

Maxwell becomes a molecular scientist at Aberdeen



- ❖ As a boy Maxwell was fond of spinning toys – the top, the diabolo, the zoetrope and no doubt the ubiquitous hoop and stick
- ❖ Maxwell invented his elaborate, completely adjustable, top to demonstrate the complex dynamics of spinning bodies
- ❖ In the same paper, written when he was in Aberdeen, he promoted the newly coined, simplifying concept of angular momentum

Idea in brass. A 19th century version of Maxwell's dynamical top, courtesy University of Aberdeen

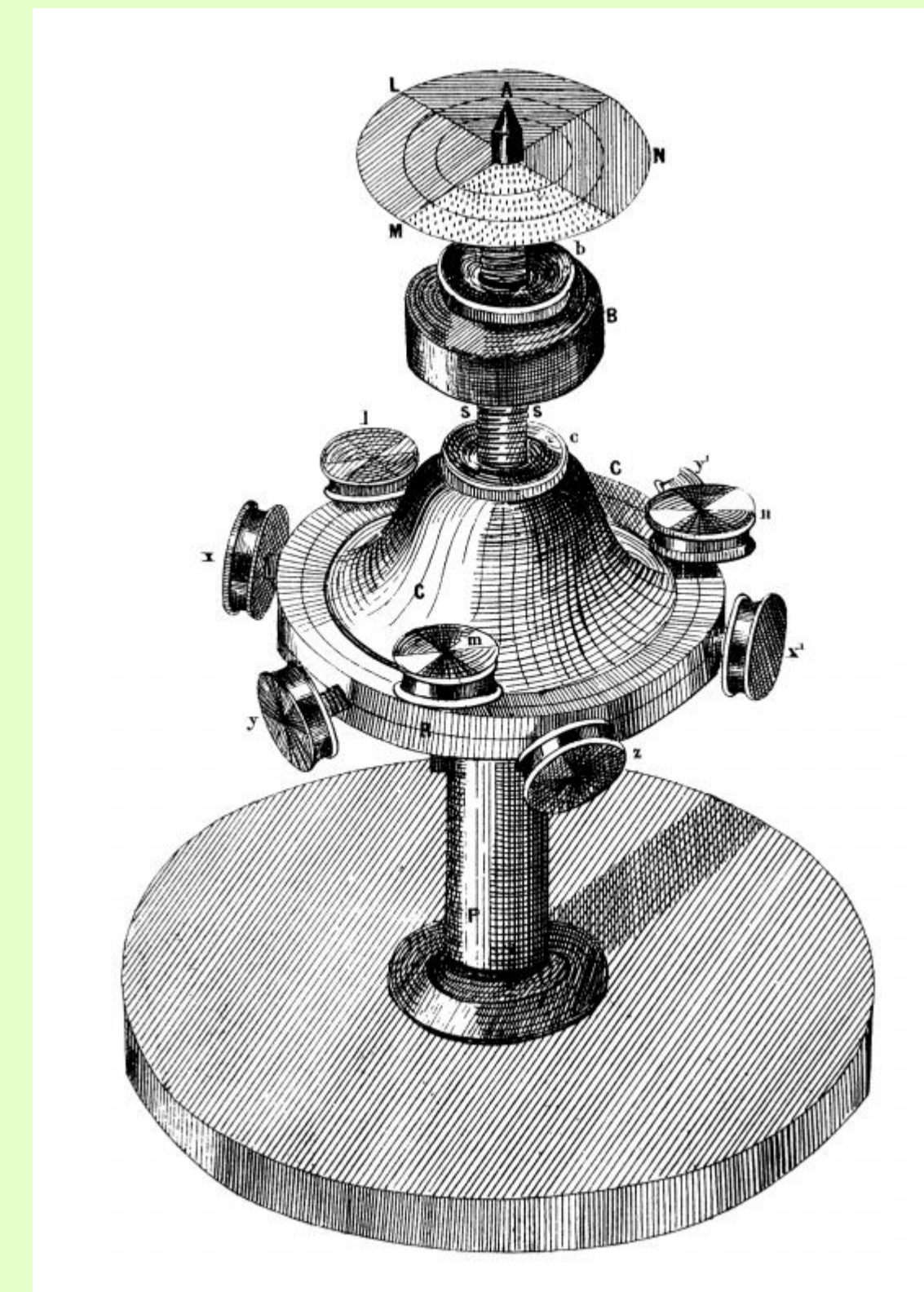
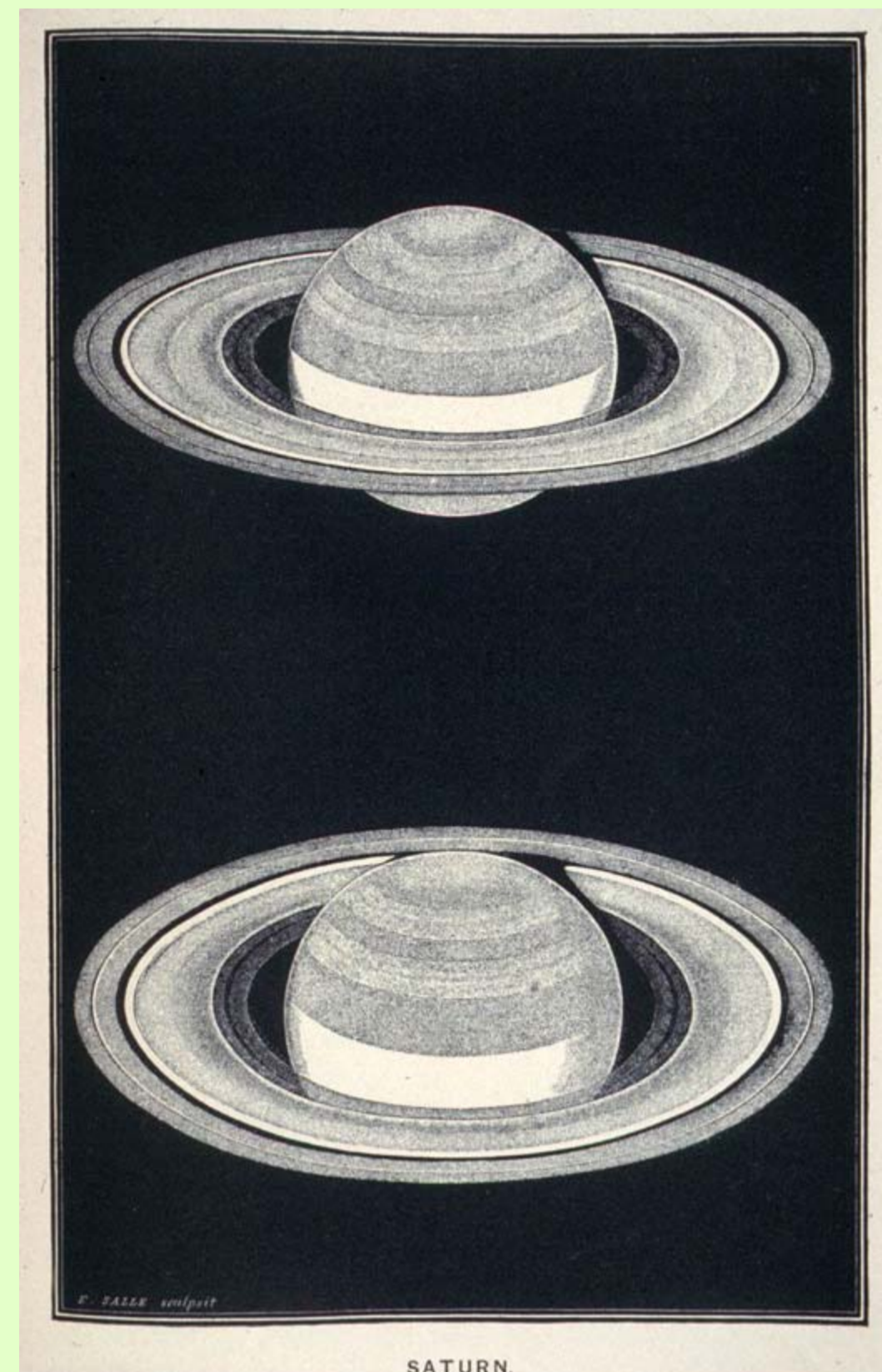


