Secretary, Daniel T. MacDougal, Botanical Garden, Bronx Park, N. Y.

The Central Botanists' Association will meet in affiliation with Section G. President, Conway MacMillan; Secretary, C. F. Millspaugh, Field Columbian Museum, Chicago, Ill.

The Entomological Club of the Association will meet at convenient times. President, E. A. Schwarz; Secretary, C. L. Marlatt, Department of Agriculture, Washington, D. C.

The Fern Chapter will meet at times to be announced. President, B. D. Gilbert; Secretary, H. D. House, Botanical Garden, Bronx Park, New York, N. Y.

The Geological Society of America will meet on Wednesday at its hotel headquarters, at the Southern. Subsequent sessions may be held in room 210 of the high school. President, S. F. Emmons; Secretary, H. L. Fairchild, Rochester, N. Y.

The Sigma Xi Honorary Scientific Society will meet at a time to be announced later. The annual banquet, to be followed by an address by Dr. David Starr Jordan, will be given at the Mercantile Club, Seventh and Locust Streets, on Thursday evening at seven o'clock. Members are requested to register and procure tickets for the banquet, at the desk of the local secretary, as early as possible in the week. President, S. W. Williston; Secretary, E. S. Crawley, University of Pennsylvania, Philadelphia, Pa.

The Society for Horticultural Science will hold its first regular meeting on Monday and Tuesday. President, L. H. Bailey; Secretary, S. A. Beach, Experiment Station, Geneva, N. Y.

The Society for the Promotion of Agricultural Science will hold its quarti-centennial meeting on Monday. President, William Frear; Secretary, F. M. Webster, Urbana, Ill.

All members of affiliated societies who are not members of the American Association for the Advancement of Science are nevertheless requested to register at the desk of the local secretary, so that an approximate record may be made of the total number of scientific men in attendance at the convocation week meetings. Members of the American Society of Naturalists and its affiliated societies, and of the Sigma Xi Honorary Scientific Society are also requested to procure tickets for the annual dinners of these societies from the local secretary as soon as possible after arrival, so that arrangements for the dinners may be perfected.

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*THE TYPICAL COLLEGE COURSES DEALING WITH THE PROFESSIONAL AND THEORETICAL PHASES OF ELECTRICAL ENGINEERING.**

At the Chicago meeting of the American Institute of Electrical Engineers held eleven years ago, I presented a paper relating to the subject now under discussion. The proposed subject then apparently created some consternation amongst the members of the committee on papers, who seemed to fear that it was not of sufficient interest to the society. The old prejudice still held against 'college men' in the minds of so-called 'practical men' who had grown influential in engineering practice without having had experience of college life and training. Happily the foundation for this prejudice has ere this been destroyed through the influence of the industrial results achieved by college men. The old prejudice, so far as it now exists, has more particularly drifted into the way of criticism of the engineering schools rather than their graduates, and the character of the schools and the training they afford are

* Paper read at the joint session of the American Institute of Electrical Engineers and the Society for the Promotion of Engineering Education, held at Niagara Falls on July 3, 1903.

subjects of eager discussion in engineering circles.

This extended interest now manifested in the work of the engineering schools produces a situation which may be of great usefulness to the schools. The character of a college may be that which its alumni determine, and any engineering school may be improved by thoughtful suggestions and broadly considered criticisms emanating from its alumni and others who have its best interests at heart.

Two fundamental propositions must be held clearly in view in all such criticisms, if they are to be of service to the educational administration of the engineering colleges:

1. That it is the business of these colleges to train young men into fertile and exact thinkers guided by common sense, who have a profound knowledge of natural laws and the means for utilizing natural forces for the advantage of man. In other words, it is the business of the engineering colleges to produce, not finished engineers, but young men with *a great capacity for becoming engineers,* the goal being obtained by the graduate only after years of development in the school of life.

2. The problem to be met by the engineering colleges is more particularly a problem in *how to properly train* to the stated purpose. The names attached to the subjects taught are not so important as the results produced by the teaching—namely, the effect impressed on the students' powers. This is a teacher's problem—a question of pedagogy, rather than of the engineering profession. It must be met with all the directness and power of the engineer's best efforts, but it can not be solved as solely relating to the engineering profession. Much error on this point lies in the minds of many who assume the part of critics of the curricula of the engineering schools.

In this connection I may be permitted to point out that proposals set up as apparently new in the presidential address one year ago, by President Steinmetz of the American Institute of Electrical Engineers, have for many years been largely included within the ideals of numerous American colleges of engineering. It must be admitted that only a few of the engineering schools are living up to their better ideals. This is partially due, on the one hand, to personal or institutional ambitions which foster the sensational or spectacular and thereby inevitably ruin good teaching, and, on the other hand, to the meager support in both encouragement and funds which I have noticed is the lot of the engineering schools attached to many universities. The latter like the former is often the result of personal prejudices or ambitions.

