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JOHN MILLINGTON, CIVIL ENGINEER AND TEACHER
1779 - 1868

A Thesis

Presented to

the Faculty of the School of Education

The College of William and Mary in Virginia

In Partial Fulfillment

of the Requirements for the Degree

Master of Arts

---

by

Lavonne Olson Tarleton

1966

APPROVAL SHEET

This thesis is submitted in partial fulfillment of
the requirements for the degree of
Master of Arts

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ABSTRACT

John Millington was an English civil engineer and teacher of science and engineering in England and in the United States during the first half of the nineteenth century. He was Professor of Chemistry, Natural Philosophy, and Civil Engineering at the College of William and Mary in Williamsburg, Virginia, from 1836 to 1848.

The purpose of this investigation was to examine the life of John Millington with particular reference to his professional life as an engineer and teacher of engineering. His twelve year association with the College of William and Mary was examined in detail in order to assess his approach to engineering education during this early period in the development of formal college training for engineers. The content of the scientific and engineering courses and the method of instruction at William and Mary College were compared with that of some other engineering schools in the United States during the same period. The level of engineering competence that could be attained by Millington's students was evaluated.

Millington intended his engineering students to supplement their college education with on-the-job training in some subordinate role under the chief engineer of a public works project. It was concluded that his students were well trained in mathematics, science, and engineering and, after their practical experience, should have been competent engineers. Millington wrote one of the first textbooks in English on civil engineering.

JOHN MILLINGTON, CIVIL ENGINEER AND TEACHER

1779 -1868

INTRODUCTION

During the years prior to the Civil War there was a clearly defined and ever increasing need for trained engineers in the United States. The economy had changed from agricultural colonies importing all manufactured goods from England to an industrial society; population had continually increased; territorial expansion had resulted in great surges of canal, road and railroad building. Competent engineers were required to accomplish this industrial revolution.

Despite the widespread recognition of the need to create a supply of engineers, there were few facilities available in which to train them. Some of the civil engineers were given formal engineering education at the United States Military Academy or Rensselaer Polytechnic Institute or one of the few liberal arts colleges that had a department of engineering; other civil engineers were trained in pupilage systems originally developed by the New York Canal System and the Baltimore and Ohio Railroad and copied by many other large internal improvements projects. Most of the mechanical engineers were self-taught.

During this first and formative stage in the development of American engineering education, John

Millington appeared on the scene. Millington was an English civil engineer and teacher of engineering for many years during England's first attempts at formal education in engineering. He was Professor of Chemistry, Natural Philosophy and Civil Engineering at the College of William and Mary from 1836 until 1848. Versatile, and with great natural mechanical ability, he brought a rare combination of talents to the College. He had been educated at Oxford and studied law. Upon graduation he turned to engineering which he found to his liking. Millington worked in England as a civil engineer on many public works projects, as an engineering consultant, and as a lecturer of civil engineering and mechanical philosophy at such institutions as the Royal Institution of Great Britain, Guy's Hospital, and London University. At the age of fifty he left England for Mexico to undertake the engineering supervision of one of the Great English Silver Mining Company's concerns. After an unsuccessful attempt to sell scientific equipment in Philadelphia, he took charge of some gold mines in Virginia. At the age of fifty-seven he came to Williamsburg and the College of William and Mary.

Statement of the Problem. The purpose of the investigation was to examine the life of John Millington with particular reference to his professional life as an engineer and teacher of engineering. His twelve year association with the College of William and Mary as the professor of

chemistry, natural philosophy and civil engineering was examined in detail in order to assess his approach to engineering education during this early period in the development of formal college training for engineers. The content of the scientific and engineering courses and the method of instruction at William and Mary College were compared with that of some other engineering schools in the United States during the same period. The level of engineering competence that could be attained by Millington's students was evaluated.

The development of engineering education through about 1850 is outlined in the first chapter of this thesis to provide a background from which to evaluate Millington's contributions. The second chapter contains a brief biography of Millington, emphasizing his professional life and his twelve years at the College of William and Mary. The third chapter includes a discussion of engineering education at the College of William and Mary and at other schools in the United States during Millington's tenure at the College; curricula, course content, and methods of teaching at the different schools are outlined and compared.

Sources. The main sources on the history of engineering education were three well-documented general studies by Charles R. Mann, Daniel H. Calhoun and James G. McGivern. In addition, several specific studies of the United States Military Academy and of Rensselaer Polytechnic Institute

yielded more detailed information on the professors, curricula, course content, teaching methods, textbooks, etc., of those schools between 1836 and 1848.

The primary sources for the life and works of John Millington were a combination of published works by Millington and unpublished manuscripts and documents by, to and about Millington. All the unpublished manuscripts and documents referred to in this thesis are preserved in the Archives and the Manuscript Collection of the College of William and Mary. The part of the Millington collection that is preserved in the Archives, in William and Mary College Papers, Folder 108, represents the few manuscripts that were not destroyed during the College fire of 1859 or during the Civil War. The "John Millington Papers" preserved in the Manuscript Collection are an extensive collection of letters, documents and diaries that were saved by Millington's family and acquired by the College of William and Mary from the estates of his daughter, Mrs. Kate M. Blankenship, and her son, Frank B. Blankenship, both of Richmond, Virginia.

The earliest of Millington's diaries to be preserved are for the year 1832. Other diaries have been preserved, in whole or in part, for the years 1835, 1847 and 1861-1868. Millington was meticulous in keeping his diaries; he recorded all his activities each day, the letters written and received, an account of all financial transactions, even his state of health. Since Millington's productive life as an engineer and teacher ended before the Civil War, that period of his

life after about 1860 was outside the scope of this thesis and the diaries for those years were only briefly examined. The author hopes that someone interested in Civil War history will study Millington's diaries of 1861 through 1868 in more detail since they are a rich source on life during the Civil War in Tennessee and in Philadelphia and immediately after the War in Richmond as experienced by an old man sympathetic with the South.

The authenticity of the letters, diaries and manuscript lecture notes written by Millington seems indisputable since those preserved by the College and those preserved by his family are all in the same handwriting.

The primary sources for the third chapter dealing with education at William and Mary College were William and Mary College Catalogues for the sessions 1836-37 through 1845-46. These catalogues are preserved in the William and Mary College Papers, Folders 61, 62 and 63, in the Archives of the College of William and Mary.

CHAPTER I

THE ORIGINS OF THE AMERICAN ENGINEERING SCHOOL

Engineering is a very old profession. Certainly every ancient army had its military engineers. Many of the works of the ancient civil engineers still stand: the monuments and hydraulic works of the Egyptians and Babylonians, the buildings of the Greeks, the roads and aqueducts of the Romans.

The Romans may have had some type of formal program to train engineers. The Emperor Constantine wrote in the fourth century:

> We need as many engineers as possible. As there is a lack of them, invite to this study persons of about 18 years, who have already studied the necessary sciences. Relieve the parents of taxes and grant the scholars sufficient means.[1]

The distinguished Roman Marcus Pollio Vitruvius, who has been called the ancestor of today's engineer and architect, wrote ten short books on architecture which may have been used as textbooks. These books treat all that was then known and practiced in civil and military engineering, including such topics as building materials, public buildings,

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[1] James Gregory McGivern, First Hundred Years of Engineering Education in the United States (1807-1907) (Spokane: Gonzaga University Press, 1960), p. 5.

interior decorations, machines, and hydraulic engineering.

From the post Vitruvius held as inspector of military engines under the Emperor Augustus and his description of the nature of warfare and warlike engines, it appears that specialization had not yet occurred to distinguish the professions of civil engineer, military engineer and architect. In time, the engineer and the architect came to rank as separate professions. The architect concerned himself with the construction of all public and private buildings; the engineer designed and built the roads, canals, waterworks, mills and machinery needed by the community, as well as the fortresses and machines of war needed by the army. It was not until the eighteenth century that engineering separated into the branches of military and civilian or civil. Under Louis XV in France and during the industrial revolution in England, engineers were trained specifically to build bridges, roads and canals for the internal improvement of the country. The first use of the title "civil engineer" seems to have been by John Smeaton of England around 1760. Further specialization of the civilian engineer into civil, mechanical and mining engineer occurred in the late 18th century in France, the early 19th century in England and the middle of the 19th century in America.

The French: Pioneers in Engineering Education. If formal engineering education was born during the Roman civilization, it was reborn in France during the reign of

Louis XV. The first school of engineering was formed in 1747 by Jean Rodolphe Perronnet, the chief engineer of the Royal Corps des Ponts et Chaussees, who was charged by Louis XV with the responsibility for:

> . . . the direction and supervision of surveyors and designers of plans and maps of the roads and highways of the realm and of all those who are appointed and nominated to said work; and to instruct the said designers in the sciences and practices needful to fulfilling with competency the different occupations relating to the said bridges and highways.[2]

In order "to instruct the said designers," Perronnet organized the school he established into three classes:

> . . . the first composed of under-instructors or under-engineers; the second of employees called eleves; and the third of young men of less education who are admitted to work in the office as auxiliaries.
> . . . the employees of these three classes not otherwise employed will report to the office of Perronnet daily, Sundays and holidays excepted, from eight to noon and from two to eight.
> . . . during the summer, the employees are to be distributed among the principal works in progress, to execute maps and plans.[3]

The students were state employees and the instructors were professors from the universities, engineers in the Corps des Ponts et Chaussees, and upperclassmen in the school. The curriculum required three years of study. In 1798 the school was renamed Ecole Nationale des Ponts et Chaussees and became one of the schools attached to the Ecole Polytechnique Institute.

The organization of this school of higher technical

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[2] Ibid., p. 8.

[3] Ibid., p. 9.

education independent of any university was copied by other European countries and by several schools in the United States. The graduates of the Ecole des Ponts et Chaussees were responsible for rapid improvements in the art and science of bridge building in France and other countries, especially England, and for advances in hydraulics and other branches of civil engineering.

A school of mining and metallurical engineering was organized at the Paris mint in 1778 to teach mineralogy, assaying and metallurgy. This school became the Ecole des Mines in 1783 when the Corps des Ingenieurs des Mines was created to promote and regulate the mineral industries of France. As with the Ecole des Ponts et Chaussees, this school was purely professional in nature, taught only the theoretical and scientific aspects of engineering, and made no effort to reproduce industrial operations in laboratories. The French technical schools operated on the principle that the art must be learned where practiced; thus, the students were placed in the mines during vacations. In 1864, Columbia University modeled its school of mines after this school which, by then, was called the Ecole Nationale Superieure des Mines.

In 1788, the Duc de Rochefoucauld founded an industrial school for the sons of non-commissioned officers in his regiment. The school was nationalized in 1799 as a training school for shop superintendents and named the Ecole National d'Arts et Metiers. This school was the first

of the mechanic arts type of engineering school and its curriculum was later adopted in the United States in 1868 by Worcester Polytechnic Institute.

During the French Revolution all schools, military as well as civil, had been suppressed. The effect of this suppression was first felt in the army and in public works. To compensate, the National Convention established the Ecole des Travaux Publics in 1794 in Paris to advance scientific knowledge and in particular to train military and civil engineers. This school became the Ecole Polytechnique Institute a year later, the name being a protest against the almost exclusive devotion to literary and abstract studies then common in the French universities. This school soon became the most outstanding scientific school in the world. Admission was open to all and based on difficult competitive examinations, chiefly in mathematics. The faculty boasted such brilliant men as Gaspard Monge and Hachette in descriptive geometry, Lagrange and Laplace in mathematics, Prony in mechanics, Delorme and Baltard in architecture, and Fourcroy and Berthollet in chemistry. These men and their successors were mainly responsible for the technical literature of France. The two-year curriculum emphasized pure science and mathematics preparatory to entering one of its engineering schools, such as the Ecole des Ponts et Chaussees or the Ecole Centrale. Here for the first time engineers were being trained in fundamental science by means of laboratories and experiments.

The Ecole Polytechnique contributed a great deal to early American engineering. Many of the graduates worked as engineers and teachers in the United States while in political exile during the Napoleonic Wars. The engineering curriculum at the United States Military Academy was first developed by Claude Crozet, a graduate of the Ecole Polytechnique and perhaps the first professor of civil engineering in the United States. The bulk of the technical literature came from the staff and graduates of the Ecole Polytechnique, which is one reason most American engineering students were required to study French.[4]

The last French school of importance to the development of American engineering education through the first half of the nineteenth century was the Ecole Centrale des Arts et Manufactures, established in 1829. The basic curriculum that Rensselaer Polytechnic Institute adopted in 1849 was largely adapted from that of the Ecole Centrale and became the model for the curricula of most American engineering schools.[5]

The English: Proponents of the Pupilage System. During the middle and latter half of the eighteenth century the need for civil engineers became acute in England. The Industrial Revolution produced a demand for internal

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[4] Ibid., p. 61.

[5] Ibid., pp. 59-60.

navigation between factories and from warehouses to harbors for the transport of raw materials and finished goods. "Hence arose those wonderful works, not of pompous and useless magnificence, but of real utility, which had the effect of rendering Great Britain pre-eminent as a manufacturing country."[6]

The engineers who built "those wonderful works" were products of the pupilage system, the accepted form of professional training. Thomas Coates wrote, in 1835:

> At present Civil Engineering can only be learned at enormous expense in the office of a professional man, who requires a fee varying from £ 1,000 to £ 500 for five years' pupilage.[7]

John Millington described the problems of a young Englishman trying to become an engineer:

> The subject of Civil Engineering is one upon which much has been written by some of the first scientific characters of the world; but their writings are so diffuse, so various, and so detached on account of their investigations having been directed to particular objects, that there is perhaps no branch of science in which the student or young beginner finds so much difficulty in obtaining the knowledge necessary to qualify him for his business, as in Civil Engineering. Among the almost numberless works which the presses of Great Britain and France issue annually, it is surprising that no attempt has yet been made (to the knowledge of the writer) at any thing like a compendium of the science of Engineering. The English nation is even avowedly poor in practical works of this description, for until the formation of the Society of Civil Engineers, of London, and the more recent establishment of the Institute of Civil Engineers, the persons who followed the profession appeared to harbour a jealous

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[6] John Millington, Elements of Civil Engineering (Philadelphia: J. Dobson, 1839), p. 20.

[7] W. H. G. Armytage, A Social History of Engineering (New York: Pitman Publishing Corp., 1961), p. 149.

> suspicion of their modes of operating and proceeding meeting the public eye; and with the exception of Smeaton's account of the building of the Eddystone Light-house, and that of the building of Essex Bridge, in Dublin, there was scarcely a work of any importance to be found in the English language. Even the papers of Smeaton would, for want of being known, probably have been buried in oblivion on the shelves of some public library, had not the late Sir Joseph Banks and others, into whose hands they fell, found them too valuable to be withheld from the public; and therefore caused them to be published after the death of this justly celebrated man, the father of the Civil Engineering profession. He was followed by Brindley, Jessup, Mylne, Walker, Rennie, Alexander, and several others, who were entrusted with all the great and magnificent works that have been executed in Great Britain; but if we look for any detailed or particular account of their operations, our search must be in vain, for nothing of their proceedings has ever been given to the public. The French, on the contrary, have been much more liberal in their publications, but their works are confined either to scientific investigations or to the account of particular objects, diffused through many large and expensive volumes, so that a student in Civil Engineering had no chance of knowing what had been done on the continent of Europe without access to a large public library; and even if he possessed that advantage it was perhaps useless to him, from not understanding the language the works were written in, or more especially from his possessing no key or directory to inform him where he should search for particular information. Thus circumstanced, the young Engineer had no chance of improving himself, except by his own practical means and observation, aided by the information he might obtain from his master, if employed in the office of an Engineer, and yet such was the state of the profession when the writer embarked in it.[8]

The education of the young civil engineers did not stop at the end of the period of pupilage. Scientific societies were founded to give comradeship and continued training. One such society was founded by John Smeaton in

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[8]Millington, op. cit., pp. v-vi.

1771 in London. The Smeatonian Society originally had sixty-five members, fifteen of them with professional engineering status; its membership included such men as Joseph Priestley, James Watt, and John Rennie. In 1793, a year after Smeaton's death, Rennie reorganized the society which had disbanded for lack of leadership. Renamed the Society of Civil Engineers, the membership was divided into two classes: real engineers employed as such and honorary members. This was the first engineering society to be founded in the world.

In 1818 the Institution of Civil Engineers was founded, requiring that members ". . . shall have been regularly educated as a Civil Engineer, according to the usual routine of pupilage."[9] This institution was organized specifically to supplement the education of engineers trained by pupilage. Its Royal Charter of 1828 stated:

> Whereas Thomas Telford, . . . and others of our loving subjects, have formed themselves into a Society for the general advancement of Mechanical Science, and more particularly for promoting the acquistion of that species of knowledge which constitutes the profession of a Civil Engineer . . .[10]

Many English workmen, who had learned their trade by a seven-year apprenticeship, advanced to the status of engineer by studying science and mechanics during the evening. In 1789 foundry workers in Birmingham got together to discuss mechanics and natural philosophy. In 1796 the first technical

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[9] McGivern, op. cit., p. 14.

[10] Ibid., p. 105.

college in Great Britain, the Royal Technical Institute of Glasgow, was founded to provide for the instruction of artisans and others unable to attend the university. It was here, in 1800, that George Birkbeck, M. D., enrolled seventy-five workmen for a series of lectures "abounding in experiments, and conducted with the greatest simplicity of expression and familiarity of illustration, solely for persons engaged in the practical exercise of the mechanic arts."[11] In 1823 the London Mechanics' Institution was founded by Birkbeck, John Millington, and others, based on Birkbeck's experiences in Glasgow. This was the start of the mechanics' institute movement; by 1850 there were seven hundred mechanics' institutes in Britain with a membership of 120,000. John Millington described the London Mechanics' Institution which he helped found:

> This difficulty, in the way of acquiring knowledge among the working classes of society, was in a great measure obviated in London by the establishment of the London Mechanics' Institution, of which the author had the honour of being one of the founders and first vice-presidents. Its beneficial influence was soon felt, and many similar societies soon arose out of it, in different parts of the kingdom, as well as in foreign countries. Working men seldom purchase books, and do not in general like to sit down to reading when the labour of the day is over; but they are always ready to attend a lecture for an hour in the evening, and to listen to good and useful instruction, provided it is given to them in a plain, simple, and intelligible form. The truth of this position is amply proved by the progress of the London Mechanics' Institution, which had not been long opened before it was joined by 1200 of the working artizans of London, who came to it voluntarily and without persuasion. The numbers being large,

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[11] Armytage, op. cit., p. 143.

> the expense was small. Each member paid an admission fee of 62 1/2 cents, and an annual contribution of $1 50. The sons and apprentices of members were admitted at the rate of 62 1/2 cents per annum, their parents or guardians entering into bond for their good and orderly conduct. Small as this sum may appear, it enabled the society to purchase and alter a large house into a lecture room, capable of holding between seven and eight hundred persons, and to fit up a library and chemical laboratory, which were well stocked with books and apparatus. In this place a plain and simple lecture, connected with science or the useful arts, was delivered every evening at eight o'clock, and the books of the library were circulated among the members. All political and religious subjects were excluded from discussion; and the author, from his own experience, can assert, that during the several years that he was connected with the institution, a better conducted, orderly, and more inquiring audience, never assembled in any public place. Hundreds, who would have spent their evenings and money in taverns and public houses, were thus quietly enticed away and gradually instructed in the rudiments of science and morality, without any trouble to themselves, and their minds and habits ameliorated at the same time. The lectures were in general gratuitously delivered by the friends and patrons of the society.[12]

An early attempt to found an engineering school was made in 1799 with the founding of the Royal Institution of Great Britain by Benjamin Thompson, Count Rumford. Count Rumford described this school as:

> . . . a public institution for diffusing the knowledge and facilitating the general introduction of useful mechanical inventions and improvements, and of teaching, by courses of philosophical lectures and experiments, the applications of science to the common purposes of life.[13]

The Royal Institution had on its staff such men as Sir Humphrey Davy, Thomas Young, Michael Faraday, and John

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[12] Millington, op. cit., p. 10.

[13] McGivern, op. cit., p. 14.

Millington. Millington described himself as Professor of Mechanics in the Royal Institution of Great Britain and said he gave lectures on mechanical philosophy and on the steam engine. His first book, An Epitome of the Elementary Principles of Natural and Experimental Philosophy, published in 1823, included:

> the essential parts of a popular course of Lectures on the Mechanical properties of ponderable matter, which he [Millington] has had the honor of delivering several times before the Members of, and Subscribers to, the Royal . . . Institution, . . . to which he has likewise added, the leading features of a distinct Course upon the Steam Engine, as read at [the Royal Institution] . . . in the winter of 1819.[14]

France and England Compared. A comparison of the first hundred years of French and English engineering education is striking. The French engineers were educated in highly organized, nationalized schools which offered rigorous curricula in pure science, mathematics, and engineering; the English engineers had on-the-job training in the offices of experienced civil engineers and spent their evenings after work attending lectures and discussions of current engineering opinion, including French advances. Small subscription libraries were formed all over England during the eighteenth century which contained the scientific journals of France, England, Scotland, and the United States. The

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[14] John Millington, An Epitome of the Elementary Principles of Natural and Experimental Philosophy (London: By the author, 1823), p. iii.