Diagram of Maxwell's top from his 1857 paper

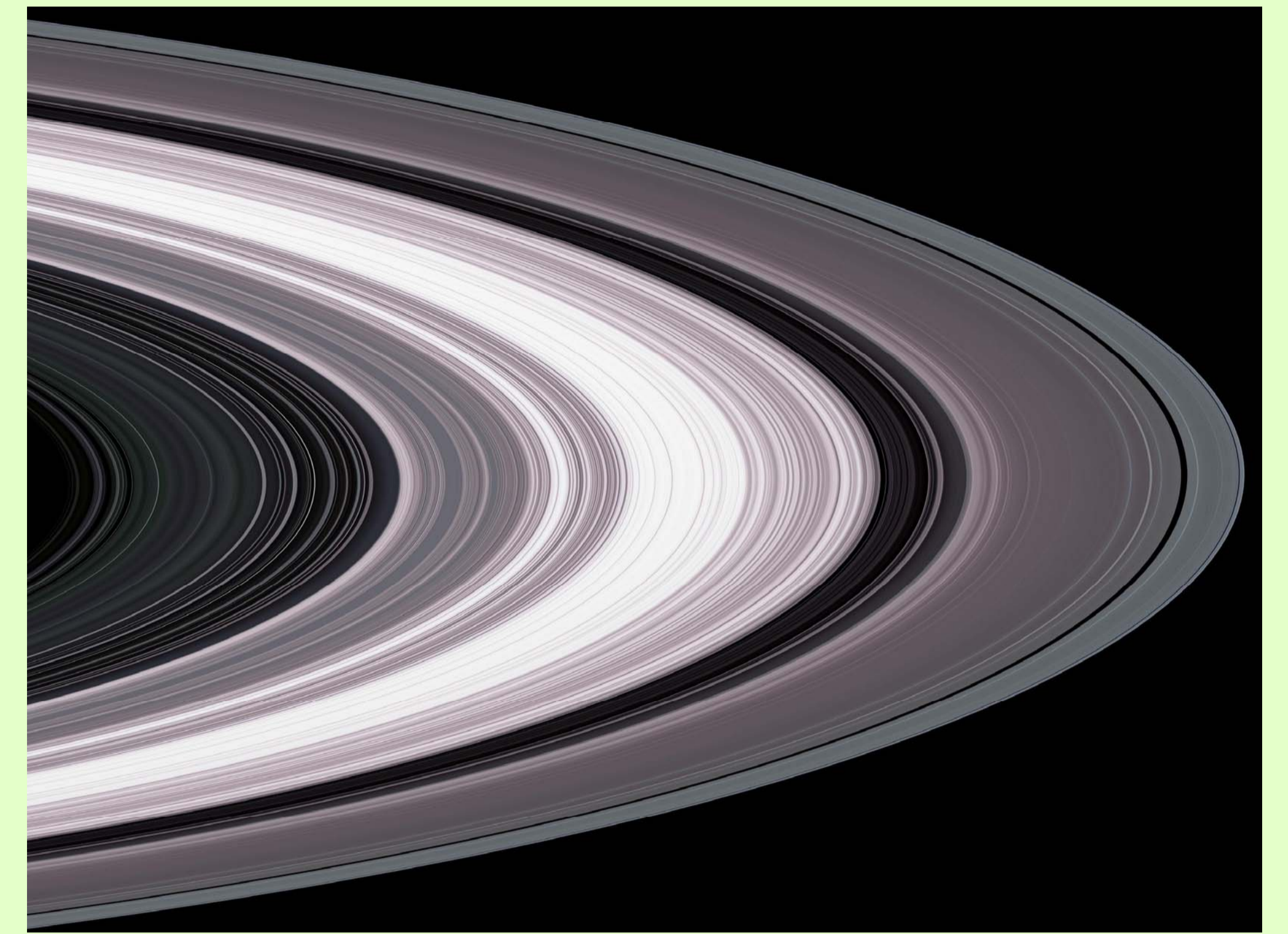
Model made in Aberdeen for Maxwell, illustrating his predicted wave motions on Saturn's rings



