The Functional Intellectual

An Excerpt from **Engineering in American Society, 1850-1875**
Raymond H. Merritt

The maturing of the nation in the second half of the nineteenth century, with its accompanying increases in industrialization and urbanization, brought about the need for a more broadly educated civil engineer to deal with an increasingly complex set of nation-building problems. However, the young profession was not ready to surrender the benefits realized from the practical education inherent in the apprenticeship system which had produced the majority of its members in the first half of the century. The solution to the dilemma was the emergence of an educational system that combined the theoretical and practical aspects of engineering.

This selection from Raymond Merritt's study of the engineering profession in the middle of the nineteenth century describes the roots of the modern civil engineering educational system. In this selection Merritt documents another important dimension of the profession which materialized during this period--the emergence of the professional society as the primary advocate for continuing professional education.

Knowledge was the critical agent in the growth of the engineering profession. Private and public corporations hired engineers because they were informed on the latest technological developments and had the administrative skill to organize and carry out technical projects efficiently. Formal academic study and an extensive apprenticeship-training qualified an engineer to direct industrial enterprises. Once in the field, he kept abreast of his practice by reading technical journals and by participating in professional societies. These national and regional groups arranged formal discussion and lectures, supplied reference and library services, and encouraged their members to publish accounts of their own successes and failures.

Publishing houses and professional associations fulfilled an educational purpose and sought to make general knowledge functional, rather than cultivate a special esoteric know-how. Most engineers did not achieve professional status merely by mastering a quantity of technical data. They wanted to be known as men with inquiring minds who were professional problem-solvers. Their success depended upon continual study and observation. In a debate over Thomas Clarke's paper "The Education of Civil Engineers," Francis Collingwood told the American Society of Civil Engineers that education was a lifelong process and that the critical task of the schools was to teach a youth how to learn. Thinking aimed thus at innovation and deviation was a prerequisite for America's technological growth. The technician who merely imitated others, or who made only small improvements in the details of basic design, was not functioning as an engineer but as a craftsman. Such a person who understood accepted building methods could be called a construction foreman or chief mechanic, not a civil or mechanical engineer. Herein lay the distinction between shopmen and those with a thorough academic training. William J. McAlpine, president of the American Society of Civil Engineers, reminded his colleagues in 1868 that the man who neglected his daily study "may rest assured that sooner or later he will be shelved, and his place supplied by one of those who by closer study and better acquaintance with modern developments" would fill his position.

Engineers could perhaps be called functional intellectuals. They were men who employed the methods and discipline of the scholar but to whom ideas were tools of cultural change rather than aesthetic experiences. During the period preceding and following the Civil War, American society called upon such men to fulfill needs and solve problems for which the past provided little help. Improving the methods of building bridges, sewers, canals, railroads, harbors, tunnels, and levees required alert and critical minds. The new materials and the new systems of construction were so complex that society could no longer rely upon craftsmen to provide estimates, supervise contractors, and efficiently manage expanding operations. Moreover, in the cities traditional solutions to the problems of transportation, communication, and sanitation were no longer adequate. The nineteenth-century engineer committed himself to an organic concept of learning much as the twentieth-century architect espoused organic architecture. A functional and expanding knowledge became the expected means of improving society.

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The growth of industrial education was quite remarkable when one considers that there were only two institutions, Rensselaer and West Point, preparing men for careers in applied science in 1840 and that by 1870 over seventy institutions of higher learning offered students an engineering curriculum with courses in mathematics, geology, physics, chemistry, hydraulics, and mechanics. Due to the growth of new schools, engineering graduates increased from less than 900 in the decade before 1870 to more than 3,800 in the 1880s.

The growth of engineering curriculums introduced two tendencies into American higher education: an emphasis upon learning through personal experience and a corresponding concern for developing professional attitudes. Rensselaer Polytechnic Institute, which pioneered in extending a student's education beyond the confines of the lecture and classroom through laboratory assignments, industrial visits, fieldwork, and a program of graduate level research, emphasized that the purpose of college education was the "discipline of the mental facilities as working forces."

