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ENGINEERING EDUCATION

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Engineering schools in common with other educational institutions have been confronted with many unique problems since the outbreak of the European War in 1914. Previous to that time an increasing number of men who entered colleges and universities elected subjects pertaining to commerce, business management, finances, etc. The growth of the schools of commerce, both as regards the number of such schools and the attendance in them, is a striking proof of this tendency. During the same period the attendance at engineering schools had in most cases decreased with the resulting decrease in new equipment, faculties, etc. This is partly accounted for by the financial crisis of 1907 but is undoubtedly due largely to the fact that the opportunities offered college graduates in purely commercial pursuits were greater than those in purely industrial work where the demand is for men having a high degree of engineering skill and a wide knowledge of applied science.

With the demand on American manufacturers for war supplies for the Allies, there developed a need for a very large number of scientifically and technically trained men for use in designing new machinery, developing new processes, etc. It was then the country realized that the number of men who had been trained in applied science was woefully small in comparison with the population of the country and the magnitude of its industries. Even before this time the engineering graduate received numerous bids for his services. In spite of this the idea was prevalent that the supply of engineering graduates exceeded the demand.

The increasing number of mechanical appliances developed as a result of the European War, necessitating an increased number of trained men in applied sciences, immediately reacted upon the engineering schools in two ways,—first, the number of men entering engineering schools increased materially, and second, the professors and instructors in these schools were in demand by the industries at salaries which it was impossible for educational institutions to meet. For the latter cause many of the teachers left the engineering schools and their places had to be taken in most cases by inexpe-

rienced teachers and almost without exception by men with less technical ability than those who had left.

This movement of engineering teachers was further accelerated when the United States declared war on Germany, due to the fact that many members of engineering faculties were called into active service as members of the Officers' Reserve Corps and the Enlisted Reserve Corps of the United States Army.

No better tribute can be paid the personnel of the teachers in engineering schools than their immediate response to their country's call.

The entrance of the United States into the war affected the student body in two ways—first, an increased attendance in the freshman class; the second and most striking was the large number of students who immediately volunteered in the various branches of the service.

This depletion of the student body of engineering schools through its members volunteering for active service in various branches of the Army and Navy was a matter of grave concern not only in educational institutions and the industries, but also to the War Department.

It had been recognized from the very beginning of the war, not only by the Secretary of War but by other officials in Washington, that the successful outcome of the war for the Allies was dependent upon the services of technically trained men. If the war were to last a year or perhaps two, all were agreed that every student should do his part by dropping his school work temporarily, but if the war was to be of longer duration, then it would become absolutely necessary for engineering students to continue in school to complete their courses in order that an adequate supply of such men should be available during the war and for the reconstruction period which must of necessity follow.

The matter became so pressing that it was taken up by the Council of National Defense and a committee on engineering education was appointed by Dr. Hollis Godfrey, a member of the advisory commission of the Council of National Defense under whose general direction came all matters pertaining to education. The members of this committee were Charles S. Howe, president, Case School of Applied Science; Milo S. Ketchum, dean of the college of engineering, University of Colorado; C. R. Mann, Carnegie Foundation for the Advancement of Teaching; S. P. Capen, specialist in higher education, United States Bureau of Education; and F. L. Bishop, dean, school of engineering, University of Pittsburgh.

This committee, cooperating with the national engineering societies, the special war committee of the Society for the Promotion of Engineering Education and other organizations, presented the matter to the Secretary of War, who modified the Selective Service

Regulations. On December 19, 1917, the following regulation became effective:

> Under such regulations as the Chief of Engineers may prescribe, a proportion of the students, as named by the school faculty, pursuing an engineering course in one of the approved technical engineering schools listed in the War Department may enlist in the enlisted reserve corps of the Engineer Department, and thereafter, upon presentation by the registrant to his local board of a certificate of enlistment, such certificate shall be filed with the questionnaire and the registrant shall be placed in Class V, on the ground that he is in the military service of the United States.

This regulation permitted students to enlist in the Engineers' Enlisted Reserve Corps and to remain in school until they completed their courses. It remained in force until superseded by the establishment of section A, Student Army Training Corps, and tended very materially to stabilize the student body in engineering schools, thus providing properly trained men not only for the War Department, but also for the industries.

