



V. Note on the motion of a gas "in mass."

Professor Tait

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Let

$$\frac{f}{e} = \cos \alpha,$$

$$\tan \chi = \frac{\sin \beta}{2 \cos \frac{\beta + \alpha}{2} \cos \frac{\beta - \alpha}{2}}.$$

There may be transmission of power from the source of e to the source of f even when $f > e$, provided that $f \cos \beta$ is not $> e$; as would appear at once from a geometrical construction on the plan given above, and in any case the condition of maximum efficiency is one of stability.

V. Note on the Motion of a Gas "in Mass."

By Professor TAIT*.

THE objections raised by Mr. Burbury and Prof. Boltzmann to certain parts of my first paper on the *Kinetic Theory of Gases* were such as I could understand; and my reply to them seems to have been accepted as sufficient.

Mr. Burbury now (Phil. Mag. Dec. 1887) raises an objection, which I do *not* understand, to an assumption made (after Clerk-Maxwell and Clausius) in my second paper. This objection is based upon a Theorem which Mr. Burbury supposes to have been established by Prof. Boltzmann. The passage objected to is as follows (the *italics* are not in the original):—" except in extreme cases, in which the causes tending to disturb the 'special' state are at least nearly as rapid and persistent in their action as is the process of recovery, we are entitled to assume that in every part of a gas or gaseous mixture a local special state is maintained. And it is to be observed that this may be accompanied by a common translatory motion of the particles (or of each separate class† of particles) in that region; a motion which, at each instant, may vary continuously in rate and direction from region to region; and which, in any one region, may vary continuously with time. This is a sort of generalization of the special state, and *all that follows is based on the assumption that such is the most general kind of motion which the parts of the system can have, at least in any of the questions here treated. Of course this translational speed is not the same for all particles in any small part of the system. It is merely an*

* Communicated by the Author.

† The "classes" here spoken of are different kinds of gases, not (as in Mr. Burbury's paper) groups of particles of one gas which have nearly the same speed.

average, which is maintained in the same roughly approximate manner as is the 'special state,' and can like it be assumed to hold with sufficient accuracy to be made the basis of calculation. The mere fact that a 'steady' state, say of diffusion, can be realized experimentally is a sufficient warrant for this assumption; and there seems to be no reason for supposing that the irregularities of distribution of the translatory velocity among the particles of a group should be more serious for the higher than for the lower speeds, or *vice versâ*. For each particle is sometimes a quick, sometimes a slow, moving one:—and exchanges these states many thousand times per second. All that is really required by considerations of this kind is allowed for by our way of looking at the mean free paths for different speeds."

I confess I cannot see how objection can possibly be taken to this assumption when the question is that of the Viscosity of a pure gas; though Mr. Burbury specially mentions Viscosity among the subjects which he considers to be *on this account* erroneously treated in my paper. And it would require, I think, a most determined sceptic to entertain a doubt of its lawfulness in the question of Thermal Conduction, also in a pure gas. In the matter of Diffusion some doubts may possibly occur to one looking at it for the first time; and it was on that account that I inserted in my paper the words quoted above. To deny their validity would, I consider, be tantamount to a wholesale repudiation of the statistical method of treatment, which has done so much for questions of this kind. Mr. Burbury departs from the statistical method in his equation (1) by treating *as a separate gas, with its own pressures and resistances*, the class of particles of one gas which have speeds from v to $v + \delta v$:—thus ignoring the community of interests which the mutual collisions secure for *all* the particles of a gas. It might be lawful, though perhaps not very useful, to treat thus a part of one gas; but it must be a part which contains particles with all varieties of speed in their proper proportions.

But more. I think I have given a self-consistent, and *therefore* accurate, solution of the problem of steady Diffusion (at all events when the masses and the diameters of the particles are the same in the two gases), basing my work entirely on the assumption above. If Mr. Burbury can show that solution to be erroneous, he may possibly make out a presumptive case against the assumption on which it was founded:—but not otherwise.