MEMOIR

OF

WILLIAM A. NORTON.

1810-1883.

BY

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PREPARED FOR THE NATIONAL ACADEMY.

BIOGRAPHICAL MEMOIR OF WILLIAM A. NORTON.

Professor WILLIAM AUGUSTUS NORTON was born in East Bloomfield, New York, October 25, 1810, and died at his home in New Haven, Connecticut, after an illness of but a few days, within a month of the completion of his seventy-third year.

His boyhood was passed in that part of Western New York which was, even in those early days, noted as being one of the centres of literary culture of the State, and which has produced so many men eminent in literature, science, and jurisprudence.

Of his early days, one of his life-long friends, who knew him intimately in his boyhood, writes: "I can recall nothing remarkable except his devotion to study and the sweet and sunny temperament which made him so great a favorite during his later years."

It would hardly be possible to find more fitting words to describe the predominant traits of Professor Norton's character than this simple tribute from one whose affectionate regard continued from their common childhood until his death. His "devotion to study" through a long and active career, uninterrupted for more than half a century, kept him constantly in the foremost rank of scientific writers and investigators, while the sweet and sunny temperament of the boy became developed into those high attributes of a strong manly character which gave him the powerful influence which he always held and maintained as an instructor of youth. During the whole of his long and active career as a teacher in the highest departments of the mathematical and applied sciences it was one of the remarkable traits of his character that he seemed to draw his students near him and secure their devotion to their studies, not only by his own enthusiasm in his work and his skill in presenting his subjects, but by a rare combination of personal accomplishments, in which dignity of demeanor and cheerful sympathy with those under his instruction invited the utmost familiarity consistent with serious and honest work on the part of the learner.

Professor Norton was graduated from the U. S. Military Academy at West Point with high honors, July 1st, 1831, in a class which embraced among its distinguished members Professor Roswell Park, Colonel Henry Clay, Jr., General A. A. Humphreys, and others, whose reputations have become national. He was assigned to the 4th Artillery, but was immediately ordered to the Military Academy to act as assistant professor of natural and experimental philosophy, which position he held until he resigned from the army in 1833. During this time he was temporarily detached from the Academy for a few months to serve in the Black Hawk expedition of 1832.

His resignation was the result of a call to the professorship of natural philosophy and astronomy in the University of the City of New York. His reputation as a teacher in science was thus prominently recognized at a time when positions of such responsibility were rarely offered to young men of his age. Professor Norton remained at the University of the City of New York six years, when, in 1839, he was called to the chair of mathematics and philosophy in Delaware College, Newark, Delaware. He occupied this position for ten years, becoming president of the college during the year 1850.

In 1850 the professorship of natural philosophy and civil engineering in Brown University, Providence, Rhode Island, was offered to President Norton and accepted by him, and he removed to Providence, where he remained until 1852, when he was elected professor of civil engineering in the Sheffield Scientific School of Yale College. He entered upon his duties in Yale College in the autumn of 1852 with a class of students who had followed their instructor from Brown University.

"Since then to the day of his death," writes one of his old pupils and afterwards his colleague in the Sheffield Scientific School, Professor A. J. Du Bois, "he has ever been found at his post of duty, and many of his old pupils, now filling responsible positions throughout the length and breadth of our country, will testify to the practical value of his instruction, to his great capacity as a teacher, and to his character as a man." "A teacher's best testimonial is the esteem and respect of his pupils, his best reward their love and confidence; and in this respect Professor Norton stood very high."

"No teacher ever had more loyal students. It has been the privilege of the writer to be once his pupil, afterwards his colleague, and always his friend; and during that period of seventeen years he has never met or known any student to entertain any doubt of Professor Norton's entire impartiality, his skill and fidelity as a teacher, or his friendly interest as a man." "With a manner peculiarly genial and endearing in the class-room, frank and manly always, and sometimes almost jovial, he made every student feel that his instructor was also his personal friend." "Ever ready with suggestions, advice, and encouragement, always young at heart himself and believing thoroughly in the young men he taught, he was much more to them than the subjects he taught, and his personal influence was better than books."

