COLLEGE TEACHING

By G. V. WENDELL.

The special course issues of The Tech which have been appearing during the college year have been of interest to me and, I am sure, to other alumni readers as offering a concise statement of the history and growth of the Intitute courses since our student days. To the Freshmen, these frank talks by the professors and graduates must have served to give a closer, perception of the meaning of the various branches of engineering and thus have materially aided them in a wise choice of a course of study. To the other undergraduates they must have given a clearer appreciation of the splendid opportunities for service in the field of engineering and in industrial life. The realization of the need of the conservation of our great national resources and the engineering and scientific problems involved must have served to quicken their investigation, enlarge their aspirations and deepen their conviction of the need of availing themselves of the unexcelled training for such service offered by the Institute.

The course in Physics, known as Course VIII, prepares a student to become a teacher of physics or to undertake investigations in that science. With this aim in view those in charge have endeavored to give with a comprehensive treatment of physics an adequate training in chemistry and mathematics. At the same time the humanistic subjects have been given the large place they deserve in the proper development of the teacher. The actual selection of subjects and the allotment of time to each must commend themselves to any thoughful person. The presence in the course of applied electricity is of value to the student who intends to teach phisics in an engineering school, both for the subject matter and also as an indication of ahe fundamental importance of physics in engineering. The wise selection of required subjects, combined with an unusually complete lecture and laboratory equipment, the insistence on work being intellegently and thoroughly done, the opportunity for association with earnest students of engineering and with those engaged in research make the Institute's Course VIII the equal of any undergraduate course in the country leading to a B. S. in physics. Another admirable feature is the close personal relation between the instructors and students of the department.

The presence at the Institute of older students engaged in research and in graduate study for the doctor's degree must have its beneficent reflex action on the undergraduate student in physics. The latter must learn through association with these men the importance of research and the necessity of further study after graduation. I cannot urge too strongly upon the undergraduate in physics who plans for a College teaching career, the prime importance today of graduate study. Excellent and thorough as the instruction in Course VIII is, the training of the men already in the profession and the remarkable increase in the number of graduate students in physics in the universities of this country and of Europe make the competition so keen that only men of the best attainments can expect to hold the places of leadership.

Not merely should every undergraduate who expects to enter college work plan to take a Ph. D., but he should arrange his graduate studies with great care. The mere asquisition of a doctor's title for its influence in securing a position should be put aside as unworthy of a true scientist.

My advice is to devote on the completion of the Institute Course two, three or four years to the acquirement of a training that will qualify the student for a greatest efficiency. Such a program of study entails naturally a considerable financial outlay which may seem to many students an unsurmountable obstacle. The difficulty is more apparant than real, however, for it shold be remembered that many universities as well as the Institute offer graduate scholarship, followships and even assistantships that place the possibility of graduate study within the reach of nearly all worthy students.

The profession of Physics offers an interesting and useful career both as a teacher and as an investigator. It should be borne in mind, however, that to enjoy the fullest fruitage a thorough preparation is indespensable.

HEAT MEASUREMENTS

By C. L. NORTON.

The Laboratory of Heat Measurements is unique among the technical laboratories of this country. Systematic work in this line may be said to have begun at the Institute when the rapid development of electric measurements called to Professor Cross' attention the similar development which was to be expected in the industrial world along the line of heat engineering. It was in 1884 that this work was begun, under Professor Cross' inspiration and with the co-operation of the late Professor S. W. Holman.

In 1897, with enlarged quarters and considerable increase in apparatus, the writer was given charge of this work. While distinctly a physical laboratory course, the instruction in heat measurements is given to the engineering students, as well as to the physicists, and might properly be counted as a professional subject in most of the engineering courses.

In the early days of this work a pyrometer was viewed by an average engineer or manufacturer as a most fickle and untrustworthy instrument, and to attempt to determine the heat of combustion of fuel with an idea to economy in the operation of power plants was to experiment with a fanciful and vain thing. The progress of the industrial world along these lines has been so great, however, that nowadays all the important industrial operations are watched very carefully from a thermal standpoint. The number of processes whose economical operation depends upon the proper adjustment of temperatures, or the regulation of the amounts of heat involved, is quite comparable with the operations whose success depends upon purely mechanical control.