English engineers were truly self-made men; their education and scientific societies were independent of government support.

A comparison of the engineering accomplishments of France and England during this period is equally striking. The French and English engineers operated in different political climates. France was engaged in the Revolution and the Napoleonic Wars and civil engineering advances arose from the needs of the army and of the highly centralized government. For instance, the army needed good roads for rapid movement and the government needed them for good communications, so P. M. J. Tresaguet (1716-1796) built the best roads in the world at that time. But in Britain, the government was stable and catered to the interests of the commercial classes. Civil engineers were less likely to be working for the government and more likely to be building the internal improvements needed by industrial enterprises. Lighthouses and harbors were built to further the export trade as well as for naval use. The British policy of keeping the trade routes open provided foreign markets for the surplus goods being produced by the new factory system and created capital to be reinvested in industry.

Thus, while English private enterprise was developing into a great industrial complex, France was absorbed in war and the advancement of military engineering. It was this that led Shortwell to say "... . the wars against Napoleon were not won at Leipzig or Waterloo, but rather in the

cotton factories of Manchester and the iron mills of Birmingham."[15]

When the United States was first developing engineering education, it was faced with this paradox: the French engineers had superior engineering education through the formal training given in the technical schools, yet the English engineers were apparently as successful. It was this success of the English engineers trained by the pupilage system that helped retard the development of engineering schools in both England and the United States. Many of the people in both countries wanted technical schools, but the governments were slow to see the need and provide the money as the French government had. As late as 1870 there were only seven schools in Britain where an engineering education could be obtained and only two of these schools had laboratories and more than one teacher. The engineering schools that were founded in the United States were modeled after the French schools, but it was not until after Congress passed the Morrill Act in 1862 that the more popular mode of educating engineers shifted from the pupilage system to formal college training.

The Americans: First Steps Toward College Training. The need for engineers in the United States grew slowly. It first became acute just after the War of 1812 and the young

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[15] McGivern, op. cit., p. 15.

nation was faced with the problem of how to train civil engineers to build the canals and roads needed by the expanding country. Two approaches were tried: pupilage systems were developed by the New York Canal System that were copied by many other large internal improvements projects, and formal college training of civil engineers was started at the United States Military Academy and a few other schools. These early efforts to train engineers in the United States are traced in this section, but a more detailed look at the curricula of the United States Military Academy and Rensselaer Polytechnic Institute is taken in Chapter III.

The need for trained engineers was everywhere apparent after the War of 1812. Louisiana had been purchased in 1803, the Northwest Territory was rapidly settled immediately after the War, and Florida was purchased in 1819. This territorial acquisition and expansion was accompanied by an increase in population from 5.3 million in 1800 to 12.7 million in 1830. The mileage of public roads, canals, and railroads increased tremendously to accomodate the movement of the increased population.[16] This construction boom lasted from about 1816 until 1837 at the start of the depression that reached its worst stage in 1843.

In 1816, when New York, Virginia, and South Carolina sought engineers for new internal improvements works, they

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[16] Ibid., p. 31.

found that there were no more than thirty available engineers or quasi-engineers in the United States at the time.[17] All these men had had some experience in directing public works, but otherwise their backgrounds differed greatly. Some were surveyors, some contractors or builders, others were landholders and speculators, two were lawyers, some architects, some European military engineers. A few of these thirty men had had some sort of definite engineering training, either in Europe or as assistants to European-trained engineers, but in general they knew little more than just what they had learned on previous jobs. Brigadier General Joseph G. Swift, Chief Engineer of the Army, answered a letter from the Virginia authorities that he knew of no qualified American engineers and recommended that they apply for an engineer to Prony, the director of public works in France.[18]

Faced with the problem of finding engineers, the New York canal system commission which was appointed by the New York legislature to build the Erie and Champlain canals, made an important decision which was to effect American engineering recruitment for many years. Joseph Ellicott, speaking for all the commissioners except Gouverneur Morris, mixed patriotism and financial caution:

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[17] Daniel Hovey Calhoun, The American Civil Engineer: Origins and Conflict (Cambridge, Massachusetts: The Technology Press, M. I. T., 1960), pp. 16-23.

[18] Ibid., p. 20.

> I would recommend employing Americans solely, and avoiding foreigners; they know very little about the management and conducting of business economically in this country; and the truth is the laying out a path for a canal neither requires conjurers nor wizzards [sic]; -- practical nature is every thing that is necessary.[19]

The New York legislature accepted the commission's majority report that "there is every inducement for preferring our own countrymen if the requisite scientific and practical knowledge can be found,"[20] and in April, 1816, organized a new commission without Morris and authorized it to begin construction.

Thus the largest of all internal improvement projects which had yet been undertaken in the United States dismissed the method most successfully used up to then of hiring an experienced European chief engineer and American assistants in favor of using only American engineers. The experienced English engineers William Weston and Benjamin H. Latrobe, who had been responsible for many of the successful canals and waterworks built during the 1790's and 1800's, were rejected along with the idea of trying to recruit an engineer in Europe.

The commission was faced, however, with the problem of creating a supply of American engineers since there were none with the "requisite scientific and practical knowledge," and no American college had yet graduated a civil engineer.

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[19] Ibid., p. 26.

[20] Ibid.

They started with a few "engineers" recruited from other occupations, principally surveyors. The three chief engineers were James Geddes, Benjamin Wright, and Charles Brodhead, all western New York surveyors; Geddes and Wright were judges in the counties in which they resided; Wright had worked as an assistant to William Weston. The commission then established the practice of training assistant engineers on the job by placing each in charge of one section of the canal. One assistant engineer was even sent to Europe to study canal construction. As the assistant engineers were promoted to the rank of principal engineer, those working in the lower ranks in the engineering field parties were promoted to assistant engineer. The men who worked up through this engineering hierarchy became a new kind of engineer: Americans without any technical schooling but with defined experience in a large public-works organization.

By 1825, with the completion of the Erie and Champlain canals, about thirty engineers and assistant engineers became available and sought after for other internal improvement projects. Three of them, including Geddes, became principal engineers in the Ohio canal system and organized much the same system of training and promotion as in New York; the hierarchy consisted of senior resident engineers, resident engineers, senior assistant engineers, and junior assistant engineers. This kind of hierarchical engineer organization with its built-in on-the-job training

system became standard on large internal improvement projects and became an important source of engineers.[21]

The other major source of engineers was developing concurrently: the engineering school. The United States Military Academy was established in 1802 in West Point, New York, for the dual purpose of training army officers and as a national school of civil engineering.[22] The appearance of West Point graduates in civil engineering began in 1818 with one man; by the Class of 1837, there were 231 graduates who worked at some time as civil engineers on internal improvement projects.[23] At least thirty percent of these men were chief engineers of important railroads, canals, or other public works.

The first professor of engineering at West Point was Captain Alden Partridge, the Superintendent of the Academy. He apparently taught little engineering. His successor was Claude Crozet, a French engineer who taught at the Academy from 1816 to 1823. He had been educated at the Ecole Polytechnique and applied its methods and textbooks to the development and teaching of the course of engineering. Crozet was followed by David B. Douglass, who was professor of engineering from 1823 to 1831. Douglass had had no formal training in engineering, but had learned the

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[21] Ibid., pp. 24-37, 47-50.

[22] McGivern, op. cit., p. 32.

[23] Calhoun, op. cit., p. 43.

profession while practicing it as an officer in the Corps of Engineers. Douglass was followed by Professor Dennis H. Mahan, an 1824 graduate of the Academy who had spent four years in Europe studying public works and military institutions and who was, for one of those years, a student in the Military School of Application of Engineers and Artillerists at Metz, France. Mahan remained at the Academy until his death in 1871. His major contribution to engineering education was the preparation and revisions of a complete set of textbooks for his courses, including the first civil engineering textbook written in the United States, perhaps the first written in English: An Elementary Course of Civil Engineering, published in 1837.

Other engineering schools were founded during this period from 1816 to 1837 when engineers were in such demand in the United States. After Captain Alden Partridge left the United States Military Academy, he conceived the idea of a civilian school to train army officers and engineers, patterned after West Point but with no specified time required to complete the program and emphasizing practical rather than theoretical education. Thus in 1819 he founded the American Literary, Scientific and Military Academy at Norwich, Vermont, later renamed Norwich University. By 1837 some 24 to 35 men had graduated who, at some time in their lives, worked as civil engineers; by 1843 another sixteen civil engineers graduated. Norwich University has continued to train civil engineers, but the number of

graduates has always been small.[24]

Rensselaer Polytechnic Institute was founded in Troy, New York, in 1824, but gave only a one-year general technical course during its first decade. This course included some instruction in Mensuration, surveying, and engineering. The course was intended for students who had completed their academic education and its purpose was to prepare teachers for scientific and practical subjects. Through curricular changes, Rensselaer Polytechnic Institute gradually evolved into a school of engineering and technology.

The senior professor, Amos Eaton, was a graduate of Williams College, studied chemistry, geology, and mineralogy at Yale, was then Professor of Science at Williams College where he became famous for his teaching, publications, and explorations. He was senior professor at Rensselaer during its first seventeen years and was responsible for its educational program at that time. His point of view was similar to Partridge's. He believed in a practical education where things, not words, are studied. He criticized the use of mathematics any more advanced than arithmetic in the teaching of engineering; he argued that textbooks were not of any great use in teaching engineering, and said that Mahan's textbook did not cover engineering as a whole but only made interesting reading about engineering materials.[25]

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[24] Ibid., pp. 43-45.

[25] Ibid., p. 45.

Rensselaer Polytechnic Institute first offered a full civil engineering program in 1835, conferring a CE degree after a one-year course. Professor Eaton published a textbook for this course in 1838 entitled Prodromus of a Practical Treatise on the Mathematical Arts: Containing Directions for Surveying and Engineering.

In 1846 B. Franklin Greene became professor of engineering. He had graduated from Rensselaer in 1842 and had been teaching at Washington College since 1843. He was responsible for the reorganization of the Rensselaer Polytechnic Institute in 1849, after having made a careful study of European technical schools. The basic curriculum that was adopted in 1849 was three years in length and modeled after that of the Ecole Centrale des Arts et Manufactures of Paris. The Rensselaer adaptation became the model for other engineering schools in the United States.

The curriculum of Rensselaer was less professional than that of the Ecole Centrale. The students at Rensselaer and other American technical schools were generally graduates of secondary schools, the professors were college-trained men with little, if any, experience as engineers, and the technical school was expected to extend general education beyond the secondary school level as well as teach engineering science courses. There was a large amount of time devoted to the study of English and French in the American schools, not for their humanistic values, but because of the need of college-level training in English and

the need to be able to read French technical publications.

Besides these three most important schools of engineering, many schools added a course in civil engineering in order to meet the demand of the 1830's. These courses were usually taught by professors of mathematics or natural philosophy. The University of Virginia organized a School of Engineering in 1836 that graduated four men in 1839. Other schools that began to teach some engineering between 1831 and 1841 as a minor part of their curriculum were Hanover College (Indiana), University of Michigan, Geneva College, the City Academy (Washington, D. C.), Georgetown College (Kentucky), Elijah Slack's School (Cincinnati), Cincinnati College, Woodward College (Cincinnati), Virginia Military Institute, and the College of William and Mary.[26]

After the depression of 1837 to 1843, several colleges organized schools of engineering that are still important. The School of Engineering of Union College, Schenectady, New York, was established in 1845. Union College produced about half as many civil engineers as Rensselaer; between 1850 and 1865, Union College graduated forty civil engineers and Rensselaer eighty-eight. The Lawrence Scientific School of Harvard and the Sheffield Scientific School of Yale were founded in 1847, the Chandler Scientific School of Dartmouth was founded in 1851, the engineering department of the University of Michigan was organized in 1855.

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[26] Ibid., p. 46.

In summary, when John Millington came to the College of William and Mary in 1836 and started a course in civil engineering, the United States was at the peak of its first great construction boom with the accompanying demand for engineers. Considering the engineering population as a whole, the experience-trained engineer outnumbered the academically-trained engineer and, of the men working as chief engineers of individual projects in 1837, sixty-five were trained on-the-job and only twenty-two were prepared through a formal academic program.[27] However, among the internal improvement projects and schools that were training civil engineers, the United States Military Academy had, by 1837, contributed more civil engineers than any other single organization with over 200 men; the New York Canal System and Partridge's Academy ranked next with about 30 engineers each; Rensselaer contributed about 25 engineers; the other internal improvement projects contributed a few engineers each.

The depression of 1837 to 1843 greatly reduced the demand for engineers and many training programs went into a decline. Between the end of the depression and the Civil War, several more engineering schools were organized, but never were there enough college-trained engineers to supply the demand. It was only after the passing of the Morrill Act of 1862 establishing the land-grant colleges that enough

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[27] Ibid., p. 52.

college-trained engineers became available and the on-the-job training programs declined in importance. Prior to 1870 there had been a total of only 866 engineering degrees granted in the United States; during the single decade from 1871 to 1880, 2,259 engineering degrees were conferred.[28]

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[28] Charles Riborg Mann, A Study of Engineering Education, Carnegie Foundation for the Advancement of Teaching, Bulletin No. 11 (New York City, 1918), p. 7.

CHAPTER II

THE LIFE OF JOHN MILLINGTON

In England. John Millington was born in London on May 11, 1779,[1] the third son of Thomas Charles Millington, an attorney. There is a painting in the Valentine Museum, Richmond, Virginia, of Millington in the arms of his mother, Ruth Hill Millington, drawn from life in the year 1780. He was baptized at St. George's Anglican Church, Hanover Square, and confirmed on March 24, 1796, by Edward Cannon, the Bishop of London, in the Chapel Royal, St. James Palace.[2]

Millington married Miss Emily Hamilton, daughter of the artist William Hamilton, Royal Academy, on December 18, 1802, at the Parish Church of St. James. They had six children of whom three survived childhood:

Emily Mary, born September 30, 1803

Cecilia, born September 8, 1810

Thomas Charles, born January 29, 1816

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[1] John Millington Papers (MSS in the Earl Gregg Swem Library, College of William and Mary), I-8. Undated notes in John Millington's handwriting listing birth dates, his baptism, marriages, and children.

[2] Ibid., V-7.

Millington was a member of the Corps of St. James's Loyal Volunteers and was commissioned as an ensign in the Corps ". . . whereof Geoffry Lord Amherst is Colonel" on January 28, 1805, the commission apparently retroactive to August 27, 1803.[3]

The education of John Millington is not well documented. Millington wrote ". . . in my youth I received a liberal education [at Oxford[4]] and was bred to the law, which I studied in the Temple during five years, and practiced during two years afterwards."[5]

There is additional evidence that Millington studied and practiced law. In the Manuscript Collection of the College of William and Mary there is a certificate dated February 11, 1802, declaring that ". . . John Millington of Golden Square in the County of Middlesex Gentleman is duly qualified to act as an attorney of His Majesty's Court of Kings Board at Westminster and as having this day taken in Open Court" before the King, George III, at Westminster, "the oaths appointed to be taken."[6] There is also a license valid from November 2, 1803, to November 1, 1804, certifying

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[3] Ibid., I-9 and I-12.

[4] George F. Holmes, "Professor John Millington, M. D., 1779-1868," William and Mary College Quarterly (series 2), III (January, 1923), p. 23.

[5] William and Mary College Papers (Earl Gregg Swem Library, College of William and Mary), Folder 108. Letter from John Millington to Professor Joseph Henry, Secretary of the Smithsonian Institution, June 25, 1847.

that ". . . John Millington of No. 34 Golden Square in the Parish of Saint James Westminster in the County of Middlesex Gentleman . . . is duly qualified to practice as an Attorney and Solicitor."[7] A similar license was dated November 2, 1804, expiring November 1, 1805.[8]

"Being always from youth attracted to the Physical Sciences . . . "[9], Millington turned to engineering. His education as a civil engineer was surely acquired from working as an assistant to an experienced engineer. He described the state of engineering education in England at the time he entered the field in the introduction to his civil engineering textbook, previously quoted on pages 13 and 14 of this thesis. He implied that he was educated in the prescribed manner of pupilage. There is no record of the name of his master.

Millington also studied medicine in London. His master and instructor was the renowned Sir Astley Cooper who "gave up one-eighth of his precious time to his charitable attendance in Guy's Hospital."[10]

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[6] John Millington Papers, op. cit., I-10.

[7] Ibid., I-11.

[8] Ibid.

[9] William and Mary College Papers, Folder 108, loc. cit.

[10] John Millington Papers, op. cit., II-23. "Professor Millington's Address" in the Memphis [Tennessee] Daily Bulletin, November 11, 1858.

The question of whether and where Millington received an M. D. is answered by a letter from Dr. S. Calhoun, Dean of the Jefferson Medical College, Philadelphia, to Millington dated March 9, 1838:

> It gives me great pleasure to state that the degree of Doctor of Medicine was conferred upon you by the Trustees of Jefferson Medical College on the unanimous recommendation of the Faculty.[11]

Millington began lecturing at the Royal Institution of Great Britain, London, in 1815, and was appointed Professor of Mechanics there on July 7, 1817. He gave annual courses of lectures on natural philosophy, mechanics, and astronomy until 1829.[12] In a letter dated January 30, 1817, J. Pond of Greenwich answered an inquiry from Millington concerning the determination of the diameters of Jupiter's satellites. Millington was apparently preparing an astronomy lecture because Pond commented that "Bailly invented a very ingenious method of determining those [diameters of the satellites] of Jupiter and which may be easily explained at a lecture." At the end of the letter Pond stated that he would "at all times be most happy to offer the means this place affords of giving you any assistance towards your lectures."[13]

As was the custom at the Royal Institution, the professors frequently sat in on one another's lectures. In

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[11] Ibid., I-68.

[12] Ibid., I-7.

[13] Ibid., I-14.

a letter to Millington dated February 25, 1828, Michael Faraday wrote his regrets at having missed Millington's lecture the previous Friday evening and asked what subject he proposed for the following Friday.[14] Millington attended the geology lectures of William Thomas Brande, who had succeeded Sir Humphrey Davy in the chair of chemistry at the Royal Institution.[15]

Millington helped found the London Mechanics' Institution in 1823 and was one of its vice-presidents and lecturers until 1829 when he left England for Mexico. A description of the purposes and method of operation of this Institution in Millington's own words appears on pages 16 and 17 of this thesis. On the occasion of his departure for Mexico, Millington was presented with a gold snuff box by several of the members of the London Mechanics' Institution. Engraved on the inside of the cover of the snuff box is the following inscription:

THIS BOX
is presented to 1829
JOHN MILLINGTON, ESQ.
CIVIL ENGINEER, etc. etc.
by a few of the Members of the
LONDON MECHANICS' INSTITUTION
in testimony of their sincere respect for his talents and scientific acquirements; of their gratitude for the valuable instructions they have received from him; and of their deep regret at having been unexpectedly deprived of his important services as one of their
VICE-PRESIDENTS.[16]

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[14] Ibid., I-16.

[15] William and Mary College Papers, op. cit., Folder

Millington also lectured on natural philosophy and chemistry at Guy's Hospital, London, and on mechanical philosophy and civil engineering at the University of London. He was one of the original fellows of the Royal Astronomical Society of London and was its secretary from 1823 to 1826. He was editor of the Quarterly Journal of Science, with Brande, and the first editor of the Library of Useful Knowledge to which he contributed several articles, including one on hydraulics.[17]

He published several other technical accounts during his last fifteen years in England, including a paper on the hydraulic ram in 1816 and a paper on street illumination in 1818, both in the Quarterly Journal of Science. His major contribution was the textbook An Epitome of the Elementary Principles of Mechanical Philosophy, published in 1823, and consisting of an expanded outline of the lectures he delivered at the various schools and hospitals of London. According to the preface to the 1830 edition, his book was well received and translated into several languages.

Of his teaching experience in England, Millington had this to say:

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108. Bound volume containing lecture notes, etc., in John Millington's handwriting.

[16] John Millington Papers, op. cit., VIII-1.

[17] Ibid., V-9.

