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REPORT

OF THE

PRESIDENT AND TREASURER

PRESENTED AT THE DECEMBER MEETING OF THE CORPORATION

JANUARY, 1907

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Report of the President.

To the Members of the Corporation:

The Report which I present to you to-day is the seventh annual Report which I have addressed to you. One year ago I presented to this body my resignation as President of the Institute, in order to undertake a work which, as it seemed to me, has the prospect of being far-reaching in its effects on American education. At that time nothing was further from my thought than that I should stand before you to-day as your President. This arrangement has been continued at the wish of the Executive Committee in order that certain problems should be advanced a little nearer completion, and in order that full time might be taken for the selection of a successor. The Executive Committee hopes to present to you, within a very brief period, a President of the Institute in my place; and that which I say now must therefore be said in the capacity of one who lays down the work rather than in the capacity of one who expects to carry it on.

CHANGES IN CORPORATION AND FACULTY.

During the past year there has been a number of changes in the Corporation of the Institute. We have lost by death Charles Merriam and Samuel Cabot, the latter called away in the midst of health and comparative youth. By resignation we have lost George A. Gardner and Thornton K. Lothrop, two men who have served the Massachusetts Institute of Technology long and well.

This year has marked the beginning of a new policy; that is, the election of members of the Alumni as term members. The following nine men have been by this means added to the Corporation: Frederick H. Newell, Richard H. Soule, Eben S. Stevens, for three years; Frederick K. Copeland, Joseph P. Gray, Frank L. Locke, for four years; Thomas C. du Pont, Charles T. Main, Frederick W. Wood, for five years.

In the Executive Committee there have been two resignations, those of Mr. A. Lawrence Lowell and of Mr. Howard Stockton. In the place of Mr. A. Lawrence Lowell, Mr. Charles A. Stone has been elected. The vacancy left by Mr. Howard Stockton remains yet to be filled.[1]

In the Faculty there have been the following changes: Associate Professor William L. Puffer in Electrical Engineering has resigned. The following associate professors have been appointed full professors: William O. Crosby, Frederick S. Woods, and Harry M. Goodwin. The following assistant professors have been appointed associate professors: Augustus H. Gill, Arthur G. Robbins, Frank A. Laws, Charles E. Fuller, William A. Johnston, Charles F. Park, and Frank P. McKibben. The following instructors have been appointed assistant professors: Nathan R. George, Archer T. Robinson, Charles E. Locke.

Two new appointments have been made of more than usual significance. The first is that of Professor Dugald C. Jackson to be Professor of Electrical Engineering and head of the Electrical Engineering Department. Professor Jackson comes to us from the University of Wisconsin, where he occupied a similar place and where he has built up the very successful school of electrical engineering which now exists in connection with that strong institution. He is a man who has combined in a successful way the practice of the engineering profession with the vocation of the teacher, a combination more and more called for in our schools of technology. A second appointment is that of Mr. George C. Shaad to the position of Assistant Pro-

[1] Filled at the meeting of December 12 by the election of Mr. Frederick W. Wood.

fessor of Electrical Engineering, in the place of Professor Puffer. Mr. Shaad also has had not only an experience in teaching, but an experience as well in the practice of his profession.

ADMINISTRATIVE CHANGES.

During the last year the Executive Committee has had under consideration at various times certain administrative changes looking toward a more definite assignment of duties among the various officers charged with administration. Until within the last few years there were only two administrative officers under the Executive Committee, the President and the Secretary. With the growth of the Institute, the increase in attendance, and the consequent enlargement of all its relations, the need of a larger administrative staff was felt. For years past Professor Tyler has combined the work of Secretary with that of head of a department. As Secretary he has had under his charge, not only the general correspondence and the work of administrative assistant to the President, but the work of Secretary of the Faculty as well, which involved membership in several important committees and supervision of correspondence which had to do with student reports and student standing. After careful consideration the Executive Committee has appointed a Secretary of the Institute, who serves as administrative assistant to the President and is in charge of the general correspondence and outside relations of the Institute. The duties of Secretary of the Faculty are performed by an officer who is elected by the Faculty, and who has to do with the immediate questions of student standing and reports and with the arrangements which the Faculty make with respect to such matters.

Professor Tyler, who has for many years performed an enormous amount of work in connection with all these duties, remains in charge of the Department of Mathematics, and expects to devote his entire time to the development of this important and fundamental branch of the work of the Institute.

To the position of Secretary of the Institute there has been appointed by the Executive Committee *pro tempore* Professor Dana P. Bartlett; and to the position of Secretary of the Faculty the Faculty has elected Professor Allyne L. Merrill. In taking this action, the Executive Committee has placed on record an expression of its high appreciation of the faithful and efficient service which Professor Tyler has rendered to the Institute in his long performance of the work of Secretary of the Institute and of Secretary of the Faculty.

THE RELATION OF THE CORPORATION TO THE GOVERNMENT OF THE INSTITUTE.

The addition of term members to the Corporation naturally suggests some consideration as to what constitutes the duty of a member of the Corporation and what function the Corporation itself ought to play in the government of the Institute.

In the early history of the Institute the Corporation was the sole body of government, and dealt directly with all the details of administration. The result was unsatisfactory. The membership of the Corporation is too large to admit of the effective transaction of business in such a way, and for this reason the By-laws were amended so as to provide for the Executive Committee, which, under the Corporation, now has charge of the details of administration. The creation of this body has had the tendency to carry the administration to the other extreme, and to intrust to the Executive Committee almost the entire direction of the institution.

The desirable administration lies, as it seems to me, somewhere between these two points. The Executive Committee should take immediate charge of the actual administration, but it is most desirable, as I view it, that the Corporation should not lose its function of passing upon all matters which have to do with the general policy and the larger purposes of the institution. During the past two years there have been submitted to the Corporation a number of such matters,—such as the consideration of the alliance with Harvard, and the proposal

to buy a new site,—and I am inclined to believe that in the discussion and settlement of such questions the Corporation will find increased interest and increased usefulness.

Another plan worth trying, it seems to me, is a modification of that which is used with great success in the Board of Trustees of the Carnegie Foundation for the Advancement of Teaching. These Trustees are a Board of twenty-five members, who are scattered over the United States and Canada, and whom it is most desirable to keep in close touch with the work of the Executive Committee. In order to effect this, the minutes of the Executive Committee are printed in full, with a free running comment on such matters as were considered, and are sent, after being printed, to all members of the Board of Trustees. It may well be that a modification of this plan, under which an abstract of the minutes of the Executive Committee might be prepared and sent to the members of the Corporation, would serve a similar purpose.

Since the addition of the term members, some of whom come from a distance, it seems increasingly desirable that some means should be adopted of informing members of the Corporation in advance of the nature of the business likely to come up for consideration at the regular meetings. It might serve the purpose, perhaps, if the President or the Secretary communicated to the members of the Corporation ten days in advance the nature of questions likely to arise.

In any body as large as the Corporation of the Institute which does not deal with the direct details of administration, the question of retaining the interest and the co-operation of the members is not always easy. Those in direct charge of the administration, with the best intentions, do not always understand that the man in the larger legislative body is likely to tire of an arrangement which does not involve actual duties and responsibilities. On the other hand, it is not desirable to bring before the larger body the details of administration which have to do with routine matters. Just how to combine the functions of these two bodies so as to preserve their mutual

interest is one of the things which those in charge of the government of the Institute need to consider.

STUDENT REGISTRATION.

In the very complete report of the Registrar will be found the usual statistics with respect to the registration of students, and a comparison with those of former years. The total number of students in the Institute is now thirteen hundred and ninety-seven as compared with fourteen hundred and sixty-six at the same time last year. This diminution is, however, but an apparent one. There was graduated last year the largest class which the Institute has ever sent out, two hundred and seventy-seven men receiving their diplomas in June, 1906. This was the class which entered just before the advance of tuition, four years ago. As the result of this increase, last year's senior class was the largest in the history of the Institute and this year's senior class is the smallest for some years. As a matter of fact, however, the number of new students in the Institute this year is five hundred and forty-six as compared with four hundred and eighty-two last year.

The number of students who are college graduates is two hundred, which is about the same number as last year. This includes fourteen who are fellows or candidates for the doctor's degree. The number of colleges and universities represented by this list is eighty-eight.

The student attendance continues to be representative of our whole country and of foreign countries. Forty-three states of the Union and one territory, besides the District of Columbia, Porto Rico, and the Philippines, are represented in the list of students. Of the whole number, thirteen hundred and ninety-seven, seven hundred and sixty-four, or fifty-five per cent. of the whole, are from the state of Massachusetts. States outside of Massachusetts which send the largest numbers are:—

New York	84	Maryland	17
Pennsylvania	55	Missouri	17
Illinois	37	Texas	15
Connecticut	36	Indiana	15
Ohio	30	Minnesota	14
New Hampshire	26	Iowa	14
Rhode Island	23	Colorado	12
California	21	District of Columbia	12
Maine	18		

From twenty-nine foreign countries there come seventy-six students. Of these the larger numbers are from the countries in the list which follows:—

Mexico	12	Cuba	4
China	7	Nova Scotia	4
England	6	Australia	3
Ontario	6	New Brunswick	3
Japan	5	Transvaal	3

The other countries represented are Argentine Republic, Armenia, Belgium, British Columbia, Bermuda, Cape Town, Chile, Denmark, Ecuador, Egypt, Honduras, India, Ireland, Jamaica, Peru, Quebec, Scotland, Turkey, and Uruguay.

THE CARNEGIE FOUNDATION FOR THE ADVANCEMENT OF TEACHING.

During the past year the Carnegie Foundation for the Advancement of Teaching has been inaugurated and has begun its active work.

This agency is likely to produce far-reaching effects upon American education, but its function and its significance are oftentimes misunderstood.

It is not an agency for the mere pensioning of superannuated professors. The foundation stands primarily for the idea that the time has come in the history of American education when it is important—not only important, but vital—to strengthen the position of the teacher and to make it attractive to strong men, men who have initiative, who have intellectual qualities, who have social attractiveness, and the ability to influence other

men. To use this large fund as a charity fund to take care of needy professors here and there would go a very short distance toward this purpose. Indeed, such a fund used as a charity is likely to do more harm than good.

The principles upon which those in charge of the fund have acted are essentially two.

1. The lifting from the teacher's life of the uncertainty which comes with old age and ill-health will counterbalance in many ways the smaller salary which goes and must continue properly to go with the teacher's calling.

2. In order that security and protection may appeal to the teacher, it must come to him as a right, not as a charity. No independent teacher desires, more than the man in any other calling, to be the recipient of charity; and, in order that the retiring allowance system may be an inducement to the best men, it must be offered to them on the same terms upon which they receive their salary and as a part of the academic compensation.

With these principles in view, the Trustees of the Carnegie Foundation for the Advancement of Teaching have gone to work to bring into the American educational system the principle of the retiring allowance to the professor in the higher institutions of learning. They have recognized some fifty-two institutions as entitled, by reason of fair standards and courses of study, to participation in this fund; and they will proceed to recognize other institutions in all parts of the United States and Canada as rapidly as this can be done with due regard to the educational standards and methods of the various sections. Among institutions thus admitted to the retiring allowance system is the Institute of Technology, so that our professors may now receive through the officers of the Institute a guarantee of the protection and the benefit of the retiring allowance system. The retiring allowance amounts, in the ordinary case, to about sixty per cent. of the active pay of the professor at the time of retirement; and under the rules of the Foundation the half of this amount is made available for the widow of the professor should she survive him.

How many institutions can be provided with an effective retiring system with the income of the Foundation is not yet absolutely determined. It may, perhaps, be set at one hundred and fifty. Denominational institutions are excluded and state institutions have not been admitted. It is clear, however, that, if such an effective system shall be inaugurated in one hundred and fifty representative colleges and universities scattered over the whole United States, the principle of the retiring allowance will be so thoroughly established that other institutions will find it necessary to make it a part of their academic system of compensation. How far-reaching this result will be in strengthening the profession of the teacher and attracting to it strong men, only those can know who have seen the uncomfortable effects of the lack of such protection in the past.

DEVELOPMENT FOR THE FUTURE.

For some years I have called attention in my annual Reports to the need of outlining as definitely as possible the policy of the Institute with respect to certain fundamental questions. These fundamental questions seem to me, in the order of their importance, to be the following:—

1. The development of the intellectual work of the Institute. This work is essentially that of the Faculty and of the President. It involves not only the carrying on of the present courses of instruction, but the examination, year by year, of the fitness of these courses to do the work for which they are intended. It involves the quickening of the means of instruction and the adaptation of the courses to student needs. During the last twenty years there has been a continual tendency to differentiate technical education to meet the demands of the subdivisions of engineering. This tendency has probably gone too far, and we need perhaps to-day to return to greater simplicity and the teaching of fundamental sciences.

2. The second problem which stands immediately before the government of the Institute is that of the settlement of the

question of its location during the next fifteen or twenty years. This should be settled at the earliest practicable moment, in order that those who have to provide for the Institute and to work for its advancement may work with definiteness of aim and with understanding of what its future is to be.

3. Having settled these fundamental questions, this Corporation needs next to consider the means of providing money for endowment and for buildings so as to make the selected site the seat of an effective and well-equipped group of engineering buildings.

EDUCATIONAL TENDENCIES.

Those who have to do with colleges of technology must admit frankly that, when these institutions undertake to give in four years the foundations of a general education and a technical training as well, they undertake a most difficult task. Out of these difficulties there has grown in the last ten years a marked tendency to give to those boys who can afford the time and have the means, first, the education of the college and, secondly, the training of the technical school. In all institutions of technology to-day a considerable proportion of students who enter have had their general college course before they come, and they enter the school of applied science as a professional school, much as students enter the medical school or the law school. The number of such students is growing. Under this tendency there will gradually be differentiated two classes of technological institutions: one, the undergraduate institution, similar to the technical college of to-day, aiming to give a technical training and so much of a general education as is possible in four years; the other, a graduate school of applied science, intended for men whose work is wholly professional and who have had already a general education. The present epoch is, therefore, one of transition for the college of technology, and we may safely anticipate in the next decade some sort of crystallization along the lines which I have just mentioned.

This tendency stands directly across the path of the Institute of Technology and is a real problem for it to meet. There are to be in this community—for Cambridge is practically a part of the community of Greater Boston—at least two high-grade technical schools of applied science. A third, in the suburbs of Boston,—at Tufts College,—is growing rapidly in numbers and in efficiency. Just what form of development and what form of leadership the Institute of Technology will seek under these tendencies is a question of vital importance so far as its future standing among the institutions of the country is concerned.

It seems to me clear that for the present and for many years to come the Institute of Technology must give the greater part of its effort to undergraduate instruction. It seems, however, equally clear that, if it is to retain any large measure of leadership, it must develop at the same time graduate and research work. To compass these two somewhat dissimilar aims in the same institution is not easy. Perhaps the best purpose I can serve at this moment is to call your attention to the existence of these tendencies, and to the fact that your choice of the policy of the Institute is likely to have an important bearing upon its future standing according as its work tends to a purely undergraduate school or as it tends to include a fair measure of graduate work and of research.

No one familiar with our schools of technology can doubt that an institution devoted to the work of applied science, professional in its character, and requiring a bachelor's degree for admission, would present great attractions to students already graduates of colleges. The greater freedom possible in such institutions is in itself a considerable factor. Furthermore, the man who has passed through his freshman and sophomore years, and been graduated from a college with the dignity of a senior, finds it more or less trying to take up again college work in the company of men just entering. From every standpoint it is clear that professional graduate schools in applied science would appeal to a large number of the very best men.

CULTURE STUDIES IN TECHNICAL SCHOOLS.

Twenty years ago schools of technology were criticised on the ground that they taught men to make a living rather than to live. In response to this criticism, many schools of applied science—of which the Institute was a leader—have added to their courses of study a growing amount of so-called "culture" studies. I think I express the opinion of many teachers in saying that the result has not been all that might be hoped for. These culture studies have consisted generally of English, History, Economics, and Modern Languages. All these are studies of great importance and of real humanitarian and cultural value if studied in the right spirit and under favorable circumstances. Their value to the student in the technical college has been of varying importance, depending partly on the atmosphere of the technical school itself, partly on the lack of thoroughness in the secondary schools.

The very earnestness which pervades a technical school, the spirit which prompts the student to bend himself to the task before him, tends to place a light value on any studies which do not lead to visible results. It is difficult to convince him that such subjects have for him a value comparable with the more direct utilitarian subjects; and to study them in this atmosphere and with this spirit is to achieve a very much smaller result than would be possible in a different atmosphere and with a different spirit.

As a matter of fact, we men in the college of technology need to recognize that it is not the study of Literature, nor of Economics, nor of History, nor of any other subject, that *per se* brings culture and a broad sympathy with men. Chemistry, Physics, and Mechanics may be taught in such a way as to develop great humanistic interests as effectively as any of the so-called culture studies. The fact that we need to lay to heart is that the thing which brings true culture to men is intercourse with other men of culture, acquaintance with the thoughts of great men, either through the medium of books or

through the words of living men. It is the rubbing of one student against another. If we desire to increase in our colleges of technology a spirit of true culture and to bring about a larger common interest, the effective way to do this is to bring into our colleges teachers who are themselves exponents of this culture and of this wide human interest.

A CLOSER CONTACT WITH INDUSTRIAL INTERESTS.

Forty years ago engineering schools of the United States were started by teachers. It is no small credit to the prevision of the American teacher that he should have been the man to recognize the need for industrial education. The Institute of Technology was started, not through the efforts of a practical man of business, but through the effort and wise foresight of WILLIAM BARTON ROGERS, a teacher and an investigator. He saw clearly, as few business men saw at that day, the purpose that such education would serve.

At first manufacturers and others who employed skilled engineers hesitated to accept the graduates of the technical school; but to-day they accept them readily, and the supply is not so large as the demand. Nevertheless, there is still found an echo of the fact that the contact between the school of engineering and the manufacturing establishment is not so close as it ought to be. The following instructions in a large manufacturing establishment illustrate the feeling in this matter. These instructions were to give the preference, first, to graduates of technical schools; second, to the graduates of academic colleges; but, third, to employ no college boy who had not been out of college for more than two years.

In a word, our colleges of technology started forty years ago were started, not in actual co-operation with manufacturing establishments, but in practical disregard of them; and, notwithstanding the success of the college of technology, it still remains true that we have yet in this country to secure an efficient contact between industry and applied science, between

the factory and the school. There is to-day no such relation, for example, between the school of Industrial Chemistry and the chemical industry in the United States as exists between the school of Industrial Chemistry and the chemical industry in Germany.

This contact needs to be shown in two ways: first, by a real appreciation on the part of the teacher of the view-point of the manufacturer and business man; secondly, by securing the actual interest of the manufacturer in the school. The first point is one which is receiving increasing attention in our schools of technology to-day, but which needs still greater elaboration and study. Various devices are being tried in institutions of learning to induce men who have close touch with engineering and applied science to take the work of professors or to assist those who are already professors to get in touch with practice. In Cornell, for instance, an arrangement has been made under which professors may spend three years in practice, returning afterwards to the school. All these efforts grow out of a keen appreciation of the lack amongst professors of contact with practical work.

It is to be remembered that the chief purpose of the school of technology is to train practitioners in applied science, just as it is the chief purpose of the medical school to train practitioners in medicine. It is necessary that there should be that about the technical school which may encourage and inspire the small minority of those who come to the life of the teacher and investigator; but the main purpose of the school is that which I have mentioned. For this reason it is important that the student should have the view-point of the practitioner of engineering, just as it is important that the medical student should have the view-point of the practitioner of medicine; and, to bring this about, the teacher in the technical school should himself be a practitioner, just as the teacher in the medical school usually is. It is one of the advantages in the teaching of medicine that the practice may be readily brought into the clinic before the students; we may well imagine what sort of

physicians and surgeons would be turned out if their instruction lay wholly in the hands of men who were teachers rather than practitioners.

To bring about a closer contact with the manufacturer and to secure the real interest of the man of business in the school of technology is also a vital need of applied science at this time. The college in the United States presents too often to the business man the attitude of the persistent beggar rather than the attitude of a co-laborer and sharer in industrial problems. How to assure closer contact with industry and business is a problem which the school of technology of the next ten years must closely study.

One way of securing this closer relation, as it seems to me, would be to develop the practical service of the school to the industrial interests of the Commonwealth and of the nation. For instance, the development of the great testing and research laboratory at Charlottenburg in connection with the school of technology has been an enormous factor in cementing together the school and the industries which it seeks to serve.

THE TREASURER'S REPORT.

The Report of the Treasurer has been printed and has been mailed in advance of this meeting to members of the Corporation. This Report shows that the receipts for current expenses have amounted during the year to $504,511. This includes $42,583.61 received from the Income Fund Committee. The expenditures have amounted to $508,407.21, which shows a deficit of $3,896.21. Without the contribution from the Alumni the deficit would have been approximately $46,000.

The Report shows, further, gifts for special purposes amounting to $31,543.88, and gifts and bequests for general purposes amounting to $50,043.18. The net result of the whole year is an addition to the property of the Institute of $86,865.85. The Walker Memorial Fund now amounts to $107,557.06, in addition to which there are certain large gifts in connection with

it which may be called for whenever the Corporation is ready to assign a site for the erection of the building.

REPORTS OF DEPARTMENTS.

I beg to call the attention of the Corporation to the reports presented by the heads of departments and to ask their careful consideration of them. It has been our plan for some years past to ask heads of departments to present specifically their own recommendations as to the development and needs of their respective departments. It has seemed to me desirable that these matters should be presented to the Corporation in this formal way by the heads of departments themselves, and I ask for all of them a careful reading.

In addition to the general questions there brought forward, I call your attention to the following points. For some time it has been evident that the pressure upon the student's time must be relieved, and a number of suggestions has been under consideration by the Faculty for doing this. In the report of the head of the Department of Civil Engineering is a recommendation looking toward a summer school for the teaching of surveying in which the whole work of instruction in surveying should be done in the summer rather than during the year. I consider this recommendation a most important one, and one which should receive early consideration.

I call the attention of the Corporation to the statement of the head of the Department of Mechanical Engineering in relation to the need for more room. The Executive Committee has granted to this department a much-needed sum for new apparatus, but this very grant increases the pressure for room already keenly felt and calls special attention to the need of a general solution of the whole question of site and buildings for the immediate future of the Institute.

Attention is called in the report of the head of the Department of Mining Engineering and Metallurgy to the very effective work of the summer school and the means adopted in it

to bring students of that department in touch with actual engineering problems. This statement emphasizes again the need for some systematic consideration of the matter of summer instruction. For a single year there was provided, through the generosity of a donor in New York, means by which students in the Mining Departments of the Institute, of Harvard, Yale, and Columbia, were enabled to unite in a summer school in a Colorado mine. Some means by which instruction in practical mining may be afforded students without large expense is an urgent need.

Besides other important recommendations, the head of the Department of Chemistry and Chemical Engineering again calls attention to the fact that the work of the department is scattered through a number of buildings, a recommendation which again emphasizes the necessity of the solution of the question of room and buildings.

The report of the head of the Department of Biology calls attention, not alone to the actual work of the department, but to the conduct of the Sanitary Research Laboratory and Sewage Experiment Station maintained by the generosity of an anonymous donor. This department is perhaps in closer touch with the industrial and sanitary work of the Commonwealth than most friends of the Institute realize. During the past year a member of the department has made a most valuable report in relation to sewage problems connected with the work of the Charles River Basin; and questions of an immediate practical sort are constantly being dealt with by members of this departmental staff. The work of an engineer who has had training in Biology is becoming increasingly important in this country, and it would seem that the facilities afforded at the Institute of Technology for such men ought to win an increasing number of students.

The head of the Department of Geology brings out in an interesting way the service which this department renders to that of Mining, and calls attention also, as has already been noted in other cases, to the pressing need of additional room.

The head of the Department of Naval Architecture submits, in addition to his ordinary report, a report of a visitation made to the ship-yards, colleges, navy-yards, and ship-model stations of Europe which is of great value and interest.

In the report of the head of the Department of Mathematics attention is called to the revision of the courses in Mathematics, a revision tending to bring fundamental mathematical courses to the better adaptation and to the better study of Mathematics, and thereby to place the tools of Mathematics in the hands of the students at an earlier age and more effectively. I consider this work one of the very greatest importance. Connected with it, and equally fundamental and important, is the work in Applied Mechanics, and in Drawing and Descriptive Geometry.

The Corporation will be interested in the report of the head of the Department of English as to the results of the first trial of entrance examinations under the new conditions. This new condition consisted in doing away, in the preparatory work, with the arbitrary requirement of a list of prescribed books, and granting permission to the teachers in the preparatory school to choose such works of literature as seem to them adapted to the needs of individual classes. This year's examinations seem to the department to furnish solid ground for hope that the results are in the direction of a better training and of a more real interest in such subjects.

The reports of the Secretary of the Faculty, of the Dean, of the Registrar, and of the Medical Examiner contain material of the greatest interest and value, and I commend them to your examination.

HENRY S. PRITCHETT.

DECEMBER 11, 1906.

Reports of Departments.

DEPARTMENTS OF CIVIL ENGINEERING AND SANITARY ENGINEERING.

During the past year there has been made in the Courses in Civil and Sanitary Engineering a very important change, which goes into effect with the present sophomore class. The chief alteration involved consists in the omission from these Courses of one year of Modern Languages. In the future, a student in these Courses will therefore be required to study Modern Languages during the first year only. He will enter, as now required, with elementary French and elementary German, and during the first year will take more advanced work in whichever of these languages he may select.

The necessity for this change has been pressing for many years, owing to the increasing demands made by other subjects of study, and by reason of the comparatively small use of Modern Languages which most graduates of these Courses make in their professional work. Furthermore, students who desire it can still continue the study of Modern Languages as an optional study in the third year or in the Summer School, so that the Institute still offers opportunity to students who desire it to obtain as much instruction in these subjects as formerly.

The pressing need for time in Courses I. and XI. arose from the desirability of devoting more time to the study of Mechanics, and of beginning that subject earlier, so as to avoid any intermission between the Physics of the second year and the Mechanics of the third year. Beginning with this year, students in these Courses will begin the study of Mechanics at the middle

of the second year; and this subject, together with that of Structures, will be one connected, continuous course. No new subjects have been introduced, but more time is to be given to those which are already taught, and it is hoped that a great increase in efficiency will follow.

Instructor S. H. Thorndike resigned his position at the close of last year, and his work has been distributed among the other members of the staff. The usual number of changes among the assistants has taken place, but no change has been made among the members of the Faculty.

In connection with the attempt which is being made to attract to the Institute more college graduates, and to offer more advanced work, that is to say, work in advance of that given in our regular four-year Course, the necessity becomes apparent of adding to the number of instructors of high grade. The present members of the instructing force, with the large classes now attending, have their time well filled, and any considerable increase in the number of courses of instruction is well-nigh impracticable.

The most serious problem confronting these Departments at the present time relates to the proper conduct of work in the field. There are two methods of carrying on such work: first, by making it a part of the regular work of the school year; and, second, by concentrating it in a separate school during the summer.

The Institute has thus far adhered to the first method. In the early days, when classes were small and when the Back Bay was not built up, this instruction could be given near at hand without waste of time; but it soon became necessary to take the classes into the country in order to carry on the work effectively. This necessitated devoting more time than a single afternoon to each exercise, and led to a change, which was put into force many years ago, by which an entire day in each week was assigned to field work for the second-year students, and another entire day in each week to field work for the third-year students. As the classes increased, it became

necessary to divide them into sections, and to assign two entire days of each week to the field work of the second year. During the winter, when field work is impracticable, the work of plotting and computing is carried on in the drawing-room.

