

but Professor Tanner was thoroughly equal to it, and did much to make the meeting the brilliant success it was. In science he will be remembered for valuable researches in the theory of partial differential equations and in some of the most abstruse branches of the theory of numbers. In the recondite theory of the multi-section of the roots of unity he made a considerable advance, and showed that, while having a thorough grasp of the principles, he could express himself to his mathematical readers with lucidity and elegance.

He became a Fellow of the R.A.S. on 1890 January 10, and was made a Fellow of the Royal Society in 1899. His researches will be found for the most part in the *Proceedings of the London Mathematical Society*.

P. A. M.

LIEUTENANT-GENERAL JAMES FRANCIS TENNANT at the time of his death was almost our oldest Fellow, and, though probably scarcely known to the majority of present Fellows, formerly took an active part in the proceedings, contributed many papers, served on the Council, and was President of the Society. The activities of General Tennant's life were those of a geodesist, a soldier, an astronomer, and a Government official, and as these were somewhat intermingled, it will be desirable to give a brief sketch of his career chronologically.

James F. Tennant was born at Calcutta on 1829 January 10. He was of Scotch origin, and was the eldest son of Brigadier-General Sir James Tennant, K.C.B., of the Bengal Artillery, and of Elizabeth, daughter of Charles Pattinson, Esq. He received his education at private schools and at Addiscombe College, the military seminary of the East India Company, from which he passed out with distinction in mathematics in June 1847, and landed at Calcutta as Second Lieutenant in the Bengal Engineers in March 1849. He was at once attached to the Trigonometrical Survey, and joined the party of Captain Strange, who had just then taken over the triangulation of the Western Section of the Great Longitudinal Series from the Sironj base to Karachi. Those who know the scheme of the geodesy of India will recognise this as half of the great span of triangulation which crosses the base of the peninsula, east to west, from Calcutta to Karachi. This work was arduous and beset with much difficulty, and Karachi was not reached until May 1853, and here it was arranged to measure another base to complete the series. This was done by January 1855, and Lieutenant Tennant took a prominent part in the work, being specially entrusted with the levelling operations and the determination of the latitude of Karachi. During this period Tennant married Miss Augusta Dick, by whom he had three sons and one daughter. He was next transferred to the triangulation of the Meridional Series, and held responsible positions, which it is unnecessary to specify in detail. He left the work of the Survey owing to the outbreak of the Mutiny in 1857. In the summer of that memorable year, Lieutenant Tennant,

being on leave, went unofficially to Delhi to watch the course of events, and the Royal Engineers being short of officers, he was kept to serve. It is related in Kaye and Malletson's *History of the Mutiny* that in the assault on Delhi on September 12, to the fourth column was assigned the task of entering the Lahor Gate, and the Engineer officers attached to this column were Lieutenants Maunsell and Tennant. With other officers of the Survey he remained for a time with the fighting forces, and was attached as Garrison Engineer at the siege of Lucknow, being mentioned by General Outram as one of the officers deserving honourable mention.

Tennant then returned to his work on the Survey, but only for a short time. In April 1858, Captain Jacob, the Director of the Madras Observatory, was obliged to return to England (for the second time) owing to ill-health, and Major Worster of the Madras Artillery took temporary charge. On 1859 October 13, Major Worster relinquished the duties to Tennant (now Major), who was temporary Director of the Madras Observatory until October 1860, when Mr. Pogson was appointed astronomer.

It is difficult to trace precisely the incidents of his professional life in the next seven years, but in this period he was occupied in the Public Works Departments in Burma, Bengal, and Madras. His first wife died in 1859, and he married again in 1867, his second wife being Miss Selina Tudor Crawford. A sentence in Sir Clements Markham's *Memoir of the Indian Surveys*, in which Tennant's name is mentioned not infrequently, seems to imply that he took no part in the Trigonometrical Survey in these years. There is one communication only by him to the Royal Astronomical Society about this time, that being on the correction of an error of sextants, and is addressed in 1865 from Akyab, a seaport on the coast of Burma; but his name was soon after brought prominently before the astronomical world in connection with the Solar Eclipse of 1868 August 17-18, which was seen Total from a track across the Indian peninsula. Tennant called attention on January 1867 to the importance of observing this eclipse scientifically. He received the support and help of the Astronomer Royal, and of the Government of India, who supplied the necessary funds, and Major Tennant, with Lieutenant John Herschel and other officers, observed the eclipse from a station near Guntoor.