> . . . I became a public Lecturer, by which my reputation spread so rapidly, that I was soon called upon to take the Chair of Natural Philosophy in the Royal Institution of Great Britain as successor to Dr. Thomas Young which situation I filled for nearly 16 years. Indeed until my resignation in consequence of leaving England, I was likewise appointed joint Professor with the late Wilbur Allen in the Medical School of Guys Hospital which I filled 13 years. And had also a Professorship in the London University - was joint Secretary with Herschell and Babbage to the Royal Astronomical Society for 3 years; and was Vice President of the London Mechanics Institute from its foundation to my leaving England. These appointments brought me into daily and intimate intercourse with Davy, Hatchett, Brande, Dr. Wollaston, Faraday and many other distinguished Chemists and Philosophers of London and Paris.[18]

Millington worked as a civil engineer in England for twenty-five years in addition to his teaching. A copy of his rates as an engineering consultant has been preserved and a Xerox copy of this list is included in Appendix A. This advertisement is entitled "A list of the charges ordinarily made by Mr. Millington, Civil Engineer, and Surveyor of Manufacturies and Machinery, together with an enumeration of some of the principal objects to which he directs his professional attention." It illustrates the extent of his activities as a civil engineer. He could design, write up specifications and make working drawings, superintend construction, arbitrate disputes, survey, give instruction in the various branches of science, and design or repeat experiments. In addition he was in the patent

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[18] William and Mary College Papers, op. cit., Folder 108. Letter from Millington to Professor Joseph Henry, June 25, 1847.

business.[19]

There are few records of the specific engineering projects he worked on. He was said to have been associated with McAdams in the construction of the macadam roads which, by 1830, had replaced Tresaguet's system of road building. He was Engineer of the West-Middlesex Water-Works and Superintendent Engineer of the Royal Grounds in London or at Kew.[20]

The best record of Millington's work as an engineer is a pamphlet entitled Reports as to the Extension of the West-Middlesex Water-Works and the Progress of the Same As Presented By Mr. Walker and Mr. Millington to the Board of Directors of That Company, 1810. In it, Ralph Walker, the Engineer of the Water-Works, presented one plan for the building of a new engine-house and extension of the water mains, and John Millington presented a different plan which he said was simpler and much less expensive. Apparently Millington's plan was accepted, because the last two reports in the booklet indicate that he was in charge of the undertaking. Millington's plan shows considerable knowledge of engineering. He was keenly aware of costs and maintenance in designing the waterworks, he took into account the nature of the soil, the tides, etc. Reports he made in November, 1810, show that the work was coming along to his satisfaction,

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[19] William and Mary College Papers, op. cit., Folder 108.

[20] Holmes, op. cit., p. 24.

the water was able to rise to the height he had calculated and reach "Water-closets in the second story, which no other Works have accomplished on such high ground." He was apparently a stockholder in the West-Middlesex Water-Works because he speaks of himself as one of the proprietors.[21]

Apparently Millington was an owner of the Hammersmith Iron-Works. Printed forms used by that company saying "Received from Taylor and Millington" have been preserved.[22]

Millington was appointed in April, 1829, to build a suspension bridge at Great Marlow, Bucks.[23] It is doubtful that he could have finished the bridge since he left England for Mexico in October, 1829.

The Anglo Mexican Mining Association owned silver mines and a mint in Mexico. Millington's interest in the Association dates back at least as far as 1828. A list has been preserved, partly in Millington's handwriting, and dated August 28, 1828, giving particulars of three boilers and fittings sold to the Bolanos Company which were at Vera Cruz or Banderilla, Mexico. Some of the machinery was to be left at Guanajuato, the site of one of the mines.[24]

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[21] William and Mary College Papers, op. cit., Folder 108.

[22] Ibid.

[23] John Millington Papers, op. cit., I-19.

[24] Ibid., I-17.

Millington was engaged in September, 1829, to be the engineering superintendent at the mine at Guanajuato. His lawyer found that the draft of the proposed contract between Millington and the Association rendered the Bonds from the directors to Millington useless. Millington tried to give up the engagement and wrote to one of the directors in an attempt to suspend further consideration of the agreement.[25] The result of this correspondence is not known, but Millington did go to Mexico.

In his letter to Professor Henry of June 25, 1847, previously cited, Millington continued:

> And yet I was foolish enough to give up all these advantages under an offer of most brilliant pecuniary prospects to take charge of one of the principal British Mining Speculations in Mexico, where I resided nearly three years, and indeed till all my bright expectations had vanished into air, and I then came to this country with the full determination of returning to England after making a Tour through it.[26]

His household goods, "The Property of a GENTLEMAN Going Abroad," were sold at auction on October 27, 1829. The catalogue of his furniture and effects included 146 items to be found in the various rooms of his house and coach house at No. 5, Doughty Street, Mecklenburg Square.[27]

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[25] Ibid., I-20.

[26] William and Mary College Papers, op. cit., Folder 108.

[27] John Millington Papers, op. cit., I-31. A printed "Catalogue of all the genuine Furniture and Effects . . . the Property of a GENTLEMAN Going Abroad," for the auction.

In Mexico. Millington, his wife, and three children left England on October 24, 1829, and sailed to Vera Cruz.[28] On December 29, 1829, his twenty-six year old daughter Emily married William Bates in Vera Cruz.[29] Bates was originally from Liverpool, but had been in business in Mexico for five or six years.

Millington was issued a pass in Vera Cruz for Guanajuato on December 30, 1829, for himself and two pieces of equipment. He was issued a passport for the Republic of Mexico on January 3, 1830, by General L. Santa Ana, Supreme Governor of the State of Vera Cruz. Both of these documents have been preserved.[30]

Millington, his wife, and nineteen-year old daughter Cecilia went to Guanajuato; Emily and William Bates and Millington's fourteen-year old son Thomas went to Mexico City. Thomas wrote his father that he liked the school he attended in Mexico City and felt he was making progress in Spanish, French, and arithmetic.[31] Emily had a baby, Emilita, sometime between August 14 and December 1, 1830. During their first year in Mexico, Cecilia and Thomas had

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[28] Ibid., III-1. Diary entry on October 24, 1832, three years later.

[29] Ibid., I-8.

[30] Ibid., I-32 and I-33.

[31] Ibid., I-36.

bad colds followed by lingering coughs, and Mrs. Millington had a serious attack of cholera.[32]

During 1830 Millington revised his textbook on mechanical philosophy. He mentioned in the preface to the second edition that he had been unable to publish a promised second volume of this work covering such topics as electricity, magnetism, light, and astronomy, because of lack of time and:

> Being now completely occupied in a distant part of the world, away from Books, from instruments, and from that scientific intercourse that would enable him to do justice to the subjects, . . .[33]

In early 1831 Millington decided to leave Mexico and travel through the United States on his way back to England. Not only had all his bright expectations vanished into air, but he found the country lawless, unhealthy, and on the verge of revolution. He obtained several letters of introduction for himself, "Director of the Anglo Mexican Mining Company at Guanajuato," to men in Philadelphia, Charlotte and Salisbury, North Carolina, New York, Washington, Baltimore, and New Harmony, Indiana. The earliest was dated May 29, 1831.[34]

The oldest surviving diaries written by Millington

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[32] Ibid., I-39.

[33] John Millington, An Epitome of the Elementary Principles of Mechanical Philosophy (second edition; London: W. Simpkin and R. Marshall, 1830), p. vii.

[34] John Millington Papers, op. cit., I-41 through I-46 and I-48.

cover the period February February 12 to December 31, 1832. During this period Millington finished his business in Mexico and traveled to Philadelphia. He wrote of being robbed of his Hamilton silver snuff box by two men on February 20 in Mexico City and of the revolution being waged by Santa Ana against Bustamante. He spent his evenings in Mexico with his Englishmen friends, losing at whist.

Many of the Englishmen at the silver mines seemed to be heading for home, some directly, some by way of the United States. Millington sent money ahead to New Orleans and then he and his son Tom left by ship from Vera Cruz on April 7, 1832. His daughter Cecilia and her husband John Hamilton Clement, an English engineer at the mines, stayed in Guanajuato; Mrs. Millington and the Bates remained in Mexico City.[35]

Letters from Mrs. Millington to her husband in Philadelphia described the uncertain situation in Mexico City. On November 8, 1832, she wrote that "Santanna [sic] has completely hemmed us in so that no one can travel in or out of the city. It is with the greatest difficulty provisions or fuel can be obtained." She complained of the monotony of their lives and of her rheumatism which had not bothered her at Guanajuato. She further wrote that William Bates, their son-in-law, had decided that if matters took a turn for the worse, he would wind up all his business

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[35] Ibid., III-1.

and leave the country. "The idea of perhaps losing everything after seven or eight years of toil is very serious." On December 11, she wrote of her anxiety about her son and husband, her last letter from them being dated July 30. Cecilia was expecting a child in January, 1833, and Emily, with two daughters already, was expecting her third in February. Mrs. Millington still had a little rheumatism. The political climate was no better: "I wish to the lord I was safe out of this horrid country - I am sure you were very fortunate to leave at the time you did for it is no very easy thing to get away now, and if you do you are liable to be robbed and murdered." She also mentioned that the Anglo Mexican Mining Company had finally agreed to release its lien against Millington's mathematical instruments and that they would be sent to him.[36]

Mrs. Emily Millington died in 1833 on her way to Philadelphia to join her husband and son.[37] She was buried at Vera Cruz. The exact date and cause of her death are not noted.

Emily and William Bates finally left Mexico in 1835 and Cecilia and John Clement left sometime after August, 1840, when their fourth child was born in Mexico. (This same child died in Williamsburg, Virginia, in May, 1844.) Both families eventually returned to England.

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[36] Ibid., I-49.

[37] Ibid., I-8.

Millington's trip from Mexico City to Philadelphia is fully narrated in his diaries of 1832. He and Tom left Mexico City by stagecoach on March 3 and eventually arrived in Vera Cruz, a city under siege. While waiting to get out of both cities, he spent his spare time sketching the antiquities in Mexico City and scenes of Vera Cruz. They sailed from Vera Cruz on April 7 and arrived in New Orleans on April 17, where he spent several days organizing his baggage, picking up his money, and visiting. They left New Orleans on April 24 by Mississippi River steamboat and arrived in Cincinnati on May 7. They then took a steamboat on the Ohio River to Pittsburgh and a stagecoach to Baltimore. Millington did some sightseeing and visited people to whom he had letters of introduction. In Washington, D. C., he commented: "I was very much disappointed with Washington city, tho' some of its Public Buildings are very fine." They arrived in Philadelphia on June 1 and, a week later, took a one-day steamboat ride to New York. After a week in New York they returned to Philadelphia by stagecoach; he sketched the Trenton Bridge during a stop-over there. On June 18, in Philadelphia, they moved out of the hotel into "my new house."[38]

In Philadelphia. Instead of returning to England as he had planned, Millington allowed himself to be talked into

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[38] Ibid., III-1.

opening a scientific equipment store in Philadelphia. He discussed this venture in his letter to Professor Henry of June 25, 1847:

> Our acquaintance began in the Philosophical Instrument Store, which I was silly enough to establish in Philadelphia without knowing any thing of the practical nature of work or workmen; in consequence of which I sustained great pecuniary loss.[39]

And later in this same letter:

> Having considerable disengaged capital I was however persuaded to embark in the Philosophical Instrument making business which turned out a complete failure.[40]

Millington started out on this venture with great enthusiasm and immediately went to work setting up the store. He went to auctions to buy tools and equipment, unpacked items arriving from Mexico, hired apprentices, set up lathes and other tools in the workroom. In January, 1833, he was ready to open his store and described the business and his availability as an engineering consultant in an advertisement:

> John Millington,
> Civil Engineer and Machinist,
> No. 207 Pine Street - 10 Doors Below Seventh Street, Philada.
>
> Late Professor of Mechanics in the Royal Institution of Great Britain - of Natural Philosophy in Guy's Hospital, London - Vice President of the London Mechanics Institution, etc. etc.
>
> Having been for many years actively engaged in the manufacture of Machinery of various descriptions, while resident in England, begs to inform the Scientific and Manufacturing public of the United States, that he has

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[39] William and Mary College Papers, op. cit., Folder 108.

[40] Ibid.

> been some months past engaged in the formation of a Manufacturing Establishment and depot as above, for the purpose of supplying all the various Machines, Instruments, Apparatus and Materials required for Mechanical, Philosophical, Mathematical, Optical and Chemical purposes. And as the whole of these are imported from the best Makers in Europe, or made upon his own premises by first-rate native workmen, under his immediate direction and inspection, he pledges himself to the excellence, accuracy, . . .
>
> He is now so far advanced in his undertaking that he can invite the public to an inspection of his STOCK,
>
> . . . . . .
>
> Many of the above will be accompanied by printed directions for their use; and a small and select collection of approved Books on Mechanics, Natural Philosophy, Chemistry, Mineralogy and Astronomy, with useful Tables and Charts, will always be kept on hand.
>
> . . . Models and Drawings of Machinery executed to order with accuracy, neatness and despatch; and advice given in the construction of Buildings and mechanical improvements on moderate terms. . . .
>
> Repairs neatly and carefully executed, and Instruments, etc. exchanged.[41]

Millington had a few customers. He was hired by Jefferson College to supervise the construction of a theatre. In the March 19, 1833, issue of The National Gazette and Literary Register, a daily newspaper published in Philadelphia, there is an advertisement by Dr. M'Murtrie about a course of popular lectures on zoology to begin the next evening. He mentioned that the dark closets for the effective exhibition of his illustrations were "expressly con-

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[41] John Millington Papers, op. cit., I-52.

structed by Mr. Millington."[42] Nevertheless, the business failed and the store was closed.

While in Philadelphia, Millington met Miss Sarah Ann Letts, who was born June 23, 1800, and they were married on July 20, 1834; Thomas C. Millington witnessed the ceremony.[43] They had three children:
Catherine Ann (Kate), born August 25, 1835, in Philadelphia;
George Beale, born September 12, 1838, in Philadelphia;
Anna Elizabeth, born January 21, 1841, in Williamsburg.[44]

In Virginia. John Millington and Andres Del Rio were appointed by the Geological Society of Pennsylvania to investigate the Rappahannock gold mines which were located about ten miles southwest of Fredericksburg, Virginia. They reported on their investigation on August 4, 1834, stating that the mines could be worked economically, but that the stream on the property was too small to provide sufficient water for the operation.[45]

By January 1, 1835, Millington was established on the property working as chief engineer for the Rappahannock Mining Company. In his diaries for 1835, he described his

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[42] Ibid., I-50.

[43] Ibid., II-127. Marriage certificate.

[44] Ibid., I-8.

[45] Andres Del Rio and John Millington, "Report of the Committee Appointed by the Geological Society of Pennsylvania, to Investigate the Rappahannock Gold Mines, In Virginia," Transactions of the Pennsylvania Geological Society, I (1835), pp. 147-156.

frequent trips back and forth to Philadelphia to visit his family, confer with some of the directors of the Company, bring the gold to the Philadelphia Mint, return to the mines with cash for salaries, etc. His duties in Fredericksburg included doing accounts, writing bills of sale, supervising construction, drawing deeds of agreement, settling disputes between the miners, etc. On July 23 he left with five and a half pounds of gold to deposit at the Philadelphia Mint, "not a little delighted to leave so turbulent and disagreeable a spot."[46]

Millington applied to William and Mary College for the chair of chemistry and natural philosophy about to be vacated by William Barton Rogers, who was going to the University of Virginia. He asked Dr. Jacob Green of Jefferson College and Professor Joseph Henry to write letters of recommendation for him.[47] Millington records in his diary on October 11, 1835, that he:

> received a letter . . . from Dr. Carmichael [the medical doctor in Fredericksburg] inclosing one from Mr. Page [the Rector of William and Mary College] saying I was elected Professor of Natural Philosophy and Chemistry in William and Mary College - I wrote answer to Carmichael to thank him, and also wrote to Mrs. Millington to inform her of my election.[48]

He decided to visit Williamsburg and, in the event he declined the appointment, to return to England.

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[46] John Millington Papers, op. cit., III-2.

[47] William and Mary College Papers, op. cit., Folder 108. Letter, Millington to Joseph Henry, May 30, 1848.

[48] John Millington Papers, loc. cit.

On October 15 Millington left Fredericksburg by stagecoach for Richmond. The next morning he took a steamboat to Jamestown and a stagecoach to Williamsburg. He read Greek classics on the way "with which I was much interested and entertained."[49] After arriving in Williamsburg he:

> Went to Mr. Page the Rector who is a lawyer and he sent for Mr. Saunders the Professor of Mathematics - had a long talk in answer to my list of inquiries and Mr. Saunders walked with me to . . . show me the college, 2 lecture rooms etc. till quite dark when he conducted me back to the Hotel after going with me to a store and post office where I got several text books to look at . . .[50]

He decided to spend another day in Williamsburg to:

> . . . inspect the chemicals and apparatus and get a little acquainted with the place - At breakfast was sent for by Mr. Page saying that 2 Visitors were at his house who wanted to see me and I went there to meet Dr. Galt and Dr. Peachy when after entering into explanations I qualified by taking the required oath and was duly inducted into the office of Professor - from thence I went with Mr. Saunders to the college and had the Keys of the laboratory and Philosophy lecture room given to me and I remained there the whole day . . . looking over the apparatus and taking an inventory of the chemical materials and noting the deficiencies till dinner . . .[51]

After breakfast on October 18 he made a list of persons to whom he had been introduced, read the rules of the College, looked over the textbooks, and began writing his introductory lecture on chemistry. On his last day in Williamsburg, October 19, he rented Mr. Bucktrout's house with separate

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[49] Ibid.

[50] Ibid.

[51] Ibid.

garden for one year for $75, Mr. Bucktrout paying the taxes, etc. He continued writing chemistry lectures.

Millington met stiff resistance in Fredericksburg to the news of his intention to leave the Mines. Some of the owners came to demand a settlement and were so abusive that Millington told them all to leave. They succeeded in changing his mind and he wrote a letter of resignation to the College. On November 1, Mr. Page arrived in Fredericksburg, and after explanations, Millington agreed to accept the professorship to commence on February 22, 1836.

He continued to work at the Rappahannock gold mines. On November 9, he sent notice of his resignation to Mr. Hemphill, president of the Rappahannock Mining Company. On November 13, Ann, Tom, and their new baby Kate joined him in Fredericksburg. On December 28, Tom indicated his desire to study at William and Mary College, being especially interested in bookkeeping and mathematics. Millington was still at the Mines at the end of the 1835 diaries, and it is reasonable to suppose he remained until time to go to Williamsburg for the second half of the 1835-36 session.

During Millington's first two full sessions at the College he taught three courses: chemistry, natural philosophy, and civil engineering. Each course involved three lectures a week and each lecture was about ninety minutes long. In addition to preparing for these lectures, he also wrote a textbook on civil engineering and assembled considerable apparatus to illustrate his lectures.

The natural philosophy course taught by his predecessor William B. Rogers included "the practical subjects of the strength of Materials, the construction of Watch and Clock work, of Roofs, Arches, Bridges, Roads, the Steam Engine, and elementary principles of Architecture."[52] The demand for civil engineers was so great by 1836 that the Board of Visitors decided to expand the teaching of "practical subjects." In the preface to his civil engineering textbook, Millington wrote:

> Early in 1836, being then Professor of Natural Philosophy and Chemistry in the venerable establishment of William and Mary College, Va., he was requested by the visitors of that institution to attempt a course of Civil Engineering, as a branch of the collegiate instruction; and although but ill prepared at that time for such an undertaking, being wholly without drawings, models, books of reference, and other means of illustration, he undertook it, using a translation of the elementary course on Civil Engineering by M. J. Sganzin, written many years ago, and intended by its author to be a mere syllabus or collection of memoranda from the course on these subjects, that he formerly delivered at the Polytechnic School in Paris. Those who are acquainted with this book need not be told how meagre and insufficient it is for an Engineer of the present day, independent of which, the language into which it is translated is so full of French words and phraseology, not adopted in this country, as to render it almost unintelligible. Under these circumstances such a book could but be discarded, and in the course of the succeeding session, 1837-8, the writer was under the necessity of preparing a set of notes of his own to lecture from, and these notes, so prepared and somewhat amplified to make them intelligible to a reader, are what are now offered to the public in the following pages.[53]

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[52] William and Mary College Papers, op. cit., Folder 61. Catalogue for the session 1829-30.

[53] Millington, Elements of Civil Engineering, op. cit., p. vii.

Millington had previously considered writing a civil engineering when:

> . . . in 1828 the writer had the honour of being appointed to the chair of Civil Engineering and the Applications of the Principles of Mechanical and Chemical Science to the Arts and Manufactures [at the University of London]; and it was in the preparation for the lectures to be given on these subjects, that he first felt the want of a Digest or Text Book, . . . and it was therefore determined that he should endeavour to produce one.[54]

But accepting the offer of the Anglo Mexican Mining Association forced him to resign his professorship and to stop his work on the intended textbook.

The other time-consuming job Millington undertook during his first years at William and Mary College was the assembling of apparatus for demonstrations during his lectures on chemistry and natural philosophy. Robert Saunders, the mathematics professor, described the work:

> When Professor Millington took the chair of Chemistry and Natural Philosophy in the College in 1836 he found the chemical apparatus so deficient in extent and so defective in character as to be altogether inadequate to the necessary purpose of illustrating a course of lectures. His immediate predecessors had for 15 years within my own knowledge, been driven to various shifts and expedients for the purpose of remedying this evil; the implements which they employed . . . never lasted beyond a very short period of using.
>
> Mr. Millington was unwilling to encounter the labor of this daily and imperfect manufacture and resolved not to risk his reputation by proceeding in his course aided only by the scanty materials at his command. . . . the funds of the College did not admit of the use of more than a trifling sum in procurring what he wanted. . . .