With still increasing numbers of students, and especially with the increasing pressure in the curriculum of other subjects to which more time ought to be devoted than has been found possible in the past, the question of the proper method of conducting field work, and of the possibility of saving some of the time now devoted to it during the school year, becomes a very pressing one.

In some other schools in this country the field work is given during the summer, leaving the school year free for work of other kinds. Harvard, Columbia, Cornell, and other institutions follow this plan.

The advantages of carrying on the field work during the school year may perhaps be summarized as follows:

(1) The arrangement of the curriculum is somewhat simplified, for the class-room work and the field work can be arranged with close reference to each other and to the other subjects in the Course.

(2) The summer is left free for students and instructors, a fact which enables them both to devote the time to professional work. Many of the students depend upon earning enough money during the summer to go far toward paying their tuition for the following year.

(3) It avoids the necessity of securing a site, and the trouble and expense of carrying on a summer camp, and of feeding, housing, and taking care of a large number of students.

(4) It avoids the necessity of charging an extra fee for summer work (as is generally done in other schools), a plan which makes the Course in Civil Engineering more expensive to students than other Courses in the school.

The advantages of a summer school for field work may be summarized as follows:—

(1) By concentrating the field work during six or eight weeks

in the summer, the school year is left free for the many other pressing subjects which demand attention.

(2) The student is not distracted from his more purely mental work during the school year by the necessity of giving a day each week, perhaps in inclement weather, to work in the field, which may leave him physically tired out, if not exhausted, and interferes with the preparation of lessons for the following day.

(3) It simplifies the arrangement of the tabular view, and releases a large amount of time during the school year.

(4) The concentration of the work in the field should be attended with an increase in efficiency.

With reference to expense, it is probable that the summer school method would prove more expensive than the plan now followed. It would require the Institute to procure a suitable location, involving the use of a large area of land to be surveyed, at some point in the country where the topography is diversified, where a railway line several miles in length might be laid out, and where there is a running stream large enough for efficient work in Hydraulic Measurements. A camp would have to be organized and administered, buildings constructed, and food and shelter provided for a large number of students. The number of instructors would also have to be large, and it might prove difficult to secure a sufficient number of properly trained men. Students from the graduating class might be induced to assist us for two months in the summer, and yet the demand for our graduates is greatest just at the close of the school year, and the temptation to accept favorable offers is likely to be so strong that the best students will yield to it. On the other hand, the number of assistants required in the Department during the school year would probably be reduced, since a considerable proportion of the time of assistants at present is devoted to field work, so that, if the number of assistants is sufficient in the early fall and late spring when field work is carried on, there is a slight excess during the winter. I do not believe, however, that the number of assistants in these Departments should be materially reduced in case the

summer school method should be adopted. The increased expense to the Institute may be met by a fee charged to all students. I am informed that the Harvard Summer School, which is held at Squam Lake, N.H., and for which the fee is about $20, exclusive of board, pays for itself and is very successful.

As a result of these considerations, and after much discussion, I believe that it is desirable that the Corporation should give immediate and serious attention to the question of inaugurating a summer school for field work which all students in Civil Engineering should be required to attend. Some changes in the courses of study would be required, but I think it would be found necessary to require students to attend such a school only during the vacation following the second year. During six or eight weeks of continuous work they ought to complete the field work in Surveying and in Railroad Engineering, and the hydraulic field work, leaving for the work of the term only the study of methods and instruments, and, to some extent, the plotting of results.

I recommend, therefore, that the Corporation give immediate and serious consideration to the question of securing a proper permanent location for such a summer school and to supplying the means of carrying it on.

It may be added that the desirability of such action will not be obviated by the removal of the Institute to any other location in the immediate vicinity of the present site. Indeed, owing to the close proximity of our present site to the railroad stations, a removal would be very likely to increase the desirability of the summer school plan. The summer school, if it is to secure the best results, should be in the country at some place similar to that where the Harvard school is located.

The Department has reason to feel much encouraged by another instance recently brought to our notice of the excellent showing which our graduates make in competitive examinations. Some years ago mention was made of the high rank obtained by graduates of the Department in examinations for the

position of Civil Engineer in the United States Navy and in the Geological Survey. The latest instance is the examination, held a few months ago, for the position of Assistant Engineer for the Board of Water Supply of New York. A grade of seventy per cent., based partly on experience, etc., was required for passing. There was a large number of applicants, and one hundred and fifty of them were successful. Of this number five out of the leading six (all but No. 3) were graduates of Courses I. and XI., and nineteen were former students of these Courses, including one non-graduate.

It is interesting to observe in this connection that the school credited with the next largest number of men who were successful in this examination was the Cooper Union. The figures at hand are not complete, and I am not able to state how many Institute men failed, if any, as compared with those who passed, but it is clear that our graduates make a good showing when put to such tests as these. It is also clear that young men working for themselves and paying their own way, like most of the students at Cooper Union, may also be very successful.

GEORGE F. SWAIN.

DEPARTMENTS OF MECHANICAL ENGINEERING AND APPLIED MECHANICS.

The number of students in the last graduating class of the Course in Mechanical Engineering was exceptionally large, there being sixty-nine graduates. This large class, together with the fact that these Departments are called upon to provide a very considerable amount of instruction for the students of Courses I., II., III., IV., VI., VIII., X., XI., and XIII., as well as the consequently large amount of investigation carried on, especially in connection with the thesis work, not only of Course II., but also of some of the other Courses, has taxed the resources of these Departments to their utmost, especially in the Laboratories, where the supply of additional apparatus has not

kept up with the needs. Indeed, it was for a time a serious question whether we should be forced to decrease the amount of instruction given to each student, especially in the higher and more purely professional portions of the work; and we have been obliged to have a larger amount of thesis work than is desirable performed outside of the Institute.

The improvements in the Course in Mechanical Engineering mentioned in the President's Report of January, 1906, have proved to be of great value in increasing the usefulness of the Course, and in aiding us materially to keep it more and more in touch with the needs of the times, and with the live engineering questions of the day. Among these improvements may be especially mentioned the increased time devoted to each of the fourth-year Options, the addition of work in power plant design, and the greater amount of instruction in Electrical Engineering subjects.

The practice of these laboratories in carrying on a considerable amount of investigation of modern engineering problems has been, as usual, continued. In this connection may be mentioned the following portion of the thesis work of the past year:—

(*a*) The investigations upon the strength of locomotive connecting rods have been continued, including tests made upon a number of large rods.

(*b*) Inasmuch as many railroads and locomotive works are encountering difficulties with the breakage of springs, an experimental study of the loads to which driving springs are subjected in service was carried on.

(*c*) There were made seventeen tests of large power plants, including five tests of steam turbine plants varying in capacity from five hundred to five thousand kilowatts, four tests of pumping plants, two of producer gas plants, and one of the engine and boiler plant of a cotton mill.

(*d*) Work upon concrete and reinforced concrete has been continued.

(*e*) Various other modern engineering problems have been investigated.

(*f*) During the last summer a thesis was carried on, the object of which was the comparison of the performance of a large passenger locomotive provided with a superheater, with that of a similar engine without a superheater, involving complete road tests of the two engines, on runs of over one hundred miles. The application of superheaters is a practice recently introduced on some railroads.

Several members of the instructing staff were employed during the summer in outside work in connection with the erection of structures of reinforced concrete.

The following gifts have been made to the Department:

(*a*) A plunger pump, by the Douglas Pump Company.

(*b*) Portions of a machine for balancing card cylinders, by the Saco and Pettee Machine Works, Newton, Mass.

(*c*) Complete sets of blue prints of locomotives by the American Locomotive Company, and by Mr. Harvey Middleton.

(*d*) Considerable data, such as specifications, and other literature has been provided for the use of the students, by the American Locomotive Company, by the Baldwin Locomotive Company, by the Crosby Steam Gage Company, and by the R. D. Wood Company, makers of gas producers.

(*e*) In connection with the thesis work on the strength of connecting rods, twelve large rods, worth about eighty dollars each, were presented to the Department for the purposes of the tests, by the Baldwin Locomotive Company.

(*f*) Valuable modern apparatus has been lent to the Department for use in connection with the work in the drawing-room by the J. Stevens Arms and Tool Company, the Ridgway Dynamo and Engine Company, and the Baush Machine Tool Company.

The urgent need of a considerable amount of additional apparatus, and the fact that until last June no special appropriation for the purpose had been made since 1900, has been frequently mentioned. It will not be repeated here, except to say

that a special appropriation of eight thousand three hundred dollars was made last June for this purpose, which will enable us to add some new apparatus to the laboratory, though much more is urgently needed.

More room is also needed for new apparatus, to relieve present crowding, to furnish room for students to carry on thesis work on apparatus brought in from outside, to provide storage room for large and miscellaneous apparatus to be used on thesis work conducted outside, and to provide room for stripping machines for the purposes of Machine Drawing.

GAETANO LANZA.

DEPARTMENT OF MINING ENGINEERING AND METALLURGY.

The John Cummings Laboratories of Mining Engineering and Metallurgy are constantly being developed to bring the student into intimate contact with the latest ideas in ore-dressing and metallurgy. In the Ore-dressing Laboratory a new jig, of the pattern approved in the Michigan copper concentrating works, is being constructed. In addition the Harz jig has received new automatic discharges, a new canvas table has just been supplied, and the Wetherill magnet is being improved.

In the furnace room a hydraulic elevator has been installed to raise materials from the bins to the main floor of the laboratory. An iron structure to handle the Devereux slag-pots has replaced the wooden one formerly used. Part of the floor has been cemented to facilitate the handling of pots filled with melted slag. In order to save time in the repair of the test used for refining copper, special forms of brick are now used, a plan which does away with the cutting of tiles to suitable sizes.

In the Metallographical Laboratory the addition of a gas furnace, an automatic recording pyrometer, and a dark room are contemplated for work on metals and alloys.

The office and library had become so crowded that relief was imperative. Space was obtained by utilizing room reserved

for the museum, and distributing the specimens. In the former museum the floor, which was five feet eleven inches from the basement, was raised two feet four inches, dividing the available space into a lower room six feet eleven inches high and an upper room nine feet six inches high. In the lower room, lighted and ventilated electrically, all the apparatus of the Metallographical Laboratory and eight show-cases of specimens are placed. In the upper room is the library of the Department. Here are the office of Professor Hofman and the desks of his three assistants. The small cases in the old library are filled with collections representing mining districts. This room serves now as office for three assistants. The original office is occupied by Professors Richards and Locke.

Professor Richards has recently presented to the library of the Department from his own library one hundred and thirty-two books and pamphlets which the former did not contain.

In the Assaying Laboratory all the balances have been overhauled and put in thorough repair. The assistants' office, formerly overcrowded, has been relieved by the library changes.

Among changes in the work of instruction may be mentioned the fact that the exercise in Laboratory Reports has been enlarged by requiring the students to make written reports on all the work that they have done in the three sections into which they are divided.

Memoirs, which used to be given once a week during both terms of the fourth year, are now given, through force of circumstances, twice a week during the second term only. The result will be watched with interest.

The number of students is not quite so large as last year, owing to the departure of the phenomenal class of 1906. The numbers in the fourth year, the third year, and the second year are respectively twenty-eight, thirty, and thirty-six.

Charles E. Locke has been promoted from Instructor to Assistant Professor of Mining Engineering and Metallurgy. Carle R. Hayward, teacher at Bellows Academy, Fairfax, Vt., has been appointed Instructor in Metallurgy, in place of

Robert Faulkner, who has gone to the National Tube Works, McKeesport, Pa. Arthur P. Watt has been appointed Assistant in place of George A. Barnaby, who is surveying in Peabody, Mass. John A. Root has been appointed Assistant in place of Moses Brown, Jr., who is surveying in the copper country at Lake Superior.

Last year Professor Sauveur resigned his position as lecturer and demonstrator in Metallography. The subject is now in charge of Professor Hofman, who gives the lectures and conducts the laboratory exercises.

Professor Richards is engaged in writing an appendix to his work on Ore-dressing, and Professor Hofman is at work on a treatise on Metallurgy. Professor Richards has also been acting in the capacity of consulting engineer for works in Pennsylvania, Virginia, Missouri, Colorado, and Oregon. He is at present investigating the rate of settling of mineral grains in water, and also the laws governing the design of hydraulic classifiers, and of the Wilfley concentrating table.

During the summer Professor Lodge attended the meeting of the American Institute of Mining Engineers, which was held jointly with the British Iron and Steel Institute in England. Professor Locke made an extensive trip among the mines of New England and Eastern Canada.

The Summer School, in charge of Professors Richards and Locke, and joined later by Professor Hofman, was held in New York, Ohio, Minnesota, Michigan, and Ontario. It included, besides the instructing staff, one graduate, three fourth-year men, two third-year, and two second-year men. Among the industries visited at Niagara were the Acheson Graphite Company, the Carborundum Company, the Niagara Falls Power Company, and the Hydraulic Power Manufacturing Company. A most enjoyable journey from Ashtabula to Duluth was made in the ore steamer "John J. Allbright." In the Mesabi region of Minnesota, at Hibbing, the Burt Poole mine and the Mahoning mine were visited. These are monster open pit mines of iron ore. At

Duluth the party inspected the great ore docks. At Ironwood, Michigan, the Newport deep mine of iron ore was studied inside and out, and the surface plant of the Norrie mine. At Iron Mountain the Chapin deep mine of iron ore was studied and also the power plant and compressed air pipe line. In the copper country the Champion and Trimountain mills were studied. The party went into the Baltic mine and made a study of it. They visited the Osceola and Quincy mills, and the surface plants of the Calumet and Hecla and the Tamarack mines, the Michigan smelter, and the Calumet and Hecla smelter. Professor Locke also made a visit to the Victoria hydraulic power plant. The party next took the passenger steamer to Sault Ste. Marie, where they studied the blast furnaces, the steel plant, the electric iron furnace, and the charcoal plant of the Algoma Steel Company. The next move was to Sudbury, Ontario, where were visited the Crean Hill mine and the Creighton mines of the Canadian Copper Company and the Victoria mine of the Mond Nickel Company, together with the smelting works of both these companies.

The Department desires to record here its thanks for the generous and cordial welcome given to the students of the Summer School by the managers of the above-mentioned companies and firms, and for the many courtesies extended by former graduates and others.

Several undergraduates were employed in mines and at furnaces during the summer vacation. One went to Colorado, seven to Cape Breton, three to Montana, two to Missouri, two to New York, three to Utah, and one to Alaska.

The demand for graduates is still active. The Department could have placed more than the large number graduating in 1906. This is especially true of places in iron and steel metallurgy.

ROBERT H. RICHARDS.

DEPARTMENT OF ARCHITECTURE.

This year the new Course Scheme made possible by the increased entrance requirements in Modern Languages is for the first time in complete operation. The two hundred and seventy hours which became available for additional general and professional work have opened the way for many modifications and improvements in the courses given by the Department, that promise well in the direction of greater efficiency in methods of teaching, and a general broadening of the Course. A generous proportion of the added time has been devoted to an increase in the structural subjects taught in Options I. and II. These changes have, on the other hand, very largely extended the labors of Professor Lawrence, who had all that he ought to carry before. As these hours represent class work, and as the instruction is practically all with individual students, each of whom may be working on a different problem in the same class, it is evident that the demand upon his time has been so materially increased that he should have aid to help him in routine work, and so give him the opportunity to do full justice in the way of extension or improvement to the courses of instruction under his charge. Undoubtedly, an assistant could be secured from the graduating class to serve next year, and I hope this will be allowed.

More applications come for graduates from Option II. than it is possible to meet, and the reputations of those offering these positions are sufficient proofs of the high consideration in which these graduates are held. This standard we are bound to maintain.

The good results that have attended the union of third and fourth-year students in a common drawing-room have made it highly desirable that the second-year students should have part in the same arrangement. Unfortunately, our limited floor area on a single story makes this impossible of accomplish-

ment, but it increases the desire for new quarters planned to profit by the experience in teaching gained during these many years. The younger men would mature more quickly but for their isolation. They need the stimulus gained by close association with men stronger than themselves, and they would more fully appreciate how much their own work stands for if they could watch more closely its theory put in practice by those who have had a year's start of them. The third and fourth-year men now meet on a common ground. They help each other in many ways. They work on each other's drawings, and they criticise each other's designs. This association seems to develop more quickly their reasoning powers, and their ability to discriminate between good and bad in architecture and to express themselves clearly in words.

Each year the question returns as to the best way of producing the Year Book of the Architectural Society. There are many objections to the present methods of conducting it. The value of the work as an advertisement of the Department has been so well proved that it is earnestly hoped the Executive Committee may see fit to put the publication on a permanent footing, and to give it the indorsement of the Institute.

Last year the Department was enabled to offer a travelling scholarship amounting to twelve hundred dollars, the very generous gift of a friend. Nine competitors, representing present and former architectural students of the Institute, met in the Department, where their drawings were made *en loge*, without any assistance after the start. The competition was very successful, and the prize was won by M. H. Whitehouse. Miss Ida A. Ryan and L. C. Clarke, Jr., received honorable mention. Mr. Whitehouse is at present studying in Italy. It is to be regretted that the opportunity the Department has to offer such a prize is the exception, and not the rule.

The Rotch Prize of two hundred dollars for the regular student making the best record during the four years was divided

equally between A. A. Blodgett and J. T. Wrinkle; and the prize of two hundred dollars for the special student doing the best work during two years was divided equally between F. C. Lebenbaum and R. G. Stebbins.

The two prizes of fifty dollars each, given by the Boston Society of Architects, were won by J. T. Wrinkle, regular, and W. Rasmussen, special student.

The two prizes of ten dollars each, the "Class of 1904 Competition Prize," were won by W. Soule, regular, and W. Rasmussen, special student.

It is a renewed satisfaction to note the continuance of good graduate work this year. There are eight candidates for the advanced degree.

FRANCIS W. CHANDLER.

DEPARTMENTS OF CHEMISTRY AND CHEMICAL ENGINEERING.

The past year has been one in which plans previously formulated for the improvement of the courses of instruction have been developed rather than a period marked by innovations. The changes outlined in the Report of last year in the Course in Chemical Engineering have attracted to that Course a fair proportion of the first-year class, and the number of graduate students from other colleges entering the Course has been gratifyingly large. The present fourth-year class is the last to graduate under the former schedule.

The third and fourth years of the Course in Chemistry have been so modified as to incorporate into them the changes previously adopted in certain chemical subjects in the Course in Chemical Engineering, including the transfer of the entire instruction in Industrial Chemistry from the third to the fourth year, and the beginning of the instruction in Organic Chemistry, both lectures and laboratory practice, at the middle of the third year. The instruction in Theoretical Chemistry has been condensed from three terms to two, and is now taken

in the third year. For the former lecture system there has been substituted one consisting of recitations, in which the subject is developed largely through the solution of problems involving fundamental principles. The time allowed for the laboratory work, which closely follows that of the class-room, has been increased so as to permit each student to devote to it one full day every other week throughout the year, and supplements the entire course. It is now true that in every branch of chemical instruction throughout the Department the work of the lecture or recitation room is correlated with laboratory practice, in which the student has opportunity to apply the most important of the principles discussed in conference, and to acquire some knowledge of the technique of the fundamental branches of his profession. Such an arrangement of work has long prevailed in a majority of the subjects taught, and its extension to the remainder gives promise of increased efficiency.

These modifications of the courses have largely increased the amount of instruction to be given in the Laboratory of Theoretical Chemistry, and have made necessary the appointment of an additional instructor in this subject. The number of students to be taught in the Laboratory of Organic Chemistry has also nearly doubled, and this has necessitated the appointment of an additional laboratory assistant and the utilization of a portion of one of the laboratories of Analytical Chemistry for organic chemical work. The need of enlarged accommodations for this work is urgently felt this year, and is likely to continue in the future, unless relief can be found.

The transfer of subjects within the courses has, on the other hand, occasioned a material reduction in the number of students in Industrial Chemistry for the present year, and the omission of the course in optical analysis of sugars, starches, etc. Professor Thorp will take charge of one of the laboratories of Analytical Chemistry, and Mr. Rolfe will assist in the first-year instruction for the present year.

The third of the biennial Summer Courses in Industrial Chemistry began at the close of the last Institute year, continuing from June 6 to June 22. It was, as formerly, under the direction of Professor Thorp, who, with Professor Talbot, accompanied the party of ten students from the third year of the Courses in Chemistry and Chemical Engineering. Besides the visits to the establishments named below, the course included the regular evening conferences conducted by Professor Thorp, at which the notes of the day were carefully reviewed and amplified after general discussion, and assignments were made to individual students of particular portions of plants or processes to be later inspected. In all, twenty-three plants were visited, as follows: Standard Sugar Refining Company, Boston; B. P. Clapp Ammonia Company, Pawtucket, R.I.; T. P. Shephard and Company, Providence, R.I.; Central Stamping Company, Newark, N.J.; American Smelting and Refining Company, Perth Amboy, N.J.; Alexander Young Company, J. T. Lewis and Brothers Company, Remmey Sons Company, Atlantic Refining Company, Burke Brothers, Dill and Collins Company, and the Point Breeze Works of the United Gas Improvement Company, all of Philadelphia; The Welsbach Light Company, Gloucester City, N.J.; Joseph Campbell Company, Camden, N.J.; Whitall Tatum Company, Millville, N.J.; Joseph Bancroft & Sons Company, Wilmington, Del.; Christopher Lipps Company, Baugh and Sons Company, D. F. Haynes and Son, Carr-Lowry Company, Sharpe and Dohme, and Fred Bauernschmidt, all of Baltimore, Md.; and the Maryland Steel Company, Sparrows Point, Md.

That the trip was a marked success was largely due to the many courtesies extended to the party by the managers of these various establishments, and by a number of our graduates. No effort was spared to make the visits profitable to our students, and in several instances the inspection of a plant was preceded by a talk descriptive of the processes involved, given by some one capable of speaking with author-

ity. The party was also delightfully entertained at luncheon by the Joseph Campbell Company, The Welsbach Light Company, The Atlantic Refining Company, The Whitall Tatum Company, and the Maryland Steel Company, and the favors extended, involving as they inevitably do a certain interruption of business in each establishment visited, should be, and are, cordially appreciated by the Department.

Within the past five years the Institute has found it possible to encourage research in Physical Chemistry by the establishment of the well-equipped Laboratory of Physical-chemical Research, under the direction of Professor Noyes, and to recognize organic chemical research by the establishment of an assistant professorship in that field. The advisability of the inauguration of a corps of research workers in Technical Chemistry has also been under discussion in the Department for some time. The problems in this branch of chemical science are not less numerous than in the more abstract fields, and there is a pressing need and a wide opportunity for investigation work of a high grade which would be of material service to the chemical industries of the country.

As a result of the course changes already referred to, certain funds are temporarily released for the present year, which make possible the employment of two research assistants in technical chemistry, who were appointed early in the summer and began work in August under the direction of Professor Walker. The problem upon which they are at present engaged —a study of the influence of the constituents of iron and steel on its corrosion—is one of importance to all chemical interests, and serves well as a type of the class of problems with which such a corps of workers might properly attempt to deal in a laboratory suitably equipped and endowed, and under a capable director. It is the hope of the Department that funds may be found for the continuation and development of this feature of our work beyond the present year. It is as yet too early to formulate extensive plans for the future, but it does not seem too much to say that the experiment of

the present year may well grow into one of the most important departments of the Institute.

The Department has also received during the year, through the generosity of Mr. Arthur D. Little, funds for the temporary maintenance of a research assistantship in Organic Chemistry, the subject of the research to relate to the chemistry of cellulose. An appointment will be made as soon as a suitably equipped assistant can be found. This gift is specially significant because of the purpose which underlies it; namely, to promote the interests and progress of a particular line of industry by the endowment of research in a field of pure science upon which the industry depends. The results hoped for are twofold: first, contributions to the scientific knowledge of the subject, which, however, under the best of conditions may be uncertain of attainment; and, second, the development of a young man who will be well versed in the existing Chemistry relating to the industry in question, and therefore in a position to serve it with unusual intelligence if transferred to the technical field. Such endowed assistantships have been established at other institutions, but this is the first in the Department. It is hoped that it may serve to attract others, to the advantage of both the industries and the Institute.

As a further indication of an encouraging spirit of co-operation on the part of the chemical industries with the educational institutions, there should be noted an invitation extended to the Department by Messrs. Harrison Brothers and Company of Philadelphia to nominate one capable student each year to enter a summer course of Applied Chemistry which they have just established at their extensive works. The course is expected to extend through a portion of three summers, and a certificate will attest its successful completion. The opportunity is apparently an unusual one, and Mr. Howard E. Batsford of the Course in Chemical Engineering, who spent a portion of the past summer in attendance on this course, found the experience highly profitable. It is to be hoped that other concerns

in other branches of Chemistry may find it possible to admit students who are recommended as responsible to similar privileges. Such a procedure could hardly fail to result in greater efficiency on the part of the graduate, and in benefit to both the industrial and the educational interests.

The Department has received gifts during the year of a valuable set of samples of chemicals, together with a suitable case for their exhibition, from the General Chemical Company, and another set of samples from the Picher Lead Company. The equipment of the Laboratory of Technical Analysis has been increased by a complete outfit for the determination of tannin, and two valuable sets of pigments, gums, and oils from the John W. Masury Company of Cleveland. These sets of samples are all of great value in connection with our instruction, and the increasing number of such contributions emphasizes anew the need of a separate room for museum purposes.

The year has been one of progress and general prosperity, but visits recently made to the laboratories of other institutions bring out clearly the great desirability of closer association of the branches of the Department than is now possible, and the loss of common interest that the present distribution of the work among the separate buildings entails. Previous reports have emphasized this departmental need, and also that of more small laboratories for research and for specialized lines of work, but the urgency of these needs justifies their reiteration here.

H. P. TALBOT.

RESEARCH LABORATORY OF PHYSICAL CHEMISTRY.

The Research Laboratory has this year a staff of seven research associates and three research assistants, who are devoting themselves exclusively to research work. In addition, five graduate students are pursuing work for the Ph.D. degree and one for the S.M. degree. Some of these candidates, as well as three others who completed their experimental work

last year, will apply for the examination for the Ph.D. degree at the end of the present school year.

Four seminars, attended by the advanced students, the research workers, and instructors from other Departments, are being carried on in the Laboratory by Professor Noyes, Dr. Lewis, and Mr. Kraus. These are devoted to a discussion of Mathematics as applied to Physical Chemistry, of the physical properties of chemical substances, of radioactivity, and of current researches.

A series of twelve articles on the electrical conductivity of aqueous solutions, describing the investigations on this subject made during the last three years in the Laboratory, is in process of publication by the Carnegie Institution at Washington. A large part of a revised scheme of qualitative analysis for the common elements, which has been worked out during the past year by Professor A. A. Noyes and Dr. W. C. Bray, has just appeared in the September number of the *Technology Quarterly*. A number of articles have also been published by Dr. G. N. Lewis on the equilibrium and free energy of some especially important inorganic chemical reactions.

Upon the financial side the Laboratory has been again assisted by a grant of $1,000 from the William E. Hale Research Fund and by a renewal of the grant of $2,000 from the Carnegie Institution to Professor A. A. Noyes in aid of certain electrochemical investigations which are being carried on in the Laboratory. In addition, a grant of three hundred dollars has been made to one of the research workers, Mr. Richard C. Tolman, from the C. M. Warren Fund of the American Academy of Arts and Sciences, to enable him to construct what will probably be the most powerful centrifugal machine ever made for experimental purposes, to be used in connection with an investigation of the electromotive force produced at the two ends of a rapidly rotating solution of any ionized substance; and a separate grant of three hundred dollars from the Rumford Fund of the American Academy has been made to Professor A. A. Noyes, which is to be used for the construction of a

calorimeter adapted to direct thermochemical measurements with solutions at 100°. A gift has also been made to the Laboratory of a large diamond, valued at about three hundred and fifty dollars, by the Ansonia Brass and Copper Company. This is to be used in insulating the electrodes within the bomb used in the conductivity investigations of aqueous solutions at high temperatures. Finally, grateful acknowledgment should be made of the assistance rendered by Dr. W. D. Coolidge, now in the Research Laboratory of the General Electric Company, in connection with the development of the apparatus for the investigation of the properties of water and aqueous solutions in the neighborhood of the critical temperature.