Special instruments for the measurement of all sorts of thermal quantities have become available. The fear of the exhaustion of our natural fuel resources has greatly stimulated the interest in the economy of all processes of combustion, and it is scarcely an exaggeration to state that the manufacturer who does not concern himself with the heat of combustion of his coal is almost as remiss as he who does not concern himself about the accuracy of the weight. The growth of all the methods of insulating hot and cold receptacles, refrigried on in the laboratory is the calori warehouses and kilns, has led to great studies and developments in the matter of insulation, and to this and the fuel problem has been devoted a great deal of the time of the instructing staff of the Laboratory of Heat Measurements for the past fifteen years.

One of the most interesting developments of the work which has been carbut of marker efficiency as workmetric apparatus for the determination of the efficiencies of fuels. This has been developed commercially by Mr. C. J. Emerson, formerly an instructor in the laboratory, and has been adopted as a standard instrument for this purpose. The original bomb of this type was made by the writer for Professor Holman in 1895.

To the students in mining and metallurgy, the position occupied by heat measurements is somewhat similar to that occupied by chemistry, and in many metallurgical operations the questions of heat and temperature are quite as vital in determining the metallurgical results as are the questions of chemistry.

The great fire loss of this country has at last brought us to a systematic and thorough study of the problems of fire prevention, and it has been the privilege of the instructing staff of the Laboratory of Heat Measurements at the Institute to serve in a sense as pioneers in this campaign of fire prevention.

Instruction to the undergraduate students is given in the measurements of such heat quantities as enter into all the teachnical and engineering problems suggested above. The equipment of the laboratory is very complete, and might be said to be essentially a working equipment, containing little material of historic interest or of museum value, but of the marked efficiency as working instruments of instruction for undergraduate students.

The short course of lectures, which precedes the laboratory work, is taken by the students in Courses III, V and VIII. The laboratory experiments themselves are varied for students in the different courses, to make the instruction bear more directly upon the professional work. Since the determination of high temperatures is of much importance to students in Course III, special stress is laid upon this work. The chemist, on the other hand, is oftentimes more concerned with the possibility of maintaining and measuring a lower temperature with a very high degree of precision, and the special apparatus which is available for measurements of this kind is used by the students in Course V in the laboratory. Again, the mechanical engineer is oftentimes more concerned with the determination of the heat of combustion of fuel or the insulating efficiency of steam-pipe coverings, and the students in Course II perform laboratory experiments for the determination of these quantities. These illustrations will perhaps show the scope of the laboratory work in the different courses.

Professor Cross' prophecy of 1884, that the Laboratory of Heat Measurements would ultimately be comparable in scope and size with the Laboratory of Electrical Measurements, seems in a fair way to be realized.

GOVERNMENT WORK

By DR. G. K. BURGESS.

Graduates of Course VIII. find their way most readily into positions requiring proficiency in the mathematical and physical sciences, and of such positions there are many in the Government Service and their number is on the increase. An enumeration of the various scientific and technical branches of the Government Service to which graduates of this course are eligible for appointment to positions immediately after graduation from the Institute, compared with the small number, six, of Course VIII., men actually so employed, leads to the belief that the Course in Physics could with advantage attract more men than has been the case heretofore.

Let us pass briefly in review those departments of the United States Government for which Course VIII men are especially well prepared to enter.

In the Department of Commerce and Labor are the Coast and Geodetic Survey and the Bureau of Standards. In the latter there are at present fifty-eight positions, held by persons trained primarily as physicists, with salaries ranging from $900 to $5,000, at an average of $1,550, and grouped as Laboratory Assistants 24, Assistant Physicists 24, Associate Physicists 8, and Physicists 2. This range of salaries is fairly typical of the scientific positions in the Civil Service.

Although the Coast Survey has no positions designated by name as Physicist, yet in fact there are a considerable number connected with its various division, such as magnetic, tidal, geodetic, and computing, which a man trained as a Physicist is well prepared to fill.

