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# 1916 SECNAV SPEE Report

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Boston, Massachusetts,
April 29, 1916.

Honorable Josephus H. Daniels,
Secretary of the Navy,
Washington, D.C.

Dear Sir:

The Committee appointed at your request by the President of the Society for the Promotion of Engineering Education to visit the United States Naval Academy at Annapolis, and to make suggestions with reference to the work of the Post Graduate School, begs leave to state that, at the invitation of Captain Eberle, it visited the Academy January 27, 28, and 29 last, and carefully examined the work of the Post Graduate School and the equipment of the same, and conferred with the officers of instruction. As a result of the consideration which it has given to the matter, it begs leave to make the following report:

The memorandum prepared for the Committee by the officer in charge of the School, Lieutenant-Commander John Halligan, Jr., states that the advice of the Committee is sought as to:

"First: Methods of improving the efficiency of the existing courses.

"Second: The practicability and advisability of establishing common courses in mechanical engineering for all post graduates, what subjects should be covered, and what changes in the present organization should be required.

"Third: The availability of technical institutions for subsequent specialized training.

"Fourth: How much time for lectures, laboratory, and preparation would be required to cover during forty-six weeks a fairly comprehensive course in metallurgy, strength of materials, metallography, and chemical analysis of steels and bronzes. The purpose of this course would be to train a student officer to an extent which would permit him to determine the chemical analysis, physical characteristics, and grain structure of a piece of metal."

The Committee, however, has not considered itself confined necessarily to these subjects and in the following report it discusses all the points which have suggested themselves as worthy of mention.

## THE SITUATION.

As the situation has been described to the Committee, there are 230 positions afloat which require post graduate education in marine or electrical engineering. At present there are 62 graduates of the post graduate department, of whom about 40 will be available for sea duty at one time, to fill these positions. The present School trains annually 15 marine engineers and 5 electrical engineers together with a few ordnance men, naval constructors and civil engineers.

The first subject which impresses itself forcibly upon the Committee after a study of the situation, is the pressing need of an enlargement of the scope of this School. A modern ship of war is a great mechanical laboratory. Its construction, and its operation as well, demand a thorough training in scientific and engineering principles. Even our present Navy requires, in the opinion of the Committee, that the number of men trained in the School should be largely increased, and with the demand for a still larger Navy and an adequate state of preparation on the part of the United States to meet any foe, the necessity for an enlargement of the School is still more evident.

In the opinion of the Committee, the School should be enlarged so as to be capable of turning out not less than 95 men annually, with provision for a still greater increase in the future. Eventually, it is probable that at least one-fourth of the students in each graduating class from the undergraduate department of the Naval Academy, will require post graduate training. The number of midshipmen in the present fourth class is 267, so that if the above proportion is correct, there is immediate need of provision for taking care of nearly 70 men each year in the Post Graduate School.

In order to carry out this suggestion, an immediate enlargement of the available space and of the technical force is urgently necessary in order to provide suitable quarters for this important branch of our naval establishment. The Committee believes that immediate steps should be taken for the erection and equipment of a new building to be devoted especially to the work of this post graduate course. The cost of this building and its equipment, would probably be not less than $500,000, and it should be liberally supported by annual appropriations for its operating expenses.

The new building should be located in a prominent place in the Academy grounds, as an object lesson in higher education for the undergraduate students, inspiring in the best of them a desire for postgraduate work, and as a demonstration of its importance. It shoul also offer facilities for advanced work for instructors in both undergraduate and postgraduate departments of the Academy. Indeed, the School should be a post graduate technical school of the highest grade

With reference to the present situation as regards the teaching force and the character of the teaching, the Committee has been much impressed with the devotion and ability of the commanding officer and of the instruction force, with the excellence of the work done, and of the present equipment. The teachers are men who thoroughly enthusiastic and alive to the importance of their work, the courses have been well arranged, well coordinated, and well adapted to the needs of the students, and the method of instruction, so far as the Committee is able to judge is excellent. A discussion will be given later of certain principles which the Committee believes should be observed, an some recommendations will be made regarding methods of instruction.

