BIOGRAPHY OF
Robert Hallowell Richards

Former Professor of Mining Engineering at Massachusetts Institute of Technology. Member of American Institute of Mining and Metallurgical Engineers since 1873; Vice President of the Institute 1879–1880; President in 1886; Honorary Member since 1911; Honorary Chairman of Committee on Milling Methods, 1920–1945

A TRIBUTE TO THE LIFE AND WORKS OF PROFESSOR ROBERT HALLOWELL RICHARDS, AND HIS ACHIEVEMENTS AS AUTHOR, TEACHER, INVENTOR, AND CONSULTANT TO VARIOUS COMMERCIAL ENTERPRISES

THE following biography was written by Frank E. Shepard, student under Professor Richards at the Massachusetts Institute of Technology in the Class of 1887. It is made up largely of extracts from Professor Richards' autobiography, entitled "His Mark," published in 1936.

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On August 26, 1844, at "Oaklands," a large estate on the Kennebec River at Gardiner, Maine, a child was born to Anne and Francis Richards, who was named Robert Hallowell Richards. He was next to the youngest in the family of seven children.

Oaklands belonged to Robert's grandfather, and his father and mother (who before her marriage was Anne Hallowell Gardiner) spent the earlier years of their married life there, but when Robert was about four years old his grandfather gave his parents a small estate, known as "The Cove," a farm of one hundred acres, from the Oaklands estate, also fronting on the Kennebec River. Robert's childhood and much of his boyhood were spent at the Cove farm.

In his memoirs Dr. Richards says that his mother tried to start him up the long hill of knowledge. "I hadn't the faintest conception of the 'why' of studying, nor did I know 'how' to study. This lack was a serious handicap throughout my preparatory school work. Up to twenty-one years of age, I was the dunce of every school I attended, but while I was doing nothing with books, my mind was active in observing and studying nature. My rambles in the woods and by the river, watching the habits of the birds and animals and studying the earth formations, were my chief delight.

"In reviewing my early education, the only thing that I do remember learning is music. When I was a very little boy, I was taken for music lessons to a colored woman who lived on the flats in South Gardiner. She taught me the do, re, mi, and so forth, with the musical intervals of the regular scale. I actually acquired that

much knowledge and it remained as a permanent part of myself. Before I reached the age of thirteen I was playing simple exercises on the piano quite well. One of my greatest regrets is that after we went to England my attention was not called to music any more, though when I was seventy years old, I tried to pick it up again. The musical intervals, however, stayed in my mind, so that today I can jot down a simple air with paper and pencil and then strum it on the piano.

"My memory goes back to the building of the first railroad in Gardiner district in Maine, known as the Kennebec and Portland, which later became the connecting link between the United States and Nova Scotia. Vessels used to anchor up and down the river in front of the Cove, in order to get lumber to carry down to the Atlantic seaports.

"When I was six years old, my brothers took me down to the frozen Kennebec to teach me how to skate. I was grasped by the hands and diligently taught, but I was still stupid, so giving me up as a bad job, they abandoned me and went whooping off. I struggled to my feet and began to stagger around on my skates. Presently, I began to push out a bit, a little later I swung into the skate step, joined the others and skated with them. This incident seems to me the key to a great deal in my subsequent life. It was always hard for me to learn from someone else. I must find out for myself the why of a thing.

"When I was a little boy about eleven or twelve years old, on a trip across the Cove, I saw an extraordinary stone. It was charged with fossil shells. On a later trip to Moose River Bridge, Maine, we found many specimens with fossils in them. Again on a trip by Long Pond, we found the rock in place that had furnished all my specimens. Doing this little thing, I had the same thrill that Galileo had when, after making his first telescope, he looked at Venus and found she was a crescent like a new moon, which was what his studies had told him she ought to be.

England

"My father, though American born, had many associations with England and was anxious that we should receive at least a little of our education there. Accordingly, in 1857, when I was thirteen years old, we went to England on the steamship 'Fulton,' of the Collins Line, the last, or nearly last, of the side-wheel steamers."

Robert stayed at his grandfather's home at Cadlington, and his two older brothers were sent to Rugby. At the end of the year they moved to Moorland Cottage, Purbrook, Hampshire, and lived there for the remainder of their stay in England. They spent the fourth and fifth years of their stay in England at Wellington College, about ten miles from Windsor Castle. After two years at Wellington, they returned to America.

Boston

After returning to America, the family lived first at Boylston Place, Boston and in 1864 moved to 85 Pinckney Street. Robert and his brother Harry attended Dr. Humphrey's school at Franklin Square for a year, with the intention of preparing themselves for college. As Robert's progress was poor, he began to study with a tutor. At nineteen years of age, he tried to get into Harvard College and failed. Then he was sent to Phillips Exeter Academy, where he remained nearly two years, studying latin, greek, algebra and geometry.

Technology

In February 1865, he received a letter from his mother informing him that their friend and connection, Prof. William Barton Rogers, was just starting the Massachusetts Institute of Technology, in Boston, and she thought that this

new school might satisfy his needs better than Harvard. M.I.T. had opened on January first in two rooms in the old Mercantile Library on Summer Street. These rooms served as lecture room and laboratory. It was a modest beginning of a chemical laboratory, containing one piece of apparatus of each kind, but there were very few kinds. There was one retort and condenser. Seven pupils used to gather around that, and the rest looked on while one pupil performed the experiment.

Richards comments as follows: "The method of teaching was completely new to all of us. We found ourselves bidding goodbye to the old learn-by-heart method, and beginning to study by observing the facts and laws of nature. We learned from experiment and experience what might be expected to happen if a given collection of material were put together, or if a given set of forces started to act. In short, our feet were set at last in the way of real knowledge. We learned, perhaps falteringly at the outset, the four steps that mark the only route to true science; how to observe, how to record, how to collate, and how to conclude. . . . The effect on the classes was totally different from anything that I had seen in any school before, and it is apparent by this time that I had had a wide field for observation. . . . The interest which began in those first days captured me, body and soul, and grew steadily throughout my three and a half years before graduation.

"I began to see for the first time what school was for, and that it need not worry even the very slow boys. I listened to lectures on chemistry where the lecturer told how things are made, demonstrating the method and providing laboratory work in which I myself handled the apparatus, and my eyes were opened to the wonderful labyrinth ever widening in all directions, of that department of nature. Lectures on physics were accompanied by experiments in which marvels happened before my very eyes. I was fascinated by the wonderful and varied range of phenomena. Lectures in geology, which were illustrated by drawings and sketches, made me realize that where the written description of an object took me minutes, or even hours, to comprehend, I could grasp ideas conveyed by drawings in a few seconds. I discovered that drawing is a separate language, and better still, a universal one. An American can talk with a Russian through drawings, even if their languages are mutually incomprehensible.

"Mechanical drawings cultivate the hand and eye to accurate observation and reproduction, as well as training in sense of beauty. Where heretofore the written page had been for me an insurmountable obstacle, through drawings and working illustrations and actual experience I was able to understand and work with books.

"Descriptive geometry and mechanical drawing were a revelation to me as methods of getting ideas on paper. I am not sure that I would not name it as the most important study of all for an engineer. It enters his daily life, his thoughts are tuned up by descriptive geometry, everything he does is affected by it.

"In fact, I found that this new school was teaching me nature, which I had loved and observed all my life; that I was being taught nature by direct contact and that mathematica, languages and history, were nothing but a means to the end. The whole aspect of school life was at once inverted. I now studied because I could not help it, where previously I had tried to study because I knew I ought to want to study. What had been a hated task, done only from love of my mother, became an active, living, intense interest. I was now converting not print, but observation, into thought. Having at last found out the use of books, I could

not read or study enough to satisfy my craving for knowledge, experience and skill. In academic schools, I had to drag myself to my books, never understanding why I must. Now I could not keep away from books, drawing board and laboratory. Education ceased to be a plague spot and became a delight.

"One and all the teachers made tremendous impressions on us, both by their inspiration and their industry. As I look back, I am again impressed by the imposing list of names; William B. Rogers in geology and physics; Frank H. Storer in chemistry; Charles W. Eliot in chemistry and metallurgy; John D. Runkle in mathematics; George A. Osborne in astronomy and navigation; William Watson in descriptive geometry and mechanical engineering; William R. Ware in architecture; William P. Atkinson in English language and literature; Ferdinand Bocher in modern languages; John B. Henck in civil engineering; A. P. Rockwell in mining engineering; Edward C. Pickering in physics; also a number of other young teachers. Even the knowledge that we acquired did not mean so much to us as the inspiration that we drew from the instructors themselves and from the atmosphere during those first golden days at Technology."*

Dr. Richards further observes: "If our course at the Institute was weak in many points, that is simply because the teachers were new at their job and did not know the true nature of an Institute of Technology. They were sincere men, doing their best for the pupils. This fact, together with their enthusiasm for their subjects, gave us what I believe to have been the greatest thing that we got from Technology—namely, the tremendous inspiration, the strong determination, to get results for the public good."