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[54] Ibid., p. vi.

> Mr. Millington therefore determined to devote a portion of his own funds to the procuring of such apparatus . . . not doubting that whenever his connections with the College should be severed, he would be able to adjust the matter with the College authorities upon terms at once just and satisfactory to both. . . .
>
> He accordingly proceeded to make, from time to time, purchases of apparatus until he expended $3600 and gathered together, as may be inferred from the expenditure, a superb collection, which he used daily in his lectures on Chemistry and on Natural Philosophy.[55]

In addition to the apparatus he purchased, Millington brought a large amount of glassware and consumable chemicals with him after shutting down his scientific equipment store in Philadelphia.[56] He also purchased a large and complete collection of mineralogical and geological specimens, and expanded his library to four thousand volumes. Millington said that his apparatus and library cost him at least $10,000.[57]

This must indeed have been a superb collection. "Several persons former students have told me that Mr. Millington's apparatus was very full."[58]

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[55] William and Mary College Papers, op. cit., Folder 108. Letter from Robert Saunders to the Rector and Visitors of William and Mary College, July 3, 1851.

[56] Ibid.

[57] Ibid., Letter from John Millington to Professor Joseph Henry, May 30, 1848.

[58] Ibid., Letter from Benjamin S. Ewell, Williamsburg, to Tazewell Taylor, Bursar of William and Mary College, September 16, 1851.

Starting with the 1838-39 session, Millington also had students who were studying for a master's degree. This required no formal lectures on his part, but he did sit down once a week with these students and discuss with them the assigned reading.[59]

Millington felt quite overworked during his first years with the College. He wrote his friend Robert Hare, Professor of Chemistry in the medical department of the University of Pennsylvania, of his discouragement. Dr. Hare replied: "I am sorry your present situation is not agreeable to you but at present know of none preferable to which you can aspire. I would recommend to you to ask for an assistant. You have too many chairs."[60]

Starting with the 1840-41 session Millington offered a private medical class in addition to these other classes. This class is described in the William and Mary College Catalogues of 1840-41 through 1843-44 as follows:

> As nearly all the Medical Colleges of the union require that a student shall have studied medicine with some practitioner for two years before he offers himself for their instruction and for graduation, Professor Millington undertakes a class in this department of science, for which he possesses ample means of illustration. It commences and ends with the college session [the second Monday in October to July 4].
>
> The subjects taught in the first session are Anatomy, Physiology, Materia Medica and Pharmacy. [Medical Botany was added in 1842.]
>
> In the second session, Anatomy of the Nerves and

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[59] Ibid., Folders 61, 62, 63. Catalogues for the sessions 1836-37 through 1845-46.

> Organs of Sense, Pathology and Therapeutics, Operations of Surgery, Materia Medica and Pharmacy continued and concluded.
>
> Fee for each session $30.
>
> Text books the same that are used in the principal Medical Colleges.[61]

In the College Catalogue of 1845-46, the fee was increased to $50 for each session and the study of chemistry, natural philosophy, and the Greek and Latin languages was recommended. Millington also described the illustrations he used and which he had bought at a cost to himself of $1350.[62]

> The illustrations are costly and extensive, including Auzoux's inimitable Dissecting Models of the whole human body, Thibert's Pathological Models from Paris, Quain's Anatomical Plates; and a well selected Medical Library is provided for the use of the students.[63]

This description of the private medical course in the 1845-46 catalogue was signed "John Millington, M. D., Formerly one of the Lecturers in the Medical School of Guy's Hospital, London." This is the earliest record where he refers to himself as "M. D."

A summary of the total enrollment at William and Mary

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[60] John Millington Papers, op. cit., I-75. Letter from Robert Hare, Philadelphia, to Millington, December 26, 1838.

[61] William and Mary College Papers, op. cit., Folder 62.

[62] Ibid., Folder 108. Letter from George W. Southall, Williamsburg, to Visitors of William and Mary College, October 5, 1848.

[63] Ibid., Folder 63.

College and the enrollment in each of Millington's courses for the sessions 1836-37 through 1845-46 is given in Appendix B.

During Millington's twelve-and-a-half years at William and Mary, there were only five professors on the teaching staff. The professors received no salary for their teaching, but instead received $20 a year from each student taking each of their courses ($30-50 for the private medical class). During each of Millington's first four full sessions, he earned between $2000 and $2640 from these fees.

Professor Millington was well liked by both faculty and students. Several of his students wrote the following letter to the Editors of the Richmond Compiler:

> In your paper of yesterday, you state as a piece of Information that Professor Silliman has in the course of the last six years delivered 145 Lectures in Boston, spoken 200 hours, and presented 2000 experiments. If this is meant as proof of his great labour and perseverance in the cause of Science, we in the South can fairly compete with him; for our veteran Professor Millington in William and Mary College has during the last three years lectured twice in every day except Saturdays and Sundays to his classes, during 40 weeks in each year; making 1200 Lectures in three years; and as the average duration of each Lecture is 1-1/2 hour; this amounts to 1800 hours of speaking, or 25 days of 24 hours each of unceasing talking in each year. - As all his subjects do not admit of experimental illustration, the number of experiments shown may probably not exceed seven or eight hundred annually. - Virginia is therefore not outdone.[64]

Millington was active in the community of Williamsburg

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[64] John Millington Papers, op. cit., I-82. Letter to the Editors of the Richmond Compiler from Several Students of William and Mary, April 12, 1843.

as well as within the College community. He had many friends, both young and old. He was a religious man and served as a lay reader in Bruton Parish Episcopal Church.[65]

Millington bought the house on the Palace Green in Williamsburg now known as the Wythe House. He and his wife Ann loved this house and years after leaving Williamsburg they still dreamed of returning to it for their last years. Before 1836 Millington always planned to return to England; after moving to Williamsburg he always yearned to return there. He wrote, "As I have gone on in the greatest harmony and friendship with my brother Professors, the Visitors, Students and my fellow citizens I had reason to believe I should have ended my days in this place."[66] The only thing he did not like about Williamsburg and the College was the location:

> I have always felt a desire to get into a more public position, . . . I then took charge of some Gold mines which carried me into Virginia, and here I have been ever since, without any other reason to be dissatisfied with my position, than the location of the place, which is such as to shut me out of the world of Science, or that communion of kindred spirits which is so necessary to keep the mind alive and in activity. - I have often regretted, that as a point of honor, I could not succeed our late lamented friend Dr. Jacob Green in the Jefferson School [in Philadelphia] when solicited to do so; but at that time our session here was just about to open, and I therefore felt that I should have done a serious injury to William and Mary College, had I left it at the time required.[67]

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[65] Ibid., I-58.

[66] William and Mary College Papers, op. cit., Folder 108. Letter, Millington to Henry, May 30, 1848.

[67] Ibid., Letter, Millington to Henry, June 25, 1847.

In August, 1840, John Millington and Dr. Samuel S. Griffin bought a house and lot on the north side of the main street of Williamsburg and leased it to Thomas C. Millington and James L. C. Griffin. It was opened on October 1, 1840, as a store selling tobacco, snuff, cigars, stationery, medicine, paint, linseed oil, whitewash, books, fabric and patterns, boots, hardware, food, spices, etc. The customers included the students and professors at William and Mary College as well as the College itself: Professor Saunders bought a pound of Epsom salts on October 10, 1840; Professor Robert Garrett was a regular customer for quinine and purchased two ounces of calomel on October 2, 1840; the College bought paint and books. Students purchased Webster's Chemistry, Mitchell's Atlas with and without Geography, Emerson's Arithmetic, Olmsted's Natural Philosophy, Say's Political Economy, Day's Algebra, dictionaries, bibles, books on anatomy, etc.[68]

Unhappily, Millington was not allowed to end his days in Williamsburg. He wrote to Professor Henry:

> Since the death of our late esteemed president Mr. Dew [in 1846], a great change has taken place in the affairs of our College - Acts of Nepotism have disturbed our former peace, a schism exists between the Faculty and the Visitors . . .[69]

He wrote to Bernard Peyton, Jr., of Richmond, Virginia:

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[68] John Millington Papers, op. cit., XI-4. "Journal of Griffin and Millington, Williamsburg, Va., 1840," September 9, 1840 to February 26, 1841.

[69] William and Mary College Papers, op. cit., Folder 108. Letter, Millington to Henry, May 30, 1848.

> I hope . . . [to leave here in] another year being quite disgusted with my old favorite Williamsburg and determined not to remain in it long[er] than I can help - I wish there was a prospect of being able to get up a college in Richmond - Myself, Holmes and Saunders would immediately join in the project.[70]

Peyton answered him, and Millington replied:

> I am glad to find the idea of establishing a University in Richmond meets your approval, and I assure you I am in ernest about it, and that it shall lack no energy on my part to carry the matter into effect.[71]

Millington went on to say that George Holmes was still interested; Charles Minnigerode would come only if guaranteed an annual salary or stipend; and Saunders, being an alumnus of William and Mary College and having been raised in Williamsburg, would not help organize the new college in Richmond because he did not want to injure the old city and its college, but he would come to Richmond to teach. Millington offered the proposed college in Richmond the use, without charge, of his apparatus, his collection of mineralogical and geological specimens, and his library of above four thousand volumes. Even with all these inducements, a college was not organized in Richmond.

Matters got worse between the Faculty and Visitors, until finally, "the visitors have requested the whole faculty to resign which request has been complied with - our chairs have been publicly advertised, and early in July

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[70] Ibid., Letter from Millington to Bernard Peyton, Jr., Richmond, Virginia, January 4, 1848.

[71] Ibid., Letter from Millington to Peyton, January 16, 1848.

a new Faculty will be elected."[72] Millington did not expect to be reelected in July "notwithstanding my devotion to the interests of the College."[73] Thus, when he saw an advertisement for an entire Faculty in a new university about to open at Oxford, Mississippi, in November, 1848, he applied. He was elected to and accepted a professorship in the University of Mississippi, and then to his surprise, he was reelected to his old chair at William and Mary. He wrote the Rector that he had:

> . . . accepted Professorship of Chemistry and Natural Philosophy in the University of Mississippi to which I was elected previous to my re-election into William and Mary College . . . therefore respectfully decline accepting the chair in William and Mary College into which the Visitors lately did me the honor to re-elect me.[74]

Millington and the Board of Visitors did not part in peace. Each felt the other owed him money. Millington had two claims against the College: he felt they should pay him the $3600 he had invested in the chemical and philosophical apparatus for his lecture demonstrations and he wanted the $75 annual allowance the professor of chemistry was granted for the ordinary support of the laboratory. During his twelve-and-a-half years at the College, he had only received $110 from this fund. Thus Millington thought the College owed him altogether about $4400. But Millington had

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[72] Ibid., Letter from Millington to Henry, May 30, 1848.

[73] Ibid.

[74] Ibid., Letter from Millington to McCandlish, August 15, 1848.

borrowed $500 from the College in 1840 and stopped paying interest on it in July, 1849. Thus the Visitors thought Millington owed the College this $500 plus interest. After three years of futile attempts at the recovery of his money, Millington placed the matter in the hands of Professor Saunders whose solution was apparently accepted by both sides: "I propose to you that you shall cause his bond to the College to be cancelled and delivered up and that the College shall be free hereafter from any claim on Professor Millington's part."[75]

In Mississippi. Millington and his family left Williamsburg for Oxford, Mississippi, on September 28, 1848. He delivered his first lecture at the University of Mississippi on December 5, 1848, to his natural philosophy class.[76]

During Millington's five years at the University, he taught chemistry, natural philosophy, geology, and agriculture.[77] He was State Geologist of Mississippi during the period of his residence in Oxford.

Millington described this period of his life at the University of Mississippi when he was still trying to recover his money from William and Mary College in a letter to his attorneys in London:

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[75] Ibid., Letter, Saunders to Rector and Visitors, July 3, 1851.

[76] Ibid., Note in Millington's handwriting on the inside cover of Volume I of a two-volume manuscript chemistry textbook based on Smith's The Principles of Chemistry.

> . . . William and Mary College got into a difficulty nearly three years ago which produced an entire stoppage of her operations and for a whole year the College was closed, and all her Professors resigned. - Being thus left without employment or income, and being invited to a similar chair to that which I held in the newly established University of Mississippi, I accepted the appointment, and have been living at this place part of two years but spending my vacation times in Williamsburg where I still retain the freehold house and land [the Wythe House] in which I have lived many years and to which I am much attached. - And where I also left most of my furniture, books, etc. and a servant to take care of them, because I expect the affairs of William and Mary College will come round and they will pay me what they owe me before another year expires in which case I shall return to live there again. Where I am now living is 700 miles west of Williamsburg and out of this world and all society tho' the country is improving very rapidly. It gives me much pleasure to hear that the long protracted chancery suit is at length brought to an end, particularly at this time when in consequence of my failure to get money from William and Mary College and the heavy expenses I had to incur in travelling with my family to this place, I am really in want of funds.[78]

In another letter to his attorneys in London, dated May 31, 1851, Millington wrote:

> . . . I shall leave this place [Oxford, Mississippi] about the 20th of July to go to my house in Williamsburg Virginia where I propose spending the whole month of August with my friends there, . . . and I shall be back again here at the University of Mississippi which opens for business on the 15th of September next, and will then require my presence.[79]

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[77] University of Mississippi Catalogue for 1850 in which Millington is listed as Professor of Chemistry, Agriculture and Geology.

[78] John Millington Papers, op. cit., II-1. Letter from Millington, Oxford, Mississippi, to J. C. and H. Freshfield, Attorneys, London, October 10, 1850.

[79] Ibid., II-6.

However, "certain events that have occurred here prevented my going to Williamsburg in Virginia as I had fully intended."[80]

Millington wrote to his London bankers asking them to transfer all his money from the Bank of England to the United States ". . . as I want money in this country to repair and improve the property I possess in Williamsburg to which place I am shortly about to return and make it my future residence."[81] He was still in Oxford in February, 1853.[82]

In Tennessee. Millington left the University of Mississippi after five years and accepted the chair of Professor of Chemistry and Toxicology in the Medical College, Memphis, Tennessee, starting with the 1853 session. He became Dean of the Faculty at the Medical College and remained in Tennessee until 1863 when the Civil War forced him to move to Philadelphia.

While in Memphis, Millington continued his engineering consulting work. In 1855 he was paid $1,597.54 for work on the Mississippi Central Railroad.[83]

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[80] Ibid., II-6. Letter from Millington, Oxford, to Freshfield, London, August 18, 1851.

[81] Ibid., II-8. Letter from Millington, Oxford, to Coults and Co., Bankers, London, December 16, 1851.

[82] Ibid., II-14.

[83] Ibid., II-17.

On November 1, 1858, he gave an address to the students of the Memphis Medical College and the public on the opening of the seventh session. This address is reproduced by Xerox and included in the Appendix C in its entirety for several reasons: it shows Millington's attitude when he was nearly eighty years old toward practical versus scientific education; it is the source of our knowledge about his own medical education in London and about his chemistry course at Memphis Medical School; it discusses the state of medical education in England and France and its development in the United States; and the address shows so well his love of teaching and interest in the welfare of his students, his love of knowledge, his commitment to helping the underpriviledged, his sense of humor, his humility, his humanity.

Millington and his wife Ann returned to Williamsburg on July 11, 1859, to do something about the Wythe House which they still owned and which still contained their furniture. The house had been vacant, but they found it in much better condition than they had expected, "tho' still very desolute and neglected for want of habitation."[84] They slept in it at night, but ate with the Saunderses and other old friends. They hoped to fix up the house and rent it furnished instead of having to sell it and move all their possessions to Memphis. "Ma is so pleased and delighted

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[84] Ibid., II-28.

with the old place that we shall not sell anything, as Ma thinks that we shall certainly return here to end our days. - The place certainly looks the picture of quiet contentment. . . . The building of the new College [after the fire of 1859] has made great progress and will be ready by the opening of the next session."[85] They were returning to Memphis by way of Philadelphia where they planned to spend two weeks.

When his daughter Kate married Robert Blankenship on October 25, 1860,[86] and moved with him to Richmond, Millington found the house in Memphis gloomy without her. He wrote her on November 20, 1860, that "our lectures have begun at the Medical College which never before opened with such flattering prospects as we opened with above 40 students and all going on very comfortably with the new faculty. I have to lecture every day except Sunday and Thursday."[87] But the Medical College closed by the end of the year and Millington's productive life as a scientist and teacher ended.

The Millingtons had succeeded in renting the Wythe House in 1859 and Millington wrote his daughter Kate on January 1, 1861: "I have been busy at the College packing

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[85] Ibid., Letter from Millington, Williamsburg, to his children in Memphis, July 20, 1859.

[86] Ibid., II-127.

[87] Ibid., II-34.

books etc. to send to Williamsburg where I am in great hopes Ma will consent to return as my house there will be vacant on the first of next October and my lease of the house we live in here expires the next day and if the war comes I wish then to return to Virginia."[88] But the war did come and Virginia was a major battlefield, so instead of moving to Virginia, Millington wrote many letters to Kate in Richmond begging her to move to Memphis where she would be safer and the family could be together whatever happened. But Kate became pregnant and did not want to travel, so Mrs. Millington went to Richmond to be with her when the baby was born in early October, 1861.

Millington was a real Southerner. He kept slaves, hoped for a war between England and the United States in order to take the pressure off the South, hoped for a Southern victory when the Civil War did come. His wife worked in the Southern Mothers Home in Memphis caring for sick soldiers.

The Millingtons moved to a home they owned in La Grange, Tennessee, in early-1863. They left La Grange in mid-1863 and moved to Philadelphia for the duration of the war. Their youngest daughter Betty joined Kate in Richmond, their son George Beale was in the Confederate Army. After the war, the Millingtons moved permanently to Richmond and lived with Kate for the rest of their lives.

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[88] Ibid., II-40.

John Millington died in Richmond on July 10, 1868, in his ninetieth year, and was buried in Bruton Parish Churchyard, Williamsburg. His grave is beside the wall adjoining the backyard of the Wythe House. On his tombstone is the memorial:

In Memory
of
John Millington, M. D.
Born in London
May 11, 1779
Died in Richmond, Va.
July 10, 1868

Ninety years of an honoured and
useful life on earth
closing in eternal rest

Engineer
for London
and Middlesex
Professor at Guy's Hospital
" Royal Institution
" London University
Vice Prest. Mechanics Institute
" " R. Astron. Society
Chief Engineer of Silver Mines and
Supt of a Mint in Mexico.
Prof Chem and Nat. Philos. at College of
William and Mary Va.
" " and Geology at University of Miss.
State Geologist of Mississippi

Science Mourns
the loss of
a devoted and indefatigable
disciple, of most varied information
and of marvelous industry, the worthy friend
and associate of men like Sir H. Davy,
Breeoster, Faraday, Hershell and
Lord Brougham.

Affection never can forget a friend so
genial generous and true.
But Faith looks up in hope and rejoices
at the blessed end of one whose crowning
glory it was to have served the Lord Jesus.

CHAPTER III

ENGINEERING EDUCATION AT WILLIAM AND MARY COLLEGE

The Curriculum.[1] A student at William and Mary College during Millington's tenure was required to take seven specified courses, write a thesis, and pass private and public examinations for the degree of Bachelor of Arts. During the first year (called the junior year), the student would normally take a course called the Junior Moral Class (belles lettres, rhetoric, logic, composition, moral philosophy, and history), chemistry, junior mathematics, and the Class of National Law which was a half-course ending February 22. In the second year (called the senior year), the student would normally take the Senior Political Class (political economy, government, and philosophy of the human mind), senior mathematics, and natural philosophy. The schedule was not rigid, however, and many students took the courses in different order or spent three or four years instead of two or took other courses such as Greek, Latin, law, and engineering as electives.

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[1] William and Mary College Papers, op. cit., Folders 61, 62, and 63. William and Mary College Catalogues for the sessions 1836-37 through 1845-46. The catalogues for Millington's last two sessions have not been preserved.

To graduate from the School of Civil Engineering, a student needed junior mathematics and two years' attendance in Millington's civil engineering class. He then had to pass private and public examinations in engineering and mathematics. If he passed the examinations, he was awarded a certificate of competency in civil engineering, which constituted graduation from the School of Civil Engineering. There is no record of the graduates of the School of Civil Engineering, but all the students who studied engineering for two years from the fall of 1836 through July, 1840, also studied chemistry and natural philosophy, and most seemed to be pursuing the degree of Bachelor of Arts.

A graduate of the School of Civil Engineering who also had taken the degree of Bachelor of Arts could obtain a master's degree by studying successfully the mathematical and physical portions of the Master of Arts course, dispensing with the moral, political, and historical portions. The purpose of the Master of Arts course was to allow the student to pursue his baccalaureate studies in more detail by reading the most approved writers in his field under the supervision of a professor. There were no formal lectures. The College catalogues state that the successful student could obtain proficiency in his field "to a degree rarely, if ever, attained at any other institution in this country." Only two students took the physical portion of the Master of Arts course and received the degree of Master of Arts during the ten sessions from 1836 to 1846; so in practice, this

course was not part of the engineering curriculum.