Most of the faults which are so trenchantly and indiscriminately charged to engineering colleges by many engineers should, so far as they are real, be laid to the pedagogical inexperience and faulty ambitions of the authorities of the many colleges; and exception should be made of the few of the first rank, in which, it is safe to say, the ideals are high and well centered and the administrative organizations hold the ideals continuously in view.

The query here naturally arises: Of what do these ideals properly consist and how fairly should they be met by the college before its course in electrical engineering may be approved as of first rank?

Electrical engineering demands industrial engineers—men with an industrial training of the highest type, competent to conceive, organize and direct extended industrial enterprises of broadly varied character. For the highest success, these men must be keen, straightforward thinkers who see things as they are, and are not to be misled by fancies; they must have an extended, and even profound, knowledge of

natural laws (more particularly of those relating to energy which rest on the law of conservation of energy), an extended knowledge of the useful applications of these laws, and an instinctive capacity for reasoning straight, from cause to effect. Moreover, they must know men and the affairs of men—which is sociology; and they must be acquainted with business methods and the affairs of the business world. Briefly, to reach his highest influence, each man must combine in one a man in the physical sciences, a man in sociology and a man of business. All engineers can not reach this high mark, but the engineering college course should start each of its students toward that degree of attainment which his individual powers will permit.

Michael Faraday (whose conservatism and intellectual clearness are proverbial) said that it requires twenty years to 'make a man' in the physical sciences. The engineering school must put each student in the way of becoming, so far as his mental and physical powers warrant, not only a man in the physical sciences, but a man in sociology and a man in business as well; and this must be done within the narrow limits of four years. It is clear that only the foundations of 'the man' may be laid in the prescribed time, and the engineering college must, therefore, rigorously hold itself to the fundamentals. The engineering college faculty which is contented to deal out so-called 'information courses' on the narrowly empirical side of engineering practice, deals a wrong to its students which they may not recognize at the moment, but which will ultimately tell heavily against their success.

The students that enter the engineering schools of the west, and I presume likewise of the east, are from amongst the most vigorous minds of the high schools and preparatory schools; and yet it must be admitted that they ordinarily possess little power of clear thinking, power of initiative, regard for accuracy, or understanding of continuous and severe intellectual effort, as these important attributes are understood in industrial circles. They are not yet mature in body and are less mature in mind (the latter being, I think, in accord with the natural order of development). But they commonly are well equipped with physical vigor and latent mental strength. Their preparatory schooling has given them a defective acquaintance with the construction of the English language and the spelling of English words, a still more defective acquaintance with French or German or a fairly good grounding in elementary Latin, a smattering of civics and history, a training in the elementary principles of arithmetic, geometry and algebra from which the factor of accuracy in application has often been omitted, and perhaps an enthusiastic interest in the physical sciences.

This enumeration of the attainments of the students entering the engineering colleges may perhaps be interpreted as reflecting on the secondary school teachers, but I wish vigorously to deny the validity of any such interpretation. I can truthfully say that, considering all of the conditions, there is no more painstaking and right-wishing body of people than these teachers.

Many of the faults in the preparatory training of our engineering college students are caused by a doubt which is now apparently agitating educational circles on account of the question whether the high schools shall be the 'people's colleges' or remain in the station of secondary or 'preparatory' schools. This doubt is apparently not yet resolved in the minds of the molders of educational thought; but the traditional old-time secondary school training which produced men who could spell and cipher and who had received a

thorough and accurate drill in the details of one language, is certainly to be preferred as a preparation for an engineering college course. In my own estimation, when accompanied with history and a year spent in civics and natural science, it is not only to be preferred as a school course for preparing the student for college, but also a course for those numerous students who can not go through college.

Taking the students as they come and may be expected to come for the present, the electrical engineering course must include the following branches of learning which are preparatory to the more strictly professional studies:

1. That fuller training in the construction of the English language which is requisite to clear thinking and clear writing, preferably accompanied by an additional language for added strength.

2. The collateral art of expression in drawing.

3. Mathematics through an appropriate amount of calculus, including the integration and solution of equations involving derivatives and instruction in the use of coplanar vectors, and perhaps quaternion quantities, all of which should be taught as applied logic, with special emphasis laid on interpreting the meaning of equations.