In his diary record for April 20, 1868, an entry was made not long before receiving his degree, stating that eight days were announced for written examinations covering the first and second years, and including French, German, political economy, astronomy, analytical geometry, calculus, descriptive geometry, general chemistry, and qualitative analysis; also, a note on May 6 of that year, for a nine day's program of written examinations covering the third and fourth years. This included analytical mechanics, civil engineering, analytical chemistry, assaying, spherical astronomy, mechanism, physics, geology, mechanical engineering and inspection drill. "I do not know what percentage of my classmates passed these tests. I am certain I did not, but evidently the faculty did not pay much attention to marks or judge me unworthy because of failure, for after graduation I was asked to stay by the Institute as an instructor. This is again indicative of how the faculty groped to find the way to make a Massachusetts Institute of Technology, for the plan of having the final examinations cover the subjects of all four years was never repeated."

Diversions and Summer Vacations

"Because we were working and studying hard, we soon found we needed exercise, so a number of us attended the old Tremont Gymnasium on Eliot Street, Boston, which was in full blast from 1865 to 1868. The baseball diamond was just developing in 1865. The Lowell Club in Boston was,

* Author's Note.—When the members of the Class of 1887 were students in the old Rogers and Walker buildings on Boylston Street, Boston, Professors Runkle, Osborne and Atkinson were still active on the teaching staff. Characteristic remarks of the professors are recalled with interest. When Professor Runkle would explain some intricate problem in mathematics, he would remark, "Do you catch on?" Professor Atkinson would say, "I don't expect to teach you much History, but I want to teach you how to study History." Sometimes when "Billy At" (William P. Atkinson), started reading a lecture on History, he would stop and say, "Gentlemen, have I read this before?" If the answer was "Yes sir," he would place the manuscript in his drawer, pull out another paper and start reading on a new subject.

I think, the first local club to use it. In the early days, a man was put out by having the ball thrown at him. Later he was touched by the ball. Straight underhand bowling was first used, developing into throwing and finally pitching curves. A certain professor of physics claimed that the ball could not be curved. To prove it, three stakes were driven in a straight line. The ball was thrown to the left of the first stake, right of the second, and left of the third. The professor admitted he was wrong."

As a boy Richards learned to row boats on the Kennebec River, in Maine. At Exeter he developed greater skill in rowing. During the next few years he rowed any sort of boat—skiffs, sea-dories, or vessel boats—and picked up in some way the idea of rowing, with a straight back, a straight arm, a quick catch and a pulling home. In 1868 he joined the Union Boat Club of Boston, and became stroke oar of the Union Boat Club for two years.

The occupations he pursued during summer vacations from Tech proved extremely efficient in helping him acquire the information that later was needed for the mining and metallurgical laboratory. In this third-year vacation he secured his first paid job, as assistant in the United States Coast Survey, making surveys for clearing the channel of the Penobscot River of deposits and edgings from the lumber mills, from Bangor down to Orrington.

"In the summer of '68, Mr. Alexander Agassiz asked me to come to Calumet, Michigan, and make chemical tests of the copper contents of the sand that was running away from the concentrating mills. The tremendous interest which I developed in ore dressing, during the summer, was undoubtedly the beginning of my career in that line. . . . This later led to my invention of a new and important classifier."

In 1869 he surveyed the Eustis mine in Quebec, and in 1894 took a party of students to make surveys for the Dominion Coal Co. In 1870 he visited England again, and then went to Germany to visit one of his classmates. During this period he saw the great Bunsen in his laboratory and also watched Richter, successor to Plattner, make quantitive tests with the blowpipe for copper and for silver.

The Struggling Seventies

The following quotations from Dr. Richards' autobiography show how earnestly he devoted himself to the solution of the difficult problems existing in the early days of the Massachusetts Institute of Technology, and how modest he was in claiming progress from his own efforts.

"I have called this period the Struggling Seventies, as indeed it was. Looking back, I am astonished at the ground we covered. It is a marvel to me that we were able to accomplish something of permanent value, considering our lack of organization, the newness of the field, the speed at which we worked and the serious lack of money, which meant meager equipment.

"My personal struggle is so much wrapped up in Tech that this account becomes inevitably a history of the development of Tech. I am not sorry for this. Indeed, it is my greatest justification for writing of myself. Because I have been privileged to take part in the beginnings and development of what has now become an important institution in America, I feel that the story warrants writing.

"Sometimes we tend to accept things too rapidly, without understanding and without true appreciation. The present Institute of Technology is, I believe, significant not so much for its excellent equipment and endowment and its marvelous facilities as because it represents the inevitable result of real inspiration backed by years of trial, effort and hard work.

"The splendid institution that is now available to thousands, had, like many valuable things in the world, an humble beginning, a real struggle for existence, before it reached its present state of excellence.

"That sincere effort and real ideas do eventually succeed is my firm belief, but now and then we overlook the years of toil that built them up. Effort cannot be estimated, nor can it be paid for in money; but when I stand and look at the Institute as it is now, white and majestic in its worthy and beautiful buildings, active and well equipped to go forward, I know that I, for my small part, am paid in full.

"I do not mean to imply that my efforts and situation were unique; all the young teachers of M.I.T. who were coming to the front were doing the same thing, making the best of difficult situations and in many cases achieving remarkable results. It was all quite typical of the stage of development of Technology. Like all pioneers, we suffered from uncertainties and privations. Perhaps we came through as we did because all Americans are pioneers at heart. We let many details slip, but in a way this brought out real values. The situation also brought out the best in men. Only those who were heart and soul in the work could stick out the difficulties. The result is that Tech is Tech and we helped make it so.

"It seems to me that I never made any plans after I came to Tech; all plans made themselves for me. After my graduation, the Institute was good enough to think that I ought to stay by the school as one of its teachers. Accordingly, I started giving first year chemistry lectures in the following fall ('68). I was not a success, as I supposed that the boys came to class to study chemistry, and I proceeded on that basis; the boys had the idea that they came to class to throw chalk at each other. The two ideas did not harmonize. Professor Storer, who had given me the job, still believed in me, and taking me away from the classroom, made me assistant instructor in the laboratory. I enjoyed this; it gave me time to catch my breath and learn how to teach, and at the same time to handle boys. My associate, William Ripley Nichols, was given the lecturing job. He seemed to be possessed of the policing power that was needed to keep the boys in order.

"I liked the laboratory work for several reasons. The boys were older and as anxious to study as I was. It was much easier for me to teach through actual handling of the apparatus and by working on problems, shoulder to shoulder with the boys, than it was to deliver classroom lectures. The next two years were both busy and happy. As far as I can see in looking back, they were successful. Mistakes? Of course I made mistakes, but I seem to have been willing to learn. The great difficulty with us beginners, in teaching as well as other things, is that we think we are superior to our pupils. We do not realize that our pupils are our very best teachers."

Professor Runkle Becomes President

In 1870, President Rogers suffered a stroke. Professor Runkle was elected to succeed him. He crossed the continent on the newly opened transcontinental railroads, the Union Pacific and the Central Pacific. His object was to visit as many mines and smelters as possible, to talk with owners and managers, explaining about the new school, its purpose and methods, and arouse interest by asking for suggestions and help. He also interviewed mine owners and manufacturers of mining machinery. The excursion was most auspicious. He succeeded in stimulating interest generally and in preparing the way for an expedition of students and faculty which he conducted the following summer. Dr. Richards says:

"I was a member of this first summer

school in June 1871. Although I directed each succeeding trip for a period of more than thirty years, the first has always stood out as 'the' summer school.

"We were conducted all over the iron mines of Missouri, and the silver and gold mines of Colorado and Utah, and we visited the manufacturers of mining machinery in San Francisco. We saw the tremendous tearing power of dynamite, then a new explosive. A charge was put on an enormous boulder of iron ore, covered with a shovelful of earth, and a slab of rock laid on top of all; the explosion was set off and the entire boulder was broken into pieces small enough to be loaded on carts.

"We brought back between two and three hundred sacks of ore from different mines, each sack weighing over a hundred pounds. We also got from the Union Iron Works in San Francisco a very perfect working model, on a reduced scale, of the regular California gold stamp mill of that day, and an amalgamating pan and settler for settling mercury. We procured a Hendy concentrator from the Joshua Hendy Machine Works at San Francisco. All this machinery, some of which was given to us outright, may be said to have been the beginning of what finally grew into the ore-dressing laboratory of Technology.

"As the time was too short for us to cover all the ground, President Runkle left a student named Parsons in Nevada to work on silver, and another boy, Locke, went to Grass Valley, California, to study gold. Ned Rollins and I left the group at Cheyenne and pursued a little side-trip of our own.