## THE CURRICULA.

There are five courses of study provided in this Post Graduate School, namely:

(a) Mechanical Engineering.
(b) Electrical Engineering.
(c) Ordnance.
(d) Naval Construction.
(e) Civil Engineering.

In each of these curricula certain work is done at the Naval Academy, and this is supplemented by work at other institutions, or industrial establishments.

Students in Mechanical Engineering spend one year (three terms) at the Naval Academy and one year at Columbia University, with practical work at the navy yards.

Students in Electrical Engineering spend one year (three terms) at the Naval Academy, one year at Columbia University, with practical work at the Navy Yard, at the works of the General Electric Company, at the works of the Sperry Company in Brooklyn, and with the American Telephone and Telegraph Company.

Students in Ordnance spend one term at the Naval Academy, and the remainder of the time at Bethlehem and Midvale, at Schenectady, at Rochester, at the proving grounds, at the Washington Navy Yard and Bureau of Ordnance, and in the study of special subjects at various points.

Students in Naval Construction spend two terms at the Naval Academy, and three years at the Massachusetts Institute of Technology.

Students in Civil Engineering spend two terms at the Naval Academy, and two years at the Rensselaer Polytechnic Institute

The Committee thoroughly approves the plan of sending the students in various post graduate courses to other institutions to supplement the work done at the Naval Academy, assuming that proper arrangements can be made and a proper coordination of courses secured. There seems no good reason why advantage should not be taken of the facilities offered by existing institutions elsewhere, to avoid the necessity for duplicating these facilities at Annapolis To provide adequately for doing all of the work at Annapolis would clearly require the establishment at that place of facilities in all different lines equal to those offered at any of our technical schools. This would involve eventually the expenditure of a very large sum of money. The object would be to provide facilities at Annapolis for a course of one year in each of the different lines, this course to be unified so far as possible. The students in each of the five courses named above, all need instruction in mathematics mechanics, applied mechanics, machine design, electricity, thermodynamics, strength of materials, chemistry and metallurgy. The courses given in these subjects given at the Naval Academy might well be the same, or nearly the same, for all students. These subjects are fundamental, and a narrow specilization should be avoided. After completing these fundamental studies, the students in each line of work shall be sent wherever they can find the best facilities for continuing their studies.

The Committee is informed that the officers selected to pursue post graduate work, after graduating from the Naval Academy, are sent to sea for from one and one-half years to five years, and are then designated to return to Annapolis to enter the Post Graduate School. The undergraduate course from which they have graduated, has given them the fundamental principles of mathematics and mechanics, as well as of other subjects, but during their service at sea they probably forget a good deal of what they have learned and their minds are out of training for close analytical work. For this reason, a considerable portion of the work of the first year at Annapolis must necessarily consist of review. It seems a waste of

valuable time to wake them up and accelerate their minds in school, rather than before coming there. The Committee suggests that this interval or hiatus should be avoided so far as practicable, and that the officers who are to return to the Post Graduate School should be selected and informed of the fact at least six months, and preferably one year, in advance, and required during this time to review the subjects of mathematics and mechanics, and such other subjects as the department might designate. It might be well to require them to pass an examination before beginning the post graduate work. It is a fundamental principle in education that in order to ensure the best results with the least expenditure of time, related or continuing subjects should be coordinated and carried on so far as practicable without intermission, in order that one subject may lead to the next and the student may follow the line of thought without the opportunity to slip backward through lack of use. A period of sea service is undoubtedly necessary, but the Committee suggests that the endeavor be made to see if this cannot be arranged in some way which will avoid in some degree the inevitable loss of time or efficiency which must result if the course of study is entirely interrupted by continuous service at sea of several years. Possibly a certain amount of study and a certain number of reports might be required while on board ship. at least from those officers who do not wish to forfeit their right to enter the Post Graduate School. Other means may perhaps be suggested by the Committee in charge of the Post Graduate Department.

