

Engineering Graduate Study After the War

By ROYAL W. SORENSEN

THE influence of the war upon engineering graduate courses presents problems the answers to which all engineering teachers and others would like to know. A special committee has been appointed by the officers of the Society for the Promotion of Engineering Education to consider this particular problem. As a member of that committee I have been interested in analyzing some of the questions involved. The committee members seem to be of the opinion that at the close of the war there will be a considerable increase in the number of graduate students above the number in attendance at college just preceding the war. The factors contributing to this increase may be analyzed as follows:

- (a). There will be released a certain reservoir of students who were planning at the opening of the war to take graduate engineering work, and who in considerable numbers will wish to complete their plans for graduate work which were interrupted by the war.
- (b). Many years preceding the war the growing requirements of the engineering profession caused educators to consider lengthening the undergraduate engineering courses to five or even six years. This idea never gained enough support to cause engineering colleges to make the regular engineering courses longer than four years. The recognized need, however, for more time for much engineering training produced what might have been called a normal rate of increase in the number of graduate students. The new devices and mechanisms which have developed in this war and the new things with which engineers have come in contact as they are occupied in the armed services of this war, indicate that a considerable number of men will have a new perspective concerning the value of their college engineering education and will endeavor to return to college for some refresher graduate courses if not for courses leading to advanced degrees.
- (c). Service men who did not take engineering courses but were prepared by education in physics and mathematics, have been trained and used for the engineering work required by the war and have no doubt developed an interest in the work of an engineer which was lacking before they entered service. It is to be expected that a number of these men will desire further technical training and that some of them will be qualified for graduate work. Also it is very likely that there will be subsidies for service men who desire further education.
- (d). A certain number of young men engaged in war industry are saving a portion of the "big pay" they are receiving. This accumulated money, together with the probability that there will be difficulties of job adjustment, may provide another group desiring further education.

If these indications are correct there will be a stimulated demand for engineering graduate courses. The

question which then arises is, what shall be the objective of graduate study immediately after the war. Unless perhaps it be for a very transient period in which colleges are providing refresher courses, I think in general the objectives of graduate study and the courses given should be much the same as they were before the war; viz., courses designed for the further education of men who during undergraduate study have demonstrated their qualifications to do work more complex than can be taught in undergraduate courses and not just additional course work of undergraduate quality. Our established pattern of education has survived many wars. Our universities and colleges have continued regardless of war to teach the essential cultures and sciences of the civilization which, though they cannot be said to follow any single curricular uniformity, have nevertheless been stable enough to resist any material changes in policy because of the wars through which they have passed and in which they have had a very active part. To appreciate this fully one has only to consider for a moment the present relation of Caltech and other engineering colleges to the research and educational activities of the war in which we are now engaged.

The four years generally devoted to peacetime, normal engineering courses, in view of modern demands upon engineers, should contain many subjects of the type that properly fit men for good citizenship. When to this requirement there also must be added the enlarging scope of technical knowledge required for our expanding technical achievements, it is obvious that those who wish to consider themselves master technicians must have one or more years of graduate work.

It seems natural to consider graduate work as being of two types,—one being in character not unlike that of the undergraduate technical courses, but more comprehensive and intensive. The second type of graduate work should lead to a doctor's degree. The courses for this degree should have a large content of advanced mathematics and physics, the emphasis being placed upon acquiring basic analytical skill regarding fundamental science and its relation to engineering rather than upon definite methods of engineering design. This means that colleges giving work for the doctorate degree must have not only a strong engineering faculty with *good research facilities, but also must have well-developed physics and mathematics departments, well-equipped and manned by research physicists and mathematicians.* Both courses should provide equipment and direction for the conduct of research work and training in research methods.

The California Institute of Technology has arranged for programs of both types. For the first group it has provided one-year (minimum time) graduate curricula, the completion of one of which qualifies the student for a Master of Science degree and two-year (minimum time) curricula, the completion of one of which qualifies the student for a Professional degree. For the second group it provides three-year (minimum time) graduate curricula, the completion of any one of which quali-

fies the student for the degree, Doctor of Philosophy.

Statistics showing the relation of graduate to undergraduate engineering students should be of interest. Yearly statistics compiled by S.P.E.E. show that for the years immediately preceding the war, about 4,700 students were annually enrolled for courses leading to the Master of Science degree. A few over 1,200, or about 26 per cent of these enrollees received the Master of Science degree each year. Taking another base for our analysis, the number of students enrolled each year for undergraduate engineering work, namely, about 106,000, we find that just preceding the war we were graduating in engineering about 13,000 with a degree of Bachelor of Science, roughly something over 12 per cent of those enrolled. About 10 per cent of those who received the bachelor's degree continued for the master's degree, which means that we had about 1.1 per cent of our 106,000 engineering enrollees receiving the Master of Science degree, whereas 4.4 per cent of our undergraduate enrollees enrolled for this degree.