- ❖ Maxwell spent a great deal of time while Professor at Marischal College refining his treatise 'On the Stability of the Motion of Saturn's Rings'
- ❖ He demonstrated that on the grounds of stability the rings had to be a multitude of small 'particles'
- ❖ Maxwell had a model made by Smith & Ramage (of Aberdeen) of waves he predicted could exist on the rings
- ❖ His treatise was published as a free-standing work and earned him the Adams' Prize from the University of Cambridge and recognition as an elite mathematical physicist
- ❖ It was over a century before space probes confirmed his deduction, the particles being rocks and ices

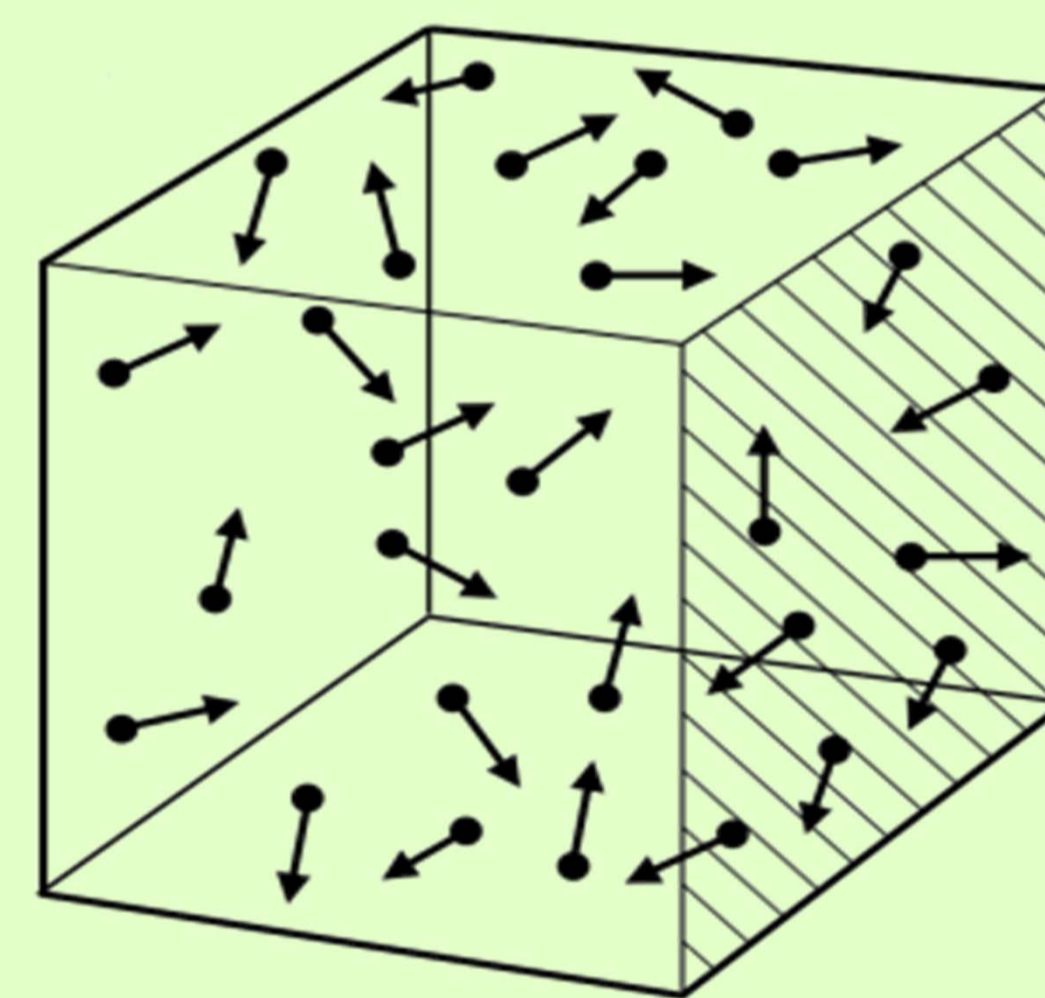


No photographs of Saturn had been made when Maxwell worked on his treatise (photography wasn't up to it). The drawings here were about the best available