"About 1874, it became necessary to have a hydraulic classifier. My assistant, William Foster, conducted a series of experiments under my supervision, and as a result, I made a new classifier which was more perfect and could be accurately controlled, largely through the use of glass tubes at certain points, which made it possible to watch the action and so manage it. This invention later proved to be a world discovery and is now known as the hindered-settling classifier."*

Presidents of M.I.T.

Dr. Richards gives a list of Presidents of M.I.T.., as follows:

William Barton Rogers	1865–1870
John Daniel Runkle, Acting President	1868–1870
President	1870–1878
William Barton Rogers	1878–1881
Francis Amasa Walker	1881–1897
James Mason Crafts	1897–1900
Henry Smith Prichett	1900–1907
Arthur Amos Noyes, Acting President	1907–1909
Richard Cockburn Maclaurin	1909–1920
Elihu Thompson	1920–1921
Ernest Fox Nichols	1921–1922
Samuel W. Stratton	1922–1930
Karl T. Compton	1931–

"William Barton Rogers was the first President of the Massachusetts Institute of Technology. As early as 1846, he and his brother Henry had already outlined such a school. In 1860 we find him writing his brother: 'My last visit to Boston was for the purpose of reading to a committee a pretty full outline of an Institute of Technology, to comprise a Society of Arts, an Industrial Museum, and a School of Industrial Science.'

"From 1859, when the first petition was made to the Massachusetts Legislature for a reservation of State land in the Back Bay District of Boston, for a Conservatory of Art and Science, until the school was formally opened on February 20, 1865, the idea marched slowly but steadily forward.

"The first petition having failed, he

* Author's Note.—About 1895 Dr. Richards invented the Richards Pulsator Classifier and the Richards Pulsator Jig, both of which machines were manufactured by the Denver Engineering Works for many years, and established a principle in the concentration of ores which is now standard practice.

prepared another in 1860 and a somewhat restricted Act to Incorporate the Massachusetts Institute of Technology was granted. He had asked for four squares of land (which later events proved would not have been enough) and was disappointed to be given only two-thirds of one square, but this setback did not prevent his devoting every energy to raising funds for the school and holding meetings to rouse interest.

"Rogers started the Society of Arts first, and used it as a means of gaining the confidence of the citizens of Boston and of interesting them in the School.

"The School actually opened in two rooms in the old Mercantile Library on Summer Street; fifteen pupils entered and the fee was $100. There were seventy pupils the next fall, when the school moved to Chauncy Street, and in January 1866, we moved into the Rogers Building on Boylston Street. The inception of this building was one of the most extraordinary things I have ever heard of. With only fifteen pupils, Rogers quietly put up a building 150 by 100 feet, and four stories high. In a letter at the time he said, 'This building will, I trust, afford sufficient space for all the operations of the school for many years.'

"Rogers continued as President until his health gave way in 1870. John Daniel Runkle was then elected President of Technology. The period of Runkle's administration was noted for the great increase of departments, the undertaking of many new things. During Runkle's presidency, a new physical laboratory was started with Professor Pickering in charge. Also the designing and organization of the School of Architecture took place; the mining and metallurgical laboratories, the course in descriptive and determinative mineralogy, the summer schools of mining and metallurgy, the steam laboratory for the mechanical engineers and the shop in wood-working, machine tool work, forging and foundry work.

"The Woman's Laboratory gave women a share in the new scientific education, and through this entering wedge the door was eventually (1883) opened for them to come to Technology on the same basis as men. In this laboratory Professor Ordway sowed the seeds of the Biological Department, which was later organized to study animal and vegetable life in water supplies and to study the beginnings of bacteriological science."

In 1878 Professor Richards accepted the position of Secretary to the Faculty. He says: "There was no typewriter in these days. I was also postman and express agent. There was no telephone. If I wished to call the janitor, I had to go to the top of the building to find him. All these are little details which show the stress and poverty of the Institute at this time."

Professor Richards made several improvements in the organization of the Secretary's office, and resigned in 1883 feeling that the machinery in the office was working smoothly. President Rogers had returned to the helm in 1878, when Runkle resigned, and although his health was not sufficiently restored for him to take over the actual work of the presidency, he tided over the period until 1880, when he secured the services of General Francis Amasa Walker. Much of the onerous work of this period was carried by Professor Ordway, as Chairman of the Faculty. Professor Richards says:

"General Walker's military training made him a splendid organizer. He took counsel with his associates and reorganized the Corporation, establishing an Executive Committee of seven members which was to have sole charge of the School. This Committee was elected from the Corporation and reported to it, and being small was able to perform its functions and served well. The Corporation

thus organized worked, and the School quickly began to grow. Its usefulness and success were established.

"From that time on, the development went by leaps and bounds. The Civil Engineering Department was put on its feet by acquiring new men, Swain, Allen, Porter, and Burton, and the starting of the laboratory for that department was accomplished. The Mechanical Engineering Department was completely reorganized with a new staff, consisting of Lanza, Miller, Merrill, Schwamb, and Peabody, and at the same time its laboratory of steam engineering was greatly enlarged. The shops for machine-tool work, forging, pattern making, foundry, and woodwork, were all put on a fine basis with plenty of apparatus and instructors. The Department of Architecture was newly organized with Chandler at its head. Dr. Drown was in charge of the new Walker Building. Not long after this, the Electrical Department was started; previously it had been a section of the Department of Physics. It now became an independent course with Jackson as head.

"An amusing story is told of General Walker and Dr. Drown. The two were talking over things in the Chemical Department, and as they stepped out into the hall of the upper story of the Walker Building, Walker pointed to some partitions which seemed to be blocking the hall and asked what they were for. 'Why,' said Dr. Drown, 'I was told that you planned them that way and that you said, "the damned mess had better go there." Walker replied, 'I do not remember having planned it, but the language is mine.'

"Under Walker's administration the high standard of the School and the pursuit of truth for its own sake continued and grew. The teachers felt that they were thoroughly backed in their efforts, and as more money was available, the departments had more with which to develop.

"Reviewing the work of the first three presidents in these early trying days, we might say that Rogers' period was that of little beginnings and of wonderful inspiration and loyalty; Runkle's was of starting new departments under terribly adverse conditions of school management; and Walker brought in the reorganization and development of both Corporation and Departments, thereby causing a great impulse to increase the prestige of the School, the demand for it, and to some extent the supplying of requisite funds. Walker's death came suddenly in 1897, due to overwork and over-anxiety for the school. He was still a young man and a person of extraordinary vigor."

"Professor Crafts was made Acting President and later on full President. He was a man loved and revered by everyone, a man who studied the history of the school and at the same time was better posted on all its aims and ideals than anyone else. An active effort was made to unite Technology with Harvard at this time, and Crafts favored it, because it would have brought much needed income. His conception, however, of the proposed union differed so widely from that of the Harvard authorities that nothing ever came of the situation." Dr. Richards says: "The Institution flourished and prospered under his administration and we all felt confident and happy in our work."

"Next came Dr. Harry S. Pritchett, and with him a great deal of the student good fellowship. The Tech Song Books were published and the student gatherings commenced, where groups got together to smoke and drink beer. Altogether, the student life took on a new aspect."

The Stein Song was written at this period. Fred Field Bullard, a student in the Department of Chemistry, and a member of the Class of 1887, composed the music of the Stein Song, as an accompaniment to the rousing words of good fellowship by Richard Hovey, of English High

School, Boston. This Stein Song is now the Alma Mater song of M.I.T.

Another determined effort was made to bring Harvard and Tech together and probably would have succeeded if the trustees of the Mackay Fund had not decided that it would be illegal to use the money in that way. They were upheld by the courts and the matter was dropped, probably for all time. The two schools agreed to work side by side and be as mutually helpful as possible without any official bond.

Dr. Pritchett served as President for seven years, and was followed by Dr. A. A. Noyes, who was made President pro tem for a period of two years, after which he resigned to follow his scientific career.

Following Dr. Noyes, Dr. Maclaurin was chosen. His great contribution was the decision to rebuild the Institute physically. By this time buildings were scattered all over Boston, at considerable distances from one another. Dr. Maclaurin organized the Alumni into an Association, which helped raise the necessary funds. He secured a piece of land in Cambridge large enough for all the necessary buildings, he consulted with each department and used its plans for each building, and he left room enough to grow. "It soon became apparent that more money would be needed, and a certain 'Mr. Smith,' who later proved to be Mr. George Eastman, made the extraordinary offer that if the Institute would raise four million dollars, he would give a like amount. The drive for this fund was successful, and just at the end of the period when last efforts were being made to complete the sum before the date terminating the offer should be reached, Dr. Maclaurin overexerted himself, caught pneumonia and died. I shall always feel sad that he did not live to see his great effort completed.