Testimonials like this might be multiplied, and the writer of this memorial for the National Academy begs to add his own tribute of affection and regard, not only as a former colleague in the staff of instructors of the Sheffield Scientific School, but as a near neighbor and friend for many years. Whatever may be the loss to science, to the cause of education, and to the community in which he lived his death falls most deeply upon those who knew him best in those unreserved social relations which bring men nearest to each other—the relations of neighbors, friends, and companions.

In all these he was noble and chivalric, warm-hearted, sympathetic, and true.

Professor Norton's contributions to scientific literature began at an early day. While he was a professor in the University of the City of New York he prepared a work on astronomy, designed as a text book in colleges and academies. This work, embracing over four hundred pages, was published by Wiley & Putnam in 1839, and was entitled "An Elementary Treatise on Astronomy."

It gave a systematic and comprehensive exposition of the theories and the more important practical demonstrations connected with astronomical problems, and also some of the more useful astronomical tables.

Of this work it may be said that it was designed to meet the wants of the student of practical astronomy, and was not intended to be a popular work. It undoubtedly constituted one of the best sources of practical knowledge of the subjects treated that existed at the time in this country. Great interest was then felt in geographical explorations and the vast unknown regions of our own country. Since then the field of operations of so many costly and important exploring expeditions and surveys seemed to call for methods as well as men in the near future and demanded an exposition of the practical branches of astromomy suited to the rising generation of students and explorers. As a contribution to the scientific wants of the country at that time this work of Professor Norton was in every respect timely and appropriate in its general features and in the treatment of the subject.

In the fourth edition, published in 1881, the tables were revised, corrected, and enlarged, and the chapters which treat of astronomical instruments, comets, the fixed stars, and the zodiacal light were almost wholly rewritten.

Professor Norton published, in 1858, another work entitled a "First Book of Natural Philosophy and Astronomy," and it was during the period of his most active work as a teacher in Yale College that he prepared the numerous contributions to the advancement of science which gave him increased reputation, and on the merits of which he was elected to the National Academy of Sciences.

His scientific memoirs were mostly published in the American Journal of Science, but occasionally in other journals, or were read before scientific societies of which he was a member.

The following list comprises some of the more important of these contributions:

Terrestrial Magnetism. Am. Journal of Science. Second Series. Vol. IV.

Periodical Variations of the Declination and Directive Force of the Magnetic Needle. American Journal of Science, 1855.

Ericsson's Caloric Engine. American Journal of Science, 1853.

Donati's Comet. Two Memoirs. Am. Journal, 1859, 1861.

Molecular Physics. Two Memoirs. Am. Journal, 1864, 1872.

Principles of Molecular and Cosmical Physics. Am. Journal, 1870.

The Corona Seen in Total Eclipses of the Sun. Am. Journal, 1870.

Physical Constitution of the Sun. Am. Journal, 1871.

Dynamical Theories of Heat. Am. Journal, 1873.

Laws of the deflection of beams exposed to a transverse strain. Tested by experiment. Proceedings of the American Association for the Advancement of Science, 1870.

Physical theory of the principle of the lever. Proc. of the Am. Association, 1870.

Results of experiments on the set of bars of wood, iron, and steel, after transverse stress. Two papers read before the National Academy of Sciences, April, 1874, and April, 1875.

A succinct statement of the conclusions of the two papers. Published in the Am. Journal of Science, April, 1876.

Result of experiments on contact resistance. Read before the National Academy of Sciences, April, 1876. Pub. in American Journal, June, 1876.

It would be hardly possible within the space which is allotted to this memorial to do full justice to these scientific papers by attempting to set forth in any manner of detail their valuable features.

They belong to the history of modern scientific progress, in which field, notwithstanding the constant demands on his time as a teacher, Professor Norton did his full share of work.