The war also had a decided effect upon the curricula of engineering schools. While educational institutions, as a rule, are very conservative and slow in making changes in material and methods of instruction, the engineering schools responded quickly to the many new factors which were developed by the war, and important changes in the curriculum were put in force. Most of these changes had to do with methods of instruction of specific subjects, such as mathematics, thermodynamics, etc. There were, however, two general changes which might well be mentioned at this time. These were the applications of economic principles to the industries and some form of cooperative system by which the student secures actual engineering experience before graduation.

The most universal of these is the greater attention which is given to the application of economic principles to industries, engineering research, and the discussion of the problems of sociology sometimes placed under the broad title of human engineering. Formerly the engineer was supposed to deal only with the material and forces of nature, but recently an entirely new factor has entered—i. e., the human factor—and, in many cases, this is the all-controlling element with which the engineer must deal. Hence it becomes increasingly important to teach the prospective engineer as much as possible concerning the fundamental problems of psychology, sociology, etc.

It has also been demonstrated that the engineering student must during his course secure the fundamental knowledge of the engineering profession through actual practice in engineering work in the industries if he is to grasp properly the instructional work as given in the school. This has led to the adoption of the so-called cooperative system by which the student spends a portion of his time in the industries under the supervision of the faculty of the school in

which he is enrolled. This differs very decidedly from the old process in which the student worked summers at any kind of a job which he might select in any place without supervision. This cooperative work was discussed by Dr. Mann in the annual report of the Commissioner of Education for 1916.

As a result of the war courses, some teachers discovered for the first time that students will study and work if they are interested. The tendency for the engineering student to become so absorbed in his work as to neglect the college social and athletic activities has been of long standing, and during the past few years has been much discussed with beneficial results. When this tendency is properly controlled and directed it provides the incentive by which a young man may be trained mentally without detriment to his social development while in college. Scholarship is not incompatible with breadth of view or a desire to take a normal part in college activities. In fact, the latter ought to be so regulated that sound scholarship would be essential to participation in them. Those who had the opportunity of becoming acquainted with the kind of men who were required to fill the responsible positions in the world war were able to appreciate the fact that sound scholarship was an essential prerequisite for their participation in the war work.

The discussion of the changes in curriculum brought about by the war tended to emphasize the different criticisms which have been expressed in regard to engineering education and engineering schools for a considerable period of time. It is felt by many that these schools were producing well-trained men for certain highly technical phases of engineering, but were failing to produce an all-round engineer required for the proper development of the resources of the country. This discussion lead even as far back as 1907 to the appointment of a joint committee on engineering education. The report of this committee, which has become available during the past year, is the result of several years of investigation of engineering schools by Dr. C. R. Mann, of the Carnegie Foundation for the Advancement of Teaching. The report undoubtedly marks an epoch in engineering education because it embodies not only the investigation of a single able investigator, but the result of Dr. Mann's investigation has been discussed repeatedly as the work progressed before engineering societies, especially the Society for the Promotion of Engineering Education. Thus the report represents to a considerable extent a composite idea of the present standing of engineering education together with an outline of the probable future developments.

While the report does not advocate any specific change in the curriculum, it does in a broad way indicate the most probable form of development which engineering schools must take if they are to

meet the requirements of the industries and produce technically trained men who will compete with those from other countries. The report emphasizes the fact that we can find a proper type of training for men for the industries only through long continued experimentation in different types of schools. It calls attention specifically to the experiment in engineering education which has to do with the introduction of cooperative work and the elimination of the practice shop from schools. That greater emphasis must be laid on the correlation of industry with the schools is one of the fundamental conclusions of the report. Given the results of this long investigation and its discussion, the question immediately arises as to what type of experiment in education will be most fruitful in the development of the proper type of men for the industries. A survey of the situation by any one familiar with industrial needs seems to point clearly to the necessity in this country of developing two different types of men for use in the industries.