"As I retired in 1914, I know Presidents Nichols, Thompson, Stratton and Compton only in my capacity as a Professor Emeritus. I suppose that I may be the only person now living who has known all the Presidents of Tech. President Compton, who is at the moment in charge, is a fine man who has been most considerate of the faculty, and has a high order of scientific knowledge. I feel very happy as regards the future development of Tech while it rests in his hands. Taken all in all, these men have been an outstanding group, and it has been my privilege to serve under seven of them and to watch and respect the work that others have done under the remaining four."

Teaching

Richards was Professor of Mining Engineering from 1873 to 1914. The list of subjects under his direction were; Mining Engineering, Assaying, Mining Laboratory, Metallurgical Laboratory, Mineralogy, Mining, Nonferrous Metallurgy and two Laboratories, Ore Dressing and two Laboratories. From 1878 to 1883 he was Secretary of the Faculty.

Professor Richards believed that familiarity with the names and faces of his students was important in establishing the friendship that should always exist between teacher and pupil, so he took photographs of the boys attending lectures on mining and smelting, one side view, one front, and by pasting tissue paper with their names along the upper margins and carrying them with him on his daily ride to school, he was able to memorize the names and faces within a week.

While teaching he never felt it safe to recommend strongly to a boy to take this or that course preparatory to one or another profession. He thought the province of a teacher is to bring to the boy's mind all the advantages and all the disadvantages of one or more professions, and allow the boy to make up his mind which profession it will be wise for him to select. He felt that the real work of the

best schools is simply to teach the boy how to teach himself.

An engineering school naturally is designed to train young men up to the pitch of engineering knowledge, so that when they get practical experience in the world of industry and commerce, they can make themselves efficient directors of works, or advisors for a number of different works. This is true of all the different engineering lines, also of chemistry and architecture.

The teacher should help a student to avoid carelessness, the utter lack of responsibility at every point, and the lack of dependability, so that business men or the family to which he belongs can depend upon him. The teacher should help him to be a gentleman, cultivating all the fine qualities that are included in that word—fairness and justice in all his dealings with his teacher and his fellow pupils; playing the game fairly, whether it is out in the field or in the classroom; in fact, following the golden rule.

In 1925, Professor Swain wrote to Professor Richards as follows:

"It is a great thing to be able to keep the heart and spirit young as you have done, notwithstanding your enormous labors and fruitful service for the Institute, for Education, and for Engineering. Some people never grow old, and you are one of them. I hope I am another. At all events, you may rest assured that you have a permanent place in the minds and hearts of all the Institute men, old and young, whoever came under the spell of your influence."

Summer Schools

Professor Richards always felt it most important that students in the Course of Mining Engineering should have the opportunity to study mining and milling methods and processes throughout the mining districts of the United States, and he organized a series of Summer Schools, which were maintained for many years.

In the early '70s he conducted a summer school of students to the famous Calumet and Hecla Copper mines in the Lake Superior district. During the summer of 1871 they visited Golden City, Colorado, and he mentions Cripple Creek, Colorado, as a mining district that had been given up by professional geologists and miners as having no ore. Winfield Scott Stratton, a carpenter, who did some prospecting on the side, took his pick and shovel one day and struck ore there which proved to be rich in gold. Since that discovery Cripple Creek has been the leading gold producer in the state of Colorado.

Trips were also made to Caribou, Central City, Black Hawk, Montezuma, Montgomery, Georgetown, and Idaho Springs, in Colorado, where the pioneer '49ers made the earliest gold discoveries in the state.

In 1884, Professor Richards visited E. W. Rollins, one of his former students at Tech, in Denver. Rollins was engineer of a narrow-gauge railroad running from Denver to Georgetown and Silver Plume, leading to the important mining centers of the earliest gold discoveries in the state. During Richards' visit, Rollings noticed something on the horizon that looked like a cloudburst, and they found that Cherry Creek was on the "boom," a flood of water rushing through Denver, several feet deep and a hundred feet wide, carrying familiar objects, such as cows, top buggies, and wrecks of buildings. Richards took photographs of the flood, and it happened that he was the only photographer in Denver to get pictures of the cloudburst. In a previous cloudburst at Cherry Creek in the year 1864, the County building was destroyed and the County safe disappeared in the bed of the Creek with all the County records, and has never been found.

In 1872, Professor Richards went to

Colorado to investigate the problem as to whether there was any serious quantity of gold being carried down as far as Golden City, thirty miles away, in any considerable quantity. Today, in 1946, large and small operators are recovering gold values, with good financial returns, from the gravel and sand along the bed and banks of Clear Creek, which had been carried away with the tailings from mill operations as early as 1859.

On this same trip he went up Mt. Lincoln, a mountain about 14,000 feet altitude above sea level. A mine was being excavated close to the top of the mountain. They reported that rock fifty feet in from the surface was frozen solid. They saw a remarkable mountain phenomenon in weather. On a bright, clear July day, a rush of warmer air from the valleys up to the mountain precipitated the moisture and snow fell to the depth of six inches in a short time, and they found difficulty in finding the trail on going down the mountain.

Summer excursions were also made to the Katahdin Iron Works in Maine, and an old-fashioned Catalan forge at work at Shady Valley, North Carolina, as well as districts in Virginia. This indicates the practical experiences enjoyed by students during early Tech days.

Ellen H. Richards

In 1870, Miss Ellen H. Swallow, a girl of twenty-eight, living in Littleton, N. H., wrote to the Secretary of Technology, asking if women were admitted to the school. Later she received word that she had been admitted to Technology. She was placed under the teaching of Professor Ordway, and besides doing her school work well, helped in many ways. Professor Nichols interested her in State Board of Health Work, and Professor Richards taught her mineralogy.

Professor Richards said he had "no ideas of what a wife ought to be to me, or what I ought to be to a wife, but I knew that Ellen Swallow's aims in life were along the lines which mine had seemed to follow." He admired her pioneer spirit. On June 8, 1875, they were married. Mrs. Richards attended some of the summer schools of Tech students, and laid out plans of the different districts to be visited and indicated what was to be seen. She assisted Professor Ordway in the development of the Woman's Laboratory. A good number of women were soon admitted, and Mrs. Richards became Dean of Women of Technology without the title or the pay.

After the close of the school year in the summer of 1876, they made a trip to Europe, visiting twenty-five cities in twenty-four days. After returning to the United States they attended the Columbian Exposition at Philadelphia. Professor Richards was so tired, he simply sat down and watched the great Corliss engine wheel go round.

David Browne, of the Copper Cliff mine, Ontario, Canada, was seeking information about his copper ore, and sent samples to a number of assayers, among them Mrs. Richards. She found one per cent of copper in the ore and also five per cent of nickel. This was the beginning of the great nickel industry of which the Copper Cliff mine was the center. David Browne always said that Mrs. Richards was the best analyst in the United States. In 1880, Professor Richards went to study the concentration of the Calumet mill at Lake Superior and Mrs. Richards went as his chemical assistant. The vice president of the company years afterward said that Professor Richards' work had saved the company from $200,000 to $300,000 a year. That work was made possible by Mrs. Richards' prompt and accurate chemical assistance.

During much of the time that Mrs. Richards worked for Technology, she did commercial work on water analysis,

gas analysis, and other things, and for this commercial work for outside parties, she received compensation. During all the earlier part of her connection with the Chemical Department of the Institute, she received no compensation from Technology, but during the latter part of the time she was compensated. Perhaps one of the most important lines that came Mrs. Richards' way, and which she took up successfully, was the founding of the New England Kitchen in 1888. This was largely the result of her friendship with Mrs. J. J. Abel. These two remarkable women met as the result of a paper that Mrs. Abel submitted to a prize competition. Mrs. Richards was anxious to study the chemistry of cooking as applied to daily life. Mrs. Abel was of the same mind: not only so, but she was willing to give a winter to working out the problem in Boston. Mrs. Richards contributed in every way and between them the New England Kitchen was started.

One of the honors that perhaps pleased Mrs. Richards as much as any was her election to the American Institute of Mining Engineers in September 1879. Here again she was the pioneer—the first woman. She remained a member until the time of her death.

In 1903, Professor and Mrs. Richards made a trip to Alaska, visiting Ketchikan, the center of salmon fishing for the great canneries: Fort Wrangel, with its totem poles: Sitka, with the building that housed the Russian Government, which now is used by representatives of the United States. They visited Skagway and White Pass, and at Juneau saw the hydraulic mining operations treating alluvial gravel for the recovery of gold, also visited the great Alaska-Treadwell mine, with its two great stamp mills for extracting gold by the amalgamation process.