It is to be especially noted of them all, however, that they were on special subjects which, at the time they were written, stood in the front rank of scientific inquiry, and occupied the attention of the best minds of the period.

A few only of these papers can be discussed in illustration of these facts.

Among the first, in point of time, appeared the paper on Ericsson's Caloric Engine, 1853.

The important developments of the dynamic theory of heat by Clausius, Rankine, Joule, and others, the first accounts of which were published in the English and European scientific journals, had but just reached this country; and, indeed, the full significance of the discoveries had scarcely yet been fully appreciated by scientific men anywhere, when Mr. Ericsson, with the far-reaching practical turn of a mind which has given to the world so many valuable improvements in mechanical constructions, conceived the idea that by the use of air in place of steam as a medium of heat in the cylinders of engines not only would great economy but other incidental advantages of no less importance result from the process. With the boldness in putting his conceptions into practice and the wonderful skill as a mechanical engineer which have always characterized his labors, and which have led him to so many triumphs, Mr. Ericsson planned the construction of an ocean steamship to be propelled entirely by heated air. The effort, the ingenuity of the mechanical constructions, and the partial success attained were worthy of the genius of the great engineer.

But there were elements in the problem proposed by Ericsson of a character intimately connected with the newly-developed theory of heat which were unseen and unsuspected by him, the want of knowledge of which rendered his great experiment a practical failure.

An experiment intended to revolutionize the motive power of sea-going vessels, planned on such a large scale, and executed at great expense, did not fail to attract the notice of scientific men; and yet there were few in this country who had the ready preparation required to analyze the difficult problems involved. Captain J. G. Barnard, of the U. S. Engineers (afterwards General Barnard) and a member of this Academy, and Professor Norton, each entered zealously upon the discussions independently of each other, and each arrived at the same general results, although Professor Norton had more to do with the practical testing of the engines of the new ship " Ericsson."

Professor Norton found the energy developed by the ponderous engines of the "Ericsson" to be 300 horse power only.

The amount claimed by the inventor previous to the trial was 600 horse power—double the power actually developed. The volume swept through by the working pistons per indicated horse power was 108 cubic feet per minute. The investigations of Professor Norton brought out several important facts. First, the great bulk of the engine for a given power and the smallness of the mean effective pressure compared with the initial pressure, requiring great strength and weight as well as bulk. The quantity of fuel consumed for each horse power per hour was found by Professor Norton to be 1.87 lbs. of anthracite coal. The efficiency of heated air as a fluid in the cylinder exceeded that for steam as the latter was used at that time, but the difficulty of heating the air without great waste of heat proved to be another obstacle to success. These difficulties have never yet been remedied, and the hot-air engine has ceased to be considered a prime mover of great importance.

Professor Norton's investigations in connection with the " Ericsson's " engines have been repeatedly referred to since, by writers on prime movers, as having, at that early day, established truths in regard to hot-air engines unfavorable to their use, at least on a large scale, which have become universally settled convictions.

Professor Norton's memoirs on the probable cause of action which produces the tails of comets (American Journal, 46th volume) gained for him the reputation of thoughtful and skillful investigator in a class of problems connected with the highest branches of physics.

His ideas of a repulsive action on the sun, in the matter of the comet, combined with the joint repulsive action of the nucleus, was worked out in such a way as to show the forms assumed by the tails of comets under certain conditions, particularly that of the Donatti comet.

The same idea had, unknown to Professor Norton, been suggested by Bessel, but the latter did not include in his theory the joint repulsive action of the nucleus of the comet, nor did he develop the theory to the same extent as Professor Norton.

The Proceedings of the American Association for the Advancement of Science for 1870 contains a paper by Professor Norton of great interest to engineering science on the "*Laws of the deflection of beams exposed to transverse strains, tested by experiment*," and two papers of the same character were read before the National Academy of Sciences, April, 1874, and April, 1875. The experiments on which these papers were based were conducted with great care, by means of a delicate apparatus devised by himself, and the results obtained indicated the existence of laws connected with the set and strength of materials under transverse stress which had not before been suspected, and constitute important additions to knowledge on these interesting subjects.

