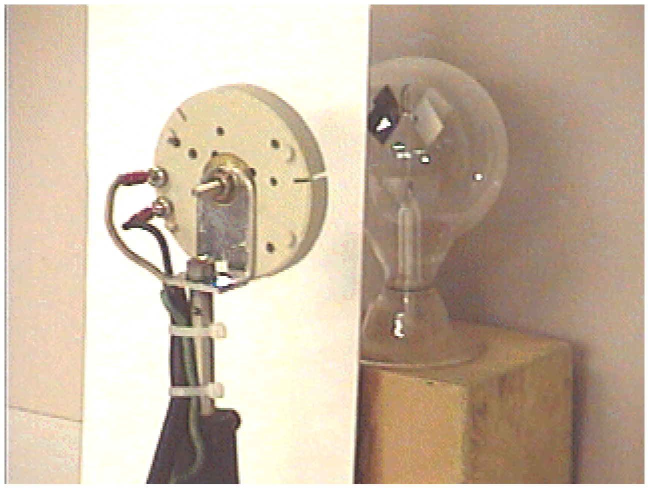
Answer #174

The answer is (b): with only the white sides of the vanes illuminated the radiometer will move in the same direction but at a much slower angular speed, as seen in an mpeg video by clicking your mouse on the photograph below.



The reason for this has to do in a very important way with *exactly* how the device operates. Much of the original research work into this device was carried out by Crookes and Reynolds. I will quote from an **excellent!** article in *The Physics Teacher* magazine: Arthur E. Woodruff, The Radiometer and How it Does Not Work, TPT 6, 358-363, (1968):

> ...Imagine two parallel plates of indefinite extent, arranged as in a parallel plate capacitor and connected to each other, with a gas in the space between. If we naively accept the argument Reynolds originally gave, then, if one of the plates is warmer on its inner surface than the other, the entire apparatus should accelerate with the warmer plate leading, without any external forces. This, of course, contradicts the fundamental principles of mechanics......
>
> . . . though the molecules make more vigorous collisions with the warmer side of the vane, they are held back more effectively from the vane by the recoiling molecules, so that the pressure over most of the vane is the same as the pressure on the cooler side. But for molecules impinging near the edge of the vane, onto a strip of order of the mean free path in from the edge, the situation differs. They are held back in part by the molecules rebounding from the vane from the cooler side. But the latter are less efficient in stopping incoming molecules. So while the individual collisions with the vane may be on the average just as vigorous as nearer the center of the hot surface, more such collisions will occur in a unit area in a given time. The pressure near the edge, then, will be greater than at the center of the warm side, and therefore also greater than the pressure on the other side. It is this excess pressure at the edge which is responsible, at least in part, for the motion of the vanes. . . .

The explanation is not nearly as simple as the difference in the momentum of photons when they are absorbed or reflected, or even as simple as the heating effect on the black side, which absorbs more photons, compared with the white side, which reflects more. This appears to be one of those physics devices that is typically explained incorrectly, even in the literature from the supplier that accompanies the radiometer.

Now, back to answering the original question regarding why, when the white side is illuminated, the radiometer advances in the same direction as when both sides are illuminated or when only the black side is illuminated. After consideration of the above information, it would seem that when **any** heat is introduced into the device, the black side immediately becomes slightly warmer as thermal equilibrium is rapidly reached. In this case, then, the argument regarding the difference between the edges of the black and white sides must apply.

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