Thus, the curriculum of the engineering student at William and Mary College who obtained the degree of Bachelor of Arts was the traditional liberal arts curriculum with two years of engineering courses as electives. Aside from practice in surveying, the engineering graduate had had little practical experience. He had the opportunity to watch many demonstrations of scientific principles but not to perform these experiments himself in a laboratory.

The technical portion of the curriculum for the engineering student pursuing a degree included junior and senior mathematics, chemistry, natural philosophy, and civil engineering. The two mathematics courses, which were taught by Professor Robert Saunders, and the science and engineering courses, which were taught by Professor John Millington, were frequently repeated by students who had not yet become proficient in the subjects. The content of these courses, the textbooks used, and the method of instruction are discussed in the following pages and compared to those courses taught at some other engineering schools in the United States during this same ten-year period from 1836 to 1846.

The Technical Courses.[2] In the junior class of mathematics, the subjects studied were algebra as far as the higher equations, plane and solid geometry and mensuration,

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[2] Ibid.

plane trigonometry and its applications to heights and distances and to land surveying, and spherical trigonometry. The use of instruments was taught, which included practice in land surveying. The textbooks were Young's Algebra, Legendre's Geometry, and Davies' Surveying.

In the senior class of mathematics, the subjects studied were equations of the higher degrees, analytical geometry including conic sections, differential and integral calculus, and the application of spherical trigonometry to nautical astronomy. The textbooks were Young's Algebra, Davies' Analytical Geometry, Davies' Calculus, and Gummere's Astronomy.

Professor Saunders met with each class three times a week. The exercises consisted of strict examination of each student upon the textbook, accompanied by such explanations and additions by Professor Saunders as the subject required.

The chemistry course was almost completely qualitative and descriptive. It began with a theory called the Doctrines of Affinity; affinity was a chemical property of matter that restrained certain elements from "indiscriminately cohering and sticking together to form an infinite variety of compounds."[3] The course then covered heat, light, electricity, and electrochemical cells. Next, the laws and

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[3] Millington, An Epitome of the Elementary Principles of Mechanical Philosophy, op. cit., p. 9.

theories of chemical combination, especially the Law of Definite Proportions and the concept of equivalent weights, were studied. The examination of compounds by testing, and the methods of examining and working the metallic ores, as applicable to mining purposes, had considerable attention. The last topic was organic chemistry in which the properties and reactions of various well-known compounds were studied. From 1836 through the 1840-41 session, Millington emphasized the application of chemistry to mining and geology; starting with the 1841-42 session, he stressed equally the application to pharmacy and medicine.

Millington used several textbooks during this ten-year period. He first used the fifth edition of Elements of Chemistry by Dr. Edward Turner. In 1838 he switched to the third edition of Manual of Chemistry by John W. Webster, M. D. In 1843 he switched again, this time to Elements of Chemistry by Robert Kane. The following session he added Principles of Chemistry, second edition, by Daniel B. Smith. Smith's book was in two volumes, one on inorganic chemistry and the second on organic chemistry. Millington removed the pages of Smith's book from its binding and pasted them individually between the pages of two blank bound notebooks. He then added to and expanded Smith's text on the blank pages. He wrote notes to himself to explain or describe certain items in more detail and to demonstrate certain principles at this point; he also pasted in newspaper clippings. The finished notebooks were clearly lecture guides

for his chemistry course.[4]

Millington met with his chemistry class three times a week and delivered ninety-minute lectures which were illustrated by his extensive collection of apparatus and instruments. The lectures in chemistry are described in the College catalogues as follows:

> Experimental illustrations of all the subjects are made before the class, and a private examination and comparison of what occurs at the lecture table, and what is stated in the text book, are made at the conclusion of each distinct subject. The Professor has a considerable collection of all the subjects described, which are laid before the students, for inspection or experiment, including an extensive Geological and Mineralogical Collection and one of the Materia Medica.[5]

The natural philosophy course dealt with mechanics, including statics and dynamics, weight, force and motion; the practical application of mechanics to the construction of machines; and such topics as friction, pneumatics, acoustics, meteorology, hydrostatics, specific gravity, hydraulics (with application to pumps, waterwheels, etc.), the steam engine, electricity, electrochemical cells, electromagnetism, and optics in theory and as applied to the construction of optical instruments and descriptive astronomy.

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[4] William and Mary College Papers, op. cit., Folder 108. A two-volume manuscript chemistry textbook prepared by John Millington incorporating Smith's Principles of Chemistry, second edition, 1842.

[5] Ibid., Folder 62. College catalogue for the session 1843-44.

When he first taught this course, Millington used his own textbook, An Epitome of the Elementary Principles of Mechanical Philosophy, and parts of the Library of Useful Knowledge. Starting in 1838, he used An Introduction to Natural Philosophy, third edition, by Denison Olmsted, A. M. of Yale College, and two essays by Millington on galvanism and electromagnetism. In 1842 he changed to the fourth edition of Olmsted's Natural Philosophy.

Millington delivered ninety-minute lectures three times a week to his natural philosophy class. The manner in which this course was taught is described in the College catalogues as follows:

> These subjects are first examined by experimental illustrations and diagrams, and their several important applications to useful and manufacturing processes pointed out, and are afterwards recapitulated with such illustrations, only, as serve to explain their powers and mathematical principles. Examinations of the students take place at the conclusion of each distinct subject, independent of the general examinations at the conclusion of the course.
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> In the Physical Department two new lecture rooms have been constructed, viz: a chemical laboratory and philosophical lecture room; both more capacious than the former rooms, replete with every modern improvement and convenience, and furnished with a very extensive apparatus for illustration.[6]

Millington's civil engineering course required two years of study. He met with the class three times a week and delivered ninety-minute lectures; there were occasional practical exercises instead of lectures. Since his textbook, Elements of Civil Engineering, was prepared from his lecture

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[6] Ibid.

notes,[7] it is an excellent record of the content of the course. In the preface, he described the course and the textbook:

> The course he has adopted, is first to explain the nature of the Engineer's profession, and the views that ought to guide him in the formation of his plans. 2ndly. The means of rendering those plans palpable by means of drawings, the method of making and copying which, and the necessary instruments, are briefly described, and as the value of all building work depends in great measure upon its quantity, so the means of ascertaining those quantities by measurement are next considered.
>
> Possessing this preliminary knowledge, the young Engineer is next supposed to be introduced into an uncultivated country, which he has to improve by carrying his plans into execution; and the first object will be to measure, and make maps of such country, upon which he may lay down the roads, canals, and other improvements that are contemplated. So much of land surveying and levelling and their necessary instruments, are therefore described in the fourth and fifth chapters as will enable him to accomplish this work.
>
> The sixth chapter treats of such operations on the soil as are necessary for the formation of roads, canals, and the foundations of buildings; and this is followed in the seventh chapter by the leading principles of road making.
>
> The selection of materials to work with, comes next under consideration; and the eighth chapter therefore describes the various kinds of building stones, and the methods of quarrying, or getting them out of the earth, which is followed by an account of the making of bricks, burning and preparing lime and hydraulic cements, and forming them into mortar. Secondly, the varieties of timber, and means of seasoning, and converting it to useful purposes, and of measuring and valuing it, either when rough or converted, are considered. Lastly, the metals claim attention, and an account is given of the production of iron from its ore, and its conversion into the pig and malleable state. This is followed by such a notice of the smithing and iron foundry business as the Engineer should be generally acquainted with, particularly the

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[7] Millington, Civil Engineering, op. cit., p. vii.

making of patterns to cast from. A few observations on steel, brass, copper, lead, and the other metals in general use, are added, and close this part of the subject.

The Engineer being thus put in possession of a catalogue of the materials he has to work with, must next consider their respective values and importance under the heads of strength and durability, which subjects occupy the ninth chapter.

Construction, or the conversion of these materials (now supposed to be fully understood) next follows, and is treated of in the tenth chapter, under the several heads of building with stone and bricks, and carpentry or building in wood. The principles of building both in stone and bricks, are here described, together with the methods of measuring and valuing the work when executed. Carpentry follows, and after an account of the principles on which this art depends, those principles are applied to the formation of various kinds of framing, such as roofs, partitions, timber bridges, and the centring or frame work necessary for the formation of large arches of stone or bricks, and some of the most approved centres that have been used are described.

The eleventh chapter is devoted to the methods of procuring firm and stable foundations, both on dry land and in the water, for walls and heavy erections; and this, of course, includes the building of piers for bridges, and the usual methods of building in water both by coffer-dams and caissoons, the driving of piles, the fixing of centring, and the construction of large arches, and building of bridges; which subjects are exemplified by a short account of some of the finest stone and cast iron bridges that have been executed, and a notice of the more recently introduced bridges of suspension.

As the foregoing matter comprises most of the information that it is necessary the young Engineer should possess, all that remains is to point out how the principles endeavoured to be established are to be applied to useful purposes; and this opens an almost endless field on account of the many ramifications of the Engineer's profession. Any attempt to describe the whole, or even the greater part of them in such manner as might prove useful, would require a work of vast extent and high price, and might not, after all, prove generally useful or acceptable; because no individual scarcely ever attempts to make himself practically acquainted with the whole of them. On this account the twelfth chapter is confined to a description of those

> operations which the Civil Engineer is most commonly called upon to design, superintend, and execute; and these are the formation of roads and railroads, the improvement of river navigation, and the construction of navigable canals. In this place, therefore, the form, construction, and methods of fixing rails, and of building locks and weirs, are alone set forth; because the necessary appendages of walls, bridges, foundations, warehouses, carpentry, and earth-work, have been fully discussed and described in preceding chapters.[8]

A careful examination of the textbooks Millington wrote and used in his civil engineering course, his Elements of Civil Engineering and his Epitome of the Elementary Principles of Mechanical Philosophy, reveals much about the course. The books are almost entirely descriptive except for two chapters in Elements of Civil Engineering. In Chapter III, "On the Principles of Mensuration," he reviewed the simple operations of arithmetic and gave formulas for calculating areas, volumes, length of the hypotenuse, etc. In Chapter IX, "On the Durability and Strength of Materials," he examined such subjects as tension and torsion, worked sample problems, and gave tables of experimental data. In other chapters he showed how to calculate the cost of materials and he suggested that practical men generally use a safety factor of four or five in designing a pillar or vertical support, a concept still used by engineers.

One teaching approach he used was the case-study method, the description of how particular construction jobs were carried out. He emphasized the human contribution, the

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[8] Ibid., pp. vii-ix.

ideas of the men who built the engineering works. For example, he discussed the building of the celebrated Eddystone lighthouse which is fourteen miles from Plymouth, England. The first lighthouse, which was built of stone in 1696 by Henry Winstanley, completely disappeared during a violent storm in 1703. A second lighthouse was built of wood very soon afterwards by a Mr. Rudyerd and burned in 1755. The third lighthouse was built of stone by John Smeaton in 1757 and was still in use when Millington was writing his account of it:

> . . . and in June, 1757, Mr. Smeaton commenced the present building, which is admitted by all competent judges to be a chef d'oeuvre of modern engineering, at least in this department of work. . . . Eddystone lighthouse is circular on the plan, cylindrical near its top, and swells at its lower part into a parabolic conoid. Mr. Smeaton observes, that he took the hint of this form from noticing the shape that the trunks of old oak trees assume, and the power they have of withstanding high winds, notwithstanding the great surface their tops expose to its effects.[9]

From these various case-studies, it would appear that civil engineering was still primarily a trial-and-error situation, design being based on the success or failure of existing structures rather than on laboratory data. In discussing equilibrium and stability of arches, Millington wrote:

> An instance of the necessity of attending to this species of equilibrium occurred in Wales in the building of a bridge over the river Taff near Llantrissent, in Glamorganshire, known in the country by the name of the Pont y ty Prydd, and which is considered one of the most extraordinary bridges in Great Britain, while it

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[9] Ibid., pp. 474-475.

is interesting on account of the history of its construction. The Taff, though by no means a wide river, runs between two rocks, and is in such a mountainous district that it is subject to great and rapid floods, and the first stone bridge erected across it consisted of three light and elegant arches, built in the valley by a Mr. William Edwards, an uneducated mason of the country, and was finished in 1746. It was much admired and gave general satisfaction, and Edwards was himself so satisfied with the stability of his work that he gave security for its standing seven years without needing repair; but in about two years and a half after its erection, a very heavy flood came on, bringing many trees, branches and other objects down the stream, and as these were stopped by the bridge, they formed a dam which impeded the water, and this rose to such a head as to wash the whole bridge away. Of course, Edwards was compelled to erect another bridge; and he proceeded on his duty with all possible speed. Being determined on this occasion to make his work secure, he adopted a single arch, which was a segment of a circle the diameter of which was 170 feet. The span or chord of the arch was 140 feet, and in order to place it completely out of the reach and danger of all floods, he raised it 35 feet above the water. The rocky sides gave him excellent foundations or abutments for such an arch, and he had no difficulty in carrying it over from one rock to the other. All that now remained to be done was building the side walls and filling in soil over the haunches to procure a level road. This work proceeded and was nearly finished, when the soil placed upon the haunches, without an equivalent balance on the crown, proved too much for them, for they sunk, pushing the crown upwards so as to force the stones out of their positions, and in 1751, just when this second bridge was on the eve of completion, it was thus wholly precipitated into the water below.

Such a succession of misfortune would have disheartened most men, but it had not that effect on Edwards. He saw the error of his proceeding, and was fully aware of the cause of his bridge failing; and believing that there was no better and effectual way of making a bridge than the one he had attempted, he began his work again, and rebuilt an arch similar in every respect to the one that had fallen down; but instead of overloading the haunches as he had done before, the happy idea of introducing hollow brick tubes or culverts across his bridge occurred to him, and he accordingly built three of these in each spandrell, making the lowest nine feet, the middle ones six feet, and the inner ones three feet in diameter. These ran horizontally from one side of the bridge to the other,

> and formed six cylindrical holes or passages through it. Earth was of course rammed into the spandrells, under, around and above these culverts for the purpose of supporting them, and raising the road to its proper level; but the smaller weight of earth required in consequence of the span occupied by the hollow tubes or culverts, completely answered the purpose, and this third bridge, which was finished in 1755, is still standing a monument of the perseverance and ingenuity of its constructor, and is universally admired for its stability combined with its lofty, light, and elegant appearance.[10]

To evaluate Millington's success in educating engineers requires an awareness of his objectives. He described the object of his civil engineering course and textbook as follows:

> It is therefore presumed that the directions given throughout the work, when combined with some practice, which is indispensable to form a good Engineer, will enable any one to digest and arrange plans; to draw them upon paper; to estimate their probable cost; to set them upon the ground; and to direct and superintend their construction.[11]

He believed that experience on-the-job was essential in the education of an engineer, for only when he is surrounded by work and workmen can he really understand the work and the workmen he will later be called upon to plan and direct. "The Engineer must be a practical mechanic"[12] to be able to pursue his profession. The best way to learn engineering was to obtain the position of clerk of the works, or resident engineer, on a large project. The duty of the clerk of

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[10] Ibid., pp. 652-653.

[11] Ibid., p. ix.

[12] Ibid., p. 17.

the works was to give no directions of his own, but to act strictly under the orders and directions of the chief engineer and to watch that all his arrangements were punctually complied with.

> No school is, however, so good for learning the practice of architectural or engineering business, as the office of clerk of the works, if entered upon with sufficient qualifications and properly made use of for that purpose. In this post, a man is constantly surrounded by work and workmen; he acquires their technical language without study; he sees operations of every kind going on at the same time, and becomes acquainted with the tools and the methods of using them; he has the inspection and examination of various materials, and becomes acquainted with their respective advantages, disadvantages, and their prices, without leaving home. He learns to judge what quantity of work a man is capable of effecting in a given time, and acquires a fund of information that will prove of vast use to him in after life; for no one need expect to become a good and efficient Engineer by study in his closet alone, however intense. He must be practically a workman, or must become intimately acquainted with the processes of working, by watching those who are proficients, and this is, therefore, a mode of instruction which every young man ought to avail himself of, if he intends to excel.[13]

While Millington was fully convinced of the value of on-the-job training, he did not feel that this was enough education:

> The practical man, when he is really nothing more, is one who can just do what he is taught to do, and who has acquired some skill and judgment in a small range of occupations. He lays up a store of receipts for particular cases, and like the cook or the dyer, works mechanically and without mental exertion.[14]

In order for engineers to be fully educated, they must acquire considerable knowledge in science, mathematics, and law:

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[13] Ibid., p. 19.

[14] John Millington Papers, op. cit., II-23.

> They should be profoundly skilled in the knowledge of the properties of the materials to be employed, and the best methods of connecting them together; and to attain this, some knowledge of chemistry is necessary. They must know so much of mathematics [and of natural philosophy] as relates to gravitation, the composition and resolution of forces, and the properties of the lever and inclined plane, before they can ascertain the stability of their works, and the pressure that one mass may exert against another; and this leads to the theory of the pressure and equilibrium of arches and formation of piers for bridges. A knowledge of mensuration is essential for measuring and estimating the various work performed by artificers, and this implies a previous acquaintance with arithmetic and geometry, which is useful in many other respects, for circles, ellipses, parabolas, hyperbolas, and many other curves, which occur in the formation of arches and mouldings; and polygons are necessary in a variety of instances. They should not be unacquainted with plain trigonometry, for this is necessary in obtaining heights and distances, as well as in surveying land and setting out roads and canals. They must understand drawing, both in simple projection and perspective, to enable them to lay down designs, and make them plain and perspicuous to their workmen. They should understand so much of the law, as will enable them to decide upon the rights and the division of property, to inform themselves of the restrictions under which they have to work, and to make binding contracts or agreements with their workmen and suppliers of materials.[15]

The final lecture to his civil engineering class, delivered on July 2, 1839, was published "at the request of the class."[16] A Xerox copy of this lecture appears in Appendix D. In it Millington further discussed the need of both a theoretical and a practical education. He emphasized again the need of a sense of ethics and a sense of responsibility on the part of the engineer. He urged that errors

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[15] Millington, Elements of Civil Engineering, op. cit., pp. 17-18.

[16] John Millington, "Address on Civil Engineering," Southern Literary Messenger, V (September, 1839), p. 592.

of construction should be on the side of too much material rather than too little deliberately used to please his employer; he further urged that the engineer must be a fair and impartial arbiter between the employer and the workman.

It would appear that Millington modeled his idea of a good engineering education after his own education: a liberal arts education with some training in the law, followed by on-the-job training in engineering. From the liberal arts education, the student would learn to express himself, to think, and to solve problems based upon the success of engineers who preceded him; he would gain a knowledge of scientific principles to support untried ideas. The application of these principles would be learned on-the-job, where one field of engineering would be learned in depth. With his knowledge of the basic principles behind engineering, the knowledge gained from this work experience could be transferred to any other engineering project.

Thus, college courses in mathematics, chemistry, and natural philosophy were of the greatest value to engineering students. In them the principles were learned which could be transferred to any engineering project. His civil engineering course, therefore, was largely descriptive, emphasized the scientific principles that applied to various phases of engineering, described many important works and how they were constructed, and discussed briefly all the fields in which a civil engineer might work. It was a course in the principles, not the practice, of civil engineering.

Engineering Education at Other Colleges. There were different approaches to engineering education at different schools. Millington was not alone in urging that theory be taught in the colleges and practical aspects of engineering be taught on-the-job. Professor William M. Gillespie, who was appointed the first professor of civil engineering at Union College in 1845, advised his students to first graduate and then accept the lowest position in some engineering corps, that of rodman, and expect to work up gradually to the rank of chief engineer.[17]

The United States Military Academy combined theory with some practical work. They taught as much, if not more theory than the other engineering schools. In addition, in the four year course, there was some time for field exercises in practical engineering and extensive practice in drawing. By graduation, the cadet had had a fair amount of practical training in civil and military engineering, but very little practical knowledge of machinery since there was neither shop-work nor field trips to industrial concerns. A contemporary of George W. Whistler, a civil engineer who was successful in locomotive construction, stated that Whistler "had as a West Point graduate the best education of the time, but with little practical knowledge of machinery."[18]

A third approach to engineering education was to

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[17] Calhoun, op. cit., p. 47.

[18] Ibid., p. 86.

teach less theory and much more practical engineering in college. Rensselear Polytechnic Institute and Norwich University (Partridge's Academy) used this method.

The only important academic source of civil engineers during Millington's tenure at William and Mary College was the United States Military Academy. The Academy followed the French tradition of combining training of military engineers and civil engineers in one institution. The graduates of the Academy were among the most renowned civil engineers in the country; became professors of engineering, science, and mathematics at many colleges; and wrote many of the early textbooks, particularly in engineering and mathematics.

The four-year curriculum[19] was the same for all students. It was quite different from that of William and Mary College since it included such required subjects as civil and military engineering, drawing, mineralogy and geology, military subjects such as tactics and artillery, and French. It was similar in requiring chemistry, natural philosophy, mathematics, English, rhetoric, geography, and history.

