CHAPTER 2

RAYLEIGH'S DIRECTORSHIP, 1880-1884

To myself they were perhaps the happiest I ever spent.

R. T. Glazebrook[1]

The remarkable credibility of this landed aristocrat, wrangler, administrator and physicist first emerged during a brief but decisive period of work on the standard unit and value of electrical resistance between 1879 and 1884.

Simon Schaffer[2]

2.1. The Election of Lord Raleigh

Maxwell's health began to fail early in 1879, and he died in Cambridge on November 5, 1879 at the age of 48. For the Cambridge scientific community, his death was a double calamity: not only had they lost a great scientist, but his passing also threatened the future of the Cavendish Laboratory. According to the regulations of his professorship, the chair was to "terminate with the tenure of office of the Professor first elected, unless the University by Grace of the Senate shall decide that the Professorship shall be continued." On November 20, the Senate passed a resolution that "the Professorship of Experimental Physics, established by Grace of the Senate Feb. 9, 1871, be continued, subject to the regulations then enacted so far they are now applicable."[3] Cambridge leaders concerned with physical science were eager to attract to the position a worthy successor to Maxwell.

William Thomson led the list of potential candidates, but it soon became clear that he could not be induced to reconsider his refusal of 1871. Thereafter, John William Strutt, who in 1873 had succeeded his father to become the third Lord Rayleigh, emerged as the preferred candidate. In 1865, he had been both senior wrangler and the first winner of the Smith Prize. Since 1869, he had published more than sixty papers on acoustics, wave propagation, jet propulsion, optics, spectroscopy, and electromagnetism.[4] His monumental two-volume treatise, *Theory*

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[1] *A History of the Cavendish Laboratory*, 74.

[2] Simon Schaffer, "Rayleigh and the Establishment of Electrical Standards," *European Journal of Physics 15* (1994): 227-285 on 277.

[3] *CUR* (18 November 1879): 121.

[4] See *Scientific Papers by John William Strutt, Baron Rayleigh*, 6 vols., reprinted (New York: Dover, 1964), vol. 1.

Figure 2.1. Lord Rayleigh (John William Strutt), Second Cavendish Professor (1879-1884) [Courtesy of the Cavendish Laboratory].

of Sound (1877-1878), had made him one of the most respected scientists of his generation. His scientific talents were such that "his mathematical analysis seemed to flow naturally into the most concise and elegant form, and, whatever might be the difficulty of the subject, it was never increased by any obscurity or ambiguity as to the meaning of the writer."[5] Rayleigh also was an excellent experimentalist who "needed nothing for his experiments but some glass tubing and a few pieces of sealing wax," and who could see "distinctly the essential points of an experiment or a measurement" and keep "that in view throughout."[6] With these talents, Rayleigh was easily regarded as Maxwell's proper successor.

Rayleigh also had special ties to the Cavendish Laboratory. He had helped overcome Maxwell's reluctance to stand for the Professorship and had been considered the most suitable alternative should Maxwell reject the post.[7] It is likely, therefore, that he felt some responsibility for guaranteeing the continuity of the Professorship. After Maxwell's death, he was urged by many, including William Thomson and Stokes, to stand for the office.[8] The Chancellor of the University himself attempted to persuade Rayleigh to accept the chair:

> Though it is perhaps somewhat unreasonable to ask you to undertake duties the discharge of which would involve heavy demands on your time, and might very probably be attended with no small personal inconvenience, I feel so strongly the advantage the University would derive from your acceptance of the office, that I hope you will allow me as Chancellor of the university, and also as taking a special interest in this Professorship, to support the appeal which I am told is about to be made to you, and to express a hope that you will consent to take the proposal into your favourable consideration.[9]

To his letter the Chancellor attached a memorial expressing the widespread view at Cambridge that Rayleigh's election "would tend greatly to the advance of Physical Science and the advantage of the University."

At first, Rayleigh was reluctant to stand for the chair. He was a hereditary peer, and at that time it seemed unthinkable to many that a member of the nobility might become a professor (at the annual salary of a mere £500). Eventually he did accept the candidacy, despite his mother's objection, and it has been suggested that economic considerations played a role in his decision. The agricultural depression of 1879 had made it difficult for Rayleigh to maintain his private laboratory at Terling, and the salary attached to the chair would provide him with "means of experimenting and zealous and duly instructed assistants and volunteers." Rayleigh

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[5] J.J. Thomson et al., "Lord Rayleigh. O. M., F. R. S. (a collective obituary)," *Nature* 103 (1919): 365-369 on 365 (J.J. Thomson).

[6] Ibid., 366 & 368 (R. T. Glazebrook). Rayleigh's interest in experimentation went back to his Cambridge years of the 1860s. He attended Stokes' lectures and tried to learn experimental skills from him but was soon disappointed. He became a self-trained experimentalist.

[7] Strutt, *Life of Rayleigh*, 48-49. In his letter from Cambridge, Rayleigh said, "Some people thought that if [Maxwell] would not, I was the proper person. It is now I believe nearly certain that he will come, and so I am relieved of having to make a difficult decision."

[8] Ibid., 99-100.

[9] Ibid., 100-101.

agreed to stand for the chair on the condition that he would take the post for a short period only, perhaps "3 or 4 years, if they can get no one else fit for the post."[10] He was elected to the chair on December 12, 1879.