First, a man who may be called a technician, who is highly trained in science and mathematics, who possesses the instinct of the research man and who can devote his entire time to highly technical research problems, either in the research laboratories which are now rapidly being developed in the large industries, or by applying the results of his research to engineering science. For the training of this type of men, there is needed the best of scientific equipment, the members of the faculty must be those who are intimately interested in research problems, and the student himself must have what is sometimes called a mathematical mind. It is doubtful if this type of a man can be developed in a four-year course under existing conditions. In fact, it is probable that such a man can be developed only in a school which has a thorough graduate department devoting its energies primarily to research but giving instruction in the fundamentals of science and mathematics.

The second type which seems to be demanded by the industries is the man who has a broad general knowledge of engineering subjects and can apply that knowledge in an effective way in present engineering problems. He must have ability to command men, a knowledge of the applications of economic principles to industries, and a broad training in the so-called humanities, since he is the man in contact with men of other types in other fields of human activities. He should not be a research man, his training in mathematics need not be of necessity so extensive as that of the research technician, but his understanding of engineering problems should be extensive. Such a man can not be trained in the ordinary schools because of the artificial conditions which of necessity exist in academic institutions. He must become familiar with the industries while yet a student in order that he may understand thoroughly the applications of his

theoretical courses in school and their application to industries and also that he may become familiar in the formative period of life with the problems of labor and the human factor in engineering. It is in the development of this type of man, who is to become the manager and operating head of our large manufacturing industries, who needs more than any other the advantages to be derived from the cooperative system.

It is unfortunate that in this country we have no institutions with sufficient funds to develop a complete school of applied science, (1) having as its foundation a modified standard four-year course of instruction, (2) accepting young men for the course upon graduation from the high schools, (3) coordinating with this a proper cooperative system, and (4) having a graduate school devoted to instruction of graduates from a four-year course not only in the applications of science, but also of economic principles to industries. This graduate school should be in close coordination with the research department, corresponding in many ways to the Mellon Institute of Industrial Research at the University of Pittsburgh, where problems in the application of science to industries are studied at first hand under ideal conditions, and later the results of these investigations are applied directly to the solution of problems of industry. The graduate student would thus have the opportunity of taking his science and mathematics in an atmosphere that would be conducive to the development of the best type of man for research.

The Civil War was the crystallizing process which brought forth the type of engineering schools which are now common in this country. The result of the world war, in the same manner, will be the crystallization of the ideas now prevalent in regard to technical and scientific training. We shall have in the near future an engineering school of a type quite distinct from that in existence at the present time.

It is only necessary to mention it to bring to mind the failure of this country to provide for a school of engineering which has a faculty, buildings, equipment, and resources comparable with similar institutions in Europe.

In this country we have schools of engineering which offer excellent courses for undergraduates. We have one or two schools like Columbia University and the Massachusetts Institute of Technology which offer graduate courses to some extent. We have certain other schools like the University of Illinois, the Ohio State University, etc., that conduct research and engineering experiment stations supported by the State. There is, however, no single school which combines in an effective way all three factors which go to make a complete engineering school, namely, undergraduate courses, graduate courses, and research both pure and applied. I propose to outline briefly

some of the factors which must be taken into consideration in establishing such a school.

The engineer must be a man of culture and broad training such as can best be secured in the atmosphere of a large university. Also it is only at a university that there are available libraries and laboratories especially of science and economics, which are essential to the student of engineering and especially to graduate and research men. The university which has such a school as a part of it must be located at the center of a great industrial district where all types of engineering are available for study at first hand by the students.

In its undergraduate department the functions of such a school would be to train young men to enter engineering industries in which the present graduates from our best engineering schools now enter.

In its graduate department the function would be to train men to enter the research division of engineering industries and to supply the ever increasing demands made by the National and State Governments for trained investigators.

In its research department the function would be two-fold: First, to develop through pure research the fundamental principles upon which all engineering is based and to obtain standard data pertaining to the various materials employed in engineering work; second, the investigations of specific problems, solutions of which are demanded by individuals, firms, or corporation.

An estimate of the faculty, buildings, equipment, and resources which would be required for such an institution shows that an endowment of $20,000,000 would be needed. Such a school should operate in close connection with the municipal, State, and National Governments in addition to its close cooperation with the industries of the country.

Since it seems at the present time impossible to secure adequate funds for such an institution it is highly desirable that different institutions in the country should devote themselves to the solution of specific problems and thus each one become an experimental laboratory for the benefit of engineering education.

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