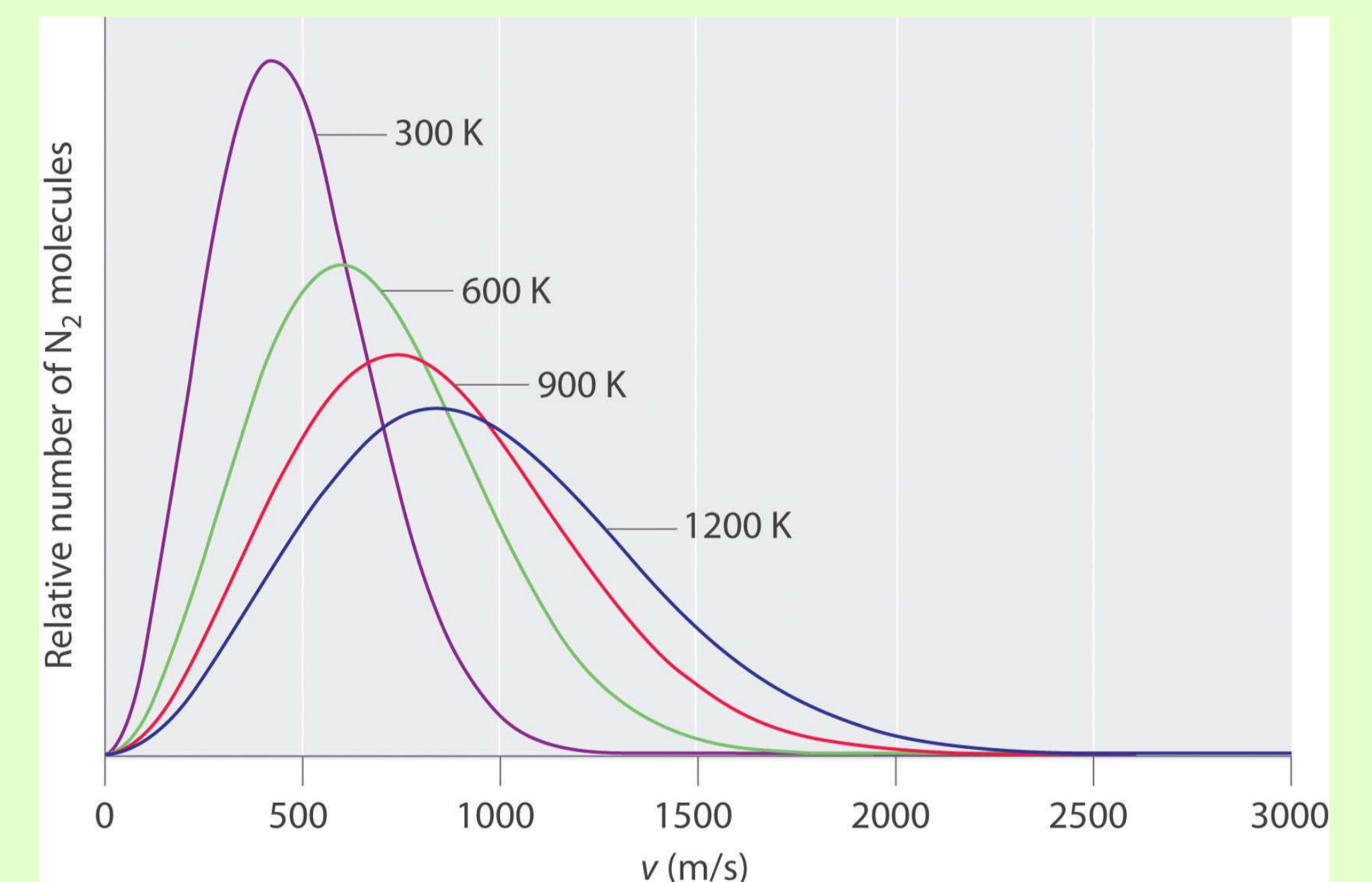
NASA image, a close-up of Saturn's rings

- ❖ Neither of the investigations above concerned molecules but Maxwell followed these works about motion with the study that would make his name as a molecular physicist
- ❖ 'Illustrations of the dynamical theory of gases' was read at the 1859 BAAS meeting in Aberdeen and published the following year
- ❖ He treated gases as a collection of molecules that moved about at random, colliding with each other
- ❖ That's what we do now but this was a novel idea in Maxwell's day. He was credited with making the invisible (molecules) a reality