The present schedule for the post graduate work at Annapolis provides for a total of 53 1/2 hours per week, including lectures laboratory, and preparation. The students taking these courses, however, are picked men selected from the graduates of the undergraduate department for their efficiency and adaptability to the particular work which they are to follow. They are also maturer men than the average student at our engineering schools, and, as a rule, they appreciate their opportunities and are enthusiastic and industrious. They, are, therefore, capable of working longer hours than the average undergraduate student in our technical schools. We are told that they actually work about 60 hours a week, or about 8 1/2 hours a day seven days in the week. This appears to the Committee rather too large. The Committee believes that about 53 1/2 hours as contemplated by the schedule, or 9 hours a day for 6 days in the week, is not excessive, although perhaps 50 hours a week would be better.

Referring to the details of the curricula of the different courses, these appear to the Committee to be well arranged and well coordinated. With reference to them, the Committee makes the following recommendations:

(1) The ordnance men should be required to spend a year, or at least two terms, at Annapolis, and the remainder of the time partly at some other institution and partly, as at present, at industrial and government establishments. These men need a more thorough training in fundamentals, such, for instance, as electricity, than they now receive. They need also, a very thorough course in the properties, manufacture, chemistry and metallurgy of steel. The foundations of this knowledge can be given at the Naval Academy if a fourth professor, suggested below, is secured for the purposes. After leaving the Naval Academy they should pursue the same subject further in some institution offering proper facilities. Until the fourth professor recommended is secured, they must gain this knowledge at other institutions.

On the other hand, these ordnance men require less steam engineering than the marine and electrical engineers. The Committee believes that all students should be required to spend one year at Annapolis.

(2) As above suggested, the various subjects should be unified, so far as practicable, for all the different courses of study. Complete unification will not be possible, because the students in some of the courses will need somewhat more instruction in certain subjects than the students in other courses; and moreover, the students in ,mechanical and electrical engineering spend two terms and a summer term at the Naval Academy, while the students in naval construction and civil engineering spend but one term and a summer term there, and the ordnance men but one term. The present courses of study appear to the Committee to be as well unified as practicable, unless it can be arranged that all students shall spend the same time at the Academy.

(3) A subject like mathematics or mechanics, which is not a descriptive subject, but one requiring intellectual concentration should have two hours outside preparation allowed for each class-room exercise.

(4) In order to obtain the best results, a heavy subject should be conducted with three class-room exercises per week. If several topics constitute really but one subject, and are properly coordinated, they may be combined into one such course, as for instance, mechanics and applied mechanics.

(5) The number of studies pursued at one time should not be so great as to result in dissapation of thought. The fundamental principles in the arrangement of studies and the number of hours required per week, is that the student should have time to really think about the things he is studying. He should not blindly accept the statements or methods in the book, or merely follow the thought of the instructor, but should develop mental initiative and original power. In order to accomplish this object he must have time to think, and he must not have too many problems assigned which can be solved by rule of thumb methods or substitution in equations. The fault in some of our technical schools today is that while the students are kept hard at work, they are not given time to think and they tend to become more automatons intellectually. In order to obtain the best results, classes should be small, preferably not over 15. This will enable personal contact at each exercise between teacher and student and adequate supervision of work. In laboratory work there should be one instructor of same grade for each five students in the class.

(6) In the arrangement of the curricula, the Committee suggests that care be taken not to attempt to carry the student too far in the various subjects, but to place the emphasis on the thorough study of fundamental principles. No academic course of study occupying a reasonable time, can be excepted to carry a student to the utmost confines of any subject. A great deal must be left for him to study by himself after graduation.

## METHODS OF INSTRUCTION.

The methods pursued at the Academy, so far as the Committee has been able to inform itself regarding them, appear to be excellent. The Committee has no criticism to make. It will, however, make a few statements as to fundamental principles which, in its opinion, should be kept in view.

(1) Instructions should not be given by the pure lecture system to any considerable extent. The student should be provided with a text book which he is required to study, and the class room exercises should consist largely in an attempt to discover how far he is able to master the subject with the aid of this text book. Repeating the words of the text will not prove that he understands. The teacher must probe into his mind and endeavor to make him see just to what extent he studies understandingly and what habits he needs to cultivate in order to do so.

(2) Problems should be given but not in too large number and not of a character which can be solved by merely substituting in formulas. The problems should be devised with the object of cultivating the students initiative and practical common sense to the greatest possible extent. Problem work easily degenerates into a routine substitution of data in equations derived theoretically, because the teacher takes upon himself the two most important function namely, the formulation of the problem and the selection of the data nothing then remains for the student, in many cases, but to proceed in a rule of thumb, unintelligent manner. Indefinite problems should frequently be given, leaving the student to select the data and the kind of result to be attained.