The general equipment of the Laboratory has been increased by the installation of a sixty-cell storage battery for furnishing a constant electromotive force for experimental purposes and providing night power during the summer.

ARTHUR A. NOYES.

DEPARTMENT OF ELECTRICAL ENGINEERING.

The changes in the instructing staff are indicated in the appointments of Professors D. C. Jackson and G. C. Shaad, the former of whom comes in February, 1907, to be head of the Department, and in the resignation of Professor Puffer.

Professor Puffer graduated from the Institute in 1884, and has served as one of the corps of instructors continuously since that time. Much of the early successful development of the Dynamo Electric Laboratory was due to his initiative and devotion, and for the original layout of the new Augustus Lowell Laboratory he was largely responsible. His engineering experience has been broad and valuable and of real service in the work of instruction. He retires from the Institute in order to devote himself wholly to the practice of his profession.

Professor Jackson comes to us as an engineer of standing and with the prestige of having developed a successful department at the University of Wisconsin.

Professor Shaad is a graduate of Pennsylvania State College in the class of 1900. After spending two years at the works of the General Electric Company at Schenectady, he was called to the University of Wisconsin, where he has since been one of the staff of the Department of Electrical Engineering. He has already entered upon his duties here as Assistant Professor of Electrical Engineering, taking up the work formerly given by Professor Puffer.

The system of instruction which has been recently developed in the Dynamo Electric Laboratory, involving a preliminary report, the performing of the particular experiment, the presentation of a final report, and recitations upon the principles involved, together with their engineering applications, must be influenced in the degree of success attained by the character of the laboratory assistants. These assistants remain at the Institute as a rule not longer than one or two years, being drawn to enter engineering practice by the more immediate and certain recognition which such practice offers. While at the Institute, they are as a rule overworked, the routine of examination of problems, the keeping of apparatus in such condition that it may be used at its highest efficiency, with the actual work of instruction, occupying their entire time. It is regrettable that the Institute cannot hold out to such of these men as show exceptional capacity inducements in salary and rapidity of advancement which will permanently enlist their services, to the end that there may be in the laboratory a body of instructors possessing experience, in addition to enthusiasm.

At the present time none of the work given in the Department to students of Electrical Engineering is in the nature of a purely lecture course. Indeed, the amount of recitation work is being considerably increased from year to year, and these recitations are conducted by the Faculty members of the staff. This last is a point of great importance, since too often such work is intrusted to the young and inexperienced instructor. The system of recitations might well be extended to include students in other Courses taking work in this Department, although

such an extension would naturally necessitate an increase in the number of instructors.

The plan of having many of the problems formerly assigned as home work now solved under the supervision of an instructor is being gradually enlarged with most satisfactory results. The opportunity for helpful suggestions and the elimination of harmful student co-operation are both accomplishments of geniune importance in the proper training of the students.

A plan which has been under consideration for two years past is this year put into effect, namely, the preparation of the preliminary laboratory reports under direct departmental supervision, instead of at home as formerly. This has resulted in a marked improvement in the character of the reports in arrangement, conciseness, and clearness. It has done away with hasty preparation and undue collaboration.

The scope of the Journal Meetings has been extended, and a greater amount of time is now devoted to this feature, as well as to the excursions to engineering plants in Boston and vicinity.

The members of the Department are particularly generous in the granting of time for individual conference with students. In fact the tutorial system, which has been introduced at Princeton University, has been practically in operation in this Department during the past two years. The effect of this more intimate contact of student and instructor is shown in the marked improvement in the student attitude towards the regular work. Taken in conjunction with the present curriculum, it gives the students a valuable engineering perspective.

The special appropriation granted by the Executive Committee has been expended largely for alternating current machinery and measuring instruments. This has put the laboratory on a sound basis so far as this particular line of instruction is concerned. There should still be, however, a considerable supplement to the direct current apparatus, in view of the unusually large number of students in the junior year of this Department (an increase of 20 per cent. compared with a year ago) and the desirability of giving a systematic course

of instruction in the laboratory for students in non-electrical engineering departments. This last cannot properly be carried on with the present equipment.

The installation of distributing centres in the Dynamo Electric Laboratory during the past summer makes possible an improved arrangement of apparatus and tends to increased efficiency in its use. This result is also distinctly helped by the enlargement and rearrangement of the instrument room. The variation in voltage on both direct and alternating current service is a serious drawback to the highest grade of laboratory work, and it is a satisfaction to announce that in the immediate future a Tirrill regulator is to be installed for regulation of the alternating current voltage. For the most satisfactory direct current service one of the Westinghouse three-wire generator sets should be placed under the immediate control of this Department, and this with the proper regulator would insure constancy of the direct current voltage. This voltage fluctuation has not only influenced the character of the regular laboratory work, but seriously interfered with the work of investigation.

In the Standardizing Laboratory the past year has resulted in a general development of the apparatus and the bringing of it to a higher state of efficiency. The publication of a pamphlet of eighty-six pages of laboratory notes has aided the systematization of the work. It is to be remarked that these notes have been planned to give general discussions of the various topics treated rather than specific directions for performing the experiments.

The demands on the laboratory for assistance in carrying out the various pieces of thesis work have continued, and, as in the past, the laboratory has proved of service to other departments of the Institute. During the year the development has been much facilitated by the employment of an additional assistant, who devotes his entire time to this special work.

A room has been set apart as a high potential laboratory and is devoted at present to the study of insulation and insulat-

ing materials. The equipment includes a 15 K.W. transformer giving 100,000 volts, together with the necessary controlling and safety devices; apparatus for testing samples of insulating material both for dielectric strength and insulation resistance; and for testing insulation of cables at various temperatures. Various measuring devices which experience has shown to be necessary are in process of development.

The division of Room 28 so that a portion is given to the assistants for office room is a distinct improvement, and adds notably to their comfort and to the efficiency with which their work may be carried on. The other horn of the dilemma is an insufficient office accommodation for the Faculty members of the Department. The lack of proper recitation-rooms still continues. It is frequently desirable to arrange a meeting for ten or twenty students at some time other than at one of the regular scheduled exercises, and this cannot be successfully carried out for want of a suitable room. More important still is the frequent impossibility of securing a proper room for the giving of experimental illustration in the regular lectures. The Lowell Building is being used more and more for work in other departments than Modern Languages, Chemistry, and Electrical Engineering. This encroachment is a serious drawback to the proper carrying out of the work of this Department.

The need of a storage battery is still felt. During the past year certain work of investigation has been given up from the lack of facilities which this particular apparatus would insure.

There have been various gifts of apparatus and samples of manufactured products by the electrical manufacturing companies. If these gifts could be properly arranged in a suitable room, they would prove especially helpful to the students in connection with their engineering work.

The annual excursion of the senior students last March largely exceeded in numbers and in interest any of those which have preceded it. This excursion in the senior year is most helpful, coming as it does when the students are keen to ap-

preciate the engineering importance as well as the scientific principles of the various types of apparatus and their commercial use.

H. E. CLIFFORD.

DEPARTMENT OF BIOLOGY.

A small but gratifying increase in the number of students is the most interesting feature of the opening of the new year. Particularly noteworthy is the increase in the number of graduate and undergraduate students devoting themselves to public health subjects or to the biological side of Sanitary Engineering. Recent developments in public, and especially municipal, sanitation show that the Institute has made no mistake in fostering studies and equipping young men for practical work in these directions, for an examination of the positions held by our graduates and other former students of Biology and Sanitary Engineering reveals the fact that some of the most important positions, and many of those having to do with the newer developments of water purification and sewage disposal, are held by our men.

In the hope of saving, if possible, the subjects of Physiology and Hygiene in the secondary schools, from which they have nearly been driven out, largely, as it is thought, by the misdirected zeal of those who have sought to use them as a means of promoting the so-called "temperance-physiology" movement, Professor Sedgwick and Professor Hough (the latter now Head of the Department of Biology in Simmons College and Professor-elect of Physiology in the University of Virginia, but for ten years and until lately attached to the staff of the Biological Department of the Institute) have for several years devoted some of their vacation time to the preparation of a text-book, which, while telling the truth about alcohol, should still be a rational and thoroughly scientific guide to the conduct of the physical life. This volume has lately been issued, and is believed by the authors to constitute an important contribution both to

general education and to the hygienic and sanitary information of the general public.

In July Professor Sedgwick was called to the Pacific coast to deal with a novel problem in municipal sanitation, namely, the question of the possible pollution of the public water supply of the city of Seattle by the construction, maintenance, and operation of a transcontinental line of railway which, in seeking entrance to the city, purposes to run for eleven miles alongside a mountain stream used, without purification, as the city water supply. He was afterward appointed one of three Commissioners to pass upon the possibility of safeguarding this water supply, and the opportunity thus given for the study of a wholly new problem in public hygiene proved unusual and important. In recognition of the useful sanitary work of the officers, graduates, and former students of the Department, Professor Sedgwick was in January of the current year made president of the New England Water Works Association, an organization of more than six hundred members, most of whom are actually engaged in the maintenance and operation of water works in New England. A large number of these same former students and graduates united during the year in the preparation and publication of a handsome volume containing nineteen original papers upon biological subjects dedicated to the head of the Department, to whom also a complimentary dinner was given by them on June 14th, on the occasion of the presentation of this volume. Both volume and dinner were tendered in celebration of the twenty-fifth anniversary of Professor Sedgwick's taking the degree of Doctor of Philosophy at Johns Hopkins University. The recipient, to whom these events were a complete surprise, desires to place on record his high appreciation of both testimonials, and especially of the expressions of interest and attachment which accompanied them.

In connection with the meeting of the American Medical Association early in June, and again during that of the American Water Works Association early in July, an extensive exhibit was made of the methods and results of sanitary instruction and

investigation in the various Departments of the Institute. The labor of installing and supervising this exhibit fell chiefly upon Assistant Professor Winslow, to whom much credit is due for its marked success. The cost of the exhibit was met by the generous contributions of a number of friends of the Department whom the head of the Department would be glad to name if he felt free to do so, and to all of whom he desires to express his heartfelt thanks.

A number of special students working together in the Research Laboratory of the Department, under the direction of Assistant Professor Winslow, have accomplished an important and elaborate piece of original investigation on the systematic relations of the bacteria of the family Coccaceæ. This work has not only cleared up the relationship of this group of organisms (which, besides some occurring in air, earth, or sewage, includes forms ordinarily causing blood poisoning), but also opens up a promising method of approach to some of the fundamental problems of variation and heredity. Professor Winslow has also given this autumn for the first time a brief course of lectures in Industrial Hygiene to students in the Heating and Ventilation option of the Course in Mechanical Engineering. It is desirable that some such instruction in the laws of health and disease, particularly as these relate to the sanitary construction and operation of industrial establishments, should be attended by more of the students of the Institute, and the Biological Department is now prepared to give such courses adapted to the specific needs of any Department.

Assistant Professor Prescott was called upon during the summer by the Charles River Basin Commissioners to make an investigation of certain alleged unsanitary conditions existing in connection with the Stony Brook conduit. These investigations he has completed, and the results have been reported to the Commissioners. It is expected that his report may soon be made public. Professor Prescott's private laboratory (the Boston Bio-Chemical Laboratory) continues to be useful not

only to the public at large, but as a model and an example for our students of Industrial and Sanitary Biology.

Dr. Stiles, Instructor in Physiology and Personal Hygiene, gave an elective course of fifteen lectures on Personal Hygiene in the spring term, with an attendance of ten students, largely from the fourth year, and representing different departments. There can be no question of the usefulness of such a course to young men about to scatter to all parts of the globe, many of them to encounter in their professional work unsanitary conditions which may easily wreck their whole careers; and sooner or later I hope to see such lectures attended by all our more advanced workers.

The Sanitary Research Laboratory and Sewage Experiment Station, affiliated as it is with this Department, has constantly proved of the highest service to students of Biology, and it is greatly to be desired that it shall become a permanent part of the Institute equipment, since it furnishes facilities altogether unique and well-nigh indispensable for students of Sanitary Biology, Municipal Sanitation, and Sanitary Science, not to mention those in Sanitary Engineering and Sanitary Chemistry.

Evidence of the continued activity of the Department in research and publication will be found in the list of publications beyond.

W. T. SEDGWICK.

SANITARY RESEARCH LABORATORY AND SEWAGE EXPERIMENT STATION.

By the continued generosity of the donor, who still prefers to remain anonymous, and who has made a further contribution of five thousand dollars for the purpose, the work of the Sewage Experiment Station has been continued successfully, and it is believed usefully, along the lines laid down in previous years. The experiments carried out in 1903–05 indicated that the trickling filter would probably offer the most economical method of purifying the sewage of such a large city as Boston. A large

outdoor filter of this type was therefore built at considerable expense in the summer of 1905, and its working has been studied continuously since that time under varying conditions and in combination with various subsidiary treatments in septic tanks and sedimentation basins. A new method of gravity distribution has been devised for spreading the sewage over the surface of the filter, and an elaborate series of investigations is being carried out, with specially designed apparatus, on the comparative efficiency of various English and American types of trickling-filter distributors. Mr. Phelps has made a study of the use of chlorine and other disinfectants for the bacterial purification of trickling-filter effluents. His work is now in press, and promises important practical results.

The results of the 1903–05 experiments, together with an historical survey of the sewage problem, the development of the art of sewage treatment, and the present status of the problem in various countries, has been published by Professor Winslow and Mr. Phelps in an edition of eight thousand copies by the United States Geological Survey, as "Water-supply and Irrigation Paper No. 185." This report constitutes Volume II. of "Contributions from the Sanitary Research Laboratory and Sewage Experiment Station," and a collection of eleven original papers on sewage and water problems by Messrs. Sedgwick, Winslow, and Phelps has been reprinted as Volume III.

An important extension of the work of the Station has also been carried out under a co-operative arrangement with the Hydrographic Branch of the United States Geological Survey. Mr. Phelps has worked out the principles of a practical method for the economical treatment of the waste from strawboard (paper) mills, and is now studying the problem of the utilization of sulphite (wood) pulp liquors. He is also carrying out investigations on the sewage pollution of Chesapeake Bay in relation to the oyster industry, and on the disinfection of the effluents from certain sewage plants in New Jersey. Professor Winslow is engaged in a study of the bacterial flora of normal waters in various parts of the country, in connection,

like the above-mentioned investigations, with the work of the Geological Survey, and also on an investigation of the micro-organisms in sewer air for a committee of the National Plumbers' Association.

We are now confronted, however, with the fact that our present facilities are both temporary and limited. We are wholly dependent on the financial support of our anonymous donor, who, single-handed, is supporting our work by annual donations with no promise of permanency. Our buildings—converted to our uses from an old livery stable—are of wood, and rapidly falling into decay. Our location, though central and convenient, has certain disadvantages of which we are frequently reminded. We need a better situation, more remote and carefully selected, but our first and greatest need is for suitable buildings. If in the past we have achieved some degree of success, it has been only at the expense of much anxious thought and effort to get along with what facilities we have had. As the work has become more advanced and specialized year by year, the inadequacy of the present equipment has become more and more apparent.

We may, it is true, continue where and as we are for many years to come, offering to students an opportunity for elementary research and contributing somewhat to the advancement of knowledge in sanitation; but, if we are to maintain the course which we have hitherto followed, keeping abreast of the best work in all countries and oft-times leading in new lines of development, an entirely new equipment is essential. Instead of the present converted stable we need a new filter-house, preferably of concrete or brick, with concrete tanks for experiments upon the treatment of sewage along the present lines. In addition, we need proper equipment for the thorough study of sewage hydraulics, flow and discharge measurements, sedimentation, and many other sanitary engineering features which we are now unable to investigate, and which, so far as I am aware, are not now subjects of practical investigation in any engineering school.

The same may be said of the pumping of sewage, and its control by gates and automatic discharge regulators, and of the pumping, pressing, and handling of sludge. These matters are of the utmost importance to every sewage disposal works; they are totally separate and distinct from the corresponding subjects relating to the treatment of water; and they should all be subjects of actual demonstration, experiment, and investigation in a properly equipped sewage experiment station.

In addition to these things we should possess a collection of all kinds of machinery and devices for the handling of sewage, such as gates of various types, sluice-gates, tide-water gates, screens, catch basins, etc., and working drawings of the best examples of pumping machinery and the more elaborate elements of a complete sewerage system. We might also to good advantage add to all this examples of modern plumbing, including sink traps, grease traps, and vents. Professor Winslow is now planning what promises to be a valuable study of the germ contents of "sewer gas." Such investigations as this are well within our field, and the testing of improved plumbing devices is certainly a matter worthy of our attention.

"Unique" seems to be the best term to apply to the whole project, and the Institute from its inception has always been noted for this characteristic. Engineering and other schools, some of them with great resources, are in many parts of the country following the lead of the Institute and equipping and maintaining laboratories of mechanical, electrical, and hydraulic engineering which rival our own great and costly laboratories in these departments. But a sewage experiment station and a practical sewage laboratory, equipped with the best of everything in which the sewage expert is interested, with facilities for mechanical, hydraulic, chemical, and bacteriological investigations going on side by side, and with a working exhibit of sewage-handling machinery, plumbing, gas and water fitting, and possibly, in the future, of ventilating devices and working models of garbage incinerators and smoke consumers,—all this would certainly make a station unique the

world over, and would put us well in advance in the teaching of sanitary science.

The cost of installing such a plant would be considerable, but the cost of maintenance need not necessarily exceed our present annual sum of $5,000, although much more could be spent to advantage.

We desire once more to express publicly to the donor our gratitude for the opportunities afforded to numerous investigators and students by the continued existence of the Sanitary Research Laboratory and Sewage Experiment Station.

W. T. SEDGWICK, *Director.*

DEPARTMENT OF PHYSICS.

There have been during the past year no material changes in the work of this Department which call for special mention. There has been a gradual increase in the amount of special instruction given in the laboratories, and it is believed that the grade of the work done in all the courses of instruction has been bettered.

An improvement was manifested in the results of the last entrance examinations in Elementary Physics. But few schools are still unable to give preparation in laboratory work, only a single school among those sending many pupils to us being in this category. It is hoped that it may shortly be possible to make the requirement in this subject an absolute one.

Difficulty has been and is still experienced in both lecture-rooms and laboratories from lack of sufficient accommodation for the large classes which we have to care for. In the lectures upon Heat in the present third year the number of students registered was larger than could be seated in the lecture-room, so great was the unexpected influx of students from other colleges entering in advance.

The extensive repairs made during the past summer will make the work of the coming year in many respects easier, and

the provision of more abundant case-room for our apparatus makes it possible to give more adequate care to its preservation in good order.

Much new apparatus of a general character has been added by purchase.

Also the Department has received a gift of a tuning-fork chronograph from Mr. R. F. Gaylord of Newton Centre. This instrument is of wide range, and is especially adapted to the accurate measurement of very short intervals of time. A complete quadruplex telegraph has likewise been presented to us.

The equipment of apparatus in the Laboratory of General Physics has been increased in the direction of our established policy of providing the best and most modern apparatus for the use of students. Among the larger accessions may be mentioned a new combination comparator and dividing engine made by Gaertner, with accessories for graduating circles, and a new standard photometer from Hartmann and Braun, with complete accessories for testing gas, incandescent, and arc lights.

As a result of the introduction of class-room instruction in the Precision of Measurements in connection with the laboratory work, referred to in the last President's Report, it has been found possible very materially to raise the standard of this work as regards the interpretation and discussion of results. The importance attached to this at the Institute seems to be unusual, judging from the laboratory records submitted by graduate students entering from other colleges; for it is only in exceptional cases that anything approximating the equivalent of the grade of work required of our students is presented. The interest which the students take in matters pertaining to abbreviated methods of computation, etc., is attested by the large attendance at Professor's Derr's elective course on Calculating Machines.

It has been found practicable to institute another change during the past year to the distinct advantage of the students in the Courses in Chemistry, Electrical Engineering, and Physics,

and that is to arrange their laboratory work in Heat in the third year concurrently with the lectures on that subject. It is hoped that a like change may be made in the schedules of other Courses.

In the Electrochemical Laboratory it has not been found necessary to make any large additions to the already existing plant. The students' equipment for electrochemical measurements has been increased, however, by the importation of a number of fine Hartmann and Braun resistance boxes, so that now each student is provided with his own. It is a matter of congratulation, in view of the very high price of platinum now existing, that sufficient platinum apparatus for all immediate needs of the laboratory was provided at the time of the establishment of the laboratory.

One of the research rooms has also been fitted with a thermostat and standard apparatus for the measurement of electrical conductivity of solutions and voltaic potentials, in order to facilitate investigations involving the measurement of these quantities. Among investigations completed or at present in progress may be mentioned the following, carried on by Professor Goodwin and Dr. Thompson: the free energy of hydriodic acid, the electromotive force of voltaic cells composed of fused salts, the melting point of refractory oxides, and investigation on "dropping electrodes."

For the Electrical Laboratory there has been purchased a large influence machine for the study of cathode rays and the use of Braun's tube.

To the equipment of the Optical Laboratory several important instruments have been added, the chief of which is a complete apparatus for microscopic photography, from the Zeiss Company, including objectives and eye-pieces of the best quality, giving an outfit suitable for photo-micrographic work of the highest grade. There will shortly arrive from the same makers their new apparatus for micro-photography by the use of ultra-violet light with which such surprising results have been obtained in the study of extremely minute objects. A

portable D'Arsonval galvanometer, a Hefner standard lamp, and several incandescent lamps of the newer types have also been procured.

For the Laboratory of Heat Measurements a special appropriation was made a year since. Much of this has been expended in the purchase of thermometers, pyrometers, including a recording pyrometer, platinum utensils, electric motors and rheostats, and for the construction of various instruments.

The equipment of the laboratory in apparatus for the measurement of very high and very low temperatures is exceptionally complete. For use in connection with precise thermometry at ordinary temperatures a standard gas thermometer is now under construction. For the determination of the heat of combustion of liquid, gaseous, and solid fuels the laboratory contains all the usual standard apparatus and much special apparatus as well. Several steel combustion bombs which are now approaching completion will furnish ample facilities to the students making tests of fuel in connection with research and thesis work, without interfering with regular class work.

An apparatus for the measurement on a large scale of the thermal conductivity of insulating materials, such as firebrick walls for boiler settings, etc., has been completed during the last term. This is to a great degree the result of thesis work of the students.

Apparatus for the production of liquid hydrogen is under way. In view of the large quantities of liquid air which are available from the Department of Mechanical Engineering, it is hoped that, when completed, it may prove very useful.

CHARLES R. CROSS.

DEPARTMENT OF GEOLOGY.

In 1906–07 the revised geological requirements of the mining schedule first take full effect. Instruction in field methods was this year given to thirty-three second-year and

thirty-four third-year students of Course III. Twenty-four fourth-year men are engaged in independent geological surveys. Of these thirteen are candidates for S.B. in the geological option of the mining Course, and one is a candidate in Course XII. The new microscopes of the petrographical laboratory are in use to the limit of their capacity, and two special students have been denied admission to the course in petrography because of lack of apparatus. The demand for men with practical training in the field and laboratory methods of topographer and geologist is constantly enforced by mining engineers, alumni of the school, and the students reflect this demand, showing keen interest and enthusiasm in their geological studies. In 1906 ten students of Course III. presented graduation theses in Geology. Two students are candidates for graduation in Course XII. in 1907. M. W. Hayward, S.B. (M. I. T. Course III., Option 1, 1906), holds an Austin Fellowship and is a candidate in Geology for a second bachelor's degree.

The total number of students enrolled in geological courses in 1892 was 290; in 1894, 367; in 1895, 399. Since 1900 the figures have been as follows:—

1900	439	1903	750
1901	501	1904	746
1902	598	1905	708
1906	823		

In 1906 there were more than three times as many students enrolled in geological courses as in 1890, when the Course in Geology was first established.

The development of Geology at the Institute shown by the foregoing statement has been occasioned principally by the service rendered to the Departments of Mining and Civil Engineering. Almost all students in Mining now receive instruction in Geology in their second, third, and fourth years; students in Civil Engineering receive such instruction in the second and third years. In these two Courses in 1905–06 were enrolled nearly half the regular students of the school for the three professional years. Furthermore, from one-third

to one-half of the graduating class in Mining now elects the geological Option and presents graduation theses in Geology. By direct comparison it is found that the total number of enrolments in geological studies (823) is not far short of the total in such elementary departments as Mathematics and Chemistry for all classes above the first year, and is greater than the total for the professional departments. It should be pointed out, therefore, that the limited space occupied by the Department of Geology (7 rooms) and the small size of the teaching force (7) are out of all proportion to those of other field and laboratory departments which give equivalent, or less, instruction, as measured in units of enrolment. Field work is believed to be the first essential of good teaching in Geology, and here the lack of experienced instructors is most pronounced. The advanced field courses are at present all guided by one professor, and it is impossible to give adequate personal attention to large classes working singly or in pairs over wide areas of rocky country. The professor's work is supplemented by that of one instructor and an assistant, who render efficient service. The nature of the subject, however, calls for extended professional experience. Three or more men of the grade of instructor might well be employed to give their whole time to the courses in Geological Surveying.

The rooms of the Department are now crowded to the limit of their capacity. The library contains three partitioned offices, desks for five officers, the book stacks and map cases, and the entire fossil collection, and is also used as a class-room. The geological lecture-room is in great demand for large classes other than Geology. In 1905–06 the requirements of of the tabular view at one time forced the course in General Geology to meet each week in three different rooms. The most pressing need is for space wherein the teachers of the Department may arrange their private collections, carry on research, and have a certain amount of privacy for their professional work. There is at present no place where this can be done. It is in the interest of the Institute that suitable laboratories be

provided for such advanced work, for in almost all cases the work may be shared by advanced students.

The opportunities for productive research in Physical Geology are nowhere greater than in a well-equipped technical school. The remarkable series of disasters in the last two decades due to earthquakes, flood-waves, and volcanoes marks the inadequacy and helplessness of earth science and its need of investigation on the practical side. The time is ripe for the establishment of research laboratories of Physical Geology devoted to experimentation and exploration-measurement of earth movements and prompt investigation in time of emergency with a view to forewarning and protection in the future. The engineering and physical laboratories can effectively co-operate in such investigations. Five thousand dollars a year for ten years at the Massachusetts Institute of Technology would establish and maintain such a laboratory, and in that time the published results ought to produce a permanent endowment. There is no field of science likely to yield a richer harvest of beneficent results. The Earthquake Investigation Committee of Japan has set an example which should be followed among all nations, and in this field alone there is an extraordinary opportunity for private endowment.

The work of Professor Crosby has been so arranged that his courses in Economic Geology are given on the intensive system; *i.e.*, in the last eight weeks of the first term and the first eight weeks of the second term. This works to the advantage of both professor and students. The former is at liberty to give a large amount of time to professional practice away from the school; and the latter are enabled to devote whole days to their Geological Surveying in the early autumn and late spring.

Professor Crosby is Consulting Geologist to the Board of Water Supply of New York City; and in that capacity he was able during the spring and early summer to make detailed geologic studies of several exceptionally interesting areas in the valley of the Hudson.

At the end of July, Professor Crosby went to Alaska and devoted two months to studying the ore-deposits and general economic Geology of Prince William Sound, Prince of Wales Island, and the Juneau District; and this was followed by six weeks of similar work in the Rocky Mountain region, including Montana, Idaho, and Utah.