The textbooks used in the science and civil engineering courses were of two general types: the popular texts of the period and the texts either written or translated

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[19] Edward S. Holden (ed.), The Centennial of the United States Military Academy at West Point, New York. "The Academic History of the Military Academy," pp. 223-466.

from the French by the professors at the Academy. Professor Charles Davies, an 1815 graduate of the Academy and professor of mathematics there from 1823 to 1837, wrote a series of mathematics textbooks, many of them used at William and Mary College. Professor Albert E. Church, an 1828 graduate of the Academy and professor of mathematics there from 1837 to 1878, also wrote a series of textbooks which replaced those of Davies and were considered by many to be the best in the country at the time they were written. Professor Dennis H. Mahan, an 1824 graduate of the Academy and professor of engineering from 1832 to 1871, wrote a complete set of civil and military engineering textbooks.

In mathematics, between 1839 and 1843, all the textbooks used were by Davies. They were his translation of Bourdon's Elements of Algebra; his translation and revision of Legendre's Elements of Geometry and Trigonometry; his Mensuration; Elements of Descriptive Geometry; Treatise on Shades, Shadows and Linear Perspective; Elements of Analytical Geometry; Elements of the Differential and Integral Calculus; and Elements of Surveying. In 1843 Davies' Calculus was replaced by Church's. Instruction in mathematics was conducted in recitations by assistant professors under the general supervision of the professor.

In chemistry, the textbooks used were essentially the same as those used at William and Mary College. The Academy used Turner's Chemistry until 1840, Webster's Chemistry until 1843, and Kane's Chemistry until 1858. Chemistry was

taught to the Second Class (the junior class) three hours a week. There were about three recitations conducted by assistant professors for every lecture with experimental illustrations delivered by the professor. There was no chemical laboratory.

The natural philosophy course was based upon a knowledge of the differential and integral calculus. Professor William H. C. Bartlett, an 1826 graduate of the Academy and professor of natural philosophy there from 1834 to 1871, was also a textbook writer. His treatise on optics replaced Brewster's in 1839 and Rochet's treatises on magnetism, electromagnetism, and electrodynamics replaced the Library of Useful Knowledge. The other textbooks used were Courtenay's translation of Boucharlat's Mechanics and Gummere's Astronomy.

Over a period of several years, Professor Bartlett purchased apparatus for the experimental illustration of the principles of natural philosophy which he used in his occasional lectures to the class. The other class meetings were ninety-minute recitations supervised by the assistant professor or one of the instructors. The classes met six days a week. There was an observatory which allowed the students some practical work in astronomy.

Engineering was taught in the senior or first-class year and consisted of a one-and-a-half-hour daily recitation six days a week. Civil engineering was taught in the Fall term and military engineering was taught during the Spring term. About one month of the military engineering course

was devoted to fortification drawing, and during this unit, the cadets spent three hours a day in the engineering drawing rooms. Professor Mahan gave very few lectures and these were restricted to military engineering.

The textbooks used in the engineering course were all written by Professor Mahan and included his Treatise on Field Fortification, Lithographic Notes on Permanent Fortification, Lithographic Notes on Mines and Other Accessories, Lithographic Notes on Attack and Defense, Lithographic Notes on Composition of Armies and Strategy, An Elementary Course of Civil Engineering, Lithographic Notes on Architecture and Stone Cutting, and Lithographic Notes on Machines. His civil engineering textbook was quite similar to Millington's. Both stressed materials of construction and were equally descriptive.

The curriculum and textbooks at Norwich University were essentially the same as at the United States Military Academy. Partridge stressed a practical education for engineers, however, believing that the training at West Point was too theoretical. The first engineering degrees were awarded in 1837 when two students received the degree of Master of Civil Engineering after completing a three year course of study. The engineering course included the following subjects:

> Algebra, Geometry, construction and use of Logarithms, Plane and Spherical Trigonometry, Mensuration of Heights and Distances, Planometry, Stereometry, Practical Geometry generally, including particularly

> Surveying and Levelling, Descriptive Geometry, Conic Sections, Mechanics, Statics, Hydrostatics, Chemistry, Geology, Architecture, Construction of Common Roads and Railroads, Canals, Locks, Bridges, Aqueducts, Viaducts; also the English and French Languages, Geography and History. Much practical field work was given. The students in this department were carefully trained in Declamation, weekly exercises in composition being required.[20]

The civil engineering program at Rensselaer Polytechnic Institute between 1836 and 1846 required one session lasting from November to the end of June for completion. The school year began with class work in "practical Mathematics, Arithmetical and Geometrical," combined with "extemporaneous speaking on the subjects of Logic, Rhetoric, Geology, Geography, and History," and "Lectures on National and Municipal Law" by the senior professor. The second term of twenty-four weeks devoted eight weeks to practice in the use of instruments; eight weeks to the study of the theory of mechanical powers, bridges, arches, canals, etc.; four weeks to calculations of the flow rate of water supplied by streams with reference to their use for various practical purposes; and four weeks to inspection of "mills, factories, and other machinery or works which come within the province of mathematical arts."[21]

Amos Eaton, the senior professor until his death in 1842, stated that the course was intended for those who had completed their academic education. There was a separate

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[20] McGivern, op. cit., p. 45.

[21] Mann, op. cit., p. 12.

preparatory school for those who were not graduates of other colleges or were otherwise disqualified for entrance to the Rensselaer School by want of education.[22]

Eaton emphasized a practical education for engineers and felt that mathematics beyond arithmetic was unnecessary. His combination of the utilitarian and the theorist led him to rebel from the common practice of teaching science as a part of the informational and cultural background of a college student. He insisted that accurate scientific training could only be acquired in the laboratory or in direct contact with things themselves. He therefore minimized the use of lectures and textbooks and emphasized the experimental laboratory, field trips, etc. He wanted his engineering students to study things, not words. He wanted to train men who could go out and actually build, mine, and manufacture with all the resources of scientific theory and technical equipment.[23]

In 1830 Eaton published his notes for the general technical course that was being given at that time and which included some instruction in mensuration, surveying, and engineering. This elementary textbook, entitled Art without Science: or, Mensuration, Surveying and Engineering, Divested of the Speculative Principles and Technical Language of Mathematics, (Albany, 1830), categorized civil engineering

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[22] McGivern, op. cit., p. 51.

[23] Palmer C. Ricketts, The Centennial Celebration of Rensselaer Polytechnic Institute (Troy: [n.n.], 1925), p. 99.

into four parts: (1) water transportation (the construction of canals and improvement of navigable rivers, lakes, etc.), (2) land transportation (the construction of roads and railways), (3) mills and other machines, and (4) massive or solid work (the construction of docks, piers, dikes, walls, and the excavation of earth).[24]

He revised and expanded this textbook in 1838 into Prodromus of a Practical Treatise on the Mathematical Arts: Containing Directions for Surveying and Engineering, (Troy, New York, 1838). He omitted from this textbook the topics of the steam engine, steamboats, and waterworks, stating that these subjects were not commonly studied by American engineers.[25] (Millington considered the study of the steam engine and of machinery of every kind an important part of the education of an engineer.)

A brief look at engineering education at the University of Virginia during this same period will allow a comparison of engineering at William and Mary College with that at another school which likewise taught engineering as only a minor part of its curriculum. In 1833 the Board of Visitors decided to introduce a course in civil engineering to be associated with the department of mathematics. Charles Bonnycastle, the professor of mathematics, delivered a series of lectures on engineering. Then the plan was

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[24] Calhoun, op. cit., p. 83.

[25] Ibid., p. 84.

temporarily dropped. It was revived in 1836 by Professor William Barton Rogers who had just left William and Mary College to assume the chair of natural philosophy at the University of Virginia. His support resulted in the formation of the School of Civil Engineering and one lecture was delivered weekly by each professor belonging to it. Seventeen students attended during the session of 1836-37, and in 1839 four graduates received diplomas.[26]

The professors teaching engineering at the University of Virginia were the professors of natural philosophy and mathematics. They had had no engineering education or experience. Professor Rogers had taught some engineering as part of his natural philosophy course at William and Mary College. After Millington's tenure, instruction in civil engineering at William and Mary College was again given by the professors of mathematics and natural philosophy.[27] This was definitely the practice at the colleges which did not specialize in engineering education.

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[26] Philip Alexander Bruce, History of the University of Virginia, 1819-1919 (New York: The Macmillan Company, 1920), II, 126.

[27] William and Mary College Papers, op. cit., Folder 63. Catalogue for the session 1854-55.

CHAPTER IV

SUMMARY AND CONCLUSIONS

John Millington believed that civil engineering was a profession and that it ought to be taught the same way the other professions were being taught--by a practitioner. One objection Millington had to the French system of engineering education was the use of professional teachers instead of practitioners to teach engineering. He felt the training was too theoretical to be of practical use to the student.

During the 1830's and 1840's in the United States, the few teachers of engineering were also professional teachers, often of natural philosophy or mathematics; Millington was probably the only experienced engineer teaching engineering at the time.

He believed that it was essential that an engineer have a scientific background and a knowledge of the principles of engineering; he also believed that the knowledge of how to apply these principles was more important and could only be learned in practice. Thus, Millington believed that the academic phase of engineering education should include the study of chemistry, natural philosophy, mathematics, and the principles of engineering; the practical phase of his

education, working under an experienced engineer, should include applying these principles to a project and learning to work with people, both workmen and employers.

During his years at the College of William and Mary, from 1836 to 1848, Millington taught chemistry, natural philosophy, and engineering in such a way that his students were well-grounded in the principles of these disciplines, but were aware also of how these principles had been applied to practical problems. He taught the application of chemistry to geology, pharmacy, and medicine; the application of natural philosophy to machines, the steam engine, optical instruments, etc. In his engineering course, through the case-study method, he was constantly pointing out the way in which certain principles had been applied in engineering projects.

Did Millington succeed in educating young men to be competent engineers? It would seem that the graduates of his science and engineering courses, upon completion of a period of pupilage under the chief engineer on some public works project, would be highly capable engineers. Their courses in science and mathematics were rigorous and textbooks that were popular in other colleges at the time were used. The course in civil engineering was probably one of the best being given in any college because Millington was one of the few professors of civil engineering who was a practical engineer. As he said in the College catalogues, "The above course is founded on the practical experience of

the Professor, who for twenty-five years followed the profession of a Civil Engineer in England."[1] His insistence on teaching the scientific principles behind the art of engineering on the college level and letting the student learn the details of the art on-the-job was sound at this period in the development of engineering. The profession was still highly empirical, there was little engineering research being done, and scientific principles were not too often applied consciously to engineering projects. The time was at hand, though, when engineering technology was becoming too complex for the uneducated engineer, and the need of a scientific education was beginning to be recognized even by the supporters of on-the-job training.

Thus, Millington's approach to engineering education was workable during the decade and more that he taught engineering in the United States. He recognized the need for on-the-job training, yet his students received the strong science and mathematics background needed to advance the state of the art.

The instruction at William and Mary consisted of lectures presented by the professors. The instruction at the United States Military Academy was given primarily in small recitation sections conducted by instructors under the supervision of the professor who, in some departments, gave occasional lectures. Both schools used the same or similar

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[1] William and Mary College Papers, op. cit., Folder 61.

textbooks and followed them rather closely. At Rensselear Polytechnic Institute lectures and textbooks were minimized; practical work and class participation in discussion sessions was encouraged.

The United States Military Academy for many years had almost a monopoly on engineering education. Basing its four-year curriculum on the French-type of technical education, the Academy taught mathematics, science, engineering, and the arts of war almost exclusively. The graduates were well-disciplined and well-trained engineers and proved their competence as civil engineers over and over before the Civil War. After the Civil War there were so many other colleges devoted to the education of civil, mechanical, and mining engineers that the Academy lost its pre-eminent position as a supplier of civilian engineers.

Rensselaer Polytechnic Institute did not really become an outstanding college for engineers until after its reorganization in 1849 into a three-year engineering school. The one-year curriculum was too short to teach the principles of engineering and too little emphasis was given to mathematics and science as tools of the engineer. Amos Eaton's goal of having his students learn things, not words, was eventually carried out as engineering schools introduced laboratories and work-shops.

Besides his teaching of engineering, Millington's other major contribution to engineering education was his civil engineering textbook, published in 1839. Professor

Dennis H. Mahan of the United States Military Academy, an academically trained but inexperienced engineer, had published a civil engineering textbook in 1837, and Professor Amos Eaton of Rensselaer Polytechnic Institute, a well-educated scientist with no engineering experience, had published a civil engineering textbook in 1838. In a newspaper account of Millington's textbook, a reviewer said:

> A work of this kind, adapted to the wants of the profession in this country, has long been a desideratum, and, we hazard nothing in saying, that Professor Millington is perhaps, better qualified, by a rare union of profound science and much practical experience, to be its author, than any other man in the United States.[2]

It was this very union of scientific knowledge and practical experience, combined with his sincere interest in education and his great energy, that made him the great teacher he was.

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[2] John Millington Papers, op. cit., V-10.

APPENDIX A

RATES CHARGED AS ENGINEERING CONSULTANT

Original List from which this Xerox copy was made may be found in William and Mary College Papers, op. cit., Folder 108.

No. 5, DOUGHTY STREET, GRAY'S INN LANE,
London, 15th July, 1828.

A LIST

OF

THE CHARGES ORDINARILY MADE BY

MR. MILLINGTON,

Civil Engineer, and Surveyor of Manufactories and Machinery,

Professor of Mechanics in the Royal Institution of Great Britain, &c. &c.

TOGETHER WITH

AN ENUMERATION OF SOME OF THE PRINCIPAL OBJECTS TO WHICH HE DIRECTS HIS PROFESSIONAL ATTENTION.

VERBAL OPINION, or Advice respecting any object of Science, or Manufactures, 1 *Guinea.*

Written Opinion, or Report, in answer to any Case stated, according to its length, *from 2 to 5 Guineas.*

Making Working Drawings, such as Plans, Elevations, Sections, &c. of Mills, or Machinery, Locks, Docks, Basins, Bridges, Water Works, Gas Light Works, new Roads, Steam Engines, with or without Machinery attached to them, for Manufacturing or other Purposes; determining the Dimensions and Power of Machinery, and estimating the Price or Value of its Construction; and attending to the passing of Private Bills in Parliament, at the rate of 5 *Guineas per Diem upon the Time which shall be so occupied.*

Clerk's Time, so occupied, when Superintendance is necessary, at the rate of 1 *Guinea per Day*—When otherwise, 10*s.* 6*d. per Day.*

Drawing Specifications of Particulars for Work to form Contracts upon, 3*s.* 6*d. for each Common Law Sheet.*

Attendance to arbitrate or settle Disputed Points—to superintend the Construction of Millwright's Work—Buildings, or Machinery connected with Chemical or Mechanical Manufactures—to take Levels—to inspect or value Machinery or Premises already put up—to suggest Improvements or Alterations, or for the purpose of obtaining Information in order to give Evidence, or for other purposes—Conference with Counsel or Committees, at the rate of *Half a Guinea for each Hour which shall be so occupied, or 5 Guineas for the whole Day.* The Time necessary to go and return from such Business will be charged where the Distance exceeds One Mile from Home.

All Business in the Country at the rate of 5 *Guineas per Day* upon the Time occupied, as well on such Business, as in travelling, together with all Expenses out of pocket.

Attendance on any Court of Justice for the purpose of giving Evidence, or explaining Processes or Machinery, 5 *Guineas per Day*, exclusive of all Expences which may be incurred.

IN PATENT BUSINESS.

Drawing and Settling the Title of a Patent for an Invention, as a Ground for applying for the King's Royal Letters Patent, 1 *Guinea.*

Passing a Patent throughout the various Offices up to its receiving the Great Seal, 10 *Guineas.*

Drawing and Settling the Specification of a Letters Patent, at the rate of 1 *Guinea for every six common law sheets*, exclusive of making Drawings, and all attendance to receive Instructions, and to alter, amend, or improve the same when drawn, which will be charged at the before-mentioned rate of 10*s.* 6*d. per Hour.*

Original Drawings of Patent or other Machinery at the rate of 5*s. per Hour* upon the Time they occupy. Copies of them 2*s.* 6*d. per Hour*, exclusive of vellum, parchment, or paper.

Obtaining a Foreign Patent, 5 *Guineas*, exclusive of all Postage and Expences.

Models of Machines, &c. also made from description or otherwise, and charged on the lowest Terms, according to the Time they occupy the Workmen.

Instructions given in the various Branches of Science, and original, or other Experiments tried or repeated, at the rate of 10*s.* 6*d. per Hour* upon the whole Time of their preparation, exclusive of all Expense for Materials, Breakage, &c.

Land Surveying and Mapping in all its Branches, and Artificer's Work measured and valued at the usual rates of Charge.

Business requiring a considerable extension of Time, will only be done on lower Terms by Special Agreement with the Parties.

Orders for Steam Engines and extensive Machinery executed with the First Houses in the Country on Commission.—And Country Business executed in London, in the same manner.

N.B. MR. MILLINGTON *has established a correspondence with the principal Cities of Europe and America, and the East Indies, for Foreign Patents, and other Business.*

APPENDIX B

ENROLLMENT AT WILLIAM AND MARY COLLEGE

Session	Total Enrollment	Chemistry	Natural Philosophy	Engi- neering	Medical Class	Physical A.M.
1836-37	113	78	29	25	0	0
1837-38	112	70	26	14	0	0
1838-39	132	75	29	16	0	2
1839-40	140	74	24		0	2
1840-41	110	56	30			0
1841-42	97	50	22			0
1842-43	80	37	14		12	0
1843-44	86	36	14		11	0
1844-45	69	28	18		4	0
1845-46	68	35	16			1

Notes:

Source: William and Mary College Papers, op. cit., Folders 61, 62, and 63. College catalogues.

A blank in the table indicates that the catalogue did not list enrollment in that course that particular year; it does not necessarily mean zero.

APPENDIX C

LECTURE AT MEMPHIS MEDICAL COLLEGE

Original newspaper clipping from which this Xerox copy was made may be found in the John Millington Papers, op. cit., II-23. "Professor Millington's Address" in the Memphis [Tennessee] Daily Bulletin, November 11, 1858.

MEMPHIS DAILY

Morning Bulletin.

NN.;) THURSDAY, NOVEMBER 11, 1858. NUMBER 36.

Morning Bulletin.

MEDICAL.

PROF. MILLINGTON'S ADDRESS.

CORRESPONDENCE.

DR. MILLINGTON—*Sir:* The students of the Memphis Medical College being desirous of having the introductory lecture published, have appointed us, the undersigned, to request of you a copy of the same for publication. By acceding to the above request you will much oblige,

Yours very respectfully,

M. W. GOLDSBY, Jr.,
T. H. HALL,
J. S. ANDREWS,
J. B. BOUCHELL,
WM. DONNAN,
—— WELLS, Committee.

J. T. LEATH, Jr., Chairman.
MEMPHIS MEDICAL COLLEGE, November 4, 1858.

MEMPHIS MEDICAL COLLEGE, Nov. 5, 1858.

To Messrs. Hall, Goldsby, Andrews, Bouchelle, Donnan and Leath Committee:

DEAR SIRS—In reply to your favor requesting a copy of my address on opening the Memphis Medical College last Monday. I beg to say that it was written so hastily, owing to the short notice I had, that it is illegible in parts to myself, and therefore requires transcribing, which I am getting done, and will send it to you and put it at your disposal as soon as finished.

I am, gentlemen, yours very truly,

JOHN MILLINGTON, M. D.

Dean of the Faculty and Professor of Chemistry.

ADDRESS OF PROF. MILLINGTON TO THE STUDENTS OF THE MEMPHIS MEDICAL COLLEGE AND THE PUBLIC ON THE OPENING OF THE SEVENTH SESSION, MONDAY, NOVEMBER 1, 1858.

It is customary in all colleges and institutions for instruction to preface each session with a brief account of the objects and purposes of the establishment and its peculiar advantages, together with a few remarks, by way of instruction, to the students and public, as to what they are about to study and have propounded to them, and the duty of delivering such an address on the present occasion fell to the lot of my esteemed friend and colleague, Dr. Robards, whose name has been announced to the public for the occasion.

It has, however, happened that a near and dear relative of Dr. Robard's, who lives at some distance from this place, had been suddenly and violently attacked by so serious an illness as to render it necessary to send an express for the Doctor, who has thus unwillingly been called away from the city, and is thereby prevented from appearing before you on the present occasion, which he much regrets.

In this dilemma, I have been requested to become his substitute, a task that I have most unwillingly undertaken, on account of my own present inferior state of health, and my having had no timely notice to prepare and arrange the few observations which it becomes my duty to lay before you. And for this reason I venture to ask your indulgence for the imperfect manner in which I may perform my duty.

We are assembled on the present occasion to open the Seventh Annual Session of the Memphis Medical College. The institution, it is true, is of rather longer date, but the first few years of its existence were thrown away in law suits, contentious and vague attempts to establish new and various means of medical practice, and it is only during the last seven years that it has been in the state that it now is in, of teaching the regular standard and well established old school practice of medicine, which has, and ever will, stand against the so-called improvements and new inventions of the last half century.