In 1888, Mrs. Richards made a trip around the White Mountains of New Hampshire to find a location for a camp for summer vacations. At Randolph, N. H., she found a satisfactory site and a camp was established, named "The Balsams." Professor and Mrs. Richards enjoyed many summer vacations there and Professor Richards spent some time there for several years after Mrs. Richards died, in 1911.

Inventions

Professor Richards comments on his inventions as follows: "A man who has made as many investigations as I have, and discovered new principles, naturally tries to put them into commercial form to benefit mankind and at the same time bring some financial profit to himself, and also help him in making further investigations and further discoveries.

"In beneficiating minerals from the earth, there are three steps:

"First; the miner blasts and digs out crude material from the ground.

"Second; the ore dresser breaks up the ore small enough to liberate ore and unlock the valuable minerals from the waste material.

"Third; the third step is the metallurgist's ore smelter."

Professor Richards' work was in the second group—separation of the valuable minerals from the waste by mechanical means. Acheson, the discoverer of carborundum, gave a talk in Boston, in which he defined the difference between an invention and a discovery;

"When you put together a lot of known things according to some logical plan, with the result that you have done something new which is useful, you have made an invention; but when you do something you know not how and get something you know not what, but you recognize it is tremendously good, and you throw up your hat with joy at what you see, you have made a discovery."

One of Professor Richards' discoveries was the principle of "hindered settling," and its effect upon two minerals of different specific gravities, as compared with free settling. With free settling, the particles are so far apart that they do not touch each other. In free settling, quartz, with a specific gravity of 2.6, and galena, specific gravity 7.5, a particle of quartz is three and one-half times the diameter of a particle of galena that settles with it. Under hindered-settling conditions, a particle of quartz is about seven times the diameter of a particle of galena that settles at the same rate. This discovery was the basis of great improvements in the concentration of ores, and established a principle that is used in various types of hydraulic classifiers.

In 1869, he developed a filter pump for use in the laboratory, which later led to improvements in the form of a jet pump, using the injector principle. In the early '90s he developed a Prismatic Stadia, by the use of an achromatic prism made by Alvin Clark, and with this prism he made a geological survey of the surface around some of the iron mines at Ishpeming, Michigan.

During the period from 1895 and 1900, Professor Richards developed the Richards Pulsator Classifier and Pulsator Jig. The former was used for the classification of ore pulps into different sizes for higher recoveries of mineral values on concentrating tables, and the latter for separation of mineral values from associated gangue material.

The pulsator principle of upward-rising pulsating currents of water proved a great improvement over the former Harz jigging operations, using pulsion and suction strokes of water currents, in which the jig bed of gravel or sand remained solid for fifty per cent of the time. With upward-rising pulsating currents of water, a jig bed is active and loose for one hundred per cent of the time, thus doubling the capacity of the jig, and producing a clean, high-grade concentrate. This pulsator principle is the basis of several types of jigs used in modern milling practice.

Before the great yacht races in which the "Puritan," "Mayflower" and "Volunteer" sailed, General Charles J. Paine asked Professor Richards to test the friction generated by running boats through the water when they had been painted with different kinds of paint. By means of a wooden cylinder rotated in a barrel of water, he found that all the paints that depended on linseed oil as the carrier caused about the same amount of friction, But one paint, consisting of varnish into which graphite had been rubbed, gave very much reduced friction, about three-fourths as much as was caused by all the other paints. General Paine used this graphite-varnish paint in all races, with successful results.

Handbooks on Ore Dressing

In 1893, Professor Richards was invited by Richard P. Rothwell, Editor of the *Engineering and Mining Journal*, to write a book on Ore Dressing. Two years were spent studying various books on metallurgy, and the Transactions of the American Institute of Mining Engineers. In 1895, Richards started with his assistant, W. A. Tucker, on a trip to visit the western mines and mills—Missouri, Colorado, New Mexico, Arizona, California, Oregon, Washington, Idaho, Montana, Dakota and Michigan. Ten years was spent in preparation of the first two volumes of this work, instead of the four months that Rothwell had asked for. The four volumes on Ore Dressing were a classic for that period, and are still used as a standard of reference for the concentration of ores. Shortly after these volumes had appeared, the Wilfley table became prominent in the concentration section of ore-milling plants, and the new process of flotation appeared and

made astonishing progress. This required a complete revision of the textbook on Ore Dressing, which was undertaken by Prof. Charles E. Locke, assisted by M. H. B. Litchman and John M. Bray, in 1922, with the idea of having it ready for the classes the first of October 1923, but the book did not appear until 1925.

Scientific Societies

The American Institute of Mining Engineers was Professor Richards' chief professional engineering society. He was also a member of the American Association for the Advancement of Science, and of the Academy of Arts and Sciences, also a member of the Engineering Education Society, and was a member of the Boston Society of Civil Engineers. For many years he was a member of the Boston Society of Natural History, and presented a few papers there, but the American Institute of Mining Engineers was the chief field for the publications of his various activities in the branches of mining: namely, ore dressing. He presented and published in the TRANSACTIONS at least thirty-five papers, all containing original work.

Professional Services

In 1880, Professor Richards inspected the Calumet and Hecla mill to see what improvements in concentration could be made, and developed improved systems of classification and better methods of jigging practice, which resulted in marked recoveries of mineral values. Colonel Thomas L. Livermore, Vice-President of the Company, announced at the time of Professor Richards' retirement from the Massachusetts Institute of Technology in 1914, when a banquet was given in his honor by the Corporation, Faculty, Alumni, and Students of the Institute, that the work he had done for Calumet and Hecla saved that company between two and three hundred thousand dollars a year.

Investigations made by Professor Richards at the Great Falls plant of the Anaconda Copper Co., of which Charles W. Goodale was manager, led to improvements in classification of ore pulps, and equipping the Anaconda round table with a canvas surface saved the company a million and a quarter dollars a year. It was at the Great Falls plant that Professor Richards proved the merits of his Pulsator Classifier and Jig, with the able assistance of Mr. Guy H. Ruggles, of the Class of 1906, M.I.T., now Manager of the Cananea Consolidated Copper Company Concentrating Plant at Cananea, Sonora, Mexico.

Mr. Lewis G. Rowand, in charge of the milling operations of the New Jersey Zinc Co., gave Professor Richards credit for the fact that where minerals of small difference in specific gravity have to be treated very close sizing of the material previous to jigging and table work should be done. At this plant, close sizing for the jigs, and the use of the Richards Pulsator classifier for the Wilfley tables brought about remarkable improvements in the recovery of mineral values.

Honors Conferred

In 1915, Professor Richards was presented with a gold medal by the Mining and Metallurgical Society of America, the presentation being made by Walter Renton Ingalls, President of the Society, and a former student at the Massachusetts Institute of Technology. The medal was given annually, the subject of that year being, "Advancement in the Art of Ore Dressing," and the award was unanimously made to Professor Richards. In presenting the medal, President Ingalls said, "It is but a small tribute that the Society pays to you, Professor Richards, and it does not give it in payment for the debt under which you have placed its

members, but it simply presents it in respectful recognition of the fact that the debt exists and never will be paid."

At this same meeting, President Saunders, of the American Institute of Mining Engineers, said; "Great is the inventor, great is the man of knowledge, but greater still is he who, through patient and laborious research, acquires useful information and freely, fully, and lucidly imparts it to others."

Charles W. Goodale said: "For his students he has been a guide, philosopher and friend, in the full meaning of those words. A guide in showing us how to take full advantage of our scholastic opportunities, a philosopher in telling us to be cheerful in life's jolts and disappointments—a living example himself—and a true friend in all the after years."

David H. Browne added: "The greatest thing in life is personality. The greatest men are those whose fingers find the chords of life and at whose touch we thrill in sympathy. It is that personal appeal that some men make to our better selves that makes them leaders, and so I place above all other attainments the personality of the man we honor tonight, Robert Hallowell Richards, our mentor and our friend."

President Ingalls continued: "The award of the gold medal of this Society is a sincere and natural expression of its membership. On its face the medal represents Knowledge breaking through the barrier rock of Ignorance. On its reverse it bears the words "For Distinguished Service." Because the membership of this Society considers that you have rendered distinguished service, I have the honor to present it to you."

Professor Richards' response on the awarding of this medal follows in part: "I want to give my thanks to my school associates for the very generous way they have helped me not only in my school work, but in my investigations, also to my engineering associates who have done the same; and again to the former students of Technology who are carrying forward the investigations and improvements in ore dressing. I am very thankful to the engineering societies for their liberality in helping me with my papers. My demands have been at times pretty near the limit. Especially am I grateful to the members of the Mining and Metallurgical Society of America for the beautiful honor that they have conferred upon me. It seems strange that you have thought me worthy when you have within your reach so many finer fellows than am I."

In 1925, the Research Department of the American Bosch Magneto Corporation, having profound interest and admiration for Professor Richards' fundamental works, requested his autographed photograph, which was placed in the Assembly Hall of the Corporation's Institute.

