HISTORICAL SKETCH

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cally planned Course in Physics, which should train young men for teaching or research in that subject. In view of this, in 1873 the Corporation of the Institute, acting upon the recommendation of Professor Pickering, decided to establish a course leading to a degree, which became Course VIII. There was one graduate from the course in 1875 and three in 1876.

In January, 1877, Professor Pickering resigned his professorship at the Institute, after ten years of devoted and fruitful service, to accept one of the most important scientific positions in the world, the Directorship of the Harvard College Observatory, of which institution he is still the honored head. Shortly thereafter the Physical Department at the Institute was placed in charge of the writer of this article, who had become one of its staff of instruction upon his graduation in 1870.

The Institute was in a state of financial embarrasment at this time, and it was necessary to restrict the staff of the Department to the professor and two assistants, These last were chosen from the graduates from Course VIII in 1876, Messrs. J. B. Henck, Jr., and S. W. Holman. Mr. Henck resigned after a few years, entering upon professional work, but Mr. Holman remained in the service of the Institute until failing health obliged him to retire a few years prior to his death in 1900. He had been promoted to the faculty in 1882, and was made full professor in 1893.

It is to Professor Holman's remarkable experimental skill, which has rarely been equalled in this country, combined with his excellence as a teacher, that the exceptional character of the physical laboratory work, which has been done at the Institute, is chiefly due. The Laboratory of General Physics and the Electrical Laboratory are, in fact, a memorial of his ability and devotion.

Course VIII was gradually strengthened in various ways in the years succeeding 1877. The next especially noteworthy advance, however, was the establishment, in 1882, of a Course in Electrical Engineering as an alternative to the Course in Pure Physics.

Much attention had always been given at the Institute to instruction in the applications of electricity. In 1870, Professor Pickering purchased in London a Wheatstone's bridge, slide wire bridge, Thomson Galvanometer, standard condenser and other electric measuring instruments, and these were shortly afterwards put into use by the students in the physical laboratory; this, as far as known, being the first instruction of the character to be given by any college in the United States. A course of lectures on electrical measurements was also introduced by Professor Pickering about the same time. In the spring of 1874 an important series of tests of Mr. Moses G. Farmer's newly-invented dynamo machine were made by him and Mr.. D. P. Strange.

It was soon after this date that the remarkable succession of electrical inventions which characterize the latter part of the 19th century began, with the invention in 1876 of the speaking telephone by Professor Bell, to be followed by the various developments in electric lighting and power, which have so completely transformed the conditions of living. There was no place in this country where one could study these subjects, and only one or two abroad. It was the desire of the writer to have facilities for such studies furnished by the Institute; but at first this seemed difficult for financial reasons. A course of optional lectures on applied electricity, given in 1881, was so well receivved, however, that in 1882 the Corporation decided to institute a Course in Electrical Engineering, which was announced in August of that year, and opened to students in the following month, it being the first course of the kind to be established in this country. The well-known course at Cornell University was not opened to students until a year later. The history of the Course in Electrical Engineering, which continued for twenty years to be carried on under the direction of the Department of Physics, has been given in a preceding paper in this series, and need not be referred to further.

In 1884 there was opened as a part of the Rogers Laboratory a Laboratory of Heat Measurements, which was altogether unique. This, for a long number of years, was in charge of Professor Holman, and was subsequently placed under the care of Professor Norton, whose article in the present number of The Tech gives further information regarding it.

In 1897 the Optical Laboratory was opened, in charge of Dr. Wendell.

The lecture and laboratory courses on the principles and processes of photography, including micro-photography and color photography, were introduced by Professor Derr in 1897. Elementary instruction in ordinary development and printing had been given at a very early date in the history of the laboratory, but the subsequent popularity of "snap-shot" photography rendered the continuance of this unnecessary.

In 1894 the Laboratory for Physico-Chemical and Electrochemical Measurements, suggested and planned by Professor Goodwin, was opened, and in 1901 a Course in Electrochemistry (now Course XIV), under his charge, was established. The Institute again was the pioneer in thus laying out a system of instruction in this new branch of applied physics.