The history and present state of the Memphis Medical College is a little singular, and is not, perhaps, generally known. It originated with a few of the leading physicians of this place, who were satisfied that young men could be better and more economically instructed in the science of medicine at home, and in the midst of those disorders and derangments that belong to, their own climate, rather than by sending them to the crowded colleges of the North, where many of their own diseases, and particularly the peculiarities of the negro race, were unknown. But this could not be effected without a considerable outlay of money, for to teach science a museum and apparatus, and models and instruments, and books and pictures, besides many other things, are necessary, as well as a building to assemble in and use them. The public-spirited individuals who first formed this College, therefore, each contributed $1,000 out of his private funds, thus forming a fund out of which all the chattel property of the institute was purchased. But the fund so raised was hardly competent to this purpose, much less to the purchase or erection of a suitable building, and the corporation of the city of Memphis, feeling and duly appreciating the value of such an establishment to their city, most handsomely granted the use of that portion of the Exchange Building in which we are now assembled, for the residence of the College, without any pecuniary rent; but in lieu thereof requested that the members of the faculty should act gratuitously as city physicians and surgeons, by attending to and prescribing for, and advising all the pauper population of the city; thus establishing the City Dispensary, where, on an average, about forty friendless, pennyless and houseless human beings (often in a state of the greatest misery) present themselves every morning, to avail of their charity, and here they are supplied with all necessary medicines and dressings, which are furnished by the Corporation, but made up and dispensed by the students of the College, who thereby not only have the advantage of a most extensive and varied *clinique*, but have excellent practice in pharmacy, and this goes on daily throughout the year.

Such is the manner in which the Medical College is carried on. The original fund has long since been laid out and expended in the scientific furniture now in the building, consequently there is no foundation fund, nor do the Professors receive any salaries for their lectures and assistance, but are satisfied with the fees paid annually by the students who attend for instruction; and that attendance has hitherto been so small that the payments have never yet amounted to half the necessary expenses for the maintainence of a single gentleman, much less for those who have families to support.

I mentioned that the history of this College was a little singular, and here we see one of its singular points—that it should have been carried on and flourished for a period of more than seven years by a set of professors (all gentlemen of high standing in their several professions,) and yet lending their aid at a positive and considerable loss of their time, which is their capital. But this is the fate of medical men, for no class yields higher examples of generosity and disinterestedness than the physician and the surgeon. My old master and instructor, in London, the renowned Sir Astley Cooper, whose practice never allowed him a moment's leisure and produced him above £10,000 a year, actually gave up one-eighth of his precious time to his charitable attendance in Guy's Hospital, for which he did not receive one cent, and so it is of all the great hospitals of England and most of Europe. Their physicians and surgeons are proud of the honor of belonging to them, although they receive nothing for their services. This would be the case also in our own instance, if the exertions of the Professors met even the smiles, much more the gratitude of their fellow-citizens. But half of them (or more) are unconscious of the existence of such an institution in their midst, and the majority of them do not care whether it exists and is carried on or is defunct. None of our leading citizens take any interest in its existence and prosperity, and under the influence of such indifference, of course the zeal of the Professors in carrying it on is much damped and diminished.

Another singular point about our institution is that, notwithstanding its acknowledged utility and benefit, it has not, since its foundation, received the slightest pecuniary aid from the State, the corporation, or any individual, and in this it differs from almost every other establishment in the country, and I must say in the civilized world. The most magnificent and extensive medical school in the world is that of Paris, founded by Napoleon Bonaparte, on national funds, which pay the Professors and all expenses, and allow students *of all nations* to take advantage of its instruction, free of any charge whatever. Next, the magnificent establishments of Guy's Hospital and St. Bartholomew's Hospital, in London, the splendid buildings of which cover several acres of ground, and each contains about one thousand beds, which are constantly occupied by the afflicted poor, were each established and endowed from the private fortunes of rich individuals on so liberal a plan that they neither cost the public or the patients a single cent. The medical department of the University of Oxford, in England, which now ranks as the highest medical school in that country, originated in the liberality of Dr. John Radcliffe, physician to Queen Anne, who gave £40,000 to erect a building, and buy books and apparatus for it.

But coming nearer home, we cannot expect such munificence in a comparatively new country like the United States. But even here much has been already for the furtherance of medical science, and much more will no doubt be effected in due time. Look at the liberal assistance that ha been furnished by Laurence and others for improving the medical and scientific departments of Harvard College in Massachusetts. And our own State may look with pride on the advantages bestowed on the medical school at Nashville, where a comparatively small amount of money out of the State funds, and the pride and fostering care of the citizens has raised the reputation of that medical school to be third in point of numbers of all the schools in the United States. But the citizens of Nashville are proud of their establishment, and do all in their power to foster, maintain and improve it. And even in the new or opposition medical school now forming in our city, a rival institution, Dr. Shelby, has presented them with $5,000 in cash to commence their operations, and the citizens have furnished their building. It may here be fairly asked, what advantage does Nashville possess over Memphis that she should be so highly patronized? and the answer must be *none in a geographical or local point of view*, for Memphis is much more accessible both by land and by water, and the one city is allowed to be as healthy as the other. On this very account the residents of Nashville are less absorbed in trade and commerce, and they have more time to devote to science, literature and education. This enables them to form a higher estimate of the value of science and mental acquirements, and produces a literary society, independent of which the maintainance of a large medical school is important in a commercial point of view and worthy of the patronage of those who do not estimate its mental advantages; for a large number of strangers sojourning, even for a short time, in a commercial community, never fail to expend a large sum of money—the advantage of which is felt by the provision dealers, clothiers, booksellers, and many other trades, which, when the numbers are small, the amount brought in is less important, perhaps, hardly worth seeking.

If we inquire what has been done toward encouraging and augmenting the Medical school of Memphis, it will soon appear that the answer is *nothing*. It may be urged that the city corporation have rendered liberal aid by granting the use of the few rooms in the Exchange Building, in which we are now assembled and carry on our business, without any rent or charge. But, though no money is required, yet the condition upon which the College holds these rooms is a very onerous one, and one that much more than pays any pecuniary rent, that could be demanded for the use of the rooms. It is no less than that a dispensary shall be formed and kept up, and that the members of the Faculty shall act as city physicians and surgeons, and shall exercise, prescribe for and operate upon all the paupers in the city, who may stand in need of medical advice or assistance, and that they shall compound and dispense all necessary medicines, which are furnished gratuitously by the corporation. This task is *no small one*, for during the last few months the number of patients who assembled in the building for medical assistance, sometimes amounted to sixty, and during the whole term averaged forty every morning, many of whom would die in the streets, were it not for this most valuable charity, the existence of which is, I believe, unknown to more than half of our inhabitants.

The faculty of the College and its senior students and graduates engage cheerfully in the administration of this dispensary from the consciousness that while they are doing good to a most helpless and wretched branch of the community, they are also doing good to the college, because the students attend the dispensary, and there are very few places in the country where they have an opportunity of seeing and examining such an immense diversity of cases as are thus daily brought before them, and it is an established fact that which is called *clinical instruction* or actual inspection and examination of the patient, is by far the most valuable part of medical education, for, notwithstanding that a great deal can be and is taught by books and lectures, yet it is an established fact that no man can become a good and competent physician or surgeon without actual practise, that is seeing and feeling the nature of a complaint and watching its progress in the living subject. And this gives the locality of Memphis a most decided superiority over almost every place except New Orleans, New York and a few of the large commercial cities where the extent of navigation and commerce brings disease and casualties from almost every part of the world. Memphis is peculiarly rich in this respect, and it amounts almost to a sin that such care and extensive means of studying disease should be thrown away as it is in Memphis, who, notwithstanding other progress and prosperity and wealth, to *her shame be it spoken*, does not contain a single station-house, watch-house, or work-house, where the poor, friendless and moneyless stranger can find a place of temporary rest and comfort even for a single night. It is true, she has an ill constructed and inconvenient jail and hospital for the sick, but neither of them on a scale or condit on to suit the now increased and daily increasing population of the city, besides which it requires the commital of a crime to claim admission into the first, and money and certain legal forms and states of disease which ignoran strangers are unacquainted with to obtain admission into the latter, which is frequently over thronged with inmates so as to render admission impossible. A larger and more accessible hospital is, therefore, required, and this might be combined with a work-house, or some building where the sick and poor stranger could be protected from the inclemency of a winter's night, and housed until h s case had been examined, and it was ascertained whether he deserved protection or not.

Let us hope that these matters will be taken into consideration by the State and city authorities, and that our beautiful and prosperous city will shortly be relieved of the opprobrium that is cast upon it by all strangers, when they become acquainted with these and its other deficiencies.

Notwithstanding all this, Memphis has proved herself to be a most admirable position for a school for acquiring medical knowledge by the efficient pupils she has sent into the world, and by the satisfaction they have all expressed of the nature and importance of the instruction they have received within these walls. Our alumni are all ready and willing to aid and support us. But what we want is the kindly aid of the State and of the public. We, in fact, languish for want of funds. Our chemical and philosophical apparatus is already as *good as modern and as complete as could be* wished, though a large part of this is my own private property. But our museum is sadly deficient, and a medical library we have none, and but few pictures or diagrams and wet preparations, and these cannot be obtained without delay and considerable expenditure of money; and although the rooms that are granted to us by the corporation do answer our purpose, yet they do not do so as effectually as rooms built for the express purpose of teaching, and so we are much cramped and inconvenienced. Besides this, the success of a school depends much on its external as well as internal appearance, for the eye has to be captivated, while the mind is instructed, and I really believe that a great portion of the success that has attended our sister school in Nashville has arisen from the work being carried on in an elegant and appropriate building, constructed by the State for the purpose for which it is used. In fact, the celebrity that our school has attained abroad, demands a better, more convenient and appropriate detached building of its own, and there is no doubt that if we possessed such a one, our school would increase greatly in numbers and perhaps in reputation, and would in this way prove more beneficial, both in an honorary as well as pecuniary, way to the city of Memphis. We want and ought to have such a building, but its cost puts it out of our reach, and we can, therefore, only look forward to the liberality of the State, or of *rich individuals, who are desirous of raising the* fame of Memphis by increasing her scientific character.

William Wagner, a mercantile and scientific citizen of Philadelphia, has lately presented the corporation of that city with a lot of ground to build upon, and his private museum of natural history and geology, with his library, which here cost him the sum of $150,000, for the purpose of establishing a college of medical and other sciences. The donations of Mr. Lawrence to Havard College for the extension of science are known to every one. Dr. Shelby, of Nashville, has lately given $5,000 to assist the new medical school now forming there, and may we not hope that some rich and patriotic individual may be found in Tennessee, who will immortalize his name by giving or bequeathing that to our medical college that will enable her to move in the sphere in which she ought to walk, when (aided by her locality) she would certainly become one of the first institutions in the world. Should we fail in this, cannot the people of the State be prevailed upon to subscribe small sums, which in the aggregate would be sufficient to build us a temple of science in a central part of the city, which, in the end, would not fail to reap the honors and profits that would accrue from such an undertaking, and I live in sanguine hopes that these views may be achieved.

I must now address a few words to you gentlemen who are about joining us as students of medicine during the session this day commencing.

Some of you are no doubt from the country, and may not be aware of the seductions and allurements of a city life. You are perhaps far away from your homes and friends, and have come here for instruction in the noble and scientific study of medicine, at very considerable expense in money. In every large city you are surrounded by temptations to waste time and spend money, and this I wish to warn you against. The studies you are about to enter upon here are of a very difficult and abstruse nature, and if you attend the six lectures that are given every day, (except Saturday and Sunday,) and read and study the subjects you have heard lectured upon, attend your meals, and the dissecting room in the evenings, you will find no time to spare for idling or dissipation. In a city you are beset with amusements of various kinds, with spurious and dangerous companions, who may tempt you to drink or to play, and who will devise schemes of every kind to get money out of your pockets. Your best protection against these is attention to business, which, if properly attended to, will leave no time for anything else, and will always afford a sufficient excuse from going into company. Above all things, I expect you not to get into a habit of drinking, for if once you are unfortunate enough to obtain a character for this propensity your future professional character is blasted forever. Endeavor by all means to cultivate your minds and store them with useful knowledge at every possible opportunity, for the physician of the present day must not only be well posted in the practice of his profession, but the progress of science of every kind is almost entirely entrusted to his care and protection, and he is expected to be a learned man. Many unfortunately enter the profession without a sufficiently extended school education—without, for example, any knowledge of the Greek and Latin languages, and this often proves a great drawback to them, because nearly all our disorders, our remedies, our implements, even parts of the body derive their names from the Latin or Greek languages, therefore, many words that appear strange and unmeaning, and difficult to remember will immediately change their character, when their meaning in the dead language is explained, and then they appear beautifully simple and appropriate. A good medical dictionary like that prepared by my friend, Dr. Dunglison, of Philadelphia, which explains all those things, should, therefore, be constantly at your elbow, and I strongly recommend your subscribing to some good medical periodical which will keep you posted up as to professional improvements, and inform you what is doing abroad. Of these, there are a great number, but those that I particularly wish to recommend to your notice, are *Dr. Hay's Quarterly Journal of Medical Science*, published in Philadelphia, for five dollars a year, and *Rankings Half Yearly Retrospect of Medicine and Surgery*, for two dollars a year. Either or both of them are supplied to you by mail, at these prices at any place, post paid; and they are both excellent and valuable works. You must likewise obtain a copy of the printed code of *Medical Ethics* as established by the American Medical Association in May, 1847, which explains the relations of the members of the medical profession towards each other, and their patients and of the patients towards them, in fact all the laws or rules by which the medical profession is conducted.

The objects of medical study and research have become so various and extended that although every physician is expected to be generally acquainted with the leading features of all of them, yet no one is hardly ever master of the whole of them, therefore a number of men are selected to form a Medical Faculty for teaching, in which each one takes a particular department which he has most closely studied and attended to, and of which he is believed to be master, and thus a degree of perfection is obtained for the student, such as could hardly be expected from the exertions of any one person. In our school Dr. John Millington takes charge of practice of medicine, for which he is amply qualified by his many years of active practice in a Southern climate. But fractures, wounds, malformations and the like, which require the use of the hand and the knife, as well as the mind, constitute the branch called Surgery, and this will be attended to by Dr. Rabards. There is another branch, compounded of practice and surgery, called Obstetrics, comprehending the diseases of women and children, which is under the care of Dr. Shanks. None of these could, however, be prosecuted or carried on without an intimate acquaintance with the form and position of every part of the human body, which knowledge constitutes the science called Anatomy, and this is taken charge of and taught by Dr. Taylor and Dr. Marable, the Demonstrator, who superintends practical anatomy.

Although Anatomy instructs us in the form and construction of the body, yet it does not explain the uses and functions of their several parts when in a normal or diseased state, and the science that teaches this is called Physiology, taken charge of by Dr. Tuck. Next, the materials which nature furnishes, chiefly from the vegetable kingdom, but partly from the mineral and animal branches, and the method of using, compounding and administering them for the benefit of mankind, constitutes another branch of science, called Pharmacy, including Botany, Mineralogy, and the Materia Medica, is ably taught and discussed by Dr. Guthrie. Lastly, Chemistry (the teaching of which is confided to my care) is now acknowledged to have more or less influence on all the other branches; and these several branches, when combined and well understood, constitute a very complete code of medical instruction, and such a one as we propose to give in our unostentatious but sound establishment.

You will, gentlemen, no doubt meet with some professional men of the *old school*, who look upon a science like chemistry as an idle and useless handmaid of medicine, and who will sneer at the revelations of the microscope, the stethescope, and the pleximeter applied to physiology or pathology. But you will generally find these to be merely *practical* men, who have either closed their eyes to the *overwhelming progress of these sciences*, or they are vexed at the idea of having first to learn their alphabet to begin the study of chemistry, or learn how to handle a microscope before they can profitably read any modern work in physiology or pathology.

The idea has spread (to a great extent) that a practical man must derive his knowledge solely from experience—that is to say, he does not in any way adhere to the rules comprising laws, likewise derived from experience. Such a man, then, if he be a physician, reasons from his own individually acquired and necessarily limited observation when a new case is brought before him. Now, we know that when we are quite truthful in our inquiries, we are liable to error. Examine our Materia Medica, and there we are furnished with a whole list of remedies, seemingly applicable to cure a certain disease. But in practice we meet with cases in which none of these prove reliable, and then, of course, the mind must go to work to discover the cause of the discrepancy.

We have learned by experience that red hot metal when touched will produce a burn, but we should be much mistaken in or conclusion that such an effect is unexceptional rule. Science predicts by deduction from determined laws, (those regarding the spheroidal condition of fluid bodies,) that a different result will sometimes be met with. Thus the French philosopher Boulignes bathed his hands in a vessel containing melted iron, and found them unhurt. I was myself called to see a foundryman, who fell, while assisting two others to carry a large pot of melted iron, and he fell in such a manner that both his hands were immured above the wrist in the melted metal. It was apprehended that the consequences would be dreadful, but to the surprise of all present, his hands were not as much injured as they would have been by dipping them into boiling water—*that* would have come into immediate contact with the skin, but the immense heat of the iron produced such a flow of steam and vapor as seemed to prevent contact of the heated iron. At least this was the only way in which I could account for the phenomenon and more recent researches have proved it to be true.

To speak in the language of a late medical writer, who hits this point exactly, the practical man, when he is really nothing more, is one who can just do what he has been taught to do, and who has acquired some skill and judgment in a small range of occupations. He lays up a store of receipts for particular cases, and like the cook or the dyer, works mechanically and without mental exertion.

To what gross absurdities the mere practical conception of any scientific process may lead the ignorant and uninstructed is strikingly illustrated in an anecdote that is told of a servant man who was engaged in the analytical laboratory of the celebrated Berzelius, who being asked what chemistry was, that made his master so celebrated, answered naively; first, I have to get many different things in large bottles, from them smaller ones are filled up, then the contents are poured by my master into still smaller ones, and finally all is thrown into a large tub, which I have to carry and empty into the gutter. This is chemistry, and of the truth of this description you will have ample proof in the progress of our lectures. Theory is the directing mind, and practice alone the mechanically working servant, both in chemistry and the whole range of medical processes.

You cannot, gentlemen, form a correct idea of the use and importance of chemistry until you have made some advance in our subjects; and then you will find that in physiology, pathology and therapentics this science is indispensable. There is not a single disease that is not attended by chemical changes; and we can never hope to comprehend or explain the nature of any process while we remain ignorant of its integral factors. Life cannot exist without chemical changes, and disease cannot exist without chemical changes; thus, much in reference to pathology, while in respect to therapentics it is superfluous to observe that chemistry plays the principal part, for where has modern pharmacology sought its chief support, save in chemical processes and principles? And if we have advanced so far towards a clear insight as no longer to ascribe supernatural forces to medicines, but to derive their efficacy from chemical properties alone, then must chemistry always be the supporting basis of pharmacy. The physician acts upon the body mostly by the aid of matter which retains its characteristic powers within no less than without the organism. If then, nervous action likewise falls within the sphere of chemical metamorphosis, the nervina or neuralica of pharmacologists must (primarily at least) act chemically on this system.

The incalculable influence which the natural sciences exercise on all the mechanic arts, and the economical advantages which the correct practical application of their principles to every branch of business at the present day, is unquestionable. What formerly could only be done by manual labor, at great expense of time and money, the natural sciences teach us to do easily, perfectly, and in the shortest time, by making the active but hidden forces of nature subservient to our wishes. Who would suppose that the awe-striking lightning of the skies would ever be tamed and made the obedient servant of human intellect? That we should be able to make good and wholesome sugar out of old rags, after they had answered for making paper? or that flour should be made from sawdust? These are but a few of the discoveries of modern chemistry, to which we may add the electric telegraph, the art of daguerreotyping or electrotyping, or copying coins, medals, etc., and covering them with gold, silver, and other metals; friction matches; the illumination of our houses and cities with gas; and of the later discoveries we must not omit that blessing to human sufferers obtained from the use of ether and chloroform, and still more recently that metals (equal in color, appearance and utility to gold and silver,) can be obtained in any quantity out of the clay upon which we walk and with which we make our bricks. How different, then, is our age of steam and electricity from the preceding ones, when witchcraft, magic, astrology, superstition and religious prosecution took the lead. Think for a moment of the deplorable fate of the Neapolitan philosopher, Giordino Bruno, who was burnt alive for publishing his opinions and discoveries, or of Galileo, who, at the age of 80, was forced to deny on his knees before the Inquisition the reality of the great discoveries he had made, (and which have since been fully established,) to escape the dungeon, or a cruel death.