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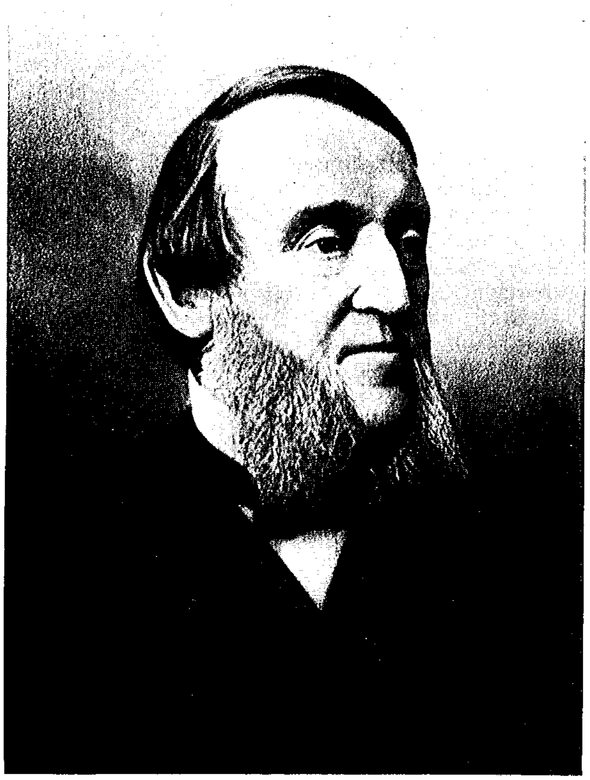
An engineering graduate, however, would soon fall behind if he relied entirely upon his formal education. He needed a continuing program of learning to keep pace with a rapidly expanding fund of technical knowledge. Professional societies provided this constant exchange of technical information. The American Society of Civil Engineers was reorganized in 1868 under determined leaders who emphasized "the advancement of science and practice in Engineering, the acquisition and dissemination of experimental knowledge, the comparison of professional experience, and the encouragement of social intercourse among its members." The Society not only arranged for the discussion and publication of formal papers and a review of current literature but also developed a reference library around the personal collection of William McAlpine. Members were asked to contribute old and new copies of government, municipal, railway, canal, and other reports, including specifications, profiles, maps, and photographs, so as to facilitate comparative studies and to preserve the historical record of important public works. Each of the Society's monthly *Proceedings* contained a section entitled "Library and Museum," listing about a hundred acquisitions.



William McAlpine

The early presidents of the Society believed that knowledge was the principle means by which engineers could maintain their status and authority. In his presidential address of 1868, William McAlpine boasted that engineering was the noblest profession because its collective intellect had breadth and depth as well as the capacity to put its thought to immediate use for the benefit of all mankind. He noted that the world had become too educated to tolerate charlatans. The Society discussed the possibility of requiring each new candidate to present a thesis on some professional subject and to require from all members the annual contribution of a paper, description, or drawing of some work of interest. Though the officers never enforced this policy, they did succeed in making the Society an educational center for the profession.

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. . . Many men actively engaged in engineering practice in the years 1850-1875 remembered the time when the engineer was a craftsman or a tradesman. William McAlpine, whose father was a millwright, noted that the "men of the old school" had become engineers "from a natural bent of mind and an intense love of the developments of the physical sciences." Formal training in mathematics and science, according to McAlpine, was the major factor in lifting engineering "from a trade to the dignity of one of the liberal professions." McAlpine had himself been apprenticed to John B. Jervis for eight years after which he served as chief engineer of the Erie Canal, chief engineer of the Brooklyn Dry Dock, state engineer of New York (1852-1857), chief engineer of the Erie Railway (1852-1857), the Chicago and Galena

Railroad (1857), and the Ohio and Mississippi Railway (1861-1864). Despite his lack of formal education, McAlpine became a consulting engineer for many of the major public works of the period. He helped plan city water systems for Chicago, Brooklyn, Buffalo, Montreal, Philadelphia, San Francisco, and Toronto; bridges for St. Louis, Niagara, and New York; the Manchester Ship Canal in England; a railway in India; and navigation on the Danube River.

