Comment on ''Dynamically maintained steady-state pressure gradients''

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Sheehan [Phys. Rev. E **57**, 6660 (1998)] recently discussed the possibility of establishing a dynamically maintained, steady-state pressure gradient in a gas filling a cavity. In this Comment it is pointed out that the pressure gradients in such a system, if attainable in the laboratory, could be used to violate the second law of thermodynamics.

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It has recently been argued [1] that it may be possible to set up a low pressure gas system which exhibits a dynamically maintained steady-state pressure gradient (DSPG). While the argument presented there seems plausible, it should be pointed out that if such a DSPG can in fact be realized in the laboratory, the consequences would be far more significant than just the novelty of a unique type of pressure gradient. The purpose of this Comment is to point out that such a pressure gradient could be used as a form of nonsentient ''Maxwell's demon,'' which separates random microscopic motions of particles and uses them to do macroscopic work, in violation of the second law of thermodynamics.

The key result from Ref. [1] is that under *isothermal* conditions and in *steady state*, a difference in gas pressure on two surfaces (S_1 and S_2) can be maintained by virtue of the different desorption rates of dimeric and monomeric gas (A_2 and A) from the two surfaces. [Equation (19) in Ref. [1] gives a specific example of such a pressure gradient.] The isothermal and steady-state conditions mean that this pressure difference is not a transient phenomenon, and is not maintained by a flow of free energy from outside the system. So if the pressure difference is harnessed to perform macroscopic work, there is no external driving force from which the energy could be coming; the source must be the thermal energy of the heat bath.

It is readily apparent that the pressure difference can be used to do macroscopic work. One way this could be implemented is by setting up a turbine with blades of material S_1 and S_2 on alternating sides, so that the gas pressure differences will cause the turbine to turn. The turning turbine could then be used to perform useful macroscopic work (running a generator, for example). In this example, the energy to turn the turbine and perform work is derived from the momentum of the gas molecules leaving the surfaces of the turbine blades. The pressure difference results from the difference in momentum of A versus A_2 leaving the surfaces (in thermal equilibrium with the surface when they leave). Thus some of the molecules are having their momenta reduced below their thermal value as they do work on the turbine. (Note that Sheehan derives the pressure gradient explicitly only for static surfaces. But since the pressure difference is caused by the differences in average thermal velocity of molecules leaving the two surfaces, the net torque should persist even when the surfaces are moving.) When they return to the heat bath, these molecules regain their thermal velocities at the expense of the heat bath. As this process continues in steady state, work is steadily done on the turbine blades, purely at the expense of energy from the heat bath and in violation of the second law of thermodynamics.

This result can be viewed in one of two ways. (1) It provides a simple way of seeing that something must be wrong with the argument in Ref. [1]: Something that has been overlooked must prevent the establishment of DSPGs in practice; or (2) The second law of thermodynamics is suspect under the conditions in which DSPGs arise. In either case, something interesting is likely to be uncovered by further investigation and discussion of the properties of these systems.

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[1] D. P. Sheehan, Phys. Rev. E **57**, 6660 (1998).