Maxwell's vision of a gas composed of randomly moving molecules

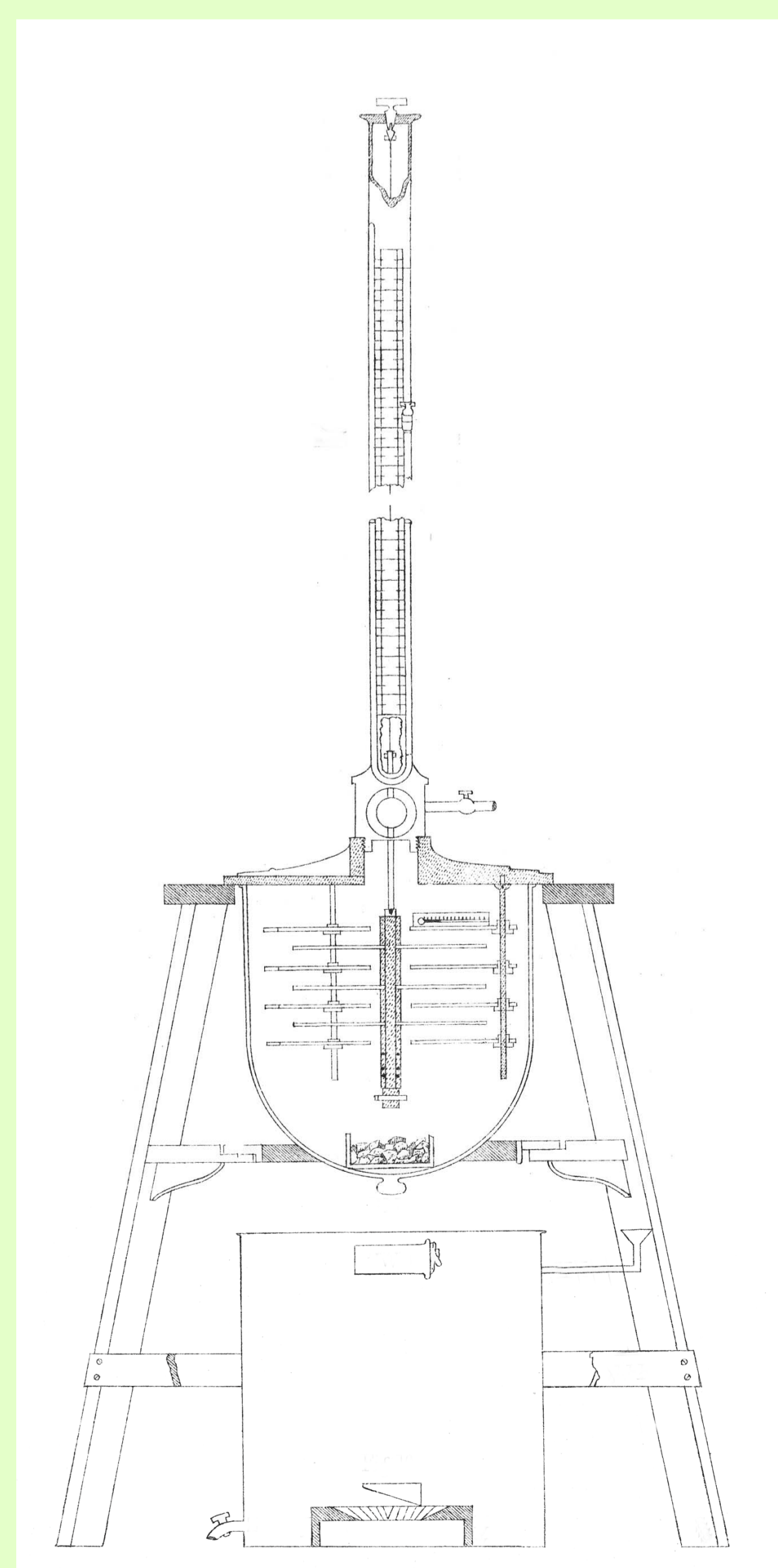
- ❖ Maxwell went well beyond his contemporaries in predicting the properties of 'an ideal gas'
- ❖ His treatment produced the first statistical law of physics
- ❖ This was the **Maxwell distribution** of speeds of gas molecules when in flight between collisions