All of this work has resulted in desirable additions to the economic geologic collections of the Institute; and a part of it will be published during the year.

Professor Warren, by resigning to Dr. Loughlin much of the instruction in Petrography, is able to give more time to Mineralogy. The class in Mineralogy for two years has been divided as follows:—

	Mining.	Chemistry.	Scattering.
1905–06	37	19	2
1906–07	40	12	2

It is to be regretted that students in Chemical Engineering, Course X., are not required to take Mineralogy. All students of Chemistry, moreover, would profit by a short course in General Geology. It is possible that such a course might profitably be introduced into the first year for a still larger group of students. Professor Warren, during the year, gave a course of fifteen lectures in Geometrical and Physical Crystallography for members of the Research Laboratory of Physical Chemistry. The mineral and rock collections have been much improved by additions, rearrangements, and by the preparation of new microscopic thin sections. Additions to the general laboratory equipment have been a Liebisch refractometer attachment to be used with the Fuess goniometer, for measuring the refractive indices of crystal plates; and a powerful electro-magnet designed by Professor Warren for use in studying the behavior of mineral grains in very intense magnetic fields. Professor Warren has developed a method for studying black sands and other rock powders in work done for the United States Geological Survey. This will be published, under the title "The Mineralogical Examination of

Sands," in the December number of the *Technology Quarterly*. A second article, which will appear in the *American Journal of Science* and the *Zeitschrift für Krystallographie*, describes a new mineral, Yttrocrasite, and is published in collaboration with Mr. W. E. Hidden. Professor Warren calls attention to a difficulty in the way of bringing to completion research in physical and chemical Mineralogy, in spite of the splendid facilities for such work which abound at the Institute. This difficulty is "lack of time, not arising from excessive hours of teaching, but from the fact that spare hours have of absolute necessity to be devoted, when the chance comes, to earning by any kind of professional drudgery enough money to make up the difference between the bare cost of living and an Institute salary." The writer believes this point is well taken, and that the junior professors and instructors at the Institute receive salaries incommensurate with their services. The mineralogical and petrographical laboratories are in great need of five hundred dollars wherewith to add to their equipment a large research microscope and a platinum resistance furnace for high temperature work.

To the Hon. George G. Crocker the Department is gratefully indebted for raising by subscription seven hundred dollars, of which five hundred dollars was used for an expedition in the far West and the remainder for the purchase of an apparatus for opaque projection. The subscribers other than Mr. Crocker were Messrs. Thomas L. Livermore, Charles A. Hopkins, Edgar Van Etten, James M. Prendergast, Galen L. Stone, and Dr. George G. Kennedy. Mr. W. F. Jones of the Class of 1909 has given the Department a valuable collection of fifteen hundred species of modern shells in a suitable walnut cabinet,—a useful adjunct to the fossil collections.

The expedition above referred to, planned and carried out in the summer of 1906 by Professor Johnson, received further support from the Austin Fund and from Harvard University. Special geologic and physiographic problems were investigated in the course of an extended wagon trip through New Mexico,

Arizona, and Utah. Dr. Shimer was a member of the party. Valuable collections were made, and a number of points of geologic interest discovered. Lantern slides of the characteristic topographic and geologic features of the region traversed will form an important addition to the teaching collections of the Department. A detailed report of the expedition will be found in the December number of the *Technology Quarterly*, while special reports on the various problems studied will be published later. While in the Southwest, Professor Johnson made an investigation of the underground water resources along a portion of the Atchison, Topeka, and Santa Fé Railway System, for which company he has acted as consulting geologist during the past year. He spent a portion of the mid-year vacation in New Brunswick, reporting on magnetite properties for a Canadian company. Before leaving for the summer, he completed the editing of a volume of geographical essays by Professor W. M. Davis, which will appear in book form in the near future. He has also been engaged in the revision of state articles (U.S.A.) for a forthcoming edition of the *Encyclopædia Britannica*. Last year Professor Johnson received a grant from the Austin Fund for work on drainage-modifications in northeastern Georgia. His report on this work, which is now in press, was awarded second prize in the Walker Memorial Prize Competition. The first prize was also awarded to an Institute man, a graduate and former teacher of the Department, Professor A. W. Grabau of Columbia University.

In June, 1906, Professor Jaggar resigned his position in Harvard University with a view to confining his teaching hereafter wholly to the Institute. This was made necessary in part by Dr. Johnson's appointment as Assistant Professor of Physiography at Harvard. Dr. Johnson gives up all connection with courses in Economic, Structural, and Field Geology at the Institute, while continuing to give instruction in Topographic Geology. Professor Jaggar completed during the year his share in the text and maps of the geologic folio of the Spearfish-Sturgis district of South Dakota. This is a

part of the Geologic Atlas of the United States, published by the United States Geological Survey. The work has occupied him for some years, and deals with the structural geology of the mining district of the northern Black Hills. In February, 1906, by invitation of the Education Committee of the Twentieth Century Club, he gave four public lectures in the Colonial Theatre, Boston, on "The Earth as a Living Organism." In April, on the occasion of the eruption of Vesuvius, he was granted leave of absence to visit the scene of the disaster and make notes and collections. This excursion was made possible by the generosity of Mr. Alexander Agassiz, who assumed the entire expense.

Dr. Shimer reports gifts of small collections of fossils from present or former students of the Institute. These were from Nova Scotia, Massachusetts, New York, North Dakota, and Arizona. In the Arizona-Utah expedition, Dr. Shimer secured valuable collections for his course on "Index Fossils," and also rock specimens, especially lava, photographs, and sketches which will be useful for the courses in Structural Geology and Lithology. In 1907 Dr. Shimer will have full charge of these courses, formerly given jointly with Professor Johnson. The course on Index Fossils has been expanded and is now required in the 3rd Option, Course III. The election of this work in Palæontology has shown a marked growth in the last four years, as follows:—

NUMBER OF STUDENTS TAKING INDEX FOSSILS.

1902–03	3 (prescribed)
1903–04	4 (1 elective, 3 prescribed)
1904–05	4 (3 elective, 1 prescribed)
1905–06	8 (wholly elective)

The completion of Part I. of Grabau and Shimer's "Index Fossils of North America" gives to geologists the first instalment of a long-needed and very useful work, involving great labor on the part of the authors.

Dr. Gerald F. Loughlin returns this year to the Department to take charge of the elementary courses in Petrography and

Economic Geology. Dr. Loughlin in 1906 completed a thesis at Yale University entitled "Contribution to the Geology of Eastern Connecticut" for the degree of Doctor of Philosophy. With Professor Barrell of Yale he is writing a bulletin for the State Geological Survey of Connecticut on the type rocks of Connecticut. He spent the summer in gathering sets of rocks to be used for distribution among schools of the state. He has further accepted the position of reviewer of foreign bibliography for the journal *Economic Geology*.

A. K. Adams, Assistant in Geology in 1905–06, was called by the United States Geological Survey in the spring to assist Mr. Diller in southern Oregon. He has since been appointed Professor of Geology in the New Mexico School of Mines. F. R. Ingalsbe was to succeed him at the Institute, but he in turn received appointment as instructor in Lehigh University. W. G. de Steiguer of the same class has been appointed Assistant in Geology.

Miss M. Hodgkins, recently appointed Librarian of the Department of Geology, reports that there are over three thousand volumes in the Geological Library and one-third of these are in pamphlet form. Of the United States Geological Survey publications and various State Survey bulletins there are now three hundred unbound. Many of these are used very frequently, and are becoming mutilated and worn. New bookcases built during the past summer have made it possible to arrange the books on the shelves with space enough for the probable accessions of two or three years at least; the maps and charts, probably between one thousand and fifteen hundred in number, are being labelled for convenience in quick identification, and the book catalogue of maps is being transferred to a card system for greater convenience in use.

The need of a larger instructing force for the teaching of Field Geology has been mentioned above. Another need, of like importance, is for money to pay the expenses of instructors whereby they may conduct summer schools of Geology and Mineralogy. These should take the form of extended trips to

localities of interest to students of Mining. All the teachers of the Department are unanimous in the belief that summer expeditions are of the utmost importance to broaden the students' experience, open new lines of study and investigation, supply the laboratories with fresh material, and suggest thesis or research work. The expense of travel is so great that our students ought not to be required to pay fees in addition. If a few scholarships could be provided, it would be well to *require* a summer course of six weeks' duration for students of Geology or the geological option in Mining. A good camping outfit of tents, mess chests, stove, wagons, and stock, in some favorable locality of the West such as the Black Hills, would be an invaluable gift to the Department of Geology.

Two other extensions of our teaching are desirable,—both would be natural outgrowths of the proposed research laboratory of Physical Geology. A technical school should offer courses in Climatology and in Oceanography with special reference to their bearing on engineering. Both subjects are of importance to students of Civil and Sanitary Engineering and Naval Architecture, and are related to Geology, Chemistry, and Biology. No great expense would be necessary in order to establish such courses, and, even if they were made elective, there would be resort to them at present by special and five-year students.

T. A. JAGGAR, JR.

DEPARTMENT OF NAVAL ARCHITECTURE.

The regular Course in Naval Architecture this year has the advantage of changes which were rendered possible by advanced requirements for admission, which demand preparation both in French and in German. The additional time assigned to professional work was applied to strengthening instruction in Ship-construction and to increasing the time given to Ship-design. The number of lectures in Ship-construction has been doubled, and is distributed so as to co-ordinate with the Ship-

design. Also courses have been added in Ventilation and Drainage and in Applied Chemistry, the latter dealing with the chemical composition of certain materials which are used in ship-building, with the nature and causes of corrosion of framing and plating, and with methods for checking corrosion and fouling.

In connection with the development of the courses of lectures on Ship-construction a large number of valuable lantern slides has been made, and our collection will be increased as opportunity allows.

There is now in process of construction for the Department a series of wooden models of ship-framing that promise to be of great importance in teaching Ship-construction; some are already completed, and others will be made by the model-making instructor. The models are about a quarter size, are easily handled by the lecturer and by students, and show at a glance many things that must be described at length, and perhaps not quite understood until the student has opportunity to see such construction in ships.

The Course for Naval Constructors has now become well established. There have been but few recent changes, and those were made to take advantage of improvements in the Department of Electrical Engineering, and have made possible a better co-ordination of the theoretical and laboratory work in that important branch of the profession.

The advantage which students in the Department have realized from making models of ships of their own design has been so evident that a tentative effort will be made this year to include that subject in the list of required exercises, the time being taken from the assignment to Ship-design. When opportunity comes, the attention given to this subject will be increased. It has long been considered that this work could be made more efficient if it could be done in Engineering Building C, where it could be more directly under the supervision of the regular instructors of the Department, and where students could more readily use extra time if so disposed. For this purpose

some of the benches for model making will be brought to the drawing-room from the shop on Garrison Street, leaving the tools for preparing stock and the painting and varnishing at that location as heretofore.

Up to the present time the entire expense of equipping the model shop, of supplying material and furnishing instruction, has been met by a friend of the Department, and now it is desirable to consider the question of providing permanently for this work. Arrangements have been made for this present year only to take the entire time of the man who has given instruction in the model shop, for the eight months of the school year. In addition to the instruction of students he will be able to make some ship models desired for illustration, to finish others ready for placing on our walls, and to do other work for the Department.

Attention was called last year to certain glass-topped tables that were given to the Department just in time for the mould-loft work of 1905: these tables were thoroughly tested last June, and have fulfilled every expectation and are believed to be superior for our purposes to tables made in a similar manner of marble, and used both in this country and abroad. Nearly the whole of the present fourth-year class took our course of instruction in mould-loft work last June, and a large portion of them made a model in our model shop in the same month.

The attention of the Chief Constructor of the Navy having been called to our model work in 1903, he decided to order the constructors of the junior class to take instruction at the end of the year before taking up their summer excursions to steel works, electric works, etc.; afterwards by their own request the senior class of constructors have taken our instruction in mould-loft work, though the Bureau of Construction and Repair has abundant facility in the mould lofts of the Navy Yards for such work.

For two consecutive years, through the kindness of a friend of the Institute, lectures have been given every fortnight by eminent specialists in Naval Architecture, Shipbuilding, Marine

Engineering, and allied subjects, and this year an unusually interesting series of lectures has been arranged. Some of the lectures which are of more general interest will be given by speakers engaged for this course, before the Society of Arts, arrangements being made for students to hear the lectures.

Thus far attention has been directed to changes and improvements in matters that are considered to be practical, in contradistinction to the theoretical instruction of the Course. Such emphasis is natural at this time, because the means and opportunity for such improvements have come more recently. On the other hand the theoretical instruction has been in process of development for about fifteen years, and recent improvements are of the nature of increased efficiency due to increased experiences or by the better correlation of theoretical instruction and the application of principles thus taught as the practical side is developed and extended. This improvement, though no less solid, is less easily explained, if indeed it may not be left to be inferred for any live course of instruction.

Some years ago there was a sudden increase in shipbuilding activity in this country, with the expansion or new installation of shipyards, and with this a large demand for men properly educated in Naval Architecture. Though the Course in Naval Architecture had a large corresponding growth, practically all our graduates from that Department who desired had good opportunities in their profession. With the more recent stagnation in shipbuilding, many of these men have found better opportunities in general engineering, and in consequence of the active demand for graduates of engineering schools many of our recent graduates have passed at once on graduation into general engineering; and yet there have been from time to time numerous applications for men to take up work in shipbuilding or related industries, for which the Department frequently could not make provision. As the revival of shipbuilding has already begun, there seems to be no reason why students who desire to take the Course in Naval Architecture should hesitate to do so.

Last spring the head of the Department was given leave of absence for the purpose of visiting colleges where Naval Architecture is taught, and to see experimental model stations and navy yards and shipyards. A report at some length has been rendered of this visit, which need not be further referred to, unless it be said that, while each college visited was found to have certain admirable features, and while advantages will be taken of suggestions from courses at these colleges to improve our own course, it is but fair to say that the Institute course need not fear comparison with any of them.

Attention has been called from time to time to the fact that the library of the Department of Naval Architecture is inconveniently housed and that its capacity will soon be overtaxed; and also that there is not proper facility for storing and caring for certain instruments and apparatus and models belonging to the Department.

This need will be emphasized when the ship-framing models begin to accumulate, and it is hoped that provision may be made before long.

During the visit abroad, already mentioned, it was found that experimental model stations, or towing tanks, are increasing both in number and in use, and that experience shows two things, first that a tank belonging to a governmental department or to a private shipyard is likely to be fully employed on its regular work, leaving little opportunity for making experiments for outside parties. At the same time there is much theoretical work that could be done at a tank where attention could be given to that side of the subject; such a tank would probably have enough work for private persons to keep in touch with the practical side of the work. Such a tank is now in operation at the University of Michigan, and there are reasons why it would be very desirable to have a tank at the Institute, which has been a pioneer in teaching Naval Architecture and in investigations in connection with that profession.

C. H. PEABODY.

SOME EUROPEAN SCHOOLS OF NAVAL ARCHITECTURE.

The four leading European schools of Naval Architecture are found at the Royal Naval College at Greenwich, the École d'Application du Génie Maritime at Paris, the Königliche Technische Hochschule at Berlin, and the University of Glasgow. There is also a well-established course in Naval Architecture at the Armstrong College at Newcastle, and instruction in the subject is given at the Glasgow and West of Scotland Technical College.

A study of the methods and conditions of instruction at these institutions and a comparison with our work in the same lines at the Massachusetts Institute of Technology have been made and are presented in this report. This study is based upon personal visits to the schools, official statements of courses of study or requirements for graduation, and other information of like character, and also upon information given by persons who have taken courses of study at some of these institutions. Such information, when given by our own alumni or by persons who have had other means of becoming familiar with the Institute of Technology, is especially valuable, since they are the better able to make intelligent comparisons of methods and results. In order that the schools might be visited while in session, the writer obtained leave of absence in the middle of last April, and proceeded immediately to visit the English and French schools. Unfortunately, the term of the University of Glasgow closed so early that this institution could not be included. The term of the Technical College at Berlin, on the other hand, extended through June; and this fact made it convenient to prosecute other objects of the trip before going to that city.

The first school for naval instruction was that established at Paris in 1765. It has at various times been moved to Brest,

to Lorient, to Cherbourg, and back to Paris, where it has long been established. To this school must be given credit for much of the leading position of the French in both the theory and the practice of Naval Architecture. The students at the École d'Application du Génie Maritime come from the École Polytechnique, so that the course of study at these two schools may properly be treated as the complete course of education offered for naval constructors. Two years at the polytechnic school are given to general and fundamental training, and two years at the school of Naval Architecture are given to special work and to its application to shipbuilding.

Students are admitted to the École Polytechnique by competitive examination, held at various cities throughout the country, and open to all young men between the ages of sixteen and twenty. The applicants for examination are numerous, and the competition is close, so that the students admitted to that school are a select class. The examination includes Arithmetic, Geometry, Algebra, Trigonometry, Analytical Geometry, Descriptive Geometry, Physics, Chemistry, Drawing, French, and German.

A careful system of ranking is carried through the two years' course at the polytechnic school, and on graduation the students, to the number of about one hundred and twenty-five, are allowed to choose (in order of their rank) appointments in various branches of government employment open to them. The appointments in naval construction are taken by men near the head of the list, so that there is thus a double system of selection for the students in the school of naval construction.

The following is a brief synopsis of the course of study at the École Polytechnique:—

Mathematics: including Differential and Integral Calculus, Fourier's series, Laplace's functions, imaginary variables, elliptic functions, and Calculus of variations.

Mechanics: including kinematics, statics, dynamics, hydrostatics, hydrodynamics, thermodynamics, theory of elasticity, and hydraulics.

Descriptive Geometry: including shades and shadows, perspective and a general geometrical study of curves and surfaces.

Physics: including heat, thermodynamics, conductibility, elasticity and magnetism, acoustics, and light.

Chemistry: inorganic, organic, and technical.

Drawing: mechanical and freehand.

Architecture.

Topography and Military Art.

Literature.

History.

German.

No study of a synopsis of the course, whether of the brief one here given or of the very complete synopsis from which it was abstracted, can give an adequate conception of the work of the school. But there are a few conclusions that are inevitable; the course is intensely mathematical and theoretical, and no one who has not a decided natural bent for mathematics can hope to finish it. Information from those who have taken the course at the school for naval constructors is to the effect that the graduates from the polytechnic school have a grasp and a facility in the use of mathematics that few American technical students ever gain. This mathematical facility carries with it a preference for mathematical forms and a confidence in the results of the application of mathematical methods to practical operations that is reflected in all the French literature of Naval Architecture and shipbuilding.

The course of instruction at the École d'Application du Génie Maritime consists essentially of lectures and of drawing and design; there have recently been added shops for manual training. The regular regimen of the school is to give to each of the two classes a lecture every morning at half-past eight; the lecture usually lasts two hours, but can be extended to three hours at the discretion of the lecturer. It is the habit to cover a large amount of work in each lecture. An opportunity is given students to ask questions, and there is some attempt at quizzing students at the end of the lecture.

Every week there are formal quizzes at which marks are given, and which are very important in the determination of the rank of the student.

The afternoons are given to drawing and design, or to shop work. A large amount of attention is given to the student's *projet* or design of a ship and its machinery. The student is encouraged to consult frequently with the professors in connection with this work, but he can avoid such consultation if he desires, and professors are likely to leave such an one to his fate. From July first to September twentieth the students are required to inspect navy yards and engine works, and to keep a diary with sketches and descriptions, which are submitted at the end of September. At that time there are oral examinations on the whole work of the year before the professors of the school and other officials designated for that purpose.

A complete synopsis of the course of study at the school was given by the Director to the writer last June, together with certain lithograph notes of lectures and a printed work on the Théorie du Navie by Clauzel. From this material a very complete idea of the work covered by the lectures can be obtained. A brief abstract of the synopsis of the course follows:—

Brief Synopsis of the Course at the École d'Application du Génie Maritime.

Ship Construction: including materials and methods of construction, accommodations, and methods of launching; also statement of problem for design.

Theoretical Naval Architecture: including displacement, geometry of floating bodies, stability (both statical and dynamical), addition of weights, grounding, docking and launching, resistance and propulsion of ships, steering, waves and rolling.

Resistance of Materials: including tension, compression, shearing and bending, and the application of the theory of elasticity.

Steam Engines: parts of engines, operation of parts, condensers, propelling agents, statement of problem for design, theory of steam engines, steam turbines, erection of engines, and piping.

Steam Boilers: shell and tube boilers, installation and working of boilers.

Mechanism: sources of energy, thermodynamics, flow of fluids, losses of energy, centrifugal fans and pumps, injectors; fly wheels and governors; brakes and indicators.

Applied Electricity: general terms and definitions, continuous currents, dynamos and motors; accumulators, electric lighting and wiring; alternating currents, transformers, motors and distribution; wireless telegraphy.

Technology: production of heat, storage and use of fuels; materials for shipbuilding; equipment of yards and shops; management of yards and shops.

Naval Artillery: interior and exterior ballistics, armor plates, projectiles, gun-carriages, turrets; offensive and defensive power of ships; submarine boats and torpedoes.

Adjustment of Compasses: deviation, compensation, placing of compasses.

Administration and Accounts.

The complete synopsis from which the preceding abstract was made, and the lithographic and printed notes of lectures, give a good idea of the scope of the work of the course. At the time of my visit the designs of ships and engines made by the students were shown, and all questions concerning them were freely answered. A number of Americans in and out of the naval service have completed the course at this school, and among them are several personal friends, who have discussed the course and the methods of instruction very frankly with the writer; in particular, one of our alumni immediately after completing the course showed me his notes, and explained the methods of work very minutely. From all this information I am of the opinion that the entire course of four years in the École Polytechnique and the École d'Application du Génie Maritime gives a training that has no superior, and that the graduates are well versed in the theory of their profession and have as much knowledge of the practice as can be gained from two summers' inspection of navy yards. If there is any criticism of the course, it may be attributed to national characteristics, such as a tendency to try

to work out problems in a strictly logical method and to place an exaggerated importance on mathematical operations.

Systematic education of naval constructors for the British navy began in 1864 with the establishment of a course at South Kensington. In 1873 the course was altered and improved and transferred to Greenwich, where it became an integral part of the Royal Naval College, which gives higher education to various classes of officers of the British navy.

There are three methods by which entrance to the course in Naval Architecture at the Royal Naval College may be attained. A small number of students at the Royal Naval Engineering College at Keyham may be designated for instruction as naval constructors and given special opportunities to learn the practical side of shipbuilding; after four or five years at this college they proceed to the Royal Naval College at Greenwich. The British Admiralty has a system of shopwright apprenticeship at the Royal Dockyards to which youths are admitted between the ages of fourteen and sixteen. The regular apprenticeship is for a term of seven years, and during the first three years they are expected to attend dockyard evening schools; those showing ability in these schools may be granted permission to take a fourth year of such instruction. From the dockyard apprentices who have completed four years of their term a number are selected after examination for training as naval constructors; those selected have a year at the college at Keyham, and from there go to Greenwich. Since the college at Keyham is to be abandoned in consequence of the adoption of the new system of education of officers for the British navy, the first source of supply mentioned above from that college and the year's training for shipwright apprentices at that college are about to terminate; what will be substituted is not yet known.

The third method of entering the college at Greenwich is by examination, and in practice this is open to all British subjects, though the authorities have absolute control of selection. Formerly foreign students were admitted in this manner;

a number of American naval constructors took this course, all of whom took leading positions in their profession either in or out of the navy; at the present time a few Japanese students are taking the course, probably in consequence of the treaty between Great Britain and Japan. Such private students, if they show proper qualifications, may be transferred to the corps of naval constructors at the termination of their course. Though it has no direct connection with the subject, it is interesting to know that dockyards foremen who have not had the advantage of the course at Greenwich may be appointed naval constructors if they show proper qualifications, a fact which is an evidence of the essentially democratic spirit of British institutions in that they always leave open a door for advance to those who are able to take advantage of it. Private students on entrance are expected to present from some shipbuilding establishment with which they have been connected an introduction showing good character and some knowledge of the practice of shipbuilding. They must pass an examination in the elements of Calculus and Applied Mechanics and in Chemistry, Physics, and shipbuilding. As an added attraction there is a scholarship of £50 a year. The number of private students has always been small, even including foreign students. A reason offered for this condition of affairs is that the mathematical requirements both for admission and in the course are very severe; and, again, the position of assistant constructor with a salary of £200 a year is not sufficiently attractive to a person having the required mathematical attainments.

There are now four professors (of Mathematics, Applied Mechanics, Chemistry, and Physics) connected with this course at Greenwich, together with a lecturer on Naval Architecture who is a naval constructor connected with the Admiralty, an instructor in naval design, an instructor in marine engine design, and certain other instructors.

The course consists of three sessions of nine months, from October to June. During the summer months the government students are drafted into the dockyards, and private students are given facilities for visiting dockyards.

A very strong course is given in pure and applied Mathematics, including Analytical Mechanics. Three mornings a week are given to this subject throughout the course.

Parallel with this is a course in Applied Mechanics, including strength of materials, framed structures, kinematics and dynamics of machines, theory of elasticity, hydraulics, thermodynamics, and theory of the steam engine, theory of waves, and resistance and propulsion of ships. A laboratory of engineering and mechanics has recently been established, sufficient for the limited number of students and equipped for work of the highest character.

Lectures are given in Physics and Electricity, and a large amount of laboratory work is undertaken. In Chemistry the lectures and laboratory work are not specially advanced.

The senior instructor or lecturer in Naval Architecture visits the college two or three afternoons of the week and gives lectures and supervises the work of the students. The actual instruction is given by the junior instructor, who is in residence at the college, and who has control of the drawing and design of all three classes, numbering about ten in each class. The time assigned for this work is six hours per week the first year, nine the second year, and twelve the third year; students commonly spend more than the allotted time on their design. All the drawings are made on antiquarian paper, in great detail, with rather a liberal use of watercolor; the designs are ambitious, mostly battleships of the largest class; the quality of draughtsmanship is not exceptionally good.

The first year and about a third of the second year are given to preliminary training in ship drawing and calculation, such as fairing lines, calculation of displacement and stability, and the construction of curves of weight, buoyancy, shearing forces, and bending moments for a ship in still water and on a wave. This last work is done in the second year for a design in the hands of third-year students. The remaining time of the second year is given to a preliminary design of a warship, the students working in pairs to distribute the labor of calculation and drawing. This design is carried to completion in the third year.

The drawing and design of the first and second years are parallel with lectures given by the senior instructor on the subjects mentioned above, and in the third year there are lectures and calculations on such subjects as the geometry of floating bodies, grounding, docking, launching, effect of bilging, and dynamic stability. Lectures are also given on rolling in still water and among waves, dipping and pitching, method of observation, and graphic investigation of rolling.

Parallel with the ship design is work on drawing and designing engines; this branch naturally receives somewhat less attention, beginning with design of single parts and afterwards taking up the general design of engines. A good deal of time appears to be given to the drawing of details following current practices. Statical calculations for strength are made, and lectures are given in dynamical actions, including balancing.

At the time of my visit to Greenwich, Professor Ewing, the Director of Education to the Admiralty, gave me every opportunity to investigate their methods, and personally conducted me through the laboratories. Professor Henderson, in charge of the department of Applied Mechanics, discussed his methods and plans most frankly and showed me lecture notes. Mr. Smith, the junior instructor in charge of the naval design work, gave me every facility to see work in progress and to talk with students concerning their work; and like courtesy was shown by the instructor in marine engineering.

In the preparation of this report I have had the advantage further of a paper by E. L. Attwood, Esq., the senior instructor in Naval Architecture, on The Admiralty Course of Study for Training Naval Architects, read before the Institute of Naval Architects at their meeting in April of 1905. And further I have had a set of recent examination papers kindly furnished me by Professor Ewing. Since, according to the usual British custom, very great weight is given to the final examination, this set of papers gives an excellent idea of the scope and thoroughness of this course of training.