McAlpine's mentor, John B. Jervis, likewise urged the American Society of Civil Engineers to fuse the recently developed program of formal scholastic study with the apprenticeship system. Jervis, who was one of America's early canal and railroad engineers, addressed the Society in 1869 on the transition of engineering from a craft to a profession. He suggested that future engineers study mathematics, mechanical philosophy, hydraulics, and existing structures, then enter the field under the direction of an experienced professional. This was similar to the advice that William Gillespie gave his students at Union College. He suggested that after graduation they "take the lowest position in some engineering corps, that of rodman, and only then expect to work up gradually to the rank of chief engineer."

Some exceptional engineers in the period 1850-1875 attained professional status through the apprenticeship system without attending a college. Isham Randolph, for example, son of a notable Virginia family, reached college age during the Civil War, when schools were closed. In 1868 he decided to apprentice as an engineer; five years later he became a resident engineer for the Baltimore and Ohio Railroad. In the 1880s he was chief engineer for the Illinois Central and in 1893 was appointed chief engineer of the Sanitary District of Chicago. He thus attained a national reputation through an effective apprenticeship training, combined with continual study and persistent work.

Most engineers advanced through four stages of apprenticeship training. The first level was that of axman or rodman, the second, transitman or levelman, the third was assistant, resident, or division engineer, and the fourth, chief engineer. Many such as Thomas N. McNair and Albert Robinson, who grew up during the early days of professionalization, attended college first, then passed through the apprenticeship system. Robinson graduated from the University of Michigan with a degree in civil engineering, remained to earn a Master of Science before he was hired in 1871 by the Atchison, Topeka and Santa Fe. He stayed with the same company for most of his career, working his way through the jobs as axman, rodman, levelman, assistant engineer, and chief engineer. After twenty-two years he became vice president and general manager of the railroad.

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Advancement to the position of chief engineer was never a routine matter. Such a man had to demonstrate the capacity to work under political and economic pressure, as well as to display technical competence. One newly appointed chief engineer wrote, "The responsibility came upon me like a thunder bolt, which caused a rather curious sensation . . . a sharp sudden pain on the upper left side of my head, that never ceased for weeks until I got thoroughly acquainted with the work of my new position."

The apprenticeship system trained young men in careful habits of observation and note-taking. The mobility of the profession demanded that notebooks should be so precise and clear that at any moment they could be turned over to a successor who would be able to understand them as well as the author. As many literary men recorded their ideas and experiences in notebooks, so also leading engineers documented their intellectual growth by systematically noting new information.

The apprenticeship system selectively advanced and rewarded only those blessed with an alert mind and administrative capacities. The apprenticeship system taught executive skills, but turned back students who were ineffective leaders.

The "new education" with its emphasis upon discovery and research fostered a great expansion of publication. The idea that publication was a necessary part of academic life also prevailed among engineers. To print up formally the results of a project or the proposal for a new design not only prepared the ground for prospective capital but also eliminated the necessity of answering countless letters from other engineers throughout the world who wished to accumulate technical descriptions, cost analyses, production methods, and other details for similar projects. The publishing house thus served as an institution of higher learning where engineers registered for a lifelong curriculum of reading and writing without expecting ever to graduate.

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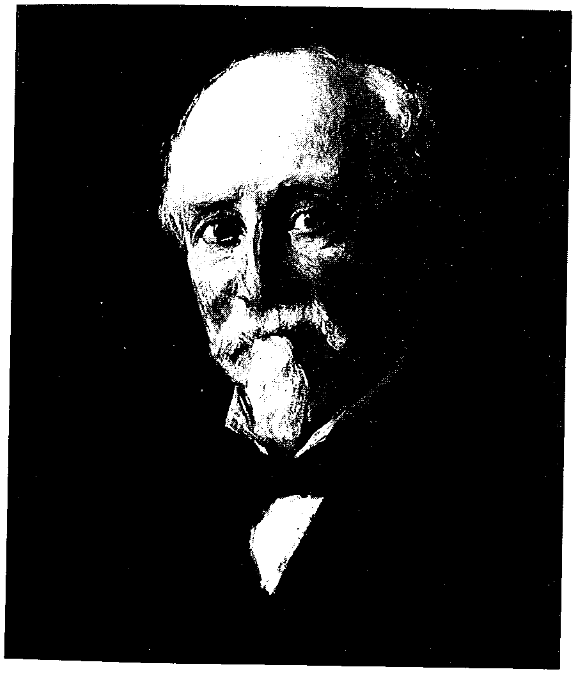