The greatest variety of positions, however, for which Physicists are required, is to be found, perhaps, in the various bureaus of the Department of Agriculture. It is beginning to be appreciated, for example, that scientific meteorology is a branch of physics, and in consequence the Weather Bureau now possesses its Mount Weather Observatory, which is essentially a physical laboratory, and a small corps of Physicists. The bureau of Soils, of Plant Industry, and of Forestry, likewise have their Physicists, as in fact do most of the scientific and technical bureaus.

Among the Bureaus of the Interior Department where Physicists may be found are the Patent Office and the Geological Survey, especially in the Technological Branch of the latter.

There are several technical bureaus in the Departments of War, the Navy, and the Treasury, in which there are positions for which Physicists in fact if not in name. Among these are the Bureaus of Ordnance, Steam Engineering, Equipment (including the Wireless Service of the Navy), the Hydrographic Office, Signal service (Wireless for the Army), the Supervising Architect's Office, and the Customs Service. The Naval Observatory is also an institution to which a Course VIII. man may legitimately aspire; and if he wants to be a teacher in the Government Service, there are the professorships in mathematics at the Military and Naval Academies.

Finally, the Smithsonian Institution, with its small but distinguished scientific staff of the Astro-physical Laboratory, which alone of all the scientific institutions in the country has the unique distinction of being composed exclusively of graduates of Course VIII.

Appointment to positions in the civil service is made only after examination by the Civil Service Commission. For scientific positions, there is usually a written examination together with a rating based on the applicant's training and experience. The written examination is rarely waived except for the highest positions. There is no politics in the civil service, and the tenure of office is usually as secure as a man cares to make it, since the men in scientific positions who leave the service, almost invariably do so to better themselves.

For positions in which ability to carry on independent research is required, it is almost a necessity for the candidates to have a doctor's degree, or at least to have shown an equivalent proficiency by his publications.

The scientific atmosphere of Washington is stimulating and there are a dozen Course X., I changed to Course VIII., with a local membership of over two thousand, so that no one lacks for a sympathetic audience before whom to expound his pet hobbies.

ASTRONOMY

By C. G. ABBOT.

I regard the Physics course at Tech as an ideal school for the astronomer, although in my time actual astronomy received little attention in Course VIII. My own experience with it may have been more limited than that of others, for after completing my second year in Course X., I changed to Course VIII., and graduated with my class, so that all the astronomical study I took at Tech comprised the reading of Young's General Astronomy during a summer vacation. It may indicate a mild form of treason to chemistry on the part of our honored Dr. Noyes, if I add that my change of course was made because he told me that, in his view, one who was interested in molecules ought not to be a chemical engineer. On my asking what course he would recommend to such a person, he replied that he wished he could recommend Chemistry, but on the whole he thought the chemical option of the physics course would be best, and so I adopted it.

The most distinguished graduate of Course VIII. who has made a profession of astronomy is Dr. G. E. Hale, Director of the Mount Wilson Solar Observatory. He has told me that from the moment he first saw a spectroscope, spectroscopy was the only thing for him as a profession, and that he had it always in view from that time on. So it has been with great astronomers, their bent was fixed from childhood. Still, I believe there is a chance for some people of another sort. I remember that as a boy I intended to be a carpenter; when I entered Tech, a mechanical engineer; in my second year, a chemical engineer; when I graduated, a teacher; and it was only because I failed to obtain that summer a teaching position that suited me that I took an additional year at Tech, and then, to my surprise, was offered a position as assistant in the Astro-physical Observatory of the Smithsonian Institution. My first view of the Director, Dr. S. P. Langley, and his first view of me, was when I emerged in overalls and jumper from research work in the basement of Walker Building, at Prof. Cross' request, to meet Mr. Langley, with whom I was to grow into solar astronomy for many years.

It seems to me, then, that while some astronomers are born and not made so by circumstances, there is also an opportunity for those who have the inclination for thorough, accurate research work of whatever kind.

It should not be supposed that celestial mechanics began with Newton's "Principia" and ended with La Place's "Mechanique Celeste." Our own countrymen, Newcomb, Hill, and Brown, have found no lack of opportunity in the present day.

Course VIII. has doubtless changed almost beyond recognition since my day,

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