This eclipse will be alluded to later. In May 1869 Tennant began to make suggestions for observation of the eclipse of 1871 December 11-12, which would also be seen Total from Southern India. Subsequently he was entrusted by the Government with the organisation of the observations of this phenomenon, and he himself observed at Dodabetta with much success. In 1872 Sir George Airy called upon him for help in arranging for observation in India of the Transit of Venus of 1874. The British Association had passed a resolution asking the Government of India to provide instruments and undertake the observation of the Transit, and, armed with this resolution and the authority of

the Astronomer Royal, Tennant addressed the Secretary of State, and after some delay obtained the necessary instruments with the proviso that these were to be eventually transferred to some solar observatory. Colonel Tennant selected Roorkee, a place to which, as he says, he was called by other duty, as his main station, and at once set about building piers, making domes, and preparing observers, these being for Roorkee, besides Tennant who used the Equatorial, Captain Campbell, and Captain Waterhouse, I.S.C., from the Surveyor-General's office at Calcutta. The latter was in charge of the photographic observations, helped by one of his own assistants and two men of the 55th Regiment, trained by Colonel Tennant. Wet collodion plates were used, and the results were pronounced to be excellent. Captain George Strahan observed the Transit at Lahore, and Mr. Hennessey at Mussooree, but not under Colonel Tennant's superintendence. Nevertheless he reduced their observations for comparison, and gave an account of the operations at the three stations in a report published by the Office of Government printing in Calcutta in 1877.

The preface to this report is addressed from H.M.'s Mint, Calcutta, for Colonel Tennant had been appointed Master of Her Majesty's Mint on 1876 January 18, an office that he had previously filled temporarily on various occasions.* He held this post until 1882 February 6, when he retired and came home to England. The writer of this notice well remembers a visit he paid to Greenwich soon after his arrival. Time had made some changes in his outward appearance on which those who knew him ten years earlier could scarcely refrain from comment, but he was full of vigour and eager with proposals for schemes for work to be initiated and carried out during his retirement. Remembering his practical knowledge of photography, it is not surprising that he was chosen as one of the British delegates at the Astrographic Conference held at Paris in 1887. He was elected to the Council of the Royal Astronomical Society in 1885, and was chosen as President in 1890 and 1891. He filled that position with dignity, tact, and judgment. In the first year of his Presidency the medal was not awarded, but in the second year he had the difficult task of delivering an address on the occasion of bestowing the medal to Professor George Darwin for his work on Tides and their influence on the Figures and Motions of the Heavenly Bodies. It is possible that in the preparation of the summary of Sir George Darwin's work, to be found in the *Monthly Notices*, he sought the help of some colleague in the Society, for the subject was rather outside his line of study.

The part that Tennant played in the eclipses of 1868 and 1871

* In this connection it is to be noted that in Kaye and Malleon's *History of the Mutiny* it is recorded that in the early part of 1857 the financial situation at Dehra Dun being somewhat difficult, a scheme for the issue of paper money was adopted on the suggestion of *Captain* (?) Tennant. J. F. Tennant was then Lieutenant.