Octave Chanute

An examination of the personal correspondence of Octave Chanute, chief engineer of the Kansas City Bridge (1867-1868), reveals how the printing press became an important tool in the work of a construction engineer. Whenever Chanute confronted a new problem, he requested Van Nostrand's to send any available technical materials dealing with his specific needs. He also ordered, at premium prices, complete sets of periodicals such as *Engineering* and meanwhile subscribed to *Van Nostrand's Eclectic Engineering Magazine*, the *Journal of the Franklin Institute*, the London-published *Engineer*, *The Nation*, *The Week*, *Putnam's Monthly*, and *The Railroad Times*. In 1868 Chanute suggested to Henry Morton that the *Journal of the Franklin Institute* publish the formal papers being prepared for discussion by the reactivated American Society of Civil Engineers, but the society made arrangements instead to publish their own *Transactions*.

Chanute's work on the Kansas City Bridge evoked much interest in the profession, part of it flowing from his argument with William McAlpine in the *Franklin Journal* over proper foundation construction. After completion of the project Chanute and his assistant George Morison wrote **The Kansas City Bridge**, a book describing the technical aspects of spanning the Missouri River. Chanute continued his research and reading even in retirement when he became interested in the gliding experiments of Otto and Gustav Lilienthal.

One might expect an extensive search for new ideas and a willingness to discuss formally new techniques from an immigrant engineer such as Octave Chanute; however, Elmer Corthell, a native American engineer trained in a liberal arts college, also boasted a large cosmopolitan library. Corthell accumulated over twelve hundred volumes, about three-fourths of them connected with his work on the Syn Island Levee; Eads' South Pass Jetties; the New York, East Shore and Buffalo Railroad; Eads' Tehuantepec Ship Railroad scheme; the St. Louis Merchants Bridge; the Chicago, Madison and Northern Railroad; harbor improvements at Tampico, Mexico; public works in Buenos Aires; and commercial projects in Para, Brazil. He published many articles in foreign and domestic newspapers, popular journals, and technical periodicals, and also issued in 1880 his **History of the Jetties at the Mouth of the Mississippi River** (1880).

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At the turn of the century George Morison, a Harvard graduate who entered the profession as an assistant engineer on Octave Chanute's Kansas City Bridge in 1865, observed while looking back over his career, that the age of "Yankee ingenuity" based on a general "knowledge of what has been done" had been replaced by persistent study and observation. Simple honesty and hard work would no longer assure success. The ability to organize, skill in communication, knowledge of a broad array of scientific principles, and the capacity to analyze and modify technical problems had become indispensable. Engineers acquired these through a whole community of schools, professional associations, and apprenticeship experiences. Classical training had given way to the new education which was concerned with changing the future rather than knowing the past. Specialization and utilitarianism were its benchmarks. The nation's colleges trained young men not simply because they wished to be scholars, but because scholars were necessary to "the good of the community." Specialization had made the professional and academic communities more dependent upon one another. Polytechnic education, like technological growth, fostered an urban world and compelled men to expand their knowledge and experience beyond a study of esoteric subjects.

The education of engineers then, rested upon a combination of formal learning and practical experience. Members of the new profession were aware that their prestige and status were dependent upon an ability to assimilate, organize and communicate useful information. Consequently, engineers became intellectuals who combined disciplined study with practical experience. Scientific discoveries, professional advancements, public criticism, and administrative innovations constantly tempered their knowledge and understanding. The learning process of the engineer was never complete.