Analyzing the prewar statistics concerning doctorate degrees, we find about 850 students were enrolled as candidates for such degrees, with 100 doctorate degrees granted per year. Thus about $11\frac{1}{3}$ per cent of the doctorate enrollees receive the doctorate degree. Referring again to our base of 106,000 undergraduate enrollees, we find about eight-tenths of one per cent of this number enrolled for the doctorate degree work and .095 per cent or less than one-tenth of one per cent of the original enrollees for undergraduate engineering continue until they receive the doctorate degree. As long as such careful sifting of candidates for graduate work in engineering is maintained, there seems little danger that educators will permit the demand for graduate training to destroy a proper perspective as to what graduate courses should be and what qualifications those who take the courses should meet. Experience with undergraduate courses, however, indicates that under the pressure of wartime and immediate postwar demands a loss of the restrictive measures which have been operative is not entirely impossible. Before the war the E.C.P.D. accrediting committee examiners, visiting engineering colleges, sometimes found that courses in some colleges were not up to designated standards. Also they quite often found that engineering students were relatively technically overeducated, or perhaps we had better say they were professionally undereducated. By technically overeducated I mean that some colleges had graduated a large number of engineering students, who, though graduate engineers, were continuing to be employed for a decade or more after graduation for substitution operation, minor jobs as draftsmen, and other positions of like rating. Men who, while in college or better before they enter college indicate that they will be so limited, either because of their own shortcomings or because of lack of available positions, should not be encouraged or even permitted to complete four-year engineering courses with the idea of being professional engineers. It is not fair to them to have them spend the time and money required for a four-year course learning how to calculate long transmission lines, solve ultra high frequency problems and other engineering problems of like advanced nature which they are not qualified to comprehend and make useful in the subengineering occupations in which they have become permanently engaged. Indeed, if we would encourage men who like technical work but who are not well endowed with math-

ematical and scientific ability, to take shorter and more practical courses, we would eliminate many of the low-salaried and usually dissatisfied men from the engineering profession.

It is well perhaps at this point to remember that one of our outstanding university presidents has definitely instituted a program of granting the degree of Bachelor of Arts to a large number of students after only two years of college work. I am not advocating a two-year course for the standard undergraduate engineering program, but I have a high regard for the two-year terminal type courses conducted by many of our junior colleges. To my knowledge these courses have produced men of fine achievement for such tasks as drafting, plant operation, and production. I realize we are not considering undergraduate courses, but some of the lessons learned by observing the cause of the low-salary group of college-trained engineers should serve well as a reminder that candidates for graduate work should be very carefully selected from the undergraduates who show promise of being able not only to carry on graduate work but also show ability to make use of it.

One of the questions considered is, "Is there any one field of engineering that should have preference as compared to the other fields from the point of view of rendering great service after the war?" I would answer that by saying that graduate study certainly should not have as its objective the training of men for immediate service, but should by all means train for the long pull. No one can be wise enough to predict that some particular engineering field or fields will have more value over a long period of time than some of the other engineering fields. It seems advisable here to emphasize the idea that an individual's choice as to the type of work to be taken up should be largely determined by his preference. He should choose that type of work which will furnish him the most enjoyment as he pursues his preparation for a life program.

In concluding the ideas presented in the above remarks, the attention of a person considering graduate work should be directed to the question, "What kind of an engineering career do I wish to have?" and also to the answer. If the answer is, "I should like to do highly technical analytical research work or be a teacher of engineering," it is quite evident that all the training available in fundamental mathematics and science will be desirable and that the preparation for such a career should normally include a three- or four-year graduate course leading to the doctorate degree. Should the answer be, "I desire to plan, design, construct and operate engineering industries," then the courses incident to the Master of Science or Professional degrees usually will provide adequate preparation.

CALTECH EXPERT SENT EAST

Dr. Royal W. Sorensen, head of the department of electrical engineering at the California Institute of Technology, left the first week in December for New York City on a government research mission which will keep him in the East until the close of the present semester.

Although the exact nature of his work has not been disclosed, it is understood that Professor Sorensen will be associated with Dr. William V. Houston, professor of physics at Caltech, now on leave.