may be considered in more detail. The first of these eclipses was a notable one in the history of astronomy. There had been no eclipse of importance since that of 1860, when the notion that the prominences are solar was endorsed, and when photography was first employed with any success in eclipse observing. It was Tennant who, in a communication to our Society in March 1867, pointed out that the next step was to decide "whether they are gaseous or composed of solid particles, whether they shine by their own light or by that of the Sun, and even to gather some information as to their constitution," and that the opportunity for doing this would soon present itself. Looking back now from a time when the answers to these questions are commonplaces of astronomy, we may regard the questions themselves as trivial and jejune, but we must remember at this moment that it was Tennant who first asked them. He urged the necessity of observing the eclipse in this sense, and that it was a case in which Government might well help, and this being acceded to, he set a precedent which has since been followed somewhat generously. He, being an Indian official, was naturally entrusted with the organisation, and himself observed the phenomenon from Guntoor. His attempt to photograph the Corona was unsuccessful, which may have been due to haze, but he was able to report a continuous spectrum from the Corona, and one of bright lines from the prominence he examined, whilst the polariscopic observations made by members of his party showed that the Corona is not self-luminous, but shines by reflected light. At the eclipse of 1871 Colonel Tennant was stationed at Dodabetta in the Nilgherry Hills. Trustworthy spectroscopic observations were made and splendid photographs of the Corona, which have now become historic, were taken by Captain Waterhouse and Mr. Hennessey under the superintendence of Colonel Tennant. The conclusion that he arrived at from consideration of his own observations, combined with those of others (*Mon. Not.*, 1872, xxxii. p. 254), is an interesting contribution to the early history of solar physics.

"The following, then, seems to be the constitution of our Sun. There is a nucleus which gives out continuous white light like solid or liquid bodies or even dense gases. Surrounding this is a layer of heavy vapours intensely heated but far less so than the nucleus, and in which, if a state of equilibrium could exist, the heaviest vapours would be lowest. Above this is a layer of glowing hydrogen of very slight density, accompanied by that gas which gives out the line D₃. Still further up, these gases in a cooler state become mixed with what gives out the green line K 1474; and lastly, that alone seems to remain."

Tennant's labours in connection with the observation of the Transit of Venus of 1874 have already been mentioned. It will be remembered that the instruments supplied were to be transferred to some public observatory, and after the operations Colonel Tennant proposed that there should be a solar observatory at Simla, specially for observations with the spectroscope and by photography, and also for the observation of Jupiter's satellites. This proposal was not sanctioned, but it led to the daily photog-

raphy of the Sun by officers of the Indian Survey at Dehra Dun that has gone on for many years past, and has formed, and is forming, such a valuable supplement to the Greenwich series. Tennant was an expert and careful photographer, as was shown by his eclipse results. Perhaps the Greenwich Sun-spot records may also be included in his epitaph.

There are fifty entries to his name in the indexes to the *Monthly Notices*, and he made five contributions to the *Memoirs*. Many of these relate to geodesy, the subject in which he was interested professionally, and some to the eclipses. Besides these there are papers on several other branches. There are some valuable contributions on the optics of reflecting telescopes which were of much help to his friend Dr. Common, and some on other instrumental matters. After his final return to England he appears to have interested himself in cometary orbits, for there are several papers on the subject, but when he had left the Presidential chair he contributed no more, and during the past twenty years has lived in perfect retirement with his daughters at Maida Hill, though he joined the Royal Photographic Society in 1898. As Master of the Mint at Calcutta it is not surprising to find that he felt it his duty to verify the standard weights in his charge, and an account by him of such a verification with the standard weights of England and with the normal standard weight of France will be found at some length in the *Journal of the Asiatic Society of Bengal*, vol. xlix., part ii. 1880. In the previous volume of the same publication there is an account by him of some experiments of coining silver into rupees; and in this connection it may be added that he was a strong supporter of the metric system for general use. He was elected a Fellow of the Royal Society in 1869, but made no contributions to the literature of that body.

He died on 1915 March 6, at the age of 86. His first family consisted of three sons and one daughter, of whom two of the sons now survive. By his second wife, who died in 1878, he had three daughters; all of whom are now living.

A crayon portrait, acquired by his bequest, hangs in our rooms. He was elected a Fellow of the Society on 1855 June 8.

H. P. H.

MICHAEL FOSTER WARD, of Ogbourne St. Andrew, Wiltshire, and Bannerdown House, Batheaston, was the eldest son of Mr. Thomas Rawdon Ward, and was born at Round Oak, Englefield Green, Berks, on 1826 March 12. He was educated at Eton College, and subsequently held a commission in the 90th Light Infantry. On leaving the army he entered fully into the duties and life of the parish and county, and at the very commencement of the Volunteer movement he raised the North Wilts Volunteers and commanded them till 1881.

When frequent attacks of sciatica necessitated his going abroad, Colonel Ward first spent some years in Switzerland, and