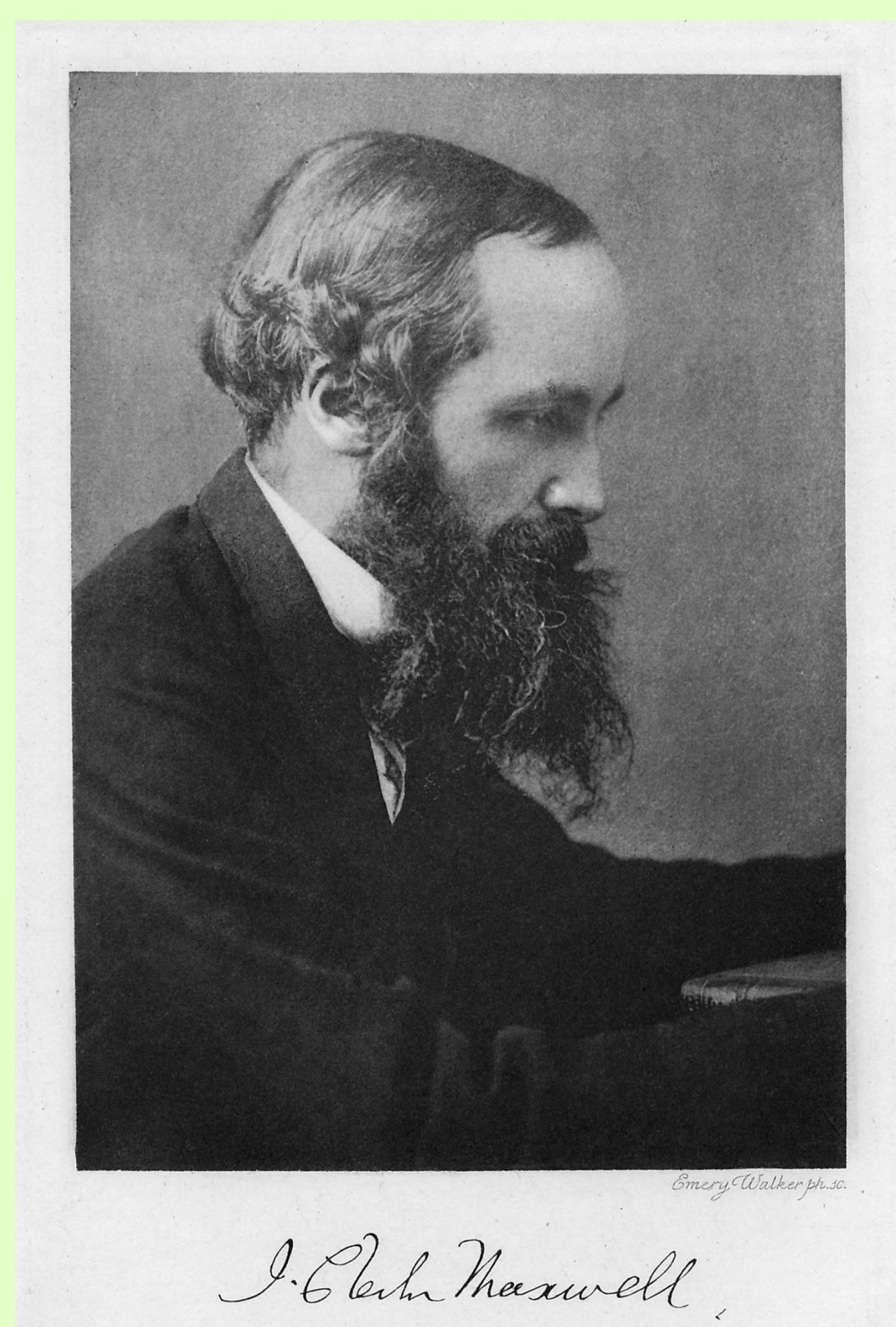
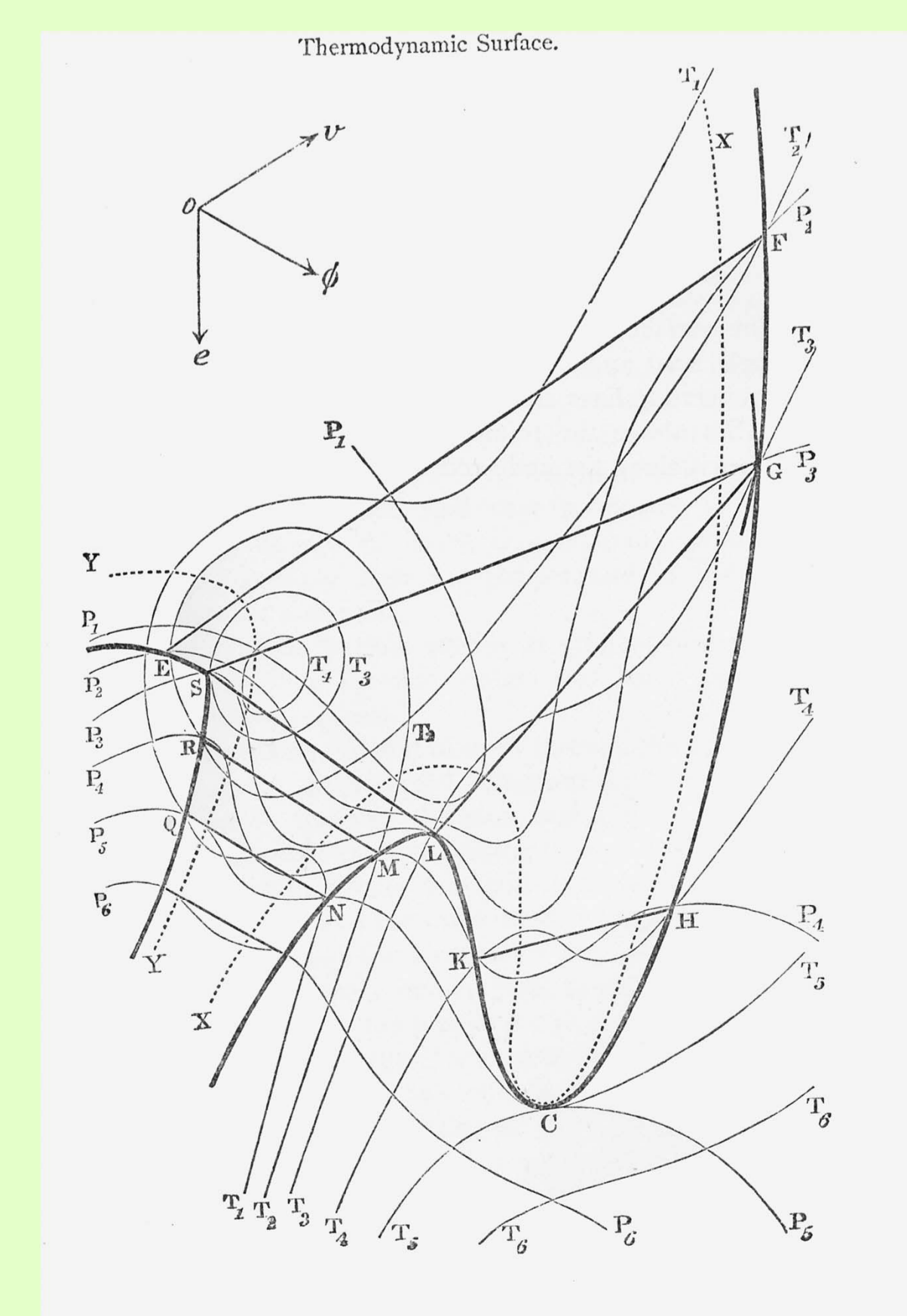
The Maxwell distribution for nitrogen molecules at different temperatures

- ❖ At first Maxwell's ideas were considered 'interesting' but unproven, for molecules were too small to see and many physicists doubted that they really existed
- ❖ Maxwell had deduced that the viscosity of a gas should be independent of pressure, which didn't seem plausible
- ❖ Maxwell refined his treatment and published further papers on the subject including in 1865 the results of his own experiments showing that viscosity was indeed independent of pressure

Below is Maxwell's diagram of his own apparatus that he used in the attic at home to verify the conjecture that the viscosity of a gas is independent of pressure



Maxwell had tremendous spatial imagination and mathematical insight. The diagram below from his 'Theory of heat' requires the student to follow changes in the 3-dimensional space of energy, entropy and volume



- ❖ Clerk Maxwell was described in 1879 as "the leading molecular scientist" of his day.
- ❖ This portrait comes from the 1920 preface to his textbook 'Matter and Motion'