A succinct statement of the results of his experiments and of the general conclusions as set forth in his several papers on the subject appeared in the American Journal of Science, Vol. XI, June, 1876.

Of his papers on Molecular Physics it may be said that he left unfinished a work to which the most earnest study of his life had been devoted. The papers on that subject, alluded to above and published from time to time in the American Journal, were but studies upon which he had built, in his own mind, a complete work, already begun and partly executed at the time of his death. This work he regarded as of greater scientific importance than all other efforts of his life, and he hoped by its publication to render a lasting and important benefit to science in connection with a subject which, though still to a great extent speculative, seems to be gradually yielding to the continued advances of mathematical and physical investigation. Few men have devoted more thought to a subject which, from its being peculiarly devoid of popular interest, must continue perhaps for a long time to present to its votaries the certainty of controversy only, instead of praise or any hope of sympathetic appreciation. The inherent difficulties of the investigations seemed only to stimulate Professor Norton during the later years of his life to continued study, until his conceptions had taken clear and definite shape capable of being formulated into laws expressed mathematically. Unfortunately the manuscripts he left, comprising the first two or three chapters only of his intended work, are not sufficient to enable any one else to complete the work, or even to do it justice in a partial presentation of the subject. The general basis on which he intended to build may, however, be understood from the following general summary or statement, which includes the fundamental hypotheses upon which he bases his theories.

1. "All the phenomena of material nature result from the action of force upon matter."

2. "All forces in operation in nature are traceable to two primary forces, viz: Attraction and repulsion."

3. "All bodies of matter consist of separate indivisible parts, called atoms, each of which is conceived to be spherical in form."

4. "Matter exists in three forms essentially different from each other: These are, first, ordinary or gross matter, of which all bodies of matter directly detected by our senses, either wholly or chiefly, consist; second, a subtile fluid, or ether, associated with ordinary matter, by the intervention of which all electrical phenomena originate or are produced. This electric ether, as it may be termed, is attracted by ordinary matter, while its individual atoms repel each other; third, a still more subtile form of ether, which pervades all space and the interstices between the atoms of bodies. This is the medium by which light is propogated, and is called the luminiferous ether, or universal ether. The atoms, or "atomettes," of this ether mutually repel each other, and it is attracted by ordinary matter, and is consequently more dense in the interior of bodies than in free space."

5. "Heat in all its recognized actions in matter manifests itself as a force of repulsion."

Hypotheses like these must be assumed, in order to facilitate investigations concerning the laws of phenomena as to the occult molecular structures and motions of matter with which such phenomena are supposed to be connected, and the direction of Professor Norton's investigations were in an advanced line of thought, which is attracting more and more the attention of physicists.

Throughout a life thus devoted to duty as a teacher and to the advancement of science Professor Norton was cheered and sustained by the companionship of one who sympathized with all his labors and with all the good impulses which filled the measure of his days.

In 1839 he married Miss Elizabeth Emery Stevens, of Exeter, New Hampshire, who survives him, beloved and cherished by a large circle of friends for her estimable character, and especially dear to them now in the time of her affliction.

Those who have partaken of the hospitalities of their cheerful home in New Haven, or who have been welcomed to their little hill-side summer cottage overlooking the beautiful lakes and valleys of Holderness, New Hampshire, will ever remember the "unity of spirit and the bond of peace" which pervaded their lives, and the cheerful gaiety, so natural and unaffected, that gave a charm and delight to their friendly greetings.

Professor Norton belonged to that rare class of men who in pursuing the even tenor of their duties to the end of long and laborious careers, leave as their best and most precious legacies memories and records of lives without reproach, and of unselfish devotion to their duties and to their fellow-men.