In all the reports and discussions of this course of study

emphasis has been given to the very high standard required in Mathematics; it has been said that this standard has had the effect of excluding or discouraging private students. Some of the graduates of the course have expressed the opinion that too much weight is given to Mathematics. It is perhaps no violation of confidence to say that the present Director of Education to the Admiralty has this question under consideration, and will correct any such tendency that he may conclude to exist.

It is very fortunate that the two leading schools of Naval Architecture, at Paris and at Greenwich, have always maintained a high standard of scientific training; as a consequence, trained naval architects have understood their profession, and it behooves any college offering education in this line to see that the real standard is not lowered. The mathematical attainments required for handling the theory of Naval Architecture are not more than any trained engineer should have. The real question to my mind is not so much the amount of time to be given to Mathematics and its applications as the attitude of mind of the teacher. At the time when the Royal Naval College was established mathematicians of high attainments and known repute were trained in the Universities, where the subject was used mainly as an instrument for educational training and where methods may be characterized as academic rather than practical. The traditions of such a school with its high reputation would naturally be conservative, and it is a fair question whether the same training and a better mastery of the instrument may not be had if the subject is treated rather from the side of the engineer and constructor.

The first course in Naval Architecture not under government control was established at the University of Glasgow in 1883. Unfortunately the exceptionally short term of this institution made it impossible for me to visit it while in session, and consequently my knowledge of the course is correspondingly imperfect, being derived from the University Calendar, from an article by Professor Jenkins in the "Transactions of the

Institution of Naval Architects" for 1889, and from reports from persons who studied at the University.

In order to understand the course of Naval Architecture and Marine Engineering, which is properly classed with the courses in engineering, it is necessary to know something of the Scottish Universities and of the methods by which young men in Great Britain gain entrance to the engineering profession. The Scottish Universities were founded in the Middle Ages, and have had an uninterrupted development along their own lines, with such changes as have been considered proper to fit them to modern conditions; in particular, attention was given at comparatively early times to the education of engineers. It is not necessary to dwell upon the reputation they have enjoyed for high scholarship and serious work.

In general, instruction has been given by lectures, and that method still has a preponderating influence. Together with such instruction by lecturers laboratory practice has been introduced in Chemistry and Physics and more recently in engineering; important engineering laboratories have recently been completed at the expense of £40,000. It is interesting to note in passing that "The laboratories are open daily; the hours of attendance are arranged with the individual students."

With the system of education mainly by lectures there is naturally given a wide discretion to students as to what work they shall undertake and how it shall be arranged. And, again, a larger weight is given to examinations, which are extensive and severe. It is, however, stated that "a candidate for the degree of Bachelor of Science shall not be deemed to have attended a class as part of the curriculum for that degree who does not present a certificate bearing not only that he has given regular attendance, but also that he has duly performed the work of the class."

In order to be admitted to a course leading to the degree of Bachelor of Science a student must pass a preliminary examination in English, Modern Languages, and Mathematics; the last subject must be of a higher standard than is in general re-

quired for students of arts. He must have been in residence at the University for three full academic years, except that permission may in some cases be granted to take some part of the work of the course at other Universities or institutions or with private teachers approved by the University; special privileges are granted for study at the Glasgow and West of Scotland Technical College. It is understood that this rule as applied to American students requires that in order to take the degree they must complete a full course of three years at the University, and that attendance is required at all classes in order to enter the corresponding examinations.

In order to qualify for examination as candidate for the degree of Bachelor of Science in engineering, the student must take nine full courses of study; there is provision for half courses in some subjects, two half courses being counted as a full course. The standard requirements for Naval Architecture and Marine Engineering are:—

1. Mathematics, including Analytical Geometry and Differential and Integral Calculus.
2. Natural Philosophy, including applied higher Mathematics.
3. Chemistry.
4. A course in physical laboratory or chemical laboratory.
5. } Two courses in Naval Architecture with Marine Engineering.
6. }
7. } Two courses of practical work in ship and engine drawing.
8. }

Students in engineering may elect to take one course in Naval Architecture without drawing; but under these conditions they cannot be considered properly to be students of Naval Architecture.

The degree of Doctor of Science may be granted to bachelors of the University after five years on presentation of a thesis or published memoir or work, provided that the candidate shall pass examinations if required.

In explanation of the list of subjects given above, it may be said that Natural Philosophy deals mainly with dynamics, treated

in such detail and with such reference to practical problems as may render it suitable for students of engineering. The calendar of the University gives examination papers for the year 1905, of which two in Natural Philosophy and one in higher Mathematics give questions in dynamics, hydrostatics, elasticity, heat, light, magnetism, electricity, harmonic variation, the catenary, projectiles, floating bodies, and thermodynamics. The examinations have each about fourteen questions, of which only nine need be answered, so that the student has a chance to select to some extent the material he will present for examination.

The laboratory course in Physics to accompany the second subject provides experiments in heat, light, and electricity.

The lectures in Naval Architecture and Marine Engineering are given three times a week throughout the yearly session for two years; and there are classes for drawing and design three hours on each of four days in the week. The calendar does not give an explicit statement of the course of study, nor have I an authoritative statement to present as in the case of the two governmental schools. The article quoted above, by Professor Jenkins (deceased), gives at great length the details of a course of instruction in Naval Architecture covering three years, and intended apparently to be equivalent to the course at Greenwich; a like statement by Professor Biles (the present incumbent) in 1891 has come to my hands through a private source; neither purports to be the course outlined in the calendar, which covers three years in all, only two being given to Naval Architecture; nor have I any information that such extensive courses have ever been given. Such information as I have been able to gain from our alumni who have been to Glasgow indicates that the instruction in Naval Architecture was at the time of their attendance in an advanced condition. All have been enthusiastic with regard to the head of the department, and regretted only that his private practice occasionally interfered with the regular progress of instruction. As Professor Biles has an international reputation and a wide professional practice, it would appear inevitable that such a difficulty might be expected to increase; I

have been informed that there is a growing dissatisfaction from that reason. In passing, the question may be raised whether an engineer who has a large private professional practice can give such time and thought to teaching as he himself would desire. Further, practical men have offered me the unsolicited opinion that the practice of engineering has the tendency to divert the mind from principles, which are the vital element of teaching, to details, which frequently are what determine success or failure in practice.

A further investigation of the calendar shows that students who are working for the bachelor's degree in engineering take, instead of the two courses (5) and (6) of the course in Naval Architecture as outlined above, two courses in engineering, including such subjects as surveying, strength and elasticity of materials, prime movers (steam engines, etc.), and hydraulics. The inference is that so much of any of these subjects as is given to students of Naval Architecture must be included in the two courses of lectures outlined above, and this inference is borne out by the large amount of attention which has been reported as given in those lectures to the question of strength. Undoubtedly there is advantage in the concentration of attention that may be given to such a subject when included in the course of lectures where its principles receive direct application; but, if the naval architect is considered to be a man who applies the principles of engineering to shipbuilding primarily, but who must also meet and overcome difficult problems in allied construction, such as installation of shipyards, design of cranes and derricks, both fixed and floating, to say nothing of the design and construction of various engines, then any influence which unduly narrows his professional horizon is unfortunate.

Before proceeding further in the consideration of engineering education in Great Britain, attention should be given to the long-established custom of receiving young men in engineering offices as pupils or apprentices. This method has, undoubtedly, produced many eminent engineers and has the advantage that the young man, during his formative age, is brought into intimate

acquaintance with his profession or trade, and he early grasps the idea that engineering is rather an art than a science, even though it be the most scientific of the professions. The Scottish universities maintain that their short sessions allow the students to devote half of each year to learning the art of their profession, and that the "sandwich" system is the best solution of the problem of engineering training.

I am informed that the engineering works and companies, especially near Glasgow, co-operate heartily in the system just mentioned, and give substantial encouragement to young men to take full advantage of it. As an instance I may quote the schemes that are maintained by the Leven Shipyard at Dunbarton. They are three in number, as follows:—

1. A bursary in the Burg Academy for the purpose of offering facilities to students for taking up the study of engineering and shipbuilding.

A student gaining one of these bursaries will be taken as a five years apprentice in the Leven Shipyard or engine works; he will be expected to attend the course for naval architects during the three winters required for completing that course; the three summers and two full years in addition he will be expected to work in the yard or engine works, or in the drawing offices. I am informed that such a young man, if he takes advantage of his opportunities, is given every facility that can be granted him to learn all the details of his profession.

2. (*a*) A bursary of £25 a year to the West of Scotland Technical College, tenable for two years with privilege of counting the time in that college toward the five year apprenticeship.

(*b*) Six Science Scholarships of £2 each to evening classes in the West of Scotland Technical College.

(*c*) £2 5*s*. toward meeting railway fares of each bursar during the session.

3. To all apprentices attending the above evening classes who have attained seventy-five per cent. of attendance, half of their fees are returned; and to students obtaining over 60 per cent. in class work prizes are awarded.

The Armstrong College at Newcastle-on-Tyne has a course in Naval Architecture, modelled in general on the course at the University of Glasgow, but not as yet so well developed. Thus far the instruction has been by a lecturer who has had experience both as a teacher and in shipyards. The authorities under the leadership of Sir William White have been trying to get some well-known naval architect to take charge of the department and to give to it the assurance of success that his reputation would command. After some efforts to induce certain individuals to take up the work, a circular was issued setting forth the requirements, the salary, and the privileges, especially the freedom offered for private practice. So late as August it was not known that any one had been appointed to the position. From discussion with persons who are familiar with the methods of British education it appears to be not unusual to advertise for professors and other officers at universities and colleges, and some impatience was expressed at an expression of opinion that such procedure might appear to be lacking in dignity. A certain professorship of Natural Philosophy found about a dozen applicants, any one of whom might have been available. The same college had once three hundred applicants for the position of secretary and director, an office which united some of the duties of the president and of the secretary of an American college.

The day classes in Naval Architecture have been small, not exceeding four. There are larger evening classes, but their work is not of the same grade. The work of Naval Architecture begins with the second year, but there is the disadvantage that Calculus is not available till the end of that year. There are four lectures a week for eight months during the two years, covering the entire field of shipbuilding. Six hours a week for the two years are assigned for ship drawing and design. Students having a keen interest were likely to double the assigned time. There is an attempt to specialize for students, giving some of them designs of merchant ships and others of warships. There was exhibited here and elsewhere a tendency among

Scotch professors and instructors to complain that English students show less earnestness than is found at Scottish educational establishments.

The Glasgow and West of Scotland Technical College, located in the heart of the city, is an old established institution, which has recently erected new and commodious buildings of which any technical college might well be proud. The provision for laboratories of Mechanical and Electrical Engineering will be excellent when these are completed, and students of Naval Architecture will have the advantage of that equipment.

Instruction, leading to the degree of Bachelor of Science, is given in Naval Architecture, though they have no professor in charge and apparently do not expect to supply the deficiency in the near future. Lectures are given by a well-known naval architect, who is attached to a neighboring shipyard, the remainder of the teaching being in the hands of instructors. There are but few day students in Naval Architecture, and they work in the general engineering drawing-room.

This college illustrates an important tendency of British engineering education; it has three hundred day students and five thousand evening students. It should, however, be stated that the evening instruction covers a very wide field, from shipbuilding to baking, and that various lines of instruction that approach the work of trade-schools are supported largely by the organizations of various arts or trades in the city. The Director, Professor Stockdale, having expressed his admiration for the large regular classes of American technical schools and colleges, gave as a reason for the relatively small classes in British engineering colleges the excellent organization of their evening classes. The instruction given in the evening may be comparatively elementary, but that is controlled by the grade of men attending, and as advanced work as is given to day classes is offered to any that can take advantage of it. Comparisons are in such case difficult, and are liable to be partial, but an off-hand estimate by the Director was to the effect that the work accomplished by good men in the evening classes was about

one-third that of the day classes,—an estimate that would appear to be liberal. Though a man may attend an unlimited number of successive winters, it is seldom that attendance exceeds three or four years. It is inevitable that the whole scheme of evening instruction must differ radically from that of the day work, and in particular that the fundamentals cannot be taught in the same way, else there would be no instruction given in special branches. A very just criticism of the present American tendency to recruit engineers to an increasing extent from graduates of technical schools was offered in that it tends more and more to separate the engineering workers into two classes, one highly educated but with little personal experience in the manual work of the art or trade, and the other familiar with the processes, but without any knowledge of their rationale. Examples were given of young men who, by aid of evening instruction, had won their way to the front rank of the engineering profession. In this connection it should be borne in mind that throughout Great Britain attention has been given to the provision of evening instruction largely in pure science rather than in special trades or professions. There are various schemes for finding and advancing those who show special aptitude, such as the Whitworth scholarships, which have brought forward many eminent scientists and engineers, and are so highly valued and so widely acknowledged that those who have held the scholarships use the abbreviation Wh. Sch. as they would the recognized form for a degree from an institution of higher learning.

As early as 1799 a technical school was instituted in Berlin, which after various changes was established in 1879 in substantially the present form as the Konigliche Technische Hochschule. In 1884 the institution was installed in the noble buildings now occupied at Charlottenburg, and in 1894 the department of Naval Architecture and Marine Engineering was established on the same footing as other departments like Architecture and Engineering. In 1899 the Hochschule in common with other institutions of like grade was empowered

to grant the degree of Doctor of Engineering, to take rank with the doctorates of the universities. As a matter of fact the time, training, and amount of intellectual effort required to gain the degree of Doctor of Engineering is far in excess of that for any University degree. The regular course of study at a German technical high school leads to graduation with degree of *Diplom-ingenieur*, which may be compared with the degree of Bachelor of Science. Graduates from the courses of Naval Architecture and Marine Engineering receive the degree of *Schiffbau-Ingenieur* or *Schiffmachinenbau-Ingenieur*. The doctorate is awarded for further work of advanced nature; but few doctors' degrees have been awarded by the school, and only one from the department of Naval Architecture.

The department of Naval Architecture and Marine Engineering is housed in the main building with commodious drawing-rooms and lecture-rooms and offices for professors and instructors. Students have the advantages of engineering and other laboratories and all the general facilities of the school. Some complaint was made of lack of instruments and other special equipment.

On the teaching staff are six professors, two *Privat-dozenten*, two first-class assistants, and nine or ten second-class assistants. There are from three to four hundred students enrolled in the department, and twenty or thirty degrees equivalent to *Diplom-ingenieur* are granted yearly. Two of the professors are naval constructors detailed to teach naval design.

In addition to the information obtained during my visit to the Hochschule there has been available for this report a History of the Hochschule, the regulations for the diploma examinations, and other printed matter furnished me by the *Rektor*, Professor Flamm, who is in charge of the department of Naval Architecture, and who further gave every opportunity to inquire into the work of the department. The work of the students in the drawing-rooms was opened freely for inspection, and encouragement was given to talk with the students, many of whom spoke English.

Students are prepared for the Technische Hochschule at the Realschule, or Gymnasia, of which the general opinion is that the scholars work more seriously and are better fitted, especially in Mathematics, than are the scholars in American and English preparatory schools.

The course requires four years' residence at a technical high school, two of which must be at Berlin. There must also be presented evidence of one year of practical work, which can be taken in several periods, partly, if not wholly, in vacation.

Following the traditions of German universities, and in accord with their idea of academic freedom, the course of study which is laid out is only recommended, and it is optional whether the student shall follow it or not. It is, however, very unlikely that a student will depart far from the recommended course and less likely that he could prepare for the examinations if he did. The course of lectures given by the professors and the work covered by such course is effectively controlled by the faculty, as must in fact be the actual working of an education that is so complex and so closely correlated as that given to a modern student of engineering. Especial interest was felt in the amount of time actually spent by students per day on their work; as was to be expected, such a question was repugnant to the idea of academic freedom, but persistent inquiry elicited the information that the average time was not far from eight hours a day.

A very complete system of controlling and facilitating students' work has been made possible and desirable by the large number of students and a corresponding teaching staff. The familiar card catalogue was found in operation and also a large number of printed forms for assignment and calculations of the various problems assigned, together with special notes and pamphlets. All this gave a familiar atmosphere, especially when in the course of conversation students produced printed forms in which they had filled out the computations for experiments in the engineering laboratories.

The drawings were in general finished in pencil, and exaggerated attention appeared to be given to keeping such drawings

clean and presentable, it being in mind that all drawings must eventually be presented at the preliminary and final examinations, which will be discussed later. There is no question that, after a student has once learned to make a proper ink drawing or tracing, he may frequently gain some time by finishing his drawings in pencil, and that further the accuracy of the drawing is better judged in the pencilled condition; but where drawings are kept in hand weeks or months, and where they present much small detail, it is frequently found that the best result, considering both time required and appearance, can be had by making a tracing, especially as a skilled draughtsman may finish much of the small detail in the tracing.

There appeared to be a considerable latitude in both the amount and the quality of the work accepted for a given requirement,—a fact which seemed to come from the tradition of academic freedom. In general the drawings were good, but had a certain amateurish appearance.

All computations and drawings are made under the supervision or direction of instructors and are countersigned to that effect.

Two examinations are required of all candidates for the diploma of the Hochschule, one after two years' residence, and one after four years' residence; the time given in both cases is the minimum, and there appears to be no maximum limit. The conditions for these examinations are given at length in the printed Regulations for Diploma Examinations, from which an idea of the scope of the work may be obtained.

The examinations consist of the presentation of required work (in the department of Naval Architecture and Marine Engineering of drawings and computations) and of examinations. The examinations are oral and appear to be individual, there being a considerable interval of time during which they may be assigned.

For the preliminary examination the following work must be presented, with a statement of the time of completion and the endorsement of the instructor:—

(*a*) Drawings of projections and shadows.

(*b*) Freehand drawings of ornaments. (Optional.)

(*c*) Drawings of parts of machines.

(*d*) Representation of a machine or parts of a machine showing original ideas.

(*e*) Construction drawings of at least three different ships and for one of them the complete standard calculations for displacement, with customary diagrams.

(*f*) Drawings of ship-construction according to the German Lloyds rules.

(*g*) Exercises in Mathematics and Mechanics.

If any drawings are presented without the endorsement of an instructor, the candidate must certify that they were finished by himself independently.

If work is found insufficient, one representation is allowed, but not more.

The oral examination includes:—

I. Physics.

II. Chemistry.

III. Mathematics, including Algebra, Analytic Geometry, Differential and Integral Calculus, Differential Equations.

IV. Descriptive Geometry.

V. Mechanics, including statics and dynamics; strength of cylinders, spheres and straight and curved beams; equilibrium of liquids and gases.

VI. Mechanical technology; qualities of materials; procedure of working, casting and machining; tools and accessories.

VII. Building construction. (Optional.)

VIII. Elements of machines; construction and calculation of parts of machine.

IX. Elements of Political Economy.

The rankings are Unsatisfactory, Satisfactory, Good, and Very Good. A rank of Unsatisfactory in one subject will cause the candidate to fail.

The final examination requires the presentation of the following work:—

FOR THE SHIP CONSTRUCTION COURSE.

(*a*) Construction drawings of at least four different ships, and for at least one of them the work must be carried through the ordinary general

arrangement, division by bulkheads, detailed calculation for speed and for stability at different inclinations.

(*b*) Drawings of the structure and important details of merchant ships according to the rules of the German Lloyds.

(*c*) Drawings of special structures and arrangements, details of warships.

(*d*) Construction drawing of a marine boiler, with detailed arrangement of riveting and necessary calculations.

(*e*) The design of a marine engine with calculation of the principal dimensions.

FOR THE MARINE ENGINEERING COURSE.

(*a*) Construction drawings of at least two different ships, and of one of the same the usual general arrangement as well as bulkhead division.

(*b*) Drawings of parts of the ship to which the machinery is attached.

(*c*) Design of a marine engine, with details of bed-plate, valve-gear, cylinder, receivers, condensers, pumps, shafting, and propeller.

(*d*) Design of two different marine boilers, one design being completed with front end, uptake, and chimney, accompanied by calculation.

As in the preliminary examination the drawings and calculations must bear a statement of the time of completion and must be endorsed by an instructor; or, if the candidate has not such endorsement, he must certify that they have been completed by himself personally. A representation is permitted, if necessary, once only.

If the work presented is satisfactory, the candidate is given an oral examination and is assigned a technical problem or design (*Diplom-arbeit*).

The oral examination covers the following subjects:—

I. Theory of machine; including theory of governors and fly wheels; theory of hydraulic machinery; thermodynamics of steam and gases; steam engines.

II. Kinematics; including simple pairing and kinematic chains; motion in lines, curves, and planes; crank-motion; gearing and ratchets.

III. Machine Design; including calculation and construction of hoisting machines, pumps and blowers, steam engines and valve gearing, steam boilers, hydraulic machinery with valves and piping.

IV. Fundamentals of iron mining.

V. Theory of Ships; including displacement, stability, resistance,

power, propelling machinery, sails, rudder, turning radius, theory of waves and rolling of ships.

VI. Ship construction.

VII. Practical Shipbuilding.

VIII. Warship Construction.

IX. Marine Engine Construction; including engines and boilers and parts of the same, with sketches as required.

X. Translation from technical French and English into German.

The examination for naval architects under the head IX. is cursory, and under the heads V., VII., and VIII. for marine engineers.

The ranks are the same as for the preliminary examination, with failure if any item receives the rank of unsatisfactory. Candidates may have a re-examination at the next examination period if failures are incurred or if a higher rank is desired, but only once.

The diploma design (*Diplom-arbeit*) is given much importance. The candidate for a degree in Naval Architecture must choose and work out one of the problems in the domain of the shipbuilding course which has for its subject an enlarged design with explanations and calculations for the same. The candidate for the degree in marine engineering, in like manner must choose and work out a problem in marine engineering.

The candidate must certify under oath that he has performed the diploma work independently. He may, however, have his descriptive text and calculations copied.

The work must be returned at the end of three months, and it may be returned earlier; delay can be obtained only under special circumstances. If the work is unsatisfactory, a new assignment may be obtained, but only once.

A comparison of our own Course in Naval Architecture with the courses in European schools, even with the evidence obtained from visits to those schools, and from all other sources, cannot be other than hazardous. And yet the opportunity for suggestions for improvements in our own Course demands the hazard. Such comparison can be made either for our regular four-year Course, leading to the degree of Bachelor of Science,

or for our special Course for Naval Constructors, leading to the degree of Master of Science. There is in addition our Graduate Course of one additional year, also leading to the bachelor's degree for bachelors of science who desire to take up warship design.

Of the four leading European courses those at Greenwich and at Paris are governmental schools for naval constructors, and their work can be compared with our Course for Naval Constructors. The course at the University of Glasgow is directly comparable with our four-year Course, while the course at Berlin must be compared with both our Courses. As for the courses at the Armstrong College and at the Glasgow and West of Scotland Technical College, they are not yet completely developed, and those in charge said openly that they are now where we were several years ago; and yet there are suggestions of value from their experience.

As compared with our regular four-year Course, the course at the University of Glasgow has the disadvantage that it consists of three terms of practically five months each; the examination period at the end of the year adds nearly a month of residence at the university. There is no evidence that the young men at entrance are better prepared than are our own, nor is there any compensating advantage to be urged. The work in Mathematics, pure and applied (the latter covering much that is included in our Applied Mechanics), appears to be more affected by academic tradition, perhaps because given at a university where Mathematics is taught mainly as a method of training. The difference to my mind is not so much that the Mathematics for an engineer should be easier as that the attitude of the teacher should be different and that the direct application to the real problem in engineering should always be in mind; this difference is naturally felt most in applied Mathematics, for which there is a direct gain in placing it in connection with the study of the strength of materials. As the course in Naval Architecture is there compressed into eighteen months of actual residence at the university, it is much restricted, and in particular

does not have a broad training in general engineering. Students in that course have always had physical laboratory practice, and now should have the advantages of the new engineering laboratories so far as they are able in the time allowed. It appears probable that the course would be much improved if a student could take four years and thus broaden the general engineering training. So far as can be learned, the theoretical training in Naval Architecture is much like our own in quality and extent, and somewhat more time has been given to ship design, though it is not certain that a correspondingly better training is given. The advantages and disadvantages of having the course under a distinguished practising naval architect have already been discussed.

The particular advantage that this course presents is the good opportunity it presents for parallel work in the profession on the so-called "sandwich" system. A Scotchman who has made himself familiar with their course and our own expressed the idea that we taught more and they gave better practical training. It should be considered whether the Institute cannot in practice obtain that every student in Naval Architecture shall get practical training in shipyards during the summer, and see that opportunities are provided; it may be said that many of our students have taken that course, and that no instance is known in which the opportunity was lacking.

The English technical colleges all have three-year courses, but in general have fairly long terms. The Armstrong College, for example, has about eight months. They have developed to a large extent the tutorial system, and in particular arrange to have students solve numerous engineering problems of graded difficulty in the drawing-room under the eye of the instructor, who is not very likely to help them too much, as the classes for that kind of work are large. This method has an advantage over handing in problems in that students must in all cases do each one his own work, and there can be no question of improper or undesirable assistance.

Of all the courses examined, the one that appeared to show

the greatest similarity to our own was that at Berlin, though there must be some reserve in such a statement, for the national differences are marked and none of my acquaintances has taken the course there. If the resemblance is real and not superficial, it is most interesting, because American and German technical schools seem to have started from diametrically opposite educational ideals. It is perhaps not too much to say that New England colleges and all that pattern after them began as exalted district schools in which definite tasks were set in text-books and truths were driven home by good disciplinarians. Much that is good in that system remains, though we use the lecture system where desirable and broaden the choice by options when possible. The Germans, though committed to lectures by doctors who speak with personal authority, and though adhering to the form of academic freedom, have practically confined students of engineering to the comparatively narrow path which experience has indicated as essential to an engineering education. The general belief appears to be that young men come to the technical schools better trained, and especially in Mathematics, though of this I have no direct evidence. The ideal of academic freedom appears even yet to have some adverse influence on the efficiency of teaching, especially in engineering laboratories, where work can best be done by groups. The requirement of extensive experience in shipyards and engine works is a step further than either British or American colleges have been able to go. The amount of drawing and design, especially if we include the *Diplom-arbeit*, is much more than we can obtain or desire to obtain from our students.

Since the German naval constructors are drawn from graduates of the schools at Berlin (or Danzig), it is proper to compare with their training our Course for Naval Constructors. In such a comparison it should be borne in mind that the officers designated for instruction at the Institute have had four years at Annapolis of severe drill that covers a wide field, after which they have two years at sea, and then come to us for three

years. In the three years at the Institute they have the theoretical work of our regular Course in Naval Architecture, together with Applied Mechanics, Steam Engineering, Dynamics of Machines and Marine Engines, and also an extensive course in Electricity, with laboratory practice. There are also advanced courses in Mathematics. The work accomplished in warship design is believed to be at least as good as that given at Berlin to students who elect that branch of their profession. A very important part of the training for constructors is obtained during the summer vacations at the electrical works and steel works.

As was pointed out in the description of the course for naval constructors at the Royal Naval College, their main source of supply has been from the dockyards apprentices, with a supplemental supply from men who have undertaken a course for naval engineers. These men, especially the dockyards apprentices, have good practical training before coming to the colleges, and there is less reason for supplementing it than exists at any other college for naval constructors; nevertheless, they have considerable laboratory work and are drafted into the dockyards in summer. The standard in Mathematics is purposely put on a par with that for honor men at the Universities, a fact which appears to be an element at once of strength and of weakness; of strength, in that there can be no question that the graduates of the school can grapple with any problem that will yield to mathematical treatment; of weakness, in that the desire to make the standard equal has tended to make it identical with that at the Universities, and in consequence apart from the proper engineering ideal. The teaching of Applied Mechanics and Steam Engineering is under revision, and is likely closely to resemble our own. My impression is that the work in electricity is better at our school. Warship design is carried on with the advantage of supervision by a constructor who is in active service, with, however, the consequence that the instructor must change from time to time.