The daily increasing popular acquisition of scientific knowledge calls upon all men, and particularly on the medical profession, to put forth vigorous efforts to win from mother nature daily more and more the riches of her stores in agriculture, mining, art and manufacture, thus working out a more expansive philanthrophy and nobler civilization, securing comforts and happiness *never before enjoyed by the human race.*

Besides this, the natural sciences afford to every ardent lover of nature, whether rich or poor, the purest and most delight ful enjoyments, pleasing the eye, refining the taste, and improving the heart. They are especially adapted to impress upon our minds the unlimited power, wisdom and goodness of God; and lastly may man compare nature, with her mighty mountains, gaily colored flowers, and variously formed animals, to the Sacred Scriptures. What in this book is revealed to us in words, we can here behold in the great Book of Nature, unfolded in the beautiful forms of real, substantial objects of creation.

To the initiated naturalist, the whole plan of nature is thus unrolled and becomes intelligible. Now the mystic veil is lifted; he can read in living symbols the inscription on the monument of Nature—the history of our planet for the past and prophecies for the future; he now contemplates the Universe with different eyes, as it were, every leaflet, every creeping worm, or rocky crystal, all revealing perfect harmony and wise design.

Let me, therefore, gentlemen, urge you to embark in the delightful studies you are about to commence with zeal, industry and perseverance. Be not alarmed at any little difficulties you may meet with, but face *them boldly and remember* while you are at college, you have your preceptors at your elbow, and it is their duty (and will be their pleasure) to remove any obstacles you may meet with as far as lies in their power. And I promise you, that if you take advantage of all this college will offer to you, that you will not be disappointed, but satisfied; and that you will reach the good for which you are all running—fame and emolument. To-morrow morning, gentlemen, the regular business of the session will commence, and six lectures will be delivered every day, until the close of our session. Till to-morrow, therefore, I say farewell.

APPENDIX D

ENGINEERING LECTURE AT WILLIAM AND MARY COLLEGE

Source: John Millington, "Address on Civil Engineering," Southern Literary Messenger, V (September, 1839), pp. 592-595.

tant truth cannot be employed, but by naming those who are still upon the stage of life, must we forbear to use these means, lest we be suspected of flattery or malignity? The necessity for doing this should indeed be always clear and strong: and you will bear me witness, that I have commonly done so with reluctance. Fortunately for me, gentlemen, (unfortunately for our country,) it has happened that I could not perform my whole duty in this particular, without showing you that there is not one among those sworn defenders of the Constitution, who stand most conspicuous as candidates for public favor, and public honors, at whose hands it has not received a wound. I have often indeed endeavored to give the history of the fact without naming the actor. Yet I have, from time to time, had occasion to name them all, and though I have never attempted to excite your indignation, yet there is not one of them whom I have foreborne to censure. I have felt it to be right that I should censure them: for, one of the most important lessons you can learn is the danger of yielding yourselves up to the impulses of that confidence, so natural to inexperienced and sanguine youth. "Put not your trust in princes, nor in the sons of men." If you go into life prepared to pin your faith upon the sleeve of any leader, to follow the fortunes and devote yourselves to the service of any political aspirant, my conscience ought to acquit me of having failed to warn you against conduct so dangerous and so criminal. It does acquit me. If such are the purposes which will accompany you into any station, to which your country may call you, the fault will not be mine. I have done what I could. With other powers I might have done more: and had I the eloquence which might inspire you with a just zeal for your country's rights, and a righteous indignation against all who invade them, I am not sure that it would not have been my duty to lay aside all reserve; to strip off all concealment; to show the assassins of the Constitution "hacking each other's daggers in its sides;" expose its bleeding wounds, and "bid them speak for me."

Yet I must not mislead you, gentlemen, by withdrawing your attention from the fact, that he, who, in political life would act alone, must always act without effect. His efforts must often be associated with those of men who do not fully possess his confidence, and to secure their coöperation, he must frequently tolerate, and sometimes support measures which his judgment condemns. This is one of those hard conditions, "twin-born with greatness," which gives the successful aspirant so much cause to envy him, who, in the independence of private life, chooses his company and regulates his conduct by the dictates of his own conscience.

In this, gentlemen, as in many other particulars, you will find that the ideas I have endeavored to inculcate, are not such as will qualify you to take an early and a prominent stand in the service of your country, or to win your way at once to the honors and emoluments of office. But if these last be the objects to which you purpose to devote yourselves, nothing that I have said will stand in your way. The political adventurer is never at a loss to divest himself of any inconvenient opinions, which might retard his progress in the career of ambition. Besides, there are no imaginable opinions which it may not at some time suit him to adopt. The devoted adherent of Cromwell the *Protector*, would have awkwardly paid his court, by echoing the sentiments of Cromwell, the *commander of the army of the Parliament*. So long as parties retain their names, their watchwords and their leaders, their principles may vary indefinitely; and the very men who might now denounce as criminal, any sentiment expressed in this discourse, may, at a future day, take it as the watchword of their party.

But after all, gentlemen, the prize most worthy to reward the toils of him who gives himself to the service of his country, is one which does not depend on the capricious coincidence of public opinion with his fixed principles and convictions. The ostracism was the crowning glory of the life of Aristides. The exile of Camillus made him the saviour of his country: and the fame that lives and will live, when all the honors that contemporary approbation can bestow, shall be forgotten, is the meed of that virtuous constancy, that alike defies the tyrant's power, and resists the unbridled passions of the multitude. The man of virtuous wisdom cannot be withheld from the service of his country. Condemned to retirement, his unambitious life affords a pledge of sincerity, which gives sanction and authority to his known opinions. The man of virtuous wisdom cannot be hid. His brightness shines through the cloud that would obscure him, and, gilded with his beams, he wears it as a glory. His fame is the gift of him, whose approbation is the only true honor. Without the vantage ground of high station, he utters his voice, and it is heard by the listening ear that leans to catch his words. His post is the post of honor, whatever it be, and he occupies it without fear of change. Man conferred it not, and man cannot take it away. And above all, gentlemen, when that day shall come, which comes alike to all; when the warrior's wreath, and the statesman's civic crown, alike shall wither at the touch of death, the garland that decks his tomb shall bloom in immortal freshness, watered by the pious tears of a grateful country, and guarded by the care of him to whom the memory of the just is precious.

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ADDRESS ON CIVIL ENGINEERING.

On Tuesday, July 2nd, Professor MILLINGTON completed the course of instruction, which he gives on the subject of Civil Engineering in William and Mary College, by a public examination of his class, and concluded with the following remarks, which are here published at the request of the class.

"Having closed this examination, my functions, as your teacher, cease for the present session, and we shall shortly have to part. I cannot, however, permit this event to take place, without some expression of my feelings on the occasion. After your experience, gentlemen, I need not tell you that the acquirement of knowledge is a dry and laborious occupation; and there is no doubt but that many (particularly among the juniors) who attend college, will look upon their instructors in the light of a set of tormentors, who are perpetually goading them onwards, in a rough and disagreeable path, to which they see no end; and even

when the end at length appears, they observe no reward to recompense them for their toil.

Far different are the views of the instructors, and those who have been instructed. Their previous labors have put them in possession of the facts, that as the world advances in civilization, the sinewy arm of the savage warrior sinks into impotence before the armed mind of the enlightened man—that virtue and knowledge are the elements of power, by which men can not only make themselves happy, but promote the welfare and happiness of those around them; and by which, not only individuals, but whole nations are made to rise in power and general estimation.

Such feelings cannot but engender an enthusiastic spirit in the breasts of instructors to promote the advancement of their pupils, so long as they find their precepts take root, and are not scattered before the winds; and such, gentlemen, have been my feelings during the progress of the session now about to close; for I can, without flattery, state to you, that the conduct of my philosophical and engineer classes, and of the major part of my junior class, has been such as not only merits, but commands my admiration and approval. They have convinced me, that they came to this place for the honorable purpose of improving themselves, that they might hereafter ornament their country; and this declaration, fortunately, does not depend upon my opinion alone, but upon the very excellent examinations they have gone through, in a manner so creditable to themselves, in the several departments of science in which they have embarked.

Still, gentlemen, you must keep in mind that the quantity and quality of instruction we can impart here, is not sufficient to make the perfect man. To some, perhaps, our course of instruction may appear long and minute; but those who duly view the subject, will find that it is a *mere skimming* over the surface, without attempting to fathom the depth. We may sow the seeds of a Bacon, a Newton, or a Locke, but it takes years for the plant to arrive at maturity. We may study the map, and become intimately acquainted with the roads, and the relative bearings and distances of places, but we know nothing of their beauties and deformities or comparative advantages without much tedious travelling, and perhaps encountering many hardships. So, gentlemen, it is with a college. All we can profess to do, is to act as your pilots—to steer you with safety from an unknown coast—to warn you of dangers and difficulties—to carry you through them, and to launch you into the wide ocean of public life, with ample sailing directions and precautions for your future safety—and here, like the pilot, we must leave you, that we may return to take charge of new adventurers.

Being now free, you may suppose that nothing more remains than to pursue your onward course and arrive at the haven of fame and prosperity. But the voyage through life is beset with many difficulties; and as the prudent mariner never ceases to keep watch for the shoals, the rocks and tempests that may assail his progress, so, like him, *you* must be watchful, and not permit indolence and apathy to lull you into the idea that your progress is certain and secure; for life, like the ocean, is beset with many obstacles—among the most prominent of which are, dissipation, idleness, and vanity, upon any of which the moral frame may be as effectually stranded and lost, as the bark of the mariner may be upon the rocks and shoals of the ocean. It is against these I desire to warn you; and it will require your every effort to steer clear of them; for they are often so sunk and disguised that you may be entangled in their mazes even before you know you are encountering them; and should you find yourselves within these trammels, safety can alone be sought by a vigorous determination and effort of mind and body to abandon the former track, and by steering a new course in the never failing path of moral rectitude. This applies equally to every calling and occupation of life. But the observations I have just been making have been more particularly called forth by the subject of our late discussions on engineering. There is, perhaps, no profession that is beset with greater difficulties and temptations than that of the civil engineer, especially on his outset into life, and on this account I shall lay before you a few remarks, drawn from my own experience in the profession, and which may, perhaps, prove useful to such of you as intend to confine your future exertions to this useful branch of business.

Civil engineering, like all other professions, arises out of the necessities of society, for they all, in common, spring from the mutual dependence of men on each other, and the advantages that accrue to individuals from a division of talent and labor. No man would call upon the lawyer to plead his cause, or the physician to attend his family under sickness, if he felt convinced that his own talents and acquirements were superior to those of the person he employs. But a confidence is engendered by his knowledge, that the men he selects as his advisers have minutely studied their several professions in their younger days, and by devoting themselves exclusively to their pursuits in after life, he feels assured they must have become expert and proficient. And so it is with the more recently formed profession of the engineer. He must study in early life, not only to learn what has been done, but what yet remains to be done; for as the arts and manufacturing processes improve and multiply in an almost countless ratio—as the civilization of a country advances, structures are required beyond the skill and reach of the ordinary builder or mechanic, and then it is that the science and acquirements of the engineer are called into action; for I have before explained to you, that the skill of the engineer is not confined to the mere construction of rail roads, canals and bridges, for the easy transportation of goods, but to the construction of machinery of every kind, for converting raw materials to useful purposes, and to many other objects.

To obtain public confidence, the young engineer must, therefore, in the first place, convince the public that he has duly studied and made himself (to a certain extent) master of his subject; and he must also accomplish or produce some work which may show that he is capable of carrying his conceptions into practical effect. The certificates of competency about to be delivered from this venerable institution to such of her alumni as have successfully prosecuted the subject of engineering within her walls, will no doubt go far to accomplish the first of these desiderata; but the second is difficult of obtention, because it seldom happens that a young engineer, without experience, is entrusted with

the execution of a large work. Still, however, in a subordinate capacity, or while acting under a more experienced master, he will have many opportunities of evincing his proficiency and obtaining preferment. Independent of this, the genius of the young aspirant is free to digest new plans, and many of the most useful works both of this country and of Britain have originated in this way. The public mind is seldom excited to action until some object is brought before it, on which it can operate. And if a young engineer can suggest plans for the improvement of his country and is able to show their benefit and advantage, it seldom happens that they are brought forward in vain. They only require to be known that they may be adopted, and then in justice to the inventor he is rewarded by being made the superintendent or executor of his own designs.

The next difficulty in which the engineer is involved, arises from his great responsibility. He is frequently employed not only to design but to execute large and national concerns, in which vast capitals may be involved. His master or employer, from the nature of the concern, is seldom a single individual, but generally a board or committee, consisting of many persons, all of whom he has to conciliate and please. His original design, therefore, requires intense thought and consideration, for it is subject to the revision and animadversion of all his employers, and the almost impossibility of pleasing every body is universally admitted. It is therefore, necessary, that he shall be prepared with sound arguments to support every part of what he is about to execute, unless he sees good reason in the discussion of his plans for altering or amending any part of them. Firmness and decision of character will here prove of great value to him.

Another difficulty the engineer has to contend with, arises from the durability of his works. Men of all professions are liable to err; but it happens, fortunately for most of them, that unless their errors are very glaring, they are soon forgotten, and fall into oblivion, and consequently do not leave an indelible stain on their professional reputation. Not so, however, with the engineer—his works are, in their very nature, permanent—and they are frequently large and open to public view—so that they become monuments which proclaim the skill or incompetency of their constructors to future generations, in language that cannot be disguised or misunderstood. Errors of construction, such as have just been alluded to, frequently arise from a desire on the part of the engineer to please his employer, (even at the risk of his own reputation,) a practice that every engineer should sedulously avoid. His skill should be such as will enable him to determine the least quantity of material which he can use with safety for a given construction, and if he swerves at all from rule, it should be on the side of additional strength rather than of insufficiency. If he introduces more material than what is palpably necessary for the strength of his construction, he will be justly blamed for a lavish expenditure of his employer's money. The error is, however, frequently on the other side; because, with the view of courting public favor or that of his employer, or for bringing his work within the first estimated cost, he frequently economizes materials and labor to such an extent as to introduce insecurity; and should a failure occur in consequence, he is never thanked for his laudable endeavor to diminish expense; but is universally blamed for want of skill, and perhaps loses his professional reputation forever.

The last point to which I wish to call your attention, regards your treatment of and demeanor towards contractors and workmen, who may be employed under your directions. In this respect, the engineer has a very important and responsible duty to perform, for he is in almost all cases the arbiter or judge between the employer and the employed. In making contracts, or valuing work after it has been executed, it becomes his duty to regulate all prices in such manner that they may be fair and equitable between both parties, without favor or affection to either. Contractors, and those who have spent years upon public works, you will in general find to be cunning and over-reaching, and ever ready to convert every thing, both in measure and price, to their own advantage. But I have always found, that when they meet a man who understands his business, and who is firm in his resolution to do justice to them, and no more, they are submissive, and ever ready to yield to what is fair and right. It has been the practice with some engineers, to grind down their workmen to the lowest cent, and barely to allow them living profits, for the sole purpose of currying favor with their employers; but such conduct never fails to lead to neglect and inattention to the work, as well as endless disputes and disagreements; and you may rest assured, on my own experience, that the only sure way to command the respect of the employer and workmen, is to observe the most strict and impartial justice between them.

It frequently happens, that the works of the engineer place him and his workmen in thinly populated, or even unfrequented places; and, as man is naturally gregarious and fond of society, intimacies may arise which ought never to be carried beyond the limits of propriety. Contractors, and the lower order of laborers under them, are naturally prone to indulgence in drinking and idle habits; and if these are once joined in, or sanctioned by the engineer, there will be an end of all future order and subordination—consequently, such practices should be scrupulously avoided. Public contractors are ever ready to stand treat, as they call it—that is to provide entertainments at their own cost; yet they probably never do so, but for the purpose of serving their own interests, by establishing friendships, in order that their omissions and defalcations may pass unnoticed, or that they may take advantage in some shape or another. Above all, the practice of borrowing money from contractors or workmen cannot be too much deprecated, for this is in fact giving up all hold upon the workman, and yielding him a degree of power which it is not right he should possess. The only true way of gaining the esteem and confidence of your workmen, is to set them a good example in your own conduct and demeanor. To be courteous and civil without being too intimate—to be punctual in all your own appointments and duties, and to exact a like return on their parts—never to find fault unless there is just cause for doing so, and then to be firm and resolute in having that which is wrong amended—to show strict and impartial justice and integrity in all your proceedings, and such a thorough knowledge of what you are about, as will give confidence in the propriety of your orders, which you must

never fail to see promptly executed. Such conduct will not only gain you the good will and esteem of your workmen, but of your employers and the public at the same time.

I have trespassed longer on your time, in laying these hints before you, than I had at first intended, but shall now conclude.

To you, gentlemen, of the engineer class, and of all my classes, I now beg to tender my warm thanks for the kind attention I have met with from you all, during the past session, and to hope that the instructions I have endeavored to lay before you, may ripen into the fruit of usefulness in your after lives. And as our relation of master and student here ceases, I wish you all health, happiness and prosperity, and trust that the friendship that has been engendered between us during our intercourse in the present session, may endure to the end of our lives, as I assure you it will do to the end of mine."

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ADDRESS

Delivered before the Students of William and Mary College, on the 3d of July, 1839, by Professor Robert Saunders. Published at the request of the Students.

Gentlemen of William and Mary—

At the close of another college session, it becomes us to offer you a few words of farewell at parting, of congratulation at your success, and of cheering on your onward course. There can, indeed, be no more worthy cause of congratulation than the simple fact that you enjoy the privilege of education—that the mysteries of your own nature have been revealed to you—that the high endowments, the far-reaching aspirations, the vast capacities, which are the immortal heritage of man, are unveiled to your view, and put in action within you—that you are not of the mass who exist, and pass from existence, in unconsciousness of the treasures they possess, but that you have been adjudged worthy of kindling fires on the altars of science and philosophy—of opening the portals beyond which lie the hidden things of nature. Such being the magnificent results of intellectual cultivation, it would seem but necessary to place them in view of the youthful aspirant, to ensure untiring energy, and a sustained and sustaining ardor in their acquisition—and it would appear an infatuation little short of madness, were he to turn aside, or linger on his path. Could we, indeed, see things as they are—were nothing obscured from our sight by the mists of familiar error, or weakened in its influence by the force of accident and habit, we should be able to set a proper value upon the glorious privilege of education. But such is our constitution, that those who possess it have their perception of its value blunted by its possession—and those who possess it not, require its aid to invest them with the very knowledge of their deficiency. For these last, this is indeed a wise and benificent provision. In this sense, but in this alone, the oft quoted line is true—that "if ignorance is bliss, 'tis folly to be wise." That those, however, having this inestimable gift, should yet esteem it not as it deserves to be esteemed, but should advance with a slow and uncertain step (if indeed they advance at all,) in the career of acquirement, unless some powerful incentive be applied to urge them forward, is one of the innumerable evidences before us, that there is no good provided for man which does not demand voluntary exertion to acquire and to retain it. You have, my young friends, so far manifested a perfect appreciation of the value of knowledge. You have commenced your career most auspiciously. The time which you have passed with us, has afforded to you moments of golden opportunity, which most of you have grasped and made your own. But the impressions which you have thus received, will be weakened, and ultimately effaced, by contact with the world. Time itself will wear them out, unless they are constantly renewed and deepened by that continued exertion of which I have spoken as the only price of learning. Are you capable of this exertion? I will not flatter you. It is arduous. But its very difficulty should arouse your pride to achieve it. This difficulty is, however, greatest on the threshold. Action is unpleasant only to the mind which is unused to it. Soon it becomes a habit—and finally, (such is the happy constitution of our intellectual nature,) what was once an irksome and a weary task, becomes the source of the purest and most exalted gratification—and the mind is gradually led to the highest state of cultivation of which it is susceptible, by receiving as the reward of each additional effort, a corresponding increment of pleasure.

The tumultuous amusements, the evanescent pleasures, and exciting employments of youth, may cause to go unheeded the restless workings of the unsatisfied spirit; but age will come, to which those amusements will be as childish toys, on whose taste those pleasures will pall, and for whose strength those employments are too fervent; then, when the bright hues which floated in the atmosphere of life's morning, have faded away, and given place to the gray of its twilight, will the mild lustre of intellectual attainments beam with delightful radiance. Then can the cultivated mind look in upon itself, and find in its ample stores a solace for that heartless want of sympathy with which the world are wont to regard old age. How blank and dreary, then, is the life of one who has neglected the opportunities of his youth!—who, in the hey-dey of enjoyment, grasped the tinsel and the dross, and cast away or heeded not the pure gold. The mind of such a man, waste, uncultivated, and barren, compared with a mind richly stored with the fruits of reading and reflection, is as the homely piece of unsightly canvass compared with the same material glowing with magic tints and embodying the immortal conceptions of the painter. Can you, under the influence of these considerations, and with the lofty destiny of the intellect fully revealed to you, be satisfied with yourselves, if you press not on to the fulfilmentof that destiny? Can you consent to the degradation, after having been within view of the sacred fane, of having it again hidden from your sight, by falling back upon those who, in the language of the Roman historian, "*Vitam transeunt veluti pecora?*"

Will you not rather hold fast what you have gained, and be able hereafter to say, with the Roman orator, "*quantum alie tribuunt tempestivis conviviis, quantum*

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