During this same year, 1925, the Chemical, Metallurgical and Mining Society of South Africa, Inc., Johannesburg, Transvaal, South Africa, informed Professor Richards that he had been elected an Honorary Member of the Society.

In 1929, shortly after his return from the World Engineering Congress in Japan, he received a cablegram saying that he had been elected Honorary Member of Nippon Koggio Kai (Japanese Mining Institute).

Now About Old Age

In 1914, Professor Richards told President Maclaurin, of the Massachusetts Institute of Technology, that he would be 70 years old, and any time he wanted him to step out, he would do so. A fortnight later, so Professor Richards says: "He told me that he had concluded to take me up on this proposition. This was hard for me to bear. It was, however, in accordance with the Carnegie pension ruling, where one can retire at 55 and must at 70."

On the subject of friendships, Professor Richards comments as follows: "I do not have many intimate friends. As a teacher, I tended to have many contacts rather than intense ones. Professor Locke and Hutchinson at Technology were probably my most intimate friends there. Locke has taken my place in ore dressing. He is a remarkable executive and really carried me along the last years of my administration. Hutchinson, a former pupil, took my place as head of the Mining Department and has brought many modern ideas."

Professor Richards' interest in old associations is shown by the fact that he made his home at 32 Eliot Street, Jamaica Plain, near Boston, which he occupied from 1875 throughout the rest of his life.

His attitude toward coming old age is interesting. He always prized the idea of living in health so far above everything else, from the results he could accomplish and the happiness he could get, that he never regretted things that he denied himself. He felt that if it contributed a little toward the happiness he could give others, and the happiness he could derive for himself by doing so, what did it matter whether he had given up some particular thing or not? He made an acrostic based on ideas of maintaining health, using the word "feast:"

Food
Exercise
Amusement
Sleep
Task, or work

He felt that if one would follow the first four parts of this acrostic, the fifth would take care of itself.

In 1912, Professor Richards married Miss Lillian Jameson, who had helped his former wife, Ellen H. Richards, in her literary work. They spent their summers at the Richards Camp at Randolph, N. H., where Professor Richards devoted himself to gardening and making additions to the camp. After his retirement from Technology, he continued his annual trips to the summer camp at Randolph for many years, and found recreation in raising vegetables, digging post holes, and other duties common to country life.

In 1905, he spent the summer at the Lewis and Clarke Fair at Portland, Oregon. On his return from Oregon, he walked around Jamaica Pond every morning before breakfast without a hat, continuing this until the thermometer was down to twenty degrees above zero, and in the rain when the wind would blow waves off the Pond.

On one of his trips to Denver, Colorado, during the '90s, he appeared wearing heavy woolen socks in the month of August, which he explained was for the purpose of curing a bunion, "and now," he said, "I am going down to Arizona where it is 120 degrees in the shade, and there's no shade."

Until 1929, he felt that an automobile was a luxury he could not afford. At that time, Ned Rollins (a pupil in his first class at Technology), joined with H. K. Moore in giving him a Ford car, and then he felt that he could hardly do without one. He was amused at the way phrases from the automobile were used in everyday talk. His doctor, he said, when urging his little girl to hurry up for breakfast, shouted, "Step on the gas," and when she got to the table, he added, "You park by your mother."

World Engineering Congress in Japan

Shortly before his eighty-fifth birthday, he received a notice that the World Engineering Congress would be held in Japan. He did not seriously consider joining the group of engineers, until urged by H. Foster Bain, Secretary of the A.I.M.E., who said: "Your pupil, Baron Takuma Dan, has particularly invited you," and so he finally accepted the

invitation. On the way to San Francisco, he stopped at Chicago to see his old pupil, William B. Allbright, M.I.T. 1878, a classmate of Takuma Dan. Stopping at Butte, Mont., he visited the Timber Butte mill and was interested to find how far the process of flotation had developed, replacing former methods of gravity concentration. At Spokane he attended a session of the mining engineers, and at a dinner in San Francisco he was made a Legion of Honor Member of the A.I.M.E., and was presented with his fifty-year honor button.

When he reached Yokohama, Takuma Dan met him and drove him to his home in Tokyo, placing at his disposal a beautiful apartment, with two secretaries and a valet. Baron Takuma Dan conducted him to the opening exercises of the World Engineering Congress, attended by about one hundred engineers from United States, fifty from foreign countries, and a large number of Japanese engineers, making a total of about seven hundred engineers.

Several banquets were given the engineers, and trips made to several points of interest in Japan. It was with real regret that Professor Richards turned toward home, leaving behind the kindest of hosts and hostesses, for he had never been treated with such consideration before, and "it was a comforting thought to know that my teaching had been of value to one of my pupils."

Avocations

Professor Richards' views on avocations are interesting. He observes that some great philosopher divided human interests into three lines—occupation, avocation, and recreation. "Occupation" would cover whatever we do to earn support for ourselves and our families, and such good works as may interest us. In his case, it was teaching young men and doing professional work referred to him for investigation. "Avocation" seems to be the working up of ideas that come to us, which are not strictly in the line of earning our bread, but which are for the purpose of accomplishing some end and not purely for purposes of recreation. "Recreation" seems to be pure amusement, to give the mind a change and rest—to use a mechanical expression, to take the strain off the spring, so that it may assume its normal condition.

In his own life, teaching was his occupation, and investigations to find out what machines and principles would be suitable for the mining and metallurgical laboratories seemed to be one of his avocations. He had a great interest in photography, spent some time on astronomy, also on botany and the study of the animal kingdom, including small things, such as insects. During periods of his life he was fond of shooting, fishing, paddling, canoeing, rowing and sailing a boat. He enjoyed glass blowing very much, and entertained many of his classes in demonstrations of the art, in which he proved to be an expert.

When he went to Boston in 1865, to enter the Massachusetts Institute of Technology, his mother suggested that he teach in the Sunday school of Emmanuel Church. In 1878, it was converted into the Church of the Good Shepherd, and he was made junior warden, later senior warden, then vestryman. He also sang in the church choir.

The Eliot School, Jamaica Plain, was started about 1690, and the "Apostle Eliot" (apostle to the Indians) was the most prominent man connected with its origin. Citizens of Jamaica Plain gave money for farm products to maintain the school, and it was said that the school was founded for the purpose of "doing away with the inconvenience of ignorance," and that it was for the inhabitants of Jamaica-Plain-by-the-Pond, including Negros and Indians. Professor Richards was made member of the Board of Trustees

about 1882, and in 1885 was made President of the Board, in which position he served for many years.

In 1869, he and his brother Harry, with two friends, sailed down the Kennebec River, and were interested in the geological formations along the valley of the Kennebec. He also became greatly interested in the flow of the tides from the Gulf of Maine through the Bay of Fundy, where at the time of the spring tides and with a certain direction of the wind, the tides flowing through the Bay of Fundy reach great heights. He conducted Technology students during several summer schools to Nova Scotia to study this interesting phenomenon.

Each summer, after the beginning of vacation, he studied botany, to determine the species of plants by their flowers. One season he was commissioned by a friend to make a study of the ferns of Bermuda, and succeeded in finding all but one or two of the lists of ferns prepared by the Smithsonian Institution of Washington and Kew Gardens of London.

His great interest in a number of subjects outside of his professional career shows the versatility of a fine mind in the study of nature's laws, and the accumulation of knowledge.

One Hundredth Anniversary

On August 26, 1944, Dr. Richards celebrated his one hundredth birthday, t his summer home at Randolph, N. H. undreds of letters and telegrams were eived by him from officials, professors, lents, and former associates of the sachusetts Institute of Technology, from the executives of industrial zations with whom he was associated in various investigations and rch on metallurgical problems. Letters appreciation were received from the Faculty and Alumni Association of Technology, also from students from the first graduating class in 1868 down to the last class graduating during his teaching career.

Dr. Karl T. Compton, President of Massachusetts Institute of Technology, wrote the following tribute:

My dear Professor Richards:

In behalf of the Corporation, and with a sense of real personal pleasure, I want to extend warm and cordial felicitations on the occasion of your one hundredth birthday.

In the seventy-six years since your class graduated, the first at Technology, the Massachusetts Institute of Technology has become rich in tradition.

We are all proud and want to take particular note of the major role you played in building the solid foundations upon which the Institute's educational policies have developed. Our motto, *Mens et Manus*, is symbolic of the technique of teaching you developed in the Mining Department in accordance with your philosophy that students should learn by doing. The success of your pioneering spirit in this field is evidenced by the fact that the same philosophy has been adopted by all departments of engineering and science, not only in Technology but throughout this country and abroad in the better institutions.