(3) The objects of the Post Graduate School are (a) to train the men in power and initiative so that they may be able to solve intelligently any technical problem which may be presented to them; (b) to supply them with a fund of technical knowledge concerning the instruments, machines, and methods which relate to their specialty, so that they may solve their problem in a way which will comply with commercial conditions and will secure the greatest efficiency at the least cost; (c) to enable them to see in proper proportion the subjects with which they have to deal and their own knowledge of these subjects, and to graduate them with a degree of self-confidence which is founded upon a realization of actual knowledge and power, and yet with a modesty founded upon a realization of the small amount of their knowledge as compared with the sum total, and of the fact that they must be continually on their guard and exercise the greatest care in order to prevent themselves from falling into serious errors. The capable man is generally modest; the incapable man who does not know his own limitations and liabilty to error, may easily, by means of a technical education, be made dangerous rather than useful. The attitude of the student towards his work and towards his teacher, and the attitude of the teacher towards the student, are therefore of great importance. The teacher should make the student realize that he is his friend and working for only his interest. He should cultivate cordial personal intimacy, and yet the teacher should criticise justly but unsparingly the mistakes and mental deficiences of the student, and should constantly endeavor to point these out while at the same time pointing out to the student in what way he can remedy them. The student should welcome such criticism.

(4) It is essential, of course, that the proficiency of the student should be judged by means of marks. It is most desirable also that their ambition should be excited and that they should be stimulated to excel. They should, however, be made to regard marks as not the object for which they are striving, but as simple an index. They should study for what they get, not primarily for the marks; but if they get what they ought to get, the marks will take care of temselves. Instruction, examinations and tests should all be designated in such a manner that no student can pass them unless he really understands the subject, Moreover, the marks assigned should take account of all the mental qualities designed to be cultivated, such as initiative, accuracy, etc. and not scholarship alo

By means of mere memorizing or learning by rote, it is not an uncommon thing for students in our colleges and technical schools to pass in a subject the real meaning of which they entirely fail to grasp. One of the most difficult things in education is to test properly the results which are attained, and this should be studied with care by the teaching force.

(5) The theory and practical applications should be brought so closely together that the student is made to see clearly the aim and usefulness of what he is studying. No division should be made between theory and practice. The man who teaches either should appreciate the other even if he is not thoroughly conversant with it. The close association between instructors, offered by the Post Graduate School, and the relatively small number of students, as compared with our larger technical schools, offers an opportunity for the instructors to get together and redistribute the topics of study, not necessarily with reference to theory or practice, but in a rational, psychological manner. The aim in teaching any subject should be to make it useful in the broadest sense, and any methods which further this end should be adopted. In many cases the concrete, practical side of a question may well be taught first, or before the theory, so that when the theory is explained the student really grasps it because he sees the need of it and understands its application. Much of the mathematical teaching in our colleges and engineering schools is almost profitless in the case of a large proportion of students because these principles are not observed.

By means such as these, the graduates may be made to take a broader view of the engineering profession and of its relation to other professions than is generally taken by graduates of technical schools, and they will be capable, efficient and firm, while at the same time modest and not possessed of intellectual arrogance.

## ORGANIZATION.

The present force of instruction consists of three professors and two instructors. This is not even adequate for the present number of students and will be still more inadequate if the enlargement of the institution above recommended, is carried out. There is needed at once, a fourth professor to have charge of the instruction in materials, metallography and metallurgical chemistry, who can also conduct the laboratory for testing materials. There is also needed at once, an instructor or assistant professor to assist in the instruction in mathematics and mechanics. If such a man can be obtained who also possesses a knowledge of chemistry and materials, he may be able also temporarily to relieve Professor in some degree until the fourth professor referred to above, can be found.

The Committee also finds that all the teachers in the School are very much overworked, requiring over forty hours per week for the regular work of instruction, preparation, correction of problems, etc. Moreover, the professors are required to do too much routine work which can be just as well done by younger and less experienced men.