4. The science of chemistry, soundly taught.

5. The science of physics, soundly taught, with particular emphasis laid on the elementary mechanics.

6. Applied mechanics.

Mechanics—the philosophy of matter, force and energy—is the backbone of the electrical engineer's college training.

Instruction in the science branches should be accompanied by well-conceived and properly conducted laboratory work, mostly of quantitative character, accompanying and illustrating the class-room instruction; and all instruction whether in natural science, mathematics or languages, should be under the direction of men who are engineers or in full sympathy with the aims and ideals of engineering.

A limited amount of manual training may well accompany these studies, and likewise, if time can be found for it without over-burdening the reasonable physical powers of the student, a limited amount of proper instruction in surveying (including the use of the compass, transit and level) will always prove a force for quickening the student's perceptions and at the same time put him into possession of processes of probable future value.

In a few of our engineering colleges which rigidly demand the best preparatory work from the high schools, and which are, at the same time, best manned in their faculties, not less than two years are required to cover the ground above described, if the work is done in a reasonably satisfactory manner. But the above ground can not be covered with anything like reasonable success in much or any less than three years in the larger number of engineering schools that are usually accorded high rank. After covering these branches, it seems to be the tendency in many colleges to fly off into superficial or descriptive courses, relating to engineering practice, during the remaining time of the allotted four years. This is especially apparent in those colleges where the faculties are ambitious to see their graduates take an *immediate* place of considerable responsibility in the world. This is a fault that destroys much of the ultimate advantage which the students may derive from their engineering course. It is a fault, also, which casts just suspicion on engineering education alike in conservative academic circles and in well-informed industrial circles.

A resort to mainly descriptive courses of instruction during the latter portion of the

students' life in college largely neutralizes the advantage flowing from the instruction in the fundamentals heretofore described. The students are yet to be taught many things relating to engineering life. They must learn something regarding the forms and formalities relating to the affairs of business life. They must learn the characteristics and uses of materials, their correct application to the building of actual structures, the meaning of kinematics and the processes of designing and using real machinery. They must also learn to reason regarding the special principles of hydraulics and thermodynamics, and the way in which they enter into the design, construction and operation of machines, and the manner in which they modify the usefulness of machines and the efficiencies of numerous industrial operations. Again, they must learn to reason clearly and rationally in regard to the specific principles relating to applied electricity, including its widely diverse factors, and the way in which these principles enter into every-day practise. And they should learn something of the history of the development of engineering and of the lives of its great men, for the stirring of proper ambitions.

The electrical engineering department should be divided into not less than four subdivisions, comprising respectively: Applied electromagnetism, which includes the principles relating to electromagnetic machinery and apparatus; the theory and practice of alternating and variable currents, which include the principles relating to all those numerous phenomena which accompany variable current flow; applied electrochemistry and electrometallurgy; and electrical installations, which includes the applications in engineering practice of the numerous principles to the design, construction, operation and testing of complete installations and the component parts thereof.

The teaching force of the department should afford a competent expert engineer for the head of each of these subdivisions, and such additional well-trained force as may be necessary to adequately carry on class-room and laboratory instruction for the particular numbers of undergraduate and advanced students which attend the college. The head of such a department should spend much of his time in supervising the teaching in class-room and laboratory which is performed by his various subordinates.

But through all of this professional instruction of the latter part of the course, it is still *principles, principles, principles,* and rational methods of reasoning which must be taught, if full justice is done the students, until each student becomes a man of open mind, keen observation, analytical thinking and accurate powers of inference. This instruction should be kept close to the tenets of good practise, and the senses of the student should be constantly stimulated by illustrations and problems drawn from practice. The drill in reasoning can undoubtedly be best gained through rational instruction in the useful applications of scientific principles and laws; and no criticism can be justly passed even by the most conservative educational circles because the graduate is enabled to earn his living as a result of this training; but the purely descriptive should ordinarily be avoided except in a few cases where it has a specific function in improving the understanding of an application of principles or is adopted as a desirable auxiliary to stimulate the sustained interest of the students and thus add vitality to the teaching. Indeed, except for the purposes here defined, the introduction of the purely descriptive into the electrical engineering course wastes the students' time and injures their training, thus abridging their prospects of ultimate breadth and power.

The typical courses in electrical engineering which are to-day advertised in college catalogues belong to three classes or combinations thereof. Only the third of these may be acknowledged to fairly meet the proper ideals in such a course. It is to be remembered that I speak of professional engineering. No one possesses a fuller sympathy with the ideals of schools for training men for the mechanical trades short of engineering and bordering thereon, but these schools are not considered in my present discussion.