During the last ten years the Course in Physics, in all its branches, has continually been strengthened, and each year it has been more complete than the year before. It has the honor to number among its graduates men who have achieved high distinction in both pure and applied science. Three of these are astronomers of world-wide reputation, several are well known as inventors, many are teachers in colleges; others are engaged in research in the scientific bureaus of the government; all have done credit to themselves and to their alma-mater.

ELECTROCHEMISTRY

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chemical laboratories of the universities and polytechnic schools of Germany and Switzerland, in order to incorporate the most modern ideas regarding equipment in the laboratory of electrochemistry. This laboratory was the outgrowth of the instruction instituted in 1894 in physico-chemical measurements, which had always included a considerable number of experiments of an electrochemical character. Since the establishment of the electrochemical laboratory proper, the laboratory course in chemical physics has been made an option in Course VIII, and the work has been confined to exact measurements in that subject, exclusive of electrochemistry. As the result of a study of the laboratory problem abroad, it was decided to equip two distinct laboratories, one provided with facilities for refined electrochemical measurements, and the other with facilities for carrying on technical processes involving the use of alternating and direct currents on a fairly large scale; in other words, a laboratory of applied electrochemistry. For the equipment of these laboratories the Executive Committee made a generous special appropriation in 1903. New apparatus has been added each year since then, and it is believed the facilities now afforded for instruction in electrochemistry are unsurpassed. Professor Thompson remained abroad from 1901 until 1903, working with Professor Lorenz at the electrochemical laboratory in Zurich, returning in the latter year to take charge of the instruction in applied electrochemistry.

The only notable change to record since the inauguration of the electrochemical option in Course VIII is the establishment of its curriculum on the basis of an independent course—Course XIV. This action was taken in the spring of 1909, the laboratories remaining as before, a portion of the Rogers Laboratory of Physics.

Upon the announcement of the course in 1901 one graduate student applied for admission in the junior year and graduated in 1903, while eight students registered in the second year, thus completing the whole curriculum in 1904. Since that time twenty-five students have been awarded the degree. The positions which they now occupy, as shown by the latest alumni register, indicate the breadth of training given by the course. About one third are filling strictly electrochemical positions, another third are following the electrical, metallurgical or general engineering profession, while the remainder are engaged in teaching, scientific research in the United States Government employ, and patent law.

Of the causes which have combined in the last twenty years to create the present demand for men trained as electrochemists, the first to be mentioned is the unparalleled development of physical chemistry, that science bridging the gap between physics and chemistry, of all chapters of which none has proved of more importance than that which deals with the mutual transformation of electric and chemical energy, and the manifold phenomena which result therefrom,—in other words, the Science of Theoretical Electrochemistry itself. In this development German investigators have been not only the pioneers, but they have also led the world in the number and importance of their contributions.

During the latter eighties and nineties students from over the civilized world were attracted to Germany to study under the leaders of the new science, becoming in their turn teachers in their own respective lands. Professorships and laboratories devoted exclusively to physical chemistry, and later to electrochemistry, were established, first at the universities, and later at the polytechnic schools, such as those at Aachen, Damstadt, Karlsruhe, and in Switzerland at Zurich. In thus early recognizing that electrochemistry was not only of growing importance as a pure science, but also that its applications to technical problems were destined to become of great and increasing value in the industrial world, German technical schools anticipated us in America. Since 1903, however, special instruction and laboratories devoted to this subject have rapidly multiplied in this country.

Prior to about 1885 the industrial applications of electrochemistry may be said to have been limited to the arts of electro-plating, electro-typing, the manufacture of certain primary and secondary batteries and to certain processes of electrolytic refining of metals, notably copper. Since then, as the result of the development of enormous quantities of electric energy at a less and less cost, and of the better understanding of the laws and phenomena underlying the transformation of electrical and chemical energy, new electrochemical processes have rapidly come into being. Among these are usually, although illogically, included those chemical processes taking place at exceedingly high temperatures, such as are readily produced only in the electric furnace,—processes in which heat energy rather than electric energy as such, plays the essential role. A number of industries, some of which have already reached large magnitudes, and which will be more fully discussed under the heading, Applied Electrochemistry, have been the immediate result of this activity. At the present time electrometallurgical methods are also assuming more and more importance, and it now appears as if electric furnace methods for the production of iron and steel have come to stay, at least as auxilcesses.