The course for naval constructors at Paris is at once very theoretical and much cumbered with descriptive lectures, which go into the minute details of materials, tools, and processes which could better be learned at navy yards. There can be no question of the mathematical training of the students, but their facility in Mathematics appears to lead them occasionally to fill lacunæ in reasoning and information with mathematical operations, as will be found in many works on Naval Architecture by men in the corps of constructors. They have no laboratory work at the École d'Application du Génie Maritime and but little at the École Polytechnique. At the present time they have some shop work, as was stated in the description of the course. They have extensive lectures in electricity, but mainly of a theoretical nature. During the summer they inspect work in dockyards and make written reports. The warship design and engine design is carried through in a thorough and systematic manner.

In conclusion, it may not be too much to assert that our courses for private students and for naval constructors need not fear comparison with those of any college. And, further, it may be said that there appears to be no reason why any American should go abroad to study Naval Architecture, even though it be admitted that residence at a foreign school or university has distinct advantages in giving variety and breadth of education, and for that and other reasons has always been favored by our faculty for men seeking an advanced degree, even when we are prepared to offer equal facilities. To be specific, attention may be called again to the fact that the English and French governmental schools are not open to foreigners. On the other hand, the policy of the German technical schools appears purposely to make the acquisition of the degree of doctor of engineering so difficult that a disproportionate effort and time would be required by an American, even if he did not find the language an additional obstruction. The University of Glasgow requires a residence of three academic years at some

British university before the bachelor's degree can be attained, and offers the doctor's degree only to its own graduates after five years' practice, in consideration of private research. Should a young man desire the advantages of foreign residence with the object of broadening his professional training in Naval Architecture, he is advised to try for a place in some shipbuilding establishment or in the office of some consulting naval architect, and in any case should give his attention to the examples and methods of construction and yard management.

C. H. PEABODY.

DEPARTMENT OF MATHEMATICS.

The year has been one of gradual progress along lines indicated in previous Reports. The increase in the assignment of time to Differential Equations for students in Mechanical Engineering, Chemical Engineering, and Naval Architecture has enabled the Department for the first time to give a satisfactory course to these students. In the Calculus Professor Osborne has carried through a revision of his text-book, making important changes, but his health has not proved equal to the completion of publication in time for use this year. There is every reason to count on the use of the new text next October. The revision of the first-year course by Professors Woods and Bailey has been carried on with energy, and the new text-book will be ready for the next entering class.

One of the important objects of the revision of these fundamental mathematical courses is their better adaptation to later actual use in engineering study and practice. The Department will welcome suggestions from graduates or others reading this Report which may facilitate the attainment of this end.

A conference with principals and teachers of Mathematics was held by the Department, with the co-operation of the Faculty Committee on Entrance Examinations, last May, with interesting and helpful discussion of the results of entrance examinations

in Mathematics. The proportion of failures in Algebra continues to be regrettably large, but it is the hope of the Department that continued emphasis on the importance of thorough preparation in this subject for students who are coming to the Institute, but whose interests may have been at times subordinated to the interests of other students preparing for admission to college, will have advantageous results, without involving hardship to schools and candidates.

During the present term the work of the Department has been somewhat seriously hampered by the simultaneous absence of Professors Osborne and Wells and the partial detachment of Professor Bartlett for service as Acting Secretary of the Institute, the situation in regard to Professors Osborne and Bartlett not having been anticipated in time to make an additional appointment for the first term. It is hoped that Professor Osborne will resume his work at the beginning of the second term with health fully restored.

Other changes in the mathematical staff include the granting of a year's leave of absence to Professor Wells on account of ill-health, the well-earned promotion of Dr. Woods to a full professorship and of Mr. George to an assistant professorship, the return of Mr. Miller from two years of graduate study at Göttingen and Harvard, and the departure of Mr. MacDonald for graduate study.

In connection with Professor Bartlett's administrative appointment he has been relieved of a considerable portion of his teaching duties and of the care of the Runkle Library of Mathematics. From the time of his original appointment in the Department in 1886 he has interested himself zealously in the development and care of this library, and its present excellent condition is in great measure the result of his efforts. A larger appropriation for the present year has made it possible to increase the supply of books of reference in the library and to fill certain gaps in the files of periodicals.

H. W. TYLER.

DEPARTMENT OF DRAWING AND DESCRIPTIVE GEOMETRY.

During the past year there have been no changes in the instructing staff of the Department.

The course in Descriptive Geometry has been somewhat modified, and printed notes have been given to the students. These printed notes will appear in pamphlet form the coming year.

A very complete idea of the course of instruction given by the Department of Drawing in the first and second years may now be obtained from the two text-books, "Mechanical Drawing" by Professor Adams, completed last year, and "Descriptive Geometry," by the same author, to be completed this year. One of the special advantages in having these text-books is in connection with the preparation of students desiring to anticipate our work in drawing before entering the Institute. Detailed descriptions of instruments and their methods of use in Mechanical Drawing have already been found of great advantage in indicating the standard of work demanded. The officers of many colleges have written to the Institute to ascertain the exact requirements for admission to our third and fourth years. As both Mechanical Drawing and Descriptive Geometry are rarely given in our colleges of liberal arts, these subjects have been stumbling-blocks to almost all candidates from such colleges. The summer courses to a certain extent enable men to anticipate this work, but there are many men who find it quite impossible to attend summer courses. To such men the two text-books, "Mechanical Drawing" and "Descriptive Geometry," will convey a complete idea of the method of instruction employed at the Institute.

In the text-book on "Descriptive Geometry" a special effort has been made to train the student to see objects in space, and to make this subject of general educational value. Descriptive Geometry holds a unique place in scientific education. There

is no other subject which does so much to develop the special sort of imagination required in engineering drawing.

The blue-print outfit asked for last year has been provided; also the cases for models and drawings. A large number of examples of standard drawings have been framed and hung on the walls of the drawing-room. The remaining needs of the Department were well set forth in last year's Report.

An interesting proof of the improvement in the instruction in the Department of Drawing is given in the relative percentage of good and poor marks received during the past year, for, though the standard has been kept as high as ever before or higher, we find that in Descriptive Geometry over sixty-seven per cent. of all the students have obtained very satisfactory records, Pass or Credit, while only about ten per cent. received total failures. In Mechanical Drawing over seventy-five per cent. obtained records of Pass or Credit, and less than four per cent. received total failures. This record compares favorably, not only with our own past records, but with the records of other colleges teaching these subjects.

ALFRED E. BURTON,
In Charge of the Department of Drawing.

DEPARTMENT OF MECHANIC ARTS.

The total number of students receiving instruction in the Mechanical Laboratories is two hundred and forty-six. Some attend more than one class, the numbers attending in the several subjects of the first year being as follows:—

Carpentry and Wood Turning, II.	60
Joinery and Pattern Work, VI.	24
Forging, II. and XIII.	88
Metal Turning, VI. and VIII.	34
Machine-Tool Work, II. and XIII.	54
Total in all classes	260
Students taking work in two or more classes and counted more than once	14
Total number of students	246

The total number of students attending last year was three hundred and thirty-one. As formerly, many students have been excused from attending the Carpentry, Wood Turning, and Forging classes, and a few from Pattern Work. The number of excuses granted in these earlier subjects is increasing but is not yet sufficiently large to warrant giving courses in advanced Wood Work, an arrangement which may prove desirable in the future.

The attendance in the Summer School was fifty-six, an increase of eight over that of last year. The numbers in the several classes were:—

Wood Work	4
Forging	16
Chipping and Filing	9
Machine-Tool Work	27
Total	56

The proportionally large attendance in Machine-Tool Work is due to the desire on the part of many students to anticipate the Mechanic Arts of the senior year, in order to obtain additional time for thesis or other departmental work.

The lap-jointed boiler installed in 1883 has been replaced by a sixty-inch butt-jointed boiler safe at a working pressure of one hundred and fifty pounds.

A new universal grinding machine and a new arbor press have been added to the equipment of the Machine-Tool Laboratory. A new Jones and Lamson turret lathe has been given in exchange for the old machine. Our old Brown and Sharpe universal grinding machine is to be replaced by a new and modern tool. Six new anvils, a swage block and stand, have been added to the equipment of the Forging Laboratory. New jack and block planes have been added to the equipment of the Wood Working Laboratory.

To maintain the present high standard in Machine-Tool Work, fourteen engine lathes and a planer purchased in 1876 should be replaced by modern machines, some of them large enough to illustrate the use of high-speed tool steels. A small

radial drill is also needed to carry on the class work successfully.

By thorough repairing the equipment of the Forging Laboratory has been put in fair shape; its renewal will, however, be necessary in a few years.

As previously stated, it is believed that instruction in Foundry Work should be given to every student in Mechanical Engineering, because of the value of a thorough knowledge of this important subject in many industrial works. The course is now optional. It is again recommended that a new and larger melting plant be installed, since under present conditions it is extremely difficult to obtain good results. It is believed that this course should be required even if time for it has to be taken from some of the present courses.

The interior of the building has been painted during the summer, and now presents a better appearance than ever before. An electric lighting plant is very much needed in place of the present inadequate gas-lighting system. A new solid plank floor should be laid in the Machine-Tool Laboratory.

No changes have been made in the instructing staff, the present force consisting of four instructors and five assistants.

PETER SCHWAMB.

DEPARTMENT OF ENGLISH.

The English Department made this year its first trial of entrance examinations under the new conditions. The arbitrary requirement in preparatory work of a list of prescribed books has been done away with; and teachers are now free to choose such works of literature as seem to them best adapted to the needs of individual classes. The examinations are now made more completely tests of the results upon a candidate of his training in the secondary schools. He is tried in composition especially for the accuracy of his thought and his power of expression; in literature for his realization and ap-

preciation of the qualities which make literature of worth. The Department feels that it has reason to be pleased with the results, both in the papers actually written by candidates for admission, and in the effects, so far as they are yet evident, of the attitude of secondary schools toward the work of the Institute. A number of teachers in the preparatory schools have voluntarily expressed approval of the change; which, indeed, is one that must sooner or later be generally followed.

Interest in the third-year option in Advanced Composition seems to be increasing. The difficulties of adjusting the hours of general studies to the tabular views of the various Courses have thrown out about a quarter of the men applying for this subject; although in order to accommodate them the course has been divided and is given in two sections. In spite of these disadvantages (of which the second affects only the instructor), the work is taken up with much spirit and is producing excellent results.

A new option offered by Mr. Seaver on "The English Bible" is this term taken by a small class, which shows much interest.

In the *personnel* of the Department no changes have been necessary this year. The division of work is practically the same as last year; and the work received from other departments is not materially altered.

ARLO BATES.

DEPARTMENT OF HISTORY.

The instruction in History continues to be carried on largely along the lines of the last two or three years,—although, it is hoped, with ever-increasing efficiency. In addition to this work the writer, as chairman of the Faculty Committee, has had charge of the General Options of the third year; and a few words relating to these may be of interest. On account of the increase in the requirement in Modern Languages for admission to the Institute, and a corresponding diminution in the time given them after entrance, which had the effect of re-

moving Modern Languages from the third year, two hundred and seventy hours were set free. The Faculty voted that one hundred and twenty hours of this time be assigned to studies of a non-professional character, and that the remaining hours be used as each department might see fit.

This change took effect in the year 1905–1906. The options provided for included the subjects of Economic History and practical Economics; English Composition and English Literature; History,—including History of Science,—Government, and International Law; French, German, and Spanish. Forty-five hours were assigned to the first term and seventy-five to the second. All regular students must fulfil the requirement in General Options, but students coming from other colleges are excused from this requirement, as from any other, provided they are able to offer a satisfactory equivalent.

The experience of one year is perhaps too brief to warrant the drawing of any conclusions as to the success of these options; but, so far as can be judged, the results have been generally satisfactory. The choices by the students have apparently been made with care; and it is worth noting that members of different Courses have distributed themselves quite widely among the options offered, and have not concentrated in any particular one in any case. This would seem to indicate that the options have been wisely arranged to carry out the original theory that they should be of a non-professional nature, intended to introduce the student to subjects and to lines of thought which shall be of advantage to him in his subsequent career, somewhat aside from the technical demands of his profession.

CHARLES F. A. CURRIER.

DEPARTMENT OF ECONOMICS, STATISTICS, AND POLITICAL SCIENCE.

The Department of Economics has little new to report. The concentration of time devoted to the general course in Political Economy given to the third-year class has been beneficial. It is believed that the course as now arranged, with three hours per week for one term, makes a more serious impression and is followed with a more sustained interest than formerly, when the work was spread over two terms with but two hours in the first and one hour in the second.

The options of Economic History, Railroads, and Banking were well attended, and, so far as can be judged, were chosen after a careful consideration by the students to meet their special needs.

There is now much more opportunity for individual work and conference, and the possibilities of further development in this direction are encouraging.

DAVIS R. DEWEY.

DEPARTMENT OF MODERN LANGUAGES.

During the summer vacation Mr. Hare was lost to the Department by resignation. His place was filled until October fifth by Mr. F. W. C. Lieder, and on and after that date by Mr. G. R. B. Meister.

The experiment was made this year of having foreign books on the lists for Summer Reading: French, German, and Spanish on the second-year list; and French and German on the first-year list. The results, as determined from the reports of students, may be tabulated as follows:—

Year.	No. of reports received.	No. of foreign books read.	No. to every ten students.
First	154	18	1.17
Second	194	25	1.29
First and second	348	43	1.23

These results seem to warrant at least a repetition of the experiment.

The reduction of the Modern Language requirements of students in Courses I. and XI., from two languages to one, has not materially lessened the work of the Department. On the first of November the students taking Modern Languages numbered seven hundred and twenty-one, only twenty less than last year. The size of the average section is eighteen, or one and one-half per cent. less than last year. The number taking Spanish is eighty-three, or eleven per cent. of the number taking Modern Languages, as against thirteen per cent. last year. This falling off may be attributed to the change of the work in Elementary Spanish from one hundred and twenty to one hundred and eighty hours a year, and a consequent loss of favor by this course as a third-year option. Only five sections number more than twenty-five students as against ten sections last year.

For the first time in four years recitations have been held in Italian. Mr. Erhardt has a class of nine students of this language.

According to the programme of the Institute, the courses in Elementary French and Elementary German will be discontinued after the current school year. These courses comprise at present six sections, holding altogether eighteen hours of recitation per week.

JOHN BIGELOW, JR.

Reports of Administrative Officers.

REPORT OF THE SECRETARY OF THE FACULTY.

The attention of the Faculty has been occupied during the past year with several important matters of new business, besides those of regular continuance or recurrence.

In the curriculum a change of possibly far-reaching significance has been made in reducing by one-half the time assigned to the study of French and German in the Courses in Civil and Sanitary Engineering. Students entering with Elementary French and Elementary German are required under the new schedule to take but one year's work in either language, instead of one year's work in each as before. This change has long been urged by the Department, and may perhaps be sought by other Departments, in view of the steadily increasing pressure of professional subjects and the diminishing relative importance of technical literature not accessible in English. A special committee has been appointed by the Faculty to report on the general policy to be followed in connection with future changes of the same character.

The distribution of third-year students among the new general options is as follows:—

Advanced English Composition,	28	History of Science	45
English Literature of the Eighteenth Century	26	Advanced French	11
The English Bible	5	French Colloquium	24
Colonial Systems	11	Advanced German	24
Economic History	31	German Colloquium	16
International Law	102	Elementary Spanish	74

In January the Faculty was invited by the Executive Committee of the Corporation to appoint a chairman for the dis-

charge of such duties as might be assigned in consequence of the resignation of the President. Professor Noyes was elected Chairman February 7.

Near the end of the year a special committee on Faculty Organization was appointed to report on a plan presented by the President for changes in the conduct of Faculty business. The committee has not yet reported upon this matter, but has been occupied since the beginning of the school year with questions growing out of the action of the Executive Committee in discontinuing the "Secretaryship of the School" and establishing a Secretaryship of the Institute. With a view to devoting his full time to the work of the Department of Mathematics in accordance with the terms of the Executive Committee's vote, the writer presented his resignation as Secretary of the Faculty, September 26. On its acceptance, November 14, Professor A. L. Merrill, of the Department of Mechanical Engineering, was unanimously elected Secretary of the Faculty.

The Standing Committee on Advanced Degrees and Fellowships has taken up during the year the question of securing due consideration for Institute graduates applying for the degree of Doctor of Philosophy in German universities. Under recent action by some of the Prussian universities preference is given to graduates of institutions included in the Association of American Universities. Application has been made in the name of the Corporation and Faculty that Institute graduates receive equally favorable treatment, on the ground that they are not less well qualified as shown by past experience. The text of this application was reprinted in the *Technology Review* for April, 1906.

On recommendation of the same committee the following persons have been appointed Fellows: Messrs. D. F. Comstock, W. K. Lewis, R. C. Tolman, G. W. Eastman, W. E. MacDonald, and E. W. Washburn.

Financial grants amounting to $5,850 have been made to fifteen persons for graduate study, ten at the Institute, and five for work elsewhere. At the end of last year the master's de-

gree was awarded to nine candidates, including three naval constructors. There are at present eleven candidates for that degree, and ten for the degree of Doctor of Philosophy.

The work of the Standing Committee on Undergraduate Scholarships is summarized in the Registrar's Report, page 137.

The procedure with students entering the Institute from other colleges with advanced standing has been the subject of Faculty consideration during the year. It has been voted to excuse the bachelors of arts entering above the second year from first-year English and United States History, second-year English Literature and European History, the third-year general option, and the summer reading. Graduates entering the third year of the Courses in Chemistry, Biology, or Physics may also offer an equivalent for Mechanical Drawing and Descriptive Geometry.

Interesting correspondence has been had with several colleges with reference to the adjustment of their work to the needs of students preparing to enter the Institute with advanced standing, and further recommendations have recently been presented to the Faculty with a view to emphasizing the attractiveness of the opportunities which the Institute can offer to such students. These recommendations, which have been adopted by the Faculty, but not yet worked out in detail, include the provision of three-year programmes of study leading to the degree of Master of Science for college graduates who have completed all but the technical subjects of the first two years of one of the undergraduate Institute courses. These programmes will probably be published before the close of the school year.

The work of the writer in general administration has ended with the recent discontinuance of the Secretaryship of the School and with the acceptance of his resignation as Secretary of the Faculty. A share of such administrative work must always be absorbed in necessary routine,—the mere lubrication of the machinery of education. The writer ventures

to hope, nevertheless, that his efforts to continue the development in the secretaryship of the Faculty of a strong co-ordinating and centripetal agency, counterbalancing in some measure the centrifugal and possibly even disintegrating tendencies of expansion and departmental specialization, may prove to have some permanent significance, as a contribution however slight toward keeping the Institute something more and better than a combination of departments.

In closing this service, he desires to express his high appreciation of the constant co-operation and generous support he has received from his colleagues in the Faculty, and of the efficient and faithful service rendered by members of his administrative staff, extending in some cases over nearly the entire period.

H. W. TYLER.
Secretary of the Faculty.

REPORT OF THE DEAN.

During the greater part of the school year the work of the Dean's office has been under the efficient charge of Professor A. L. Merrill of the Department of Mechanical Engineering. Professor Merrill had regular office hours for consultation with students and took charge of the various committees of which the Dean is chairman. This arrangement proved to be most satisfactory in every way to the Faculty and to the student body.

During the year the routine work of the office was carried on as usual. The lodging and boarding house list was kept up, and was consulted very largely by the new students. In addition to the endeavor made by the Dean's office to find outside employment during the term and for the summer vacation for such students as made application for assistance in this direction, Mr. Rand, the Bursar, found employment for some students who applied to him, and Mr. Gates, the

college secretary of the Y. M. C. A., also kept a list of available positions.

On Wednesday evening, December 27, 1905, students who were unable to be at their homes during Christmas week were entertained at the Technology Club, by invitation of Mr. Guy Lowell, President of the Club. Over fifty men were present and enjoyed an illustrated talk by Professor Derr on a trip which he had taken through Japan. There were students present from England, China, Japan, South Africa, India, Egypt, Uruguay, and Mexico.

On three successive Wednesdays, December 6, 13, and 20, from four to five o'clock, short addresses were given to the first-year students by the heads of the professional departments, outlining the nature of the studies pursued in their respective Departments. These talks were intended to assist the students in choosing their courses of study, and were preceded on the first afternoon by an address by Dr. Tyler, who outlined in a most excellent and comprehensive manner the work of the Institute and pointed out the reasons which should guide a student in the selection of his course of study. Attendance at these exercises was compulsory, and was made a part of the prescribed work in English, each student being required to present an abstract of at least one of the addresses delivered on each afternoon.

Upon Professor Burton's return from Europe September 1, after a year's leave of absence, he again took up the work of the office. The customary arrangement for meeting new students in the General Library for advice and consultation on the Monday and Tuesday preceding the opening of the term was carried out as usual. Advisers were appointed for all new students, men from other colleges who were entering with advanced standing being assigned, when practicable, to the heads of the Departments in which they were to take up work. In general the number of students assigned to one adviser does not exceed eight.

On Friday evening, October 26, the Technology Club united

with the Walker Club in giving a reception to all new students entering the Institute from other colleges. More than one hundred and fifty invitations were sent out, and there was a good attendance. After brief addresses by the Presidents of the clubs and by the Dean, opportunity was given for the men to become acquainted. This reception has always proved to be of great benefit to the college men, as it is almost the only opportunity which they have during the first year to meet those outside their own courses of instruction.

Mr. John F. Mahan, coach for the athletic teams, reports that the approximate number of men who have taken part in the different kinds of recognized athletics carried on by the Massachusetts Institute of Technology Athletic Association is as follows:—

Track Athletics	90	'09 Tug-of-war	61
Hare and Hound Run	30	'10 Football Team	26
Basket Ball	30	'10 Tug-of-war	65
Lawn Tennis	25	Total	344
'09 Football Team	17		

The approximate number of students who used the Technology Athletic Field from September 26 until October 27 is ninety men per day.

STATISTICS OF ILLNESS FOR THE SCHOOL YEAR. 1905-06.

Fourth-year Class.

There were three hundred and eighty-one students, regular and special, in the fourth-year class. Of these twenty-two were reported ill during the school year 1905–06. Classified by diseases, there were the following cases: abscess in throat, 1; eye trouble, 4; grippe, 1; injury to foot, 1; injury to hand, 1; mumps, 2; ptomaine poisoning, 1; rheumatism, 1; sprained ankle, 1; typhoid fever, 1; not specified, 7. There was one death in this class, that of Mr. P. K. Dodge, on March 19, 1906, due to accident.

Third-year Class.

The whole number of students in this class was three hundred and fifty-eight. Of this number twenty-five were reported ill during the year.

Classified by diseases, there were the following cases: bronchitis, 1; cholera morbus, 1; eye trouble, 2; grippe, 3; injury to arm, 1; injury to leg, 1; indigestion, 1; jaundice, 1; malaria, 2; measles, 1; typhoid fever, 1; cases in which illness was not specified, 6.

Second-year Class.

The regular and special students in this class numbered four hundred and nine, of whom forty-one were reported ill during the school year. The following cases were reported: boils, 1; cold, 1; eye trouble, 1; felon, 1; grippe, 1; injury to eye, 1; injury to foot, 1; measles, 5; mumps, 1; operation on nose, 1; overwork, 2; pharyngitis, 1; sprained ankle, 1; tapeworm, 1; tonsillitis, 1; typhoid fever, 1; unspecified cases, 11.

First-year Class.

The first-year class numbered two hundred and ninety-two. Of this number twenty-nine were reported ill during the year. Classified by diseases, the cases were as follows: appendicitis, 1; bronchitis, 1; cold, 1; diarrhœa, 1; eye trouble, 2; grippe, 3; injury to foot, 1; malaria, 1; measles, 1; overwork, 1; rheumatic fever, 1; rheumatism, 3; stomach trouble, 1; tonsillitis, 3; illness unspecified, 7. There was one death in this class, that of Mr. W. H. Wingate, on February 5, 1906.

SUMMARY.

	No. in Class	No. Ill.	No. of Deaths.
Fellows and Graduates	26	—	—
Fourth Year	381	22	1
Third Year	358	25	—
Second Year	409	41	—
First Year	292	29	1
Total	1,466	117	2

ALFRED E. BURTON, *Dean.*

REPORT OF THE DIRECTOR OF PHYSICAL TRAINING.

This Department has become well established in the new gymnasium, and has greatly increased facilities for work and development. Our new quarters are well heated, lighted, and ventilated, and are in every way a great improvement over the old gymnasium.

Owing to the lateness in getting into the new building, the work of the Department was somewhat delayed. Only about seventy-five men took physical examinations in the fall, and regular class-work did not begin until December 11th. The work was of the same general character as that of the preceding year. Much interest was displayed by the classes, and this continued throughout the year. In January the Gymnastic Team, formed for the purpose of stimulating interest in heavy gymnastics, began work, and on April 13th gave a very successful exhibition in the gymnasium. About thirty men took part. Regular class-work continued until April 20th, when the second physical examinations began. About sixty men took these examinations, and in all cases there was great improvement. The Cabot Medals for Improvement in Physical Training were awarded to L. T. Tuckerman, '06, J. E. Tresnon, '07, P. P. Greenwood, '07, J. F. Tobin, '08, and F. Jaegar, '09.

WINFIELD C. TOWNE,
Instructor in Gymnastics.

REPORT OF THE MEDICAL ADVISER.

There have been no important changes in the work of the Medical Adviser's Office during the past year. Consultation hours have been held as usual in the Pierce Building twice a week, and the students have fully utilized the appointed time, four to five o'clock in the afternoon. As a rule, more students came for advice than could be seen in an hour, and the time of consultation was extended when necessary, so that each man was seen. This extension of time varied with the season. On a half-dozen occasions, during the winter months, nearly two hours additional were needed. In the late spring no extra time was needed as a rule. The average extra time required for consultation throughout the year was thirty-five minutes more than the appointed hour.

The following table gives the number of office visits made and

Classified by diseases, there were the following cases: bronchitis, 1; cholera morbus, 1; eye trouble, 2; grippe, 3; injury to arm, 1; injury to leg, 1; indigestion, 1; jaundice, 1; malaria, 2; measles, 1; typhoid fever, 1; cases in which illness was not specified, 6.

Second-year Class.

The regular and special students in this class numbered four hundred and nine, of whom forty-one were reported ill during the school year. The following cases were reported: boils, 1; cold, 1; eye trouble, 1; felon, 1; grippe, 1; injury to eye, 1; injury to foot, 1; measles, 5; mumps, 1; operation on nose, 1; overwork, 2; pharyngitis, 1; sprained ankle, 1; tapeworm, 1; tonsillitis, 1; typhoid fever, 1; unspecified cases, 11.

First-year Class.

The first-year class numbered two hundred and ninety-two. Of this number twenty-nine were reported ill during the year. Classified by diseases, the cases were as follows: appendicitis, 1; bronchitis, 1; cold, 1; diarrhœa, 1; eye trouble, 2; grippe, 3; injury to foot, 1; malaria, 1; measles, 1; overwork, 1; rheumatic fever, 1; rheumatism, 3; stomach trouble, 1; tonsillitis, 3; illness unspecified, 7. There was one death in this class, that of Mr. W. H. Wingate, on February 5, 1906.

SUMMARY.

	No. in Class	No. Ill.	No. of Deaths.
Fellows and Graduates	26	—	—
Fourth Year	381	22	1
Third Year	358	25	—
Second Year	409	41	—
First Year	292	29	1
Total	1,466	117	2

ALFRED E. BURTON, *Dean.*

REPORT OF THE DIRECTOR OF PHYSICAL TRAINING.