First, are courses in which predominate the old time instruction in physics with far more to do with the illustration of the beauties of nature than with the great underlying natural laws. The teaching of mathematics, mechanics and like groundwork studies is not ordinarily well supervised in colleges that maintain such courses in electrical engineering, because the administrative authorities are out of touch with the industrial world and mistakenly put the superficial and spectacular in science into the place of that sound instruction only through which an engineering course may be rightly maintained. It is needless to add that the average graduate from courses of this type is ordinarily of less value in engineering than the average graduate from an old-time classical course where at least thoroughness is a requirement; and electrical engineering courses of this type are rapidly disappearing through a merging into one of the following types.

Second, are courses in which the groundwork studies (English, mathematics, chemistry, physics, mechanics) are perhaps reasonably well taught through the earlier years, but in which the latter part of the course is diverted to the training of inexperienced students for immediate 'jobs' where the students may find some responsibility and proportionate pay immediately after graduation. These courses do not teach engineering in the sound sense. They are likely to injure the future of promising students by occupying time in teaching them handicrafts in college which they could better learn in the factory or field, or in teaching empirical methods of practise which change almost before they can be put to useful account by the graduates.

The students in these courses frequently gain the impression that the highest type of engineering practice is no more than an advanced artisanship, and that a graduate from the electrical engineering course is the equivalent of a journeyman. The most serious injury flows from this, through the undesirable narrowing of ideals and ambitions. This unfortunate result occurs the more readily because the popular usage of the word engineer makes it denote either an engine driver (a man of purely manual calling) or a man skilled in the principles and professional practice of engineering.

Third, are courses following the ideals which I have herein earlier described. Incompetent students who enter these courses are soon discouraged and drop out. Those whose calling is to artisanship go elsewhere either to a different school or directly to an apprenticeship. Those who complete the course, as a rule, are competent men; but they are not likely to enter immediately into positions of much responsibility, but rather to go into the so-called 'cadet' positions or 'student' positions of great industrial enterprises, for the purpose of gaining that experience in the crafts which may enable them to make the most extended use of their training in principles. Here they gradually 'find themselves' and ultimately reach the influence in the industrial world for which their caliber and training fit them. These men, if properly taught, have clean-cut ambitions and high ideals as well as the

ability to think well and do wisely. Their earnings and perhaps their usefulness to their employers, may be not so great for a short interval as those of the men who are taught more of empiricism and artisanship and less of rational science during their college courses, but the advantage soon flows in a strong current towards the scientifically trained.

The men who are responsible for this third type of electrical engineering courses may reasonably cry to be delivered from judgment upon the success of their work, which is based on the average earnings of the graduates during their first year out of college. The medical schools and law schools are judged by the attainments of their graduates reached in a decade or even in a quarter of a century, and this also should be the basis upon which to judge the work of the electrical engineering courses of this third and highest type.

Do not believe for a moment, however, that I would teach all theory and no practise. The earlier parts of this paper prove the contrary. In truth, right theory and the best practise are one, and practise which is out of accord with right theory is mere rule of thumb and can be bettered. The best college course in electrical engineering is the one which so teaches the fundamentals that right theory may be fully grasped, and which constantly illustrates the bearing of theory by examples derived from good practise. The administration of such a course requires thoughtful, clear-headed men, who are acquainted with the principles and right practise of pedagogy as well as trained in the principles and experienced in the practise of engineering.

My discussion of the subject makes it clear that there is a wide variance between the methods of the colleges which support electrical engineering courses. Complete unity is not only impossible but would undoubtedly be undesirable, since scope for individuality is as essential here as in the control of industrial enterprises; but the cause of sound college training for electrical engineers would be advanced by any action which clearly places the true aims of the college courses in electrical engineering before the authorities of all of our colleges which support such courses. And I may add that many of the greatest weaknesses of electrical engineering courses are due to the fact that the executive heads of the colleges or universities do not always understand what engineering truly stands for, and they equally often have no fair conception of the soundness of training that is required for its practise.

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British Association for the Advancement of Science—Section of Anthropology.

The seventy-third annual meeting of the British Association was held in Southport, Lancashire, September 9–16. As will be seen by the dates, the meeting lasts a whole week, from Wednesday to Wednesday. Professor Johnson Symington, of Queen's College, Belfast, presided over the anthropological section. His address, published in a recent issue of this journal, was a plea for a more thorough and systematic collecting of human brains for purposes of detailed and comparative study; also a more thorough study of the cranial cavity in relation to the outer surface of the skull, on the one hand, and, on the other, its relation to the brain itself. It is known that definite areas of the cerebral cortex are connected with the action of certain groups of muscles; and that the nervous impulses, starting from the organs of sight, hearing, smell and touch, reach defined cortical fields. But all these do not cover