2.2. Organizational Changes

Rayleigh's first task as director of the Cavendish Laboratory was to consolidate its organization. Over the next five years, he would create another demonstratorship and two new assistant demonstratorships, improve the Laboratory's teaching system, raise new funds, and expand the stock of instruments. As a result of these improvements, the Cavendish Laboratory would emerge as the University's center for the teaching of experimental physics to undergraduates as well as a center for graduate research.

During Maxwell's stewardship of the Cavendish, the number of students attending the Elementary Lectures given by demonstrator Garnett had increased beyond the capacity of a single teacher. Garnett's lecture courses drew from 18 to 42 undergraduate students and "from 2 or 3 to about 20" of the more advanced students who conducted private studies at the Laboratory.[11] When Garnett resigned his post for a college job, Rayleigh asked the Vice-Chancellor to divide Garnett's duties and stipend into two demonstratorships at salaries of £75 each per year. The Vice-Chancellor obliged, and in the fall of 1880 Rayleigh appointed R. T. Glazebrook and W. N. Shaw, two able researchers who had worked with Maxwell, to the new positions.[12]

In creating the additional demonstratorship, Rayleigh had two goals. The first was to strengthen the Cavendish's teaching system. The second was to ease the burden on the individual demonstrator so he could pursue his own research. The demonstratorships indeed offered "the best possible training for independent teaching posts both in Cambridge and elsewhere."[13] Each demonstrator was expected to fulfill his teaching responsibility by attending the Laboratory from 10:00 a.m. to 5:00 p.m. three days a week. "On the other three days [they] were free for research work, College duties, or private teaching, as the case might be."[14] In time, both new demonstrators were appointed to additional University teaching posts: in 1884 Glazebrook became Mathematical Lecturer and in 1887 Shaw

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[10] Ibid., 99-100.

[11] *CUR* (3 June 1879): 676. Maxwell's annual report of 1879 gives an idea of the number of students attending the Demonstrator's elementary lectures: for the 1878 Easter term, lectures on Electrostatics and the Elements of Thermo-electricity and Voltaic Electricity, a class of 33; for the 1878 Michaelmas term, lectures on Voltaic Electricity and Electro-magnetism, including the principal electrical measurements required in telegraphic engineering, & on Experimental Mechanics, two classes, together numbering 18; for the 1879 Lent term, lectures on Heat, & on Hydrostatics, two classes, together numbering 42.

[12] *CUR* (15 March 1881): 407; (29 March 1881): 438. It is interesting to note that the official recognition of the establishment of the second demonstratorship by the Senate was long delayed.

[13] *CUR* (2 March 1880): 329.

[14] *A History of the Cavendish Laboratory*, 47-48.

became Natural Science Lecturer. Both men also received remuneration as examiners and their stipends from the University would soon be increased. Thus, although the initial demonstrator stipend had been reduced by half, the real income of the new demonstrators eventually became larger than that of the former demonstrator, Garnett. The Cavendish demonstratorships (and later the assistant demonstratorships) were to become posts highly sought after by Cavendish researchers who wanted to remain at the Laboratory to conduct their own studies.

The first challenge for Rayleigh and his two new demonstrators was designing an efficient teaching system to meet the University's increasing demand for physics education. One source of the growing demand for the Laboratory's services was a flow of students preparing for medical examinations. Since 1875, the Board of Medical Studies (which became the Special Board for Medicine in 1882) had regularly published a list of physics lectures required to be attended by candidates for the first examination for the medical degree (M. B.).[15] These requirements made medical students a large majority of the students attending elementary physics lectures. Another source of the demand was precipitated by changes in the NST regulations made two months before Rayleigh's election, in October of 1879, when the Board of the NST published new regulations to take effect in 1881.[16] In the reformed NST, the elementary and advanced parts of the examination would be taken a year apart, and physics would become a completely separate subject. A third source of demand for physics education stemmed from a highly encouraging recommendation made by the Board for Biology and Geology and the Board for Physics and Chemistry. In December of 1882, the two Boards issued a report in which they deemed it desirable "to encourage Mathematical Students to study Physics not only in books but in the Laboratory, and not to confine their reading to those parts of the subject which admit of Mathematical treatment."[17] To this end, the Boards recommended that the advanced part of the NST be opened to honours graduates of the Mathematical Tripos, a recommendation that was instituted at the University in 1883. Meanwhile, from 1882 on, the MT was divided into three parts. The first two parts were almost the same as those of the 1870s, but the newly introduced third part included higher subjects of mathematics and was open only to wranglers.[18] All these changes in the MT and the NST brought more students to the Laboratory.

To meet the diverse needs of the different groups served by the Laboratory and

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[15] *CUR* (5 October 1875): 15-17. To meet both oral and practical examinations, hydrostatics, heat, and electricity were recommended subjects.

[16] *CUR* (28 October 1879): 64-65; a slightly amended report was published in the next year (*CUR* (10 February 1880): 280-282).

[17] *CUR* (12 December 1882): 225.

[18] See *CUR* (27 February 1883): 423-424, & Wilson "Experimentalists among Mathematicians," 369-371. The more mathematical the MT became, the more central the NST was to physics education. The combination of the MT and the NST then became the major way to train Cambridge physicists: Wilson pointed, "From 1871 to 1881 half of the students emphasizing physics in the NST had already taken the MT, and from 1882 to 1889 about two-thirds taking physics in part II of the NST had already taken the MT (p. 352)."

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