In the industrial development of the science the United States has taken the lead, thanks in part to the enormous power available at Niagara for the production of electrical energy, and in part to the characteristic American readiness to try out a novel process on a large scale, often at considerable financial risk, before it has been "demonstrated."

As indicative of the growing interest in electrochemistry in this country, it may be said that prior to 1902 there was no journal especially devoted to this science and no society primarily concerned with its interests. In that year the American Electrochemical Society was established, and its membership has increased until at the present time it is over one thousand. Two volumes of transactions are published annually, and a monthly journal serves to circulate the current technical news, patent literature, etc. The corresponding society, now known as the Bunsen Gesellschaft, established in 1894 in Germany, is also a very active and thriving society. England, too, has followed the example of Germany and America in the establishment not only of special laboratories for instruction in Electrochemistry, as that for example at the University of Manchester, but also an electrochemical society—the Faraday Society—devoted wholly to electrochemical interests.

To be properly equipped to attack electrochemical problems, particularly if they involve processes to be carried out on an industrial scale, it is essential that one should have a thorough grounding in the theory of direct and alternating currents and their application to the machinery on the one hand, and a corresponding thorough knowledge of chemistry, including theoretical, analytical and applied chemistry on the other. It is this combination of studies which is offered in Course XIV, and which forms the backbone of the course and basis for the professional work in electrochemistry itself. In addition to the fundamental studies, as many engineering subjects, such as mechanism and steam engineering, are included as the time in a four years' course permits. The range of subjects with which it is desirable an electrochemist should be familiar is so wide, however, that it is practically impossible to include all which are admittedly valuable in a four years' course. For this reason, a student who can arrange his work on a five years' basis will find it possible to include a number of additional subjects to great advantage. This may also be accomplished by following the four years' course by a fifth year, leading to the Master's degree.

From the nature of the subjects of electricity and chemistry, which form so large a part of the curriculum of Course XIV, much of the instruction is given in the laboratory. The problems to which an electrochemist is likely to be called upon to solve in the practice of his profession are usually experimental in character; Hence a student intending to take this course should have a distinct fondness for experimental work, and the greater his originality and power of attacking new problems the greater are his chances for eminent success. Skill in manipulation and fondness for experimentation, however, are not alone sufficient to insure success in this course. Good mathematical ability is equally essential to cope with the problems arising in theoretical and applied electricity, particularly that branch treating of alternating currents, the application of which is of great importance in many electrical furnace operations.

With the present outlook, a man who has successfully completed Course XIV should have no difficulty in obtaining a position for which his training has fitted him. It should never be lost sight of, however, that a successful career depends not only upon the knowledge, and of much greater importance, the power to apply it, but also on character, savoir faire, and the ability to meet and deal with men. The development of these essentials for success in life should never for a moment be lost sight of during student days. In many instances, it is these more than scholarship alone which recommend a student on graduation for positions of responsibility and larger opportunity.

EXPERIMENTAL PHYSICS

By H. M. GOODWIN

The Course in Physics is often characterized as the "hardest Course at Tech." Those who are fortunate enough to count themselves among its graduates will not, of course, dispute the title, but it may be doubted whether a properly prepared student finds the work more difficult than that required in certain of the Engineering Courses, inasmuch as the Course is homogeneous in character and contains fewer subjects than are required in the more composite Courses. Be this as it may, the Course does require for its satisfactory completion unquestionable ability on the part of the student in two distinct directions: he must be a good mathematician, and he must have reasonable skill in laboratory manipulation, and in the interpretation of experimental results. The two options offered in the Course (the mathematical and chemical options, respectively,) afford considerable latitude in the direction of specialization; but whichever option he may elect, the student must have a clear logical mind and a love

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