Not only have you been recognized nationally as a leader in the field of technical education, and internationally in your special field of Ore Dressing, but the time you gave in the interest of government projects as well as serving industry in the development of the natural resources of the United States set the pace for the staff at Technology and has served as a continuing inspiration to all of us who at present share some of the burden of service to this country and its industry in the struggle for technical and productive supremacy in time of war.

In looking back to the early years of this country, the Corporation appreciates the wisdom and courage you provided as leader of the Faculty in urging the maintenance of that independence developed during the first forty years of the Institute's existence.

Through your interest in sports, both as a participant on the crew and as a keen observer of Technology sports throughout your whole career, you again symbolize the aims of the Institute in producing well-rounded young

men. As donor of the much coveted Richards' Cup, you have provided a perpetual reminder that good scholarship through earnest application of the mind to academic studies and good sportsmanship through active participation in competitive athletic games result in a man of great stature.

Again may I express in behalf of my colleagues and personally our heartful appreciation for your distinguished service in the whole life of the Massachusetts Institute of Technology, during which you have given so unstintingly of your time and effort.

With sincere good wishes for your happiness and continued good health, I am

Cordially yours,

(Signed) KARL T. COMPTON,
President.

In a letter from Charles E. Locke, Professor of Mining and Ore Dressing at Technology, extending congratulations from the Class of 1896 at M.I.T., the following sentiments were expressed:

There is also my own personal tribute that I wish to pay you in addition to the message from the class. It was my good fortune to become associated with you very shortly after my graduation, and to have kept up that intimate association ever since, but more particularly during the years that you continued in active teaching.

I cannot think of any better fortune that could come to a man in his younger formative years than to have a close relationship with you and to follow the fine example which you set. You not only gave me professional knowledge, but what was far more important, you gave me also a fine knowledge of human relations and the ability to deal with problems which constantly arise in the lives of everyone.

I can recall many frank words of wisdom and advice that came to me from you, and furthermore, you did not give advice as such, but imparted your advice in such an indirect manner that the recipient did not realize that it was advice he was getting, but, nevertheless, he was influenced by your words. I learned many phenomena of nature from you.

I learned patience and forebearance. I cannot recall that I ever saw you angry, or ever heard you speak an unkind word. That in itself was a record of which you should be proud. My life is all the better for having had this association with you for over half a century, beginning at the time when I first came to M.I.T. and met you as a freshman, and it is therefore most pleasing to have had you continue to live on to the century mark with the peaceful, quiet existence that you now enjoy.

The best wish I could make for any man would be that he might make such a fine record as you have made in moulding the lives of many people.

Yours sincerely,

(Signed) CHARLES E. LOCKE,
Professor of Mining and Ore Dressing

RICHARDS MEMORIAL VOLUME

When it was announced that the American Institute of Mining and Metallurgical Engineers will publish during the year 1946 a bound TRANSACTION volume on Milling and Concentration with the proposal to make this a memorial to Dr. Richards, letters were received from industrial leaders, professors and former students of Professor Richards expressing their appreciation of his talents as an engineer, and skill in the teaching of the principles of ore dressing. Following are extracts from some of the letters received on this subject.

From Mr. A. B. Parsons, Secretary of the American Institute of Mining and Metallurgical Engineers:

Forty years ago when I started to study mining engineering I early learned that the name "Richards" was to Ore Dressing as "Webster" was to Dictionary. If Dr. Robert H. Richards had done nothing but write "Ore Dressing," his professional reputation would be secure.

But he also excelled as an inventor, consulting engineer and, above all, as a teacher. He probably has given friendly instruction to more students in mining than any other man in history.

Dr. Richards joined the American Institute of Mining and Metallurgical Engineers in 1873, two years after its founding. He has served in many official capacities, including

the presidency in 1886; and he received the highest honor that the Institute can bestow by election as an Honorary Member in 1911.

It is a pleasure and a privilege as Secretary of the Institute, but more particularly as a personal friend and admirer, to add my tribute to those that you propose to publish.

Sincerely yours,
(Signed) A. B. PARSONS,
Secretary A.I.M.E.

From Mr. Daniel C. Jackling, of San Francisco, California; Metallurgical Engineer, Member of Council, Mining and Metallurgical Society of America, come his tribute:

I came to know him (Dr. Richards) first shortly after I founded the Utah Copper enterprise, in which he had a deep interest—somewhat skeptical at the start, as was the case with many engineers of that time. He visited the properties with me, I think, twice during the first three years of preliminary and, in considerable measure, experimental or research operations. By the time the first big concentator, known as the Magna Plant, went into commission during the autumn of 1907, the Doctor had realized the economic merit of the undertaking, and I enjoyed much correspondence with him relative to apparatus and methods employed at the new plant. His text book and personal advice and guidance were most helpful, particularly in respect to the all important feature of hydraulic classification. The Doctor was one of the most kindly and liberal minded engineers I have ever known and unquestionably the most capable specialist in the art of ore dressing of his time. I and my associates engaged in the development of the Utah Copper enterprise undoubtedly received from him the most valuable advice and assistance derived from any source outside our own organization in the improvement of ore dressing practices at the Magna Mill, where the initial capacity was 6,000 tons of ore per day, this being gradually increased to more than 50,000 tons per day during or shortly after Dr. Richards' active professional life. He was generous in his appraisal of the part I had in this new phase of copper producing industry; and, in candor, the same degree of generosity on my part is due to him in recognition of his contributions to the success of that new concept in copper producing industry which, in less than half a century, has spread all over the world and is now responsible for approximately two-thirds of newly mined copper output of the United States and, correlatively, about the same proportion of newly mined copper the world over.

My foregoing emphasis on the magnitude of a new departure in copper producing industry, based on the mass beneficiation of low grade ores of copper mostwise in the form of its sulphide minerals from which no copper in commercial quantities had ever been produced prior to the turn of this century, is precedent to my well considered pronouncement that Dr. Richards had a more important part in this innovation in practice of copper producing technology than any other consultant from whom I sought and received advice and assistance in exemplification of the most revolutionary transition in the commercialization of any natural resource in his time or mine, and probably in any period in history of such duration. His concepts and activities in these connections are sufficiently well known and recorded to fully substantiate my appraisal of the great credit due him for the rather marvelous success of this natural resource enterprise of world-wide scope, largely inspired and guided by his written teachings and spoken advice.

Of course, I will expect you to put into your own words such of the foregoing as you may care to select for the purpose you have in mind, although I have not the slightest objection to the full use of my tribute as written and also to the use of my signature.

Very sincerely yours,
(Signed) D. C. JACKLING.

Mr. Louis S. Cates, President of Phelps Dodge Corporation, wrote:

I was a student of his, graduating in 1902, and in all my experience I have never met a man who imbued one so thoroughly with the desire for more knowledge: His lectures were most entertaining and informative and I think his great charm was in making one feel that he was opening the door to additional information which you, as a student, had to acquire by hard work and deep study. His character

was sweet and firm and I only wish that the world contained more men of his type.

He was successful but never tried to overpower one with his knowledge and it was the sweet humbleness that he possessed that made him a lifelong friend and a man whom you admired.

Yours very truly,
(Signed) LOUIS S. CATES.

Professor Edward P. Mathewson, of the College of Mines, University of Arizona, Tucson, Arizona, said:

I became acquainted with the Doctor a few months after my arrival in this country. I was employed by the old Pueblo Smelting & Refining Company, and he was sent out from Boston to report for the Company on a new all fire method of refining copper. This involved a lot of assaying on the part of Dr. Richards' assistant, Dr. Lodge, and the Control Assayers. Dr. Richards at that time spent several weeks studying the process, and I got well acquainted with him. He was always a good companion, and looked on the bright side. This acquaintance deepened into real friendship, and we kept in close touch with each other for many years. The Doctor and I frequently met at the annual meeting of the A.I.M.E.

Sincerely yours,
(Signed) E. P. MATHEWSON.

Mr. Walter Renton Ingalls, Consulting Metallurgist, New York City, wrote:

When I entered M.I.T. in 1882 our freshman year was spent in receiving general instruction. We did not divide into the several courses, or departments, until we became sophomores. Except for a shed for military drill Rogers was our only building. In its commodious basement was the laboratory of mining and metallurgy, including assaying, that was the creation of Professor Richards, who instructed us in the handling of these pieces of apparatus and taught us to use the batea and the gold pan and showed us how he could manipulate the vanning shovel of Lake Superior and cause a concentrate of native copper to climb up-hill with a dexterity that among us no one else ever acquired.

Those who graduated from the classrooms and laboratories of Professor Richards were imbued by him with the spirit of experimentation. Also with the idea that performance and results with miniature plant would be repeated or bettered with large plant if nothing were taken for granted. They were trained to weigh and measure input and output of products and to balance them and when they were out of balance, to study where losses occurred.