This Department has become well established in the new gymnasium, and has greatly increased facilities for work and development. Our new quarters are well heated, lighted, and ventilated, and are in every way a great improvement over the old gymnasium.

Owing to the lateness in getting into the new building, the work of the Department was somewhat delayed. Only about seventy-five men took physical examinations in the fall, and regular class-work did not begin until December 11th. The work was of the same general character as that of the preceding year. Much interest was displayed by the classes, and this continued throughout the year. In January the Gymnastic Team, formed for the purpose of stimulating interest in heavy gymnastics, began work, and on April 13th gave a very successful exhibition in the gymnasium. About thirty men took part. Regular class-work continued until April 20th, when the second physical examinations began. About sixty men took these examinations, and in all cases there was great improvement. The Cabot Medals for Improvement in Physical Training were awarded to L. T. Tuckerman, '06, J. E. Tresnon, '07, P. P. Greenwood, '07, J. F. Tobin, '08, and F. Jaegar, '09.

WINFIELD C. TOWNE,
Instructor in Gymnastics.

REPORT OF THE MEDICAL ADVISER.

There have been no important changes in the work of the Medical Adviser's Office during the past year. Consultation hours have been held as usual in the Pierce Building twice a week, and the students have fully utilized the appointed time, four to five o'clock in the afternoon. As a rule, more students came for advice than could be seen in an hour, and the time of consultation was extended when necessary, so that each man was seen. This extension of time varied with the season. On a half-dozen occasions, during the winter months, nearly two hours additional were needed. In the late spring no extra time was needed as a rule. The average extra time required for consultation throughout the year was thirty-five minutes more than the appointed hour.

The following table gives the number of office visits made and

the number of students seen. A few figures of the previous years are given for comparison.

	1904.	1905.	1906.
Total number of office visits made	349	406	345
Total number of different students seen	185	191	195
Greatest number of students seen per day			11
Least number of students seen per day			2
Average number of students seen per day			6
Number of students making more than one visit			61

A comparison of these figures for the last three years shows that the amount of work of the medical office remains fairly uniform from year to year, and that the time at present devoted to giving medical advice to the students will probably prove sufficient for their needs in the immediate future.

It is evident that more than two-thirds of the men found it necessary to make only one visit, usually for the treatment of some acute and promptly curable condition.

A classified list of the diseases treated, and the number of each, will be found at the end of this report. A large number of conditions were treated, the most numerous being diseases of the digestive apparatus, of the nose and throat, of the skin, and surgical affections. About a dozen men suffered from severe illness, such as appendicitis, Bright's disease, malaria, jaundice, goitre, cocaine habit, and fractures. Two men had to leave the Institute on account of pulmonary tuberculosis. A small number of students were referred to specialists for treatment of the eye, ear, and skin. A small number of students were referred to the Massachusetts General Hospital, where the Institute has free beds for the treatment of such acute diseases as appendicitis, grippe, malaria, asthma, fracture, etc.

In addition to the work at the Institute office I have seen about sixty sick men at my private office and a much smaller number at their homes.

In addition to sick students, six healthy men were examined for the United States Civil Service, or for athletic teams. Each year I see about a dozen healthy men, who are anxious about

their physical condition, and whom it is a great satisfaction to be able to reassure, and to keep out of the hands of quacks.

Each year the Medical Adviser sees a few men who get tired early in the fall term and in whom the cause of this unfortunate condition is found in too arduous or continuous work through the summer. If the officers of instruction at the Institute have an opportunity to advise the students about summer work, I think it is very desirable that they should tell the men that it is wise to take some rest at the end of the school year before beginning summer work, and again during September before the fall term begins.

The number of contagious diseases at the Institute for the year is as usual very small, owing, no doubt, to the scattered residence of the men. The men have a very strong and natural desire to return to the Institute promptly after illness, in order not to get behind in their work, and the temptation is great to cut short the necessary period of quarantine after contagious disease, so that it is not surprising that now and then a man is found who is a little careless about exposing his fellow-students to infection.

The discovery the last year that an Institute janitor had well developed tuberculosis of the lungs, and a sputum loaded with the germs of the disease, indicates the necessity for some control or inspection of the Institute workmen in case of illness.

Three talks on personal hygiene were given by the Medical Adviser to the whole freshman class upon the following subjects:—bathing, exercise, care of the eyes, the use of tobacco and alcohol, minor ailments and emergencies, and the prevalence and dangers of venereal disease.

At the suggestion of Professor Talbot a talk was given the instructors and students of the Chemical Department upon the emergency treatment of injuries to which chemists are especially exposed. The subjects covered were burns, including those made by mineral acids and phosphorus, the treatment of suffocation or poisoning by gases such as hydrogen sulphide, carbon monoxide, chlorine, bromine, ammonia, hydrocyanic

acid, arseniureted hydrogen, ether, and turpentine vapors and poisoning by the accidental swallowing of mineral poisons. The emergency treatment of cuts and hemorrhage was outlined, and the method of carrying on artificial respiration demonstrated. In addition to the lectures and work of caring for sick students, letters of parents about the health of their sons have been answered, advice given to instructors and students about isolation in case of contagious diseases, and upon other topics, such as the risks to health from work in tropical climates or from work in caissons.

DISEASES TREATED BY THE MEDICAL ADVISER.

Stomach and Bowels, 32

Constipation	9	Acute diarrhœa	8	Gastric neurosis	5
Hemorrhoid	3	Appendicitis	3	Tapeworm	2
Gastroptosis	1	Catarrhal jaundice,	1		

Nose and Throat Cases, 31

Acute rhinitis	11	Pharyngitis	9	Chronic rhinitis	5
Nose-bleed	12	Chronic atrophy of tonsils	2	Laryngitis	1
Adenoids	1				

Skin, 32

Acne	7	Eczema	7	Herpes	3
Urticaria	3	Wart	3	Alopecia	2
Scabies	2	Psoriasis	1	Ringworm	1

Eye, 12

Eye-strain	7	Conjunctivitis	3	Foreign body	2

Surgical Cases, 35

Abscess	4	Sprain	4	Cut	2
Hernia	4	Ankle sprain	3	Flat-foot	2
Synovitis	2	Fractured rib	2	Hematoma	1
Spinal curvature	1	Ulcer, foot	1	Bruise of elbow	1
Sprain, finger	1	Crushed finger	1	Phlebitis	1
Fracture of nose	1	Septic wound	4		

Specific Infectious Diseases, 13

Tonsillitis	6	Grippe	3	Mumps	2
Malaria	1	Measles	1		

Genito-urinary Cases, 15

Varicocele	5	Urethritis	4	Balanitis	2
Nephritis	2	Albuminuria	1	Specific	1

Lungs, 10

Bronchitis	6	Pulmonary tuberculosis	2	Pleurisy	1
Asthma	1				

Heart, 3

Cardiac neurosis	3

Ear, 5

Otitis media	4	Polyp	1

Miscellaneous Cases, 41

Emissions	12	Neurasthenia	10	Phys. exam. for U. S. Civil Service	5
Overwork	4	Muscular rheumatism	2		
Phys. exam. for track team	1	Neuritis	1	Neuralgia	1
Goitre	1	Cocaine habit	1		

FRANKLIN W. WHITE, M.D.,
Medical Adviser.

REPORT OF THE LIBRARIAN.

The total accessions to the Libraries of the Institute during the year ending September 30, 1906, amount to 3,991 items, as follows:—

TABLE OF GROSS ACCESSIONS CLASSIFIED BY SOURCES.

By Purchase	1,313
By Binding	1,093
By Gift, Volumes	1,045
By Gift, Pamphlets and Maps	540
Total	3,991

Comparing these figures with those of last year, it will be noticed that there is some increase in the number of accessions by purchase and by binding, and a falling off of about 270 in the number by gift

Bills approved in this office for the purchase of books and periodicals and for binding and library supplies amount to the sums given below:—

Books and Binding	$5,073.37
Periodicals	1,723.08
Supplies	223.50
Total	$7,019.95

The net accessions, calculated by deducting from the gross accessions the books lost or destroyed and old books reaccessioned, amount to 3,392 volumes, 388 pamphlets, and 136 maps; increasing the total contents of the libraries to 74,695 volumes, and 20,982 pamphlets and maps. The particulars of the growth of the several Libraries in numbers of volumes, pamphlets, and maps, with the amount expended for each Library and the present total contents, are shown in the following table:—

TABLE OF THE NET INCREASE WITH THE COST OF THE SAME DURING THE YEAR 1905–06, AND THE TOTAL CONTENTS OF THE LIBRARIES OF THE INSTITUTE, SEPT. 30, 1906.

LIBRARIES.	Net Increase.				Total Contents.	
	Volumes.	Pamphlets.	Maps.	Cost.	Volumes.	Pamphlets and Maps.
General Library:						
General	202	57	—	$194.60	7,084	5,038
English	57	—	—	102.45	3,372	44
Military Science	6	—	—	3.95	340	9
Walker Memorial	8	—	—	—	485	—
Drawing	11	—	—	17.75	39	1
Totals General Library	284	57	—	$318.75	11,320	5,092
Architecture	130	—	—	324.03	3,935	241
Biology	144	14	—	175.40	3,270	634
Chemistry	468	60	—	847.31	10,295	1,864
Electrical Engineering	207	14	—	438.20	1,225	56
Engineering	802	131	—	1,085.90	12,737	4,573
Geology	108	14	134	167.92	2,762	2,826
History and Economics	388	1	—	342.35	11,895	3,565
Margaret Cheney Room	—1	—	—	8.35*	669	13
Mathematics	149	3	—	304.60	1,644	217
Mining	283	13	2	406.57	4,190	668
Modern Languages	61	1	—	23.26	1,671	50
Naval Architecture	136	2	—	127.71	1,195	106
Physics	232	78	—	503.02	7,887	1,077
Totals	3,391	388	136	$5,073.37	74,695	20,982

An estimate of the present value of the several Libraries of the Institute having been called for in haste, in the early part of the

* Paid for periodicals charged to Cheney Fund.

summer, it seems desirable at this time to place on record a more careful estimate of the capital represented in the Libraries of the Institute. A careful estimate was made in the report for 1898–99. With that as a basis, and adding the amount actually expended for the Libraries from September, 1899, to September, 1906, we obtain the amounts given in the following table:—

ESTIMATED VALUE OF THE LIBRARIES OF THE INSTITUTE, SEPTEMBER 30, 1906.

LIBRARY.	Estimate * 1899.	COST 1899–1906.			Total Value 1906.
		Books, etc., charged to Dept.	Periodical Account.	Total.	
Rogers.					
General	$10,833	$3,267.15	$910.98	$4,178.13	$15,011.13
Mathematics . .	2,028	1,544.11	458.21	2,002.32	4,030.32
Mining	5,196	2,764.48	1,112.75	3,877.23	9,073.23
History and Econ.	13,450	2,783.70	1,162.99	3,946.69	17,396.69
Walker.					
Chemistry . . .	16,932	4,993.51	1,259.56	6,253.07	23,185.07
Physics	13,093	3,629.90	1,122.45	4,752.35	17,845.35
Engineering A.					
Engineering . . .	18,563	7,299.54	2,580.78	9,880.32	28,443.32
Pierce.					
Architecture . . .	18,402	2,871.32	1,121.46	3,992.78	22,394.78
Biology	4,890	1,658.73	1,771.28	3,430.01	8,320.01
Geology	4,412	930.92	296.59	1,227.51	5,639.51
Margaret Cheney R.	1,357	28.95	—	28.95	1,385.95
	Estimated Value of Books Transferred.				
Engineering C.					
Naval Architecture	$1,560	703.32†	83.16	786.48	2,346.48
Lowell.					
Electrical Eng. .	871	1,870.80	177.45	2,048.25	2,919.25
Modern Languages	1,275	267.96	332.57	600.53	1,875.53
Total . . .	$112,862	$34,614.39	$12,390.23	$47,004.62	$159,866.62

* As modified by transfers from Gen. to M. L. 981 at $1.30 . . . . . $1,275
H. & E. to Gen. 1,025 at 1.50 1,538
Phys. to E. E. 396 at 2.20 871
Eng'g. to N. A. 700 at 2.20 1,560

† Including gifts of Dr. Weld, costing $332.22.

In this table the total in the first column of figures is the same as in the report for 1898–99, but the amounts charged to several of the Departments have been modified by the transfer of books to the newly established Departmental Libraries, as indicated in the footnote. In the case of the Department of Naval Architecture, where are placed a large number of gifts from Dr. Weld, the cost of these gifts, so far as known, has been added to the amount charged to the Department. No other account of the gifts received has been made in this estimate, as it seemed fair to assume that the ordinary gifts, consisting largely of government and other official reports, would not more than offset the deterioration of the purchased books. Without taking these gifts into account, it will be seen that the total value amounts in all to $159,866.62.

The General Catalogue has grown during the year by the addition of 6,641 cards, making the total number of cards now in the General Catalogue 80,800. There were 1,272 orders issued for the purchase of books and periodicals and 1,244 orders issued to the binders. So far as a record has been kept of the circulation of books outside the Library, the data in regard to that may be tabulated as follows:—

CIRCULATION.

General Library	1,278	volumes	and	pamphlets.
Biological Library	179	"	"	"
Chemical Library	1,696	"	"	"
Engineering Library	1,820	"	"	"
Mining Library	945	"	"	"
Modern Languages Library	135	"	"	"
Physics Library	1,200	"	"	"

In the preparation of the following table, which shows the number of periodicals and other serials received during the year, special pains have been taken to insure accuracy. Comparing this table with that of the previous year, it will be noticed that the number of subscriptions charged to the periodical account has been decreased by nine, and the larger total is due chiefly to more careful tabulation of the various serial publications charged to the departmental appropriations. In estimating

the cost of exchanges, the actual number of copies of the *Technology Quarterly* that are mailed is taken as the basis. It would seem easy to give an accurate statement of the cost of the periodicals that are purchased for cash, but, as a matter of fact, many of the periodicals, especially those published in Germany, change in price so much from year to year that it is difficult to make a tabulation that will remain true for any considerable length of time.

TABLE OF PERIODICALS AND OTHER SERIAL PUBLICATIONS RECEIVED DURING THE YEAR 1905–06, CLASSIFIED BY DEPARTMENTS AND METHOD OF PAYMENT.

LIBRARIES.	Number Received.					Estimated Cost.			
	Gifts.	Charged to Department.	Periodical Account.		Totals.	Dept. Account.	Periodical Account.		Totals.
			Exch.	Subs.			Exch.	Subs.	
General	39	22	28	27	116	$63.31	$24.00	$86.59	$173.90
Architecture	7	11	2	29	49	58.54	2.00	130.31	190.85
Biology	8	18	15	33	74	75.62	18.00	254.38	348.00
Chemistry	13	48	15	32	108	169.86	32.00	195.17	397.03
Electrical Engineering	7	14	5	5	31	44.34	14.00	27.10	85.44
Engineering	44	68	64	57	233	174.38	102.00	227.27	503.65
Geology	12	8	11	7	38	33.64	4.00	38.90	76.54
History and Economics,	58	51	4	38	151	110.80	2.00	119.56	232.36
Margaret Cheney Room,	—	6	—	—	6	17.20	—	—	17.20
Mathematics	2	4	2	16	24	9.60	2.00	73.53	85.13
Mining	10	12	36	24	82	29.27	64.00	102.85	196.12
Modern Languages	1	1	1	18	21	2.16	2.00	85.18	89.34
Naval Architecture	5	11	5	6	27	53.93	10.00	19.13	83.06
Physics	17	19	22	24	82	79.17	30.00	103.08	212.25
Totals	223	293	210	316	1,042	$921.82	$306.00	$1,463.95	$2,690.87

The General Library has been kept open during term time until 10 o'clock in the evening The average attendance for the 157 days from 5 to 7 P.M. was 6.4, and from 7 to 10 P.M. 5.7, the total attendance for these periods being 1,011 and 912, respectively.

The more notable gifts received during the year are 56 volumes on Naval Architecture from Dr. Charles Goddard Weld, of the Corporation; four volumes of her works from Mrs. Ellen H. Richards, of the instructing staff: 60 volumes from Mrs.

Jerome Sondericker, these volumes having formed a part of the library of her husband, the late Professor Sondericker of our Faculty; a copy of "The Mechanical and Electrical Inventions of E. K. Adams," 2 volumes, from his father, Edward D. Adams, Esq.; 153 volumes, mostly chemical journals, from Edward R. Warren, Esq., of Brookline, through the courtesy of President Eliot; from Professor C E. Holmberg, of Helsingfors, four volumes of his works.

The great need of the Library is space. If it should be decided to move the Institute to a new site, provision should be made in the administration building for a much larger General Library than we now have. While the present general reading-room is adequate for the present number of students, if the student body should increase very much in size, a larger reading-room would be required. But the chief need is stack room for the storage of books. The shelves of the General Library are now filled very nearly to their full capacity, as are also the shelves in the adjoining Room 16, the office and lecture-room of the Professor of English, in which have been placed a large number of books of classes not often consulted. In planning new library rooms, there should be provided a room that could be completely filled with book stacks. It should be easily accessible from both the general reading-room and the office of the Librarian, and should be capable of indefinite extension. It would be used not only to store the less frequently consulted books of the General Library, but also—and this would be probably its greatest value—to store surplus books from Departmental Libraries; that is, books that the Institute must keep in its Library, but which are so little used that they could be transferred from the Departmental Libraries to the General Library without serious inconvenience, provided that they can be properly classified and arranged in such a stack as is here suggested.

The ever-present need for more space is felt perhaps most keenly in the office of the Librarian. A well-lighted and well-ventilated room four times the size of the present office would be no more than sufficient for the use of the central library

staff. Every book, periodical, or map, purchased by or given to the Institute passes through this office at least once; if, then, the book has to go to the bindery to be bound or numbered, it passes through this office twice more. Every time a book enters or leaves the office it must be recorded. New books and volumes of periodicals newly bound must be entered in the record of accessions, catalogued, and classified. In addition to all this, duplicate cards have to be made for the Departmental Libraries, unbound books and periodicals have to be taken apart and arranged for the binder, especially those printed in foreign languages, letters have to be written, and the usual work of a business office attended to. In order that such work can be carried on economically and without confusion, there are needed, in addition to the usual desks, large tables where books can be spread out or arranged in convenient piles. The office should be furnished also with sufficient shelves and cabinets to hold the library supplies, to store new books awaiting invoices or classified by Departments preparatory to being catalogued, and recently catalogued books again classified by Departments and awaiting transportation to the Departmental Libraries; and there are needed shelves for a small library of reference books for use in connection with the ordering, cataloguing, and classification of new books. When books are received in large numbers, as frequently happens, it is not possible or economical to catalogue them or to send them to the Departmental Libraries all at once, and storage space for these must be provided. The conduct of such an office with the maximum of efficiency and economy depends upon each member of the staff being employed fully and continuously in an orderly sequence of duties, without hurry, worry, or interruption, and without unnecessary mechanical difficulties to be overcome. For such a condition in this department, the space and conveniences that I have attempted to describe are absolutely essential.

Besides the stream of books and periodicals that is constantly passing in and out of the Librarian's office, there is a large

number that for some reason must be retained for a greater or less period; for example, there are volumes of periodicals that are sent from the Departmental Libraries to be bound, but are found to be defective and must be held until the missing parts can be recovered, or perhaps obtained from abroad; there are duplicates that cannot be disposed of until it is certain that the corresponding volumes have been securely bound and placed upon the shelves of the Library; and, most important of all, there is the great quantity of books and periodicals received between the middle of June and the last of September, which cannot be sent to the Departmental Libraries because no one is there to receive them until the next term begins. Since books are bulky and incompressible, and are received in such numbers, it is impossible to retain them in the present office during the vacation, and do any work there. Storage in various places has been tried, but every summer serious inconvenience and loss is suffered from some of these books being misplaced or stolen. For the safe-keeping of these books an ample storeroom should be provided, opening into the office only and capable of being securely locked. There is needed also a small room opening into the General Library and into the office, and provided with desks for the Librarian and one assistant, this room to be used as a private office where the Librarian can be consulted by officers and students and can transact such business as requires personal interviews without disturbing the other workers.

In the Departmental Libraries the shelves are practically completely filled. The condition is such that in order to place new volumes upon the shelves in their proper places large numbers of books have frequently to be shifted. This not only means great loss of time and wasted energy on the part of the assistant in charge, but it causes great inconvenience to the users of the books, who cannot find them in their accustomed places. The Librarian frequently receives complaints from persons who have difficulty in finding books on this account. Data in regard to the annual growth of the Libraries were given in the report for

1904–05, pp. 85-87. Consideration of those facts would indicate that in planning buildings for the several Departments the space allotted to Libraries should be in most cases twice, and for two or three of the Departments considerably more than twice, the space now used for that purpose. In this connection I wish to urge once more the necessity of an extensible storage space, or stack, connected with the General Library for the relief of the Departmental Libraries. These Libraries, surrounded, as they must be, by the laboratories and drawing-rooms of the Departments with which they are connected, will always tend to grow beyond the space allotted to them, however generous a provision be made for them in the first place. But, if the older and less useful books can be transferred from time to time to the General Library, the Departmental Libraries can easily be kept within their proper limits, and at the same time fully supplied with the latest literature, while we may hope that the Library, as a whole, may retain its present position as the largest and most complete library belonging to any school of technology in this country.

ROBERT P. BIGELOW,
Librarian.

REPORT OF THE REGISTRAR.

The total number of members of the Instructing Staff as shown by the annual Catalogue this year, including those at the Mechanical Laboratories, but excluding the Research Associates and Assistants and those who are announced annually as lecturers only, is one hundred ninety-nine. Counting all, there are two hundred forty-one. Not taking into account the Research Associates and Assistants and Lecturers, the number of members of the Instructing Staff to that of students in regular attendance bears the proportion of one to six and nine-tenths. Last year it was seven and three-tenths.

The number of students has dropped again, this year, from fourteen hundred sixty-six to thirteen hundred ninety-seven, but the number in the first-year class has risen from two hundred ninety-two to three hundred forty-six. The senior class of last year was the largest in the history of the school. This year its place is taken by a smaller one. The third-year class is larger than that of last year, while last year's second-year class is replaced by the small first-year class of last year. The number of regular students is somewhat smaller than the number of the year before, but the ratio of regular students to specials is larger this year.

The number of new students is five hundred forty-six, as compared with four hundred eighty-two of last year. The percentages of new students, for these two years, are thirty-nine and thirty-four, respectively.

The number of graduates enrolled this year is two hundred. This includes fourteen who are either fellows or candidates for the doctor's degree. The number last year was two hundred one. The numbers of colleges and universities represented this and last year are eighty-eight and eighty-five, respectively.

There is no large gain in any of the professional Courses. The Course in Electrical Engineering has the same number of regular students, while there has been a slight drop in the corresponding number in all the Courses, except in Chemical and in Sanitary Engineering, where there has been a slight

gain. The greatest losses in per cent. are those in the Courses in Mining Engineering, Chemistry, and Naval Architecture. There are no regular students in the Courses in General Science or Geology.

The decrease in number of students at the Institute is distributed among all the five divisions of the United States, except the South Central States. Students are now registered from North Carolina, North Dakota, and South Dakota, states that were not represented by students last year. No student, however, comes from Arkansas this year. The students from foreign countries have risen in number from sixty-six to seventy-six, and five more countries are represented.

Forty-three states of the Union and one territory, besides the District of Columbia, Porto Rico, and the Philippines, are represented on our lists of students. Of the total number of thirteen hundred ninety-seven, seven hundred sixty-four are from Massachusetts, or fifty-five per cent. of the whole; the same per cent. as last year. All the counties of the state except Nantucket send students to the Institute.

One hundred thirty cities and towns of this state are on the list. A table shows the number of cities and towns of each county sending pupils, and also gives the aggregate number from each county. Middlesex County sends two hundred thirty; Suffolk, two hundred nineteen; Essex comes third with ninety-eight; Norfolk, fourth with ninety-one.

The registration in the Summer School (two hundred twenty-nine) was less than last year by thirty-seven; the number of students (thirty-nine) from other colleges or schools was smaller, by one, than last year. There was an increase in the number of those who attended to make up failures or deficiencies, while there was a marked decrease in those who were anticipating work. Courses were anticipated principally in Mechanic Arts, Descriptive Geometry, Architectural Design, Languages, Mechanical Drawing, and Surveying; chiefly by former students.

The Faculty Committee on Undergraduate Scholarships, at

its annual meeting for the awards for the current year, entertained one hundred ninety-two applications for aid. One hundred forty awards, amounting in all to $19,420, were made. Thirty-seven of these awards were replaced wholly or in part by State aid, to total amount of $4,925. The number who made applications for State aid and did not ask for Institute aid was forty-two. This makes a total of two hundred thirty-four applications for Scholarship aid. The twenty-nine State awards to those who received no Institute assistance, added to the one hundred forty Institute awards, gives a total number of one hundred sixty-nine students who are receiving scholarship assistance.

As was stated above, the class that was graduated last June was the largest in the history of the school. Of the two hundred seventy-seven who received the degree of Bachelor of Science, one hundred ninety completed the course in four years, while thirty-six fulfilled the requirements in five years, two were at the Institute for six years, and one completed his course in three years. Of the two hundred seventy-seven, forty-eight entered the Institute from other colleges, and, of these forty-eight, thirty came with degrees. It is interesting to note that the largest number and almost one-half of the college graduates spent two years to complete their courses and about one-quarter took three years; only three of the thirty received the degree in less than two years.

The usual tables of statistics for the current year are presented on the next few pages.

THE CORPS OF INSTRUCTORS.

The following table shows the distribution among the several classes of instructors, in comparison with last year:—

	1905-06.	1906-07.
Professors	35	39
Associate Professors	15	18
Assistant Professors	24	21
	74	78
Instructors	72	69
Assistants	53	52
	125	121
Research Associates	6	8
Research Assistants	4	3
	10	11
Lecturers	39	31
Total	248	241

STUDENTS BY CLASSES.

The aggregate number of students for 1906–07 is divided among the several classes, as follows:—

Fellows	7
Graduate students, candidates for advanced degrees	25
Regular students, Fourth Year	178
" " Third "	194
" " Second "	169
" " First "	272
Special students	552
Total	1,397

The following table shows the division of the whole body of students among the several years:—

Class.	Regular.	Special.	Total.
Fellows and Graduates of the M.I.T.	32	—	32
Fourth Year	178	133	311
Third Year	194	182	376
Second Year	169	163	332
First Year	272	74	346
Total	845	552	1,397

THE COURSES OF INSTRUCTION.

The following table presents the number of the regular and the special students in the second, third, and fourth years, by Courses:—

Year.		Civil Engineering.	Mechanical Engineering	Mining Engineering and Metallurgy.	Architecture.	Chemistry.	Electrical Engineering.	Biology.	Physics.	General Science.	Chemical Engineering	Sanitary Engineering	Geology	Naval Architecture	Total.
4th Year Class	Reg.	43	42	10	15	8	29	–	2	–	11	5	–	13	178
	Sp.	22	17	18	23	11	18	4	3	–	5	4	2	6	133
3d Year Class	Reg.	47	49	11	10	10	41	1	4	–	7	3	–	11	194
	Sp.	38	32	16	17	8	44	–	1	–	13	7	–	6	182
2d Year Class	Reg.	29	40	18	14	6	31	3	5	–	12	10	–	1	169
	Sp.	31	34	27	15	6	29	2	3	–	7	3	–	6	163
Total . . .	Reg.	119	131	39	39	24	101	4	11	0	30	18	0	25	541
	Sp.	91	83	61	55	25	91	6	7	0	25	14	2	18	478
		210	214	100	94	49	192	10	18	0	55	32	2	43	1,019

The following table shows the number of regular students in the foregoing table, in comparison with the corresponding figures for the next ten preceding years:—

Year.	Civil Engineering.	Mechanical Engineering.	Mining Engineering and Metallurgy.	Architecture.	Chemistry.	Electrical Engineering.	Biology.	Physics.	General Course.	Chemical Engineering.	Sanitary Engineering.	Geology.	Naval Architecture.	Total.
1896	99	117	24	65	66	106	7	11	* 11	34	8	–	25	573*
1897	109	119	38	71	60	90	8	9	10	36	7	1	26	578
1898	93	108	52	64	64	94	6	8	12	38	7	1	33	574
1899	99	113	60	53	58	84	8	7	11	30	14	1	38	575*
1900	89	127	69	53	50	87	6	4	8	34	17	1	38	582
1901	102	129	76	40	35	96	6	13	9	30	14	1	39	590
1902	129	133	83	43	58	118	2	20	9	30	12	1	65	703
1903	132	161	91	53	55	126	4	23	6	27	14	1	72	765
1904	140	158	77	41	46	98	4	13	—	32	22	1	49	681
1905	134	149	54	44	36	100	1	13	—	29	13	—	38	611
1906	119	131	39	39	24	101	4	11	—	30	18	—	25	541

* Deducting those counted twice.