It is self-evident that, in order for a professor to do his best work, he must not be overburdened. No work is quite so wearing as the routine work connected with teaching. The professors in the Post Graduate School at Annapolis should have adequate time for recreation and relaxation, and also for independent research and study of their own, entirely outside of their teaching duties. The Committee believes that twelve class room exercises a week is all that should be required of a professor in charge of a department, and that each professor should have an assistant to relieve him of a good deal of the routine work of correcting problems, etc.

Instructors or assistants should be expected to give to the work of the department, the regular working hours, just as they would give in an engineering office. A professor however, should have much time at his own disposal in order that he may keep himself intellectually fresh, and ambitious, and thoroughly informed with regard to his subject.

The Committee therefore believes that the School needs four professors and four instructors at the present time, and that, as the number of students is increased, the number of teachers must be increased also, so that, counting instructors of all grades, there shall not be more than ten students to one teacher. The Committee believes that the importance of this School to the Government and to the country is so great that every effort should be made to promote its efficiency. Individual instruction to such an extent as is necessary should be provided for and the number of instructors should be fully adequate to the requirements. The United States Government cannot afford anything less than the best school which is possible.

The Committee believes that with the great demand for officers in the naval service, the instructors in the Post Graduate School should be taken, so far as possible, from civil life. The naval department can not afford to train men to be teachers unless it is possible to secure competent teachers without doing so. The Committee believes that the civilian instructors can be secured who will probably be better teachers than the Navy Department could train, and who would have a thorough knowledge of their subjects.

COOPERATION WITH OTHER INSTITUTIONS.

For the purpose of avoiding the duplication which will be necessary if the Post Graduate School were to furnish all the instruction required for its engineer officers, the Committee entirely approves the utmost cooperation which is practicable with other institutions, and the sending of the students after one year at Annapolis, to such outside institutions as may be selected by the officer in charge of the Post Graduate School. At the present time we understand that there are 31 students in the School at Annapolis. 20 electrical and mechanical engineering students at Columbia University, 3 civil engineering students at the Rensselaer Polytechnic Institute, and 3 naval constructors at the Massachusetts Institute of Technology. An increase in the size of the Post Graduate School, as recommended in this report, would result in sending a larger number of students to the selected institutions, and this would be an advantage by making it practicable to secure a closer cooperation in the specialized courses required.

MISCELLANEOUS CONSIDERATIONS.

The work of this Post Graduate School should not be confined to the year which the students spend at Annapolis. The School should be a living force permeating the entire corps of officers of the Navy. All graduates of the Naval Academy, in whatever branch of the service, should be encouraged to correspond with the officer of the Post Graduate School and to resort to them for advice and assistance in any technical problems with which they may have to deal. The Post Graduate Department should send out printed or typewritten information which it considers of service to officers, and should keep in touch with them after graduation. The School must not become an exclusive, aristocratic institution for a few highly trained men. Every officer in the Navy should feel that it is his school whether he has ever been a student there or not. The undergraduates in the Naval Academy should be inspired with interest in it, should be kept acquainted with its work, and should be encouraged to aspire to being selected to pursue post graduate work there.

The School should be liberally supported by Congress and recognized as a most important and valuable branch of the Navy Department? It now has a budget of about $2000 a year for general expenses. This is ridiculously small, and if the school herein recommended is enlarged and made a technical school of the highest grade, with due regard to the limited length of the course pursued there, the appropriations will have to be largely increased.

With reference to the fourth question asked by Commander Halligan, quoted on page one, the Committee does not believe that the Post Graduate School should attempt to qualify ordnance officers to make analyses of steels or bronzes. The chemical analysis of such materials is too large a subject and may easily be made a life work by itself. The ordnance men should know the effect of the various chemical elements which may occur in steel, and should have a good knowledge of the general chemistry of the subject, but they should not be chemists. They should have a thorough knowledge of the strength of materials, and of metallurgy and metallography as applied to the materials used in ordnance. For this purpose the time necessary would probably be not less than 9 hours a week for 46 weeks, including class room and preparation, together with about 6 hours laboratory per week.

/s/ GEORGE F. SWAIN

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