Professor Richards clung to his favorite subject—ore-dressing—and in the course of his work created a science out of what had previously been empirical, i.e., the practice of handymen without regard to science and theory. In the course of time his studies were published in articles in technical magazines and the transactions of societies and finally were summarized in his monumental volumes on the art of ore dressing, two of them published in 1903 and two in 1909. In these he crystallized the science of the art in a classic of technical literature.

Yours truly,
(Signed) W. R. INGALLS.

From Bradley Stoughton, Professor of Metallurgy, Lehigh University, Bethlehem, Pa., came these words:

Robert H. Richards was an inspiring teacher and, particularly, he impressed the force of his personality so strongly on his students that they benefited all their life.

I knew him well because I remained at Tech for one term after graduation to teach in the mining laboratory and, also because he stayed at my house in New York on more than one occasion. I also saw him frequently at A.I.M.E. meetings.

I can't testify too highly to the splendid influence he had on the young men who were fortunate enough to be associated with him.

Sincerely yours,
(Signed) BRADLEY STOUGHTON.

Professor Carle R. Hayward, Department of Metallurgy, Massachusetts Institute of Technology, said:

My favorite mental picture of Professor Richards shows him standing beside the now obsolete round slime table operating a vanning shovel. Here was laboratory instruction at its best with a master technician who was also a

born teacher and a top flight scientist, demonstrating a fundamental principle. Even after he was officially retired he was often invited to show the students how the round table worked. No one could do it so well.

Those who accompanied Professor Richards on the annual summer trips to mines and smelters were never kept under strict supervision but were told to always remember that the honor and reputation of M.I.T. was in their hands. The students noted the respect which was always paid to Professor Richards at the plants and this, together with his own example on all occasions, made such an impression that no restrictions were necessary to maintain discipline.

Living with him intimately on these trips developed ties of friendship which were enduring.

(Signed) CARLE R. HAYWARD.

Mr. Earl Smith Bardwell, Superintendent of Copper Refineries, Anaconda Copper Mining Co., Great Falls, Montana, member of the Class of 1906 at M.I.T., wrote:

During several years following my graduation from the Institute I was closely associated with Dr. Richards, both in connection with his ore testing work and in the preparation of his books on Ore Dressing. During the summer of 1907 it was my privilege to spend some weeks with him at his summer home in the White Mountains of New Hampshire. More and more as the years pass by I have come to realize the beneficient influence which his fine character and Christian outlook on life had on me during those days and weeks that we were together.

In the ferns and wild flowers we found a common interest. His fund of nature lore was a constant delight. To have him explain some curious adaptation of plant life was to make one feel that behind the perfectness of Natures plan, he saw the hand of a Divine Planner. To me Dr. Richards was not only teacher but friend, one of the most lovable characters that I have ever been privileged to meet along life's way, one of whom it may truly be said,

Beautiful life is that whose span
Is spent in duty to God and man;
Beautiful calm when the course is run,
Beautiful twilight at the set of sun,
Beautiful death with a life well done.

Sincerely yours,
(Signed) E. S. BARDWELL.

Arthur F. Taggart, Professor of Mineral Dressing, School of Mines, Columbia University, New York City, said:

My acquaintance with Professor Richards started the last year of his active teaching. I had been rashly offered, and had brashly accepted the job of teaching ore dressing at Yale—knowing nothing about the subject. I turned, of course, to Professor Richards. He took me under his wing in kindly and competent fashion. I had only a half year available. He encouraged me to take the elementary course, one of each of the two kinds of thesis researches then offered, and an advanced course, in which I was the only student registered, and which he wryly remarked at the time would probably be advanced to the extent that in it he would try to keep me up with the other courses. This he labored faithfully to do, with the result that while I have taken a number of "advanced" courses of various kinds since, I have never learned as much in a given period of time as I did under him, nor worked with a teacher who was so determined that I should learn.

That was a hard session for both of us. I know that I was absorbing a lot of facts, and thought that that was the measure of my learning. I later found that the important thing that he was teaching was the principle upon which his own work had been based: "Don't just talk about what will happen; try it and see what does happen. Take sensible safeguards; don't attempt mill-scale work, if there is time for laboratory and pilot-plant work; don't take a risk disproportionate with the possible gain; but don't just sit around and talk."

I left Tech and Professor Richards' guidance with what I later found was the feeling characteristic of his students; a sincere and deep affection, and the highest respect for his knowledge and integrity.

Yours sincerely,
(Signed) ARTHUR F. TAGGART.

From Mr. Ralph H. Sweetser, Consultant in Blast Furnace Practice, New York City:

It was my good fortune to study mining engineering and metallurgy of iron under Professor Richards, graduating in 1892, with the degree of S. B. in Mining Engineering and Metallurgy. Professor Richards helped me to get a job in the blast furnace department of the Maryland Steel Co., at Sparrows Point, Md., under David Baker, M.I.T. '85, in the "monkey wrench" gang, and as stove-tender, foreman, etc., until the complete shutdown in January, 1894.

In the summer of 1894 I wrote to Prof. Richards, asking for a recommendation as teacher of chemistry in the High School of Portsmouth, N. H., my home town. He answered at once and said that he would not give me any such recommendation because he wanted me for himself, and that I should come at once and live in his home in Jamaica Plain, and help him write his "Notes on the Metallurgy of Iron."

By the end of the year 1894 we had finished "Notes on the Metallurgy of Iron"; the part on the Bessemer process was written by John W. Cabot, Course III, and his drawings are initialed "J. W. C." Some work was done by W. A. Tucker, Course III, '93. The 148-page volume was written in long hand with lithographic ink and reproduced on one side of the paper only; it was copyrighted in 1895. On the fly leaf of my own bound copy is written, under date of Feb. 17, 1894, the following,—"I marvel more and more at the wonderful resources of Prof. Richards. He is whole-souled, generous, broadminded. He has the faculty of listening to a man until he is through talking, although the man may be telling what he already knows, or what he knows is false or absurd. His mode of attack is excellent and his laying-out methods of work help him greatly. He grasps the situation if presented graphically, but he is a very slow reader."

Professor Richards was color blind and a scarlet tanager was the same color as a sparrow, but he could tell by the shape what sort of a bird it was.

When the Notes on Iron was finished, Prof. Richards asked me to remain and help him on his monumental work, "Ore Dressing." This included research work in the library and laboratory at Tech. On working out some sizing or grinding problem, the Professor would sit in his rocking chair in the library at home and rock slowly, saying, "the lamp of genius seems to burn more brightly in a rocking chair." In my letter to him on his 100th birthday, I mentioned the arm chair and the lamp of genius. In his card of acknowledgment, he said, "Dear Sweetser, I still enjoy my rocking chair—even though the lamp of genius seems *not* to burn." That was the last message from a great teacher, a dear friend, and a noble man.

Yours very truly,
(Signed) RALPH H. SWEETSER.

Mr. John Van Nostrand Dorr, President, The Dorr Company, Engineers, Manufacturers of Metallurgical Machinery, New York, wrote:

It is a great privilege to write of Dr. Richards. Coming into metallurgy from chemistry, I felt the greatest respect for its leaders and early acquired his monumental work on Ore Dressing. It was never my good fortune to contact him in the field but at technical meetings his friendly greetings and kind appreciation of my own contributions meant a lot to me.

We were both delegates to the World Engineering Congress in Tokyo, and the devotion shown to him by Baron Takuma Dan, head of the House of Mitsui and one of his earliest students, was most touching. Wherever he went the Baron had one or more young engineers with him ready to render any service.

I took colored movies in those days and I cherish today films taken of Dr. Richards with the Baron's young granddaughters at a reception at his home. We can well say of him, the whole century of his life was a benediction to his profession and the World.

Sincerely yours,
(Signed) JOHN V. N. DORR.

Mr. H. Foster Bain, Mining Geologist; formerly Secretary of the A.I.M.E., paid him this tribute:

I was delighted to learn that the A.I.M.E. is to publish a "Robert H. Richards Volume." As past president, Honorary Member and so

long an active worker in the Institute, this is particularly appropriate. It is even more so that his great contributions to the service and art of ore dressing, and to the general body of knowledge of his profession should be so recognized.

Probably no one, in the long years of his life time did more to build up right thinking and right standards of action in his profession, and certainly no one made larger contributions to the knowledge of his specialty.

I was one of those on the outer fringe of his wide friendship as I knew him mainly through his writings and through occasionally but stimulating contacts at A. I. M. E. Meetings. It is one of my great regrets that I missed an opportunity in 1929 to come in closer personal contact since we were to have been fellow house guests of his former pupil Dr. Takuma Dan during the Engineering Congress held that year in Tokyo. I planned to go but legal difficulties forced me to give up the trip.

Richards was greatly honored in Japan where his work was widely recognized.

Cordially,

(Signed) H. FOSTER BAIN.