GRADUATES BY YEARS AND COURSES.

YEAR.	Civil Engineering.	Mechanical Engineering.	Mining Engineering.	Architecture.	Chemistry.	Metallurgy.	Electrical Engineering.	Natural History or Biology.	Physics.	General Course.	Chemical Engineering.	Sanitary Engineering.	Geology.	Naval Architecture.	Total.
1868	6	1	6	–	–	–	–	–	–	1	–	–	–	–	14
1869	2	2	–	–	1	–	–	–	–	–	–	–	–	–	5
1870	4	2	2	–	1	–	–	–	–	1	–	–	–	–	10
1871	8	2	5	–	2	–	–	–	–	–	–	–	–	–	17
1872	3	1	5	–	3	–	–	–	–	–	–	–	–	–	12
1873	12	2	3	1	7	–	–	–	–	1	–	–	–	–	26
1874	10	4	1	1	–	–	–	–	–	2	–	–	–	–	18
1875	10	7	6	1	1	–	–	–	1	2	–	–	–	–	28
1876	12	8	7	–	5	1	–	2	3	4	–	–	–	–	42
1877	12	6	8	4	2	–	–	–	–	–	–	–	–	–	32
1878	8	2	2	3	3	–	–	–	–	1	–	–	–	–	19
1879	6	8	3	1	3	–	–	1	1	–	–	–	–	–	23
1880	3	–	3	–	1	–	–	–	–	1	–	–	–	–	8
1881	3	5	6	3	8	–	–	1	–	2	–	–	–	–	28
1882	2	5	5	3	6	–	–	1	1	1	–	–	–	–	24
1883	3	7	5	1	3	–	–	–	–	–	–	–	–	–	19
1884	5	6	13	–	12	–	–	–	–	–	–	–	–	–	36
1885	4	7	8	2	4	–	2	–	–	1	–	–	–	–	28
1886	9	23	7	1	7	–	10	1	–	1	–	–	–	–	59
1887	10	17	8	1	9	–	8	1	1	3	–	–	–	–	58
1888	11	25	4	5	10	–	17	3	1	1	–	–	–	–	77
1889	14	24	5	3	8	–	17	1	1	2	–	–	–	–	75
1890	25	28	3	5	13	–	18	3	2	6	–	–	–	–	103
1891	18	26	4	6	11	–	23	3	3	1	7	–	1	–	103
1892	22	26	4	13	7	–	36	6	1	7	4	6	1	–	133
1893	25	30	5	2	8	–	41	2	–	6	8	–	2	–	129
1894	21	31	4	14	11	–	33	1	3	5	12	3	–	–	138
1895	25	30	3	15	14	–	33	–	2	4	11	4	–	5	144*
1896	26	34	10	24	17	–	48	3	3	7	7	4	3	5	190*
1897	25	40	7	16	20	–	33	2	3	7	12	4	1	9	179
1898	32	41	7	29	25	–	33	3	4	6	9	3	–	7	199
1899	30	37	9	22	22	–	32	2	2	1	10	1	–	8	173*
1900	32	34	21	21	19	–	23	3	3	5	11	4	–	9	185
1901	37	39	18	21	17	–	25	1	1	6	14	4	1	16	200
1902	24	46	14	18	14	–	35	5	3	3	9	7	–	14	192
1903	26	37	27	15	13	–	39	1	4	1	10	4	1	12	190
1904	34	45	32	24	15	–	34	3	13	5	7	2	1	17	232
1905	46	54	26	12	23	–	31	3	3	3	13	5	1	24	244
1906	46	69	38	22	21	–	37	2	7	–	10	6	–	19	277
Totals	651	811	344	309	366	1	608	54	66	96*	154	57	12	145	3,669*
Names counted twice, students graduating in two different years . . .															16
Bachelors of Science															3,653*
Masters of Science, not included in the above															17
Total . . .															3,670*

* Deducting names counted twice (students graduating in two courses).

YEARLY REGISTRATION.

The following table shows the registration of successive years from the foundation of the Institute:—

Year	No. of Students.	Year.	No. of Students.
1865-66	72	1886-87	637
1866-67	137	1887-88	720
1867-68	167	1888-89	827
1868-69	172	1889-90	909
1869-70	206	1890-91	937
1870-71	224	1891-92	1,011
1871-72	261	1892-93	1,060
1872-73	348	1893-94	1,157
1873-74	276	1894-95	1,183
1874-75	248	1895-96	1,187
1875-76	255	1896-97	1,198
1876-77	215	1897-98	1,198
1877-78	194	1898-99	1,171
1878-79	188	1899-1900	1,178
1879-80	203	1900-1901	1,277
1880-81	253	1901-1902	1,415
1881-82	302	1902-1903	1,608
1882-83	368	1903-1904	1,528
1883-84	443	1904-1905	1,561
1884-85	579	1905-1906	1,466
1885-86	609	1906-1907	1,397

The special students this year constitute forty-one per cent. of the whole body, as against forty-two per cent. last year and thirty-five per cent. the year before.

The following table shows, by classes and by Courses, the number of regular students who have registered themselves as electing to distribute the required studies and exercises over the period of five years:—

Year.	Total.	Course.												
		I.	II.	III.	IV.	V.	VI.	VII.	VIII.	IX.	X.	XI.	XII.	XIII.
1st . . .	–	–	–	–	–	–	–	–	–	–	–	–	–	–
2d . . .	5	–	3	1	–	1	–	–	–	–	–	–	–	–
3d . . .	8	2	2	1	–	–	1	–	1	–	–	–	–	1
4th . . .	9	2	2	–	–	–	4	–	–	–	–	–	–	1
5th . . .	6	3	1	–	–	–	–	–	–	–	1	1	–	–
	28	7	8	2	–	1	5	–	1	–	1	1	–	2

The following is the number of students, either regular or special, pursuing certain leading branches of study, in each of the four years:—

	First Year.	Second Year.	Third Year.	Fourth Year.	Total.
Mathematics	334	344	192	–	870
Chemistry	344	103	98	66	611
English	324	225	50	2	601
French	226	–	42	–	268
Physics	–	300	375	48	723
German	188	78	41	–	307
Mechanic Arts . . .	–	130	73	65	268

The following table exhibits for ten years the distribution of the total number of students among two classes: first, those students whose names are found upon the Catalogue of the year preceding; and, secondly, those whose names appear first upon the Catalogue of the year to which the statement relates:—

Year.	(1) Total No. of Students.	(2) No. of Students in the catalogue of the previous year who remain in the Institute.	(3) No. of New Students entering before issue of catalogue.	(4) Of those in column (3) the following number are regular First-year Students.	(5) No. of New Students not of the regular First - year Class.
1897–98	1,198	757	441	277	164
1898–99	1,171	769	402	278	124
1899–1900	1,178	764	414	275	139
1900–1901	1,277	789	488	312	176
1901–1902	1,415	844	571	396	175
1902–1903	1,608	949	659	432	226
1903–1904	1,528	1,042	486	249	237
1904–1905	1,561	986	575	295	280
1905–1906	1,466	984	482	213	269
1906–1907	1,397	862	535	272	263

GRADUATE STUDENTS.

The number of students who are graduates of this and other institutions is two hundred. Of these thirty-two are candidates for advanced degrees, nineteen being our own graduates.

One hundred seventy-five are graduates of the following institutions, and are pursuing undergraduate courses of study with us either as regular or as special students:—

Universities.

Acadia	1	Montevideo	1
Boston	2	Northwestern	2
Brown	2	Ohio State	2
Bucknell	1	Ohio Wesleyan	1
Cambridge	1	Pennsylvania	1
Chicago	1	Princeton	10
Columbia	1	Rochester	1
De Pauw	1	Saint Louis	3
Georgia	1	South Dakota	1
Georgetown	1	Southwestern	2
Harvard	23	Southwestern Presbyterian	1
Havana	1	Spanish	1
Indiana	2	Tennessee	1
Johns Hopkins	6	Texas	3
Louisiana State	1	Virginia	1
McMasters	1	Washington and Lee	1
Maine	1	Wyoming	1
Minnesota	2	Wesleyan	2
Mississippi	1	Yale	7
Missouri	1		93

Colleges.

Adelbert	2	Lafayette	1
Adrian	1	Massachusetts Institute of Technology	23
Amherst	4	New Hampshire Agricultural	1
Anatolian	1	Oregon Agricultural	1
Bates	5	Randolph-Macon	1
Beloit	4	Rhode Island Agricultural	1
Boston	2	Rock Hill	1
Bowdoin	1	Rutgers	2
Bradley Polytechnic Institute	1	Sacred Heart	1
Canisius	1	Saint Johns	1
Case School of Applied Science	1	Saint Vincent	1
Centenary of Louisiana	1	Saint Xavier	1
Central Technical, London University	2	South Carolina	1
Centre	1	Texas Agricultural and Mechanical	2
Charleston	1	Throop Polytechnic Institute	3
Colby	1	U.S. Naval Academy	17
Colegio El Parvenir	1	Virginia Military Institute	1
Cooper Union Night School of Science	1	Washington and Jefferson	3
Dalhousie	2	Williams	6
Earlham	1	Wittenberg	1
Franklin and Marshall	1	Worcester Polytechnic Institute	1
Hamilton	1	Graduates of Colleges	113
Hampden-Sidney	1	Graduates of Universities	93
Immaculate Conception	1		206
Iowa	1	Double count	6
Iowa State	2	Total	200
Japanese Naval Engineering	1		
Kansas State Agricultural	1		

WOMEN STUDENTS.

The number of women pursuing courses with us is thirteen. Of these one is a college graduate. Of the total number one is a regular student of the fourth year, and five are of the second year. Seven are special students. Of the six regular students of the upper classes four take Course IV., Architecture; and two, Course V., Chemistry. Of the special students, four devote themselves to Architecture, one to Geology, while two are first-year students.

AGES OF STUDENTS.

The next table exhibits the ages of our students upon entrance, after taking out two who are repeating the first year, and seven persons of unusual ages. These deductions leave two hundred sixty-three as the number of students whose ages have been made the subject of computation.

Period of Life.	1905–1906.		1906–1907.	
	Half-year Groups.	Yearly Groups.	Half-year Groups.	Yearly Groups.
16 to 16½ years	1	—	—	—
16½ to 17 "	4	5	5	5
17 to 17½ "	13	—	14	—
17½ to 18 "	28	41	29	43
18 to 18½ "	42	—	51	—
18½ to 19 "	34	76	49	100
19 to 19½ "	30	—	51	—
19½ to 20 "	23	53	33	84
20 to 20½ "	14	—	12	—
20½ to 21 "	6	20	11	23
21 to 22 "	7	7	8	8
	202	202	263	263

The results appear in the table above in comparison with the corresponding results of 1905–06.

From the foregoing it appears that the average age on entrance is eighteen years and ten months.

In this connection are presented the ages, at graduation, of the class which left us in June. The two hundred seventy-eight members of the class were distributed among the different periods of life as follows:—

Under 20½	3
Between 20½ and 21	28
" 21 " 21½	20
" 21½ " 22	40
" 22 " 23	72
" 23 " 24	43
" 24 " 25	29
" 25 " 26	22
26 and over	21
Total	278

The average age was twenty-two years and nine months.

STATISTICS OF ADMISSION.

Of the 1,397 students of the present year, 535 were not connected with the school in 1905–06. Of these 248 were admitted as regular students of the first year upon the basis of their entrance examinations. The 287 remaining comprise (1) those who had previously been connected with the Institute, and have resumed their places in the school; (2) those who were admitted provisionally without examinations; (3) those who were admitted by examination as regular second year or as special students; (4) those who were admitted on the presentation of diplomas or certificates from other institutions of college grade. In addition to the 248 who were thus admitted to the first year on examination, and have taken their place in the school, 63 were admitted on examination, but have not entered the school.

In the case of the 271 persons who were admitted on examination, and have joined the school as regular students or as special students, the results of the examinations, embracing both those of June and those of September, were as follows:—

	Regulars.	*Specials.*
Admitted clear	159	7
" on one condition	52	7
" on two conditions	30	3
" on three conditions	7	6
	248	23

Of the 685 persons who presented themselves in June for examination, 19 Complete, 8 Final, 92 Preliminary, and 15 Partial candidates, a total of 134, were rejected. In September 17 Complete, 10 Final, and 17 Preliminary candidates were rejected. 292 candidates, including those for advanced standing, attended the September examinations.

92 college entrance examination board certificates were submitted.

STATISTICS OF GRADUATION.

Table to show the number of years spent at the Institute by students graduated with the class of 1906.

Total number of degrees of Bachelor of Science awarded June, 1906, 277.

Number receiving degree at end of 3d year	1
" " " " " " 4th "	190
" " " " " " 5th "	36
" " " " " " 6th "	2
Number entering from other colleges	48
	277

Of the college men 30 were graduates and 18 non-graduates.

STUDENTS FROM OTHER COLLEGES.

Yrs. at the Inst.	*Graduate*	*Non-graduate*	*Total*
1	3	0	3
2	14	6	20
3	8	7	15
4	3	3	6
5	2	2	4
	30	18	48

RESIDENCE OF STUDENTS.

The following tables show in detail and for the school as a whole the residence of students for the current year and for the last five years.

A Table to show the Number of Students in Each Year, from 1900, coming from Each State or Territory.

States and Territories.	1900.	1901.	1902.	1903.	1904.	1905.	1906.
North Atlantic.							
Connecticut	35	42	43	44	48	50	36
Maine	22	30	35	34	26	22	18
Massachusetts	779	837	935	869	889	807	764
New Hampshire	26	31	34	23	36	32	26
New Jersey	8	6	8	13	16	11	15
New York	68	79	96	104	94	71	84
Pennsylvania	37	36	44	52	56	58	55
Rhode Island	35	38	40	28	19	24	23
Vermont	15	15	12	11	5	5	4
Total	1,025	1,114	1,247	1,178	1,189	1,080	1,025
South Atlantic.							
Delaware	4	3	4	3	2	1	2
Dist. of Columbia	13	14	17	15	17	13	12
Florida	1	1	2	2	4	3	3
Georgia	3	4	6	4	6	8	4
Maryland	13	16	27	25	18	19	17
North Carolina	2	6	6	7	1	–	1
South Carolina	1	2	4	–	–	1	3
Virginia	3	5	7	7	4	7	8
West Virginia	1	1	–	–	–	1	2
Total	41	52	73	63	52	53	52
South Central.							
Alabama	1	2	1	1	1	1	2
Arkansas	1	1	1	1	–	1	–
Kentucky	5	9	11	9	8	5	5
Louisiana	2	1	2	2	5	1	2
Mississippi	–	–	–	4	4	4	5
Tennessee	6	4	3	5	2	2	3
Texas	4	7	9	11	13	16	15
Total	19	24	27	33	33	30	32
North Central.							
Illinois	39	44	49	44	43	42	37
Indiana	7	11	14	6	10	10	15
Iowa	10	8	8	6	9	13	14
Kansas	–	1	1	1	4	7	6
Michigan	8	12	10	9	9	10	7
Minnesota	7	10	10	9	11	13	14
Missouri	13	19	20	22	25	29	17
Nebraska	4	3	5	4	5	4	2
North Dakota	–	–	1	1	1	–	3
Ohio	27	27	43	37	35	34	30
South Dakota	1	2	1	3	2	–	1
Wisconsin	8	11	11	13	14	12	7
Total	124	148	173	155	168	174	153
Western.							
California	10	9	15	19	18	23	21
Colorado	8	6	10	11	16	17	12
Idaho	–	1	–	–	–	–	–
Montana	5	4	3	2	5	3	3
Nevada	1	–	–	–	–	1	1
New Mexico	–	–	1	1	2	–	–
Oregon	1	2	4	7	8	5	2
Utah	7	7	2	3	3	2	3
Washington	2	4	3	3	2	2	5
Wyoming	–	–	1	–	–	2	5
Total	34	33	39	46	54	55	52

States and Territories.	1900.	1901.	1902.	1903.	1904.	1905.	1906.
Hawaii	1	–	–	1	1	1	2
Philippine Islands	–	–	–	–	4	2	3
Porto Rico	–	1	2	2	4	5	2
Total	1	1	2	3	9	8	7
Total for the United States	1,244	1,372	1,561	1,478	1,505	1,400	1,321

A Table to show the Number of Students in Each Year, from 1900, coming from Each Foreign Country.

Foreign Countries.	1900.	1901.	1902.	1903.	1904.	1905.	1906.
Argentine Republic	–	–	–	–	–	–	1
Armenia	–	–	–	1	1	3	2
Australia	–	–	2	3	1	3	3
Austria	–	1	–	–	–	–	–
Belgium	–	–	–	–	–	–	1
Bermuda	1	2	1	1	–	1	1
Brazil	–	4	5	3	3	1	–
British Columbia	–	–	–	–	–	–	1
Cape Colony	–	–	–	–	–	–	1
Central America	–	–	–	–	1	–	–
Chili	–	1	1	1	1	2	1
China	–	1	1	2	8	8	7
Cuba	–	1	2	3	4	4	4
Denmark	1	1	1	1	1	1	1
Ecuador	–	–	–	–	1	–	2
Egypt	–	–	–	–	–	1	2
England	3	3	3	4	4	5	6
France	4	1	–	–	1	1	–
Germany	2	3	1	2	–	–	–
Honduras	–	–	–	–	–	–	1
India	–	–	–	1	1	2	1
Ireland	–	–	1	1	–	2	2
Italy	–	–	–	–	–	2	–
Jamaica	1	1	–	–	1	–	1
Japan	2	2	1	2	1	3	5
Korea	–	–	–	–	2	–	–
Malta, Island of	–	–	–	1	1	–	–
Manitoba	–	–	1	1	–	–	–
Mexico	7	7	10	8	4	7	12
New Brunswick	2	2	2	1	2	4	3
Nova Scotia	2	6	8	9	4	1	4
Ontario	–	3	2	2	5	6	6
Peru	–	–	–	–	–	1	1
Quebec	4	2	–	1	2	1	1
Russia	1	1	–	–	–	–	–
Scotland	–	–	1	1	2	1	1
Sweden	–	–	–	–	1	–	–
Syria	–	–	–	1	1	–	–
Transvaal	–	–	–	–	1	3	3
Turkey	3	1	4	–	2	1	1
Uruguay	–	–	–	–	–	2	1
Total	33	43	47	50	56	66	76
Total in school	1,277	1,415	1,608	1,528	1,561	1,466	1,397

RESIDENCE OF STUDENTS FOR THIS SCHOOL YEAR.

States.	Candidates for Advanced Degrees.	Fourth Year.	Third Year.	Second Year.	First Year.	All Regular Students.	Special Students.	Total.
Alabama	–	–	1	1	–	2	–	2
California	–	3	2	1	2	8	13	21
Colorado	1	2	2	2	1	8	4	12
Connecticut	–	6	7	5	2	20	16	36
Delaware	1	–	–	1	–	2	–	2
D st. of Columbia	2	2	–	–	3	7	5	12
Fliorida	–	–	1	–	1	2	1	3
Georgia	–	1	–	–	–	1	3	4
Hawaii	–	–	–	1	–	1	1	2
Illinois	–	6	1	5	6	18	19	37
Indiana	2	2	1	4	1	10	5	15
Iowa	–	2	2	2	1	7	7	14
Kansas	–	1	1	–	–	2	4	6
Kentucky	–	1	–	–	–	1	4	5
Louisiana	–	–	–	–	–	–	2	2
Maine	–	2	4	3	4	13	5	18
Maryland	1	4	2	1	–	8	9	17
Massachusetts	13	91	121	105	187	517	247	764
Michigan	–	1	–	–	2	3	4	7
Minnesota	–	4	1	–	–	5	9	14
Mississippi	–	3	–	1	–	4	1	5
Missouri	–	2	1	3	–	6	11	17
Montana	–	–	1	–	1	2	1	3
Nebraska	–	–	1	–	–	1	1	2
Nevada	–	–	–	–	–	–	1	1
New Hampshire	1	3	4	2	7	17	9	26
New Jersey	1	1	4	2	3	11	4	15
New York	1	13	9	7	20	50	34	84
North Carolina	–	–	–	–	1	1	–	1
North Dakota	–	–	–	–	2	2	1	3
Ohio	3	5	3	1	2	15	15	30
Oregon	–	–	–	–	1	1	1	2
Pennsylvania	2	8	9	4	7	30	25	55
Philippine Islands,	–	–	–	–	–	–	3	3
Porto Rico	–	–	–	–	–	–	2	2
Rhode Island	–	2	3	4	2	11	12	23
South Carolina	–	–	–	1	–	1	2	3
South Dakota	–	–	1	–	2	1	–	1
Tennessee	1	–	–	–	–	1	2	3
Texas	1	4	1	3	1	10	5	15
Utah	–	–	–	–	1	1	2	3
Vermont	–	–	–	–	2	2	2	4
Virginia	–	1	1	1	2	5	3	8
Washington	–	–	–	–	1	1	4	5
West Virginia	–	1	–	–	–	1	1	2
Wisconsin	1	2	1	–	1	5	2	7
Wyoming	–	–	–	–	–	–	5	5
Foreign Countries.								
Argentine Repub.	–	–	–	–	1	1	–	1
Armenia	–	1	–	1	–	2	–	2
Australia	–	–	–	–	–	2	1	3
Belgium	–	–	–	–	–	–	1	1
Bermuda	–	–	–	–	–	–	1	1
British Columbia,	–	–	–	–	–	–	1	1
Cape Town	–	–	–	1	–	1	–	1
Chile	–	–	–	1	–	1	–	1
China	–	–	–	–	–	–	7	7
Cuba	–	2	–	–	–	2	2	4
Denmark	–	–	1	–	–	1	–	1
Ecuador	–	–	–	–	1	1	1	2
Egypt	–	–	–	–	–	–	2	2
England	–	2	1	2	–	5	1	6
Honduras	–	–	–	–	1	1	–	1
India	–	–	–	–	–	–	1	1
Ireland	–	–	–	–	1	1	1	2
Jamaica	–	–	–	–	1	1	–	1
Japan	–	–	–	–	–	–	5	5
Mexico	–	–	2	1	3	6	6	12
New Brunswick	–	–	–	–	–	–	3	3
Nova Scotia	1	–	1	1	–	3	1	4
Ontario	–	–	–	2	–	2	4	6
Peru	–	–	–	–	–	–	1	1
Quebec	–	–	1	–	–	1	–	1
Scotland	–	–	1	–	–	1	–	1
Transvaal	–	–	–	–	–	–	3	3
Turkey	–	–	–	–	–	–	1	1
Uruguay	–	–	–	–	–	–	1	1
Total	32	178	194	169	272	845	552	1,397

RESIDENCE OF MASSACHUSETTS STUDENTS.

(1) From Counties.

County.	No. of Towns.	No. of Students.	County.	No. of Towns.	No. of Students.
Barnstable	2	4	Hampshire	2	2
Berkshire	6	21	Middlesex	34	230
Bristol	9	29	Norfolk	21	91
Dukes	1	3	Plymouth	13	29
Essex	22	98	Suffolk	4	219
Franklin	3	4	Worcester	10	16
Hampden	3	18	Total	130	764

(2) FROM CITIES WHICH SEND FIVE OR MORE STUDENTS.

Boston	203	Salem	11	Pittsfield	7
Newton	49	Springfield	11	Abington	6
Brookline	33	Taunton	11	Melrose	6
Cambridge	22	Wakefield	10	North Adams	6
Somerville	21	Gloucester	9	Reading	6
Malden	19	Haverhill	9	Adams	5
Lowell	15	Lynn	9	Natick	5
Newburyport	15	Quincy	8	New Bedford	5
Waltham	15	Wellesley	8	Peabody	5
Lawrence	13	Chelsea	7	Revere	5
Hyde Park	12	Medford	7		

SUMMER SCHOOL.

TABLE SHOWING THE NUMBER OF STUDENTS REGISTERED IN EACH OF THE COURSES OF THE SUMMER SCHOOL FOR THIS YEAR AND THE YEAR BEFORE.

	1905	1906
Air, Water and Food Analysis	0	4
Analytic Geometry	30	20
Applied Mechanics	24	19
Bacteriology	2	0
Carpentry and Wood Turning	8	4
Chemistry, Inorganic and Analytical	42	39
Chipping and Filing	3	9
Descriptive Geometry	36	35
Design	6	9
Forging	10	16
French	14	9
German	19	10
Integral Calculus	12	14
Machine-Tool Work	26	27
Mechanical Drawing	19	21
Mechanical Engineering Drawing	9	19
Mechanism	6	18
Metal Turning	0	1
Pattern Work	9	3
Physical Laboratory	15	10
Physics	43	39
Precision of Measurements	0	6
Shades and Shadows	5	1
Surveying	27	14

Additional Statistics.

	1905	1906
Number from other colleges and schools attending	46	39
Number not referring to any other college or school	8	4
Number from Massachusetts Institute of Technology	218	186
		229
Number who registered, but did not attend	13	14
Number who applied, but cancelled registration	10	2

From Other Colleges and Schools.

Bucknell University	1
Harvard University	6
Johns Hopkins University	1
Princeton University	1
Purdue University	1
Unión University	1
Washington University	1
Yale University	1
University of Chicago	1
University of Michigan	1
University of Mississippi	1
University of Texas	1
Amherst College	1
Bates College	2
Bowdoin College	1
Dalhousie College	1
Hampden-Sidney College	1
Wellesley College	1
Woodstock College	2
Worcester Polytechnic Institute	2
1 each from District School, Adamsville, Que., Groveland High School, Lynn English High School, Massachusetts Normal Art School, Millis High School, New York Technical School, Norfolk Academy, Oswego Normal School, Parrsboro High School, Peekskill Military Academy, and Portland High School	
	39

From Massachusetts Institute of Technology.

	1905	1906
Number of subjects taken to make up failures or deficiencies	196	166
Number of subjects taken to anticipate work	149	220

WALTER HUMPHREYS, *Registrar.*

The Society of Arts.

To the President of the Massachusetts Institute of Technology:

Sir,—On behalf of the Executive Committee I have the honor to present the annual report of the Society of Arts for the year ending May 10, 1906.

The first meeting of the Society for the present year was held on October 12, 1905. Thirteen meetings have been held, with an average attendance of one hundred and seven. The interest manifest in the Society for several years has been continued during the past year, not only by the members, but by the public at large and by many of the students of the Institute, the attendance of the latter when papers of technical interest have been presented being especially gratifying. The range of subjects presented has been a wide one, and as a consequence nearly all the students have had the opportunity to hear a paper on some subject of professional interest.

The following papers have been read:—

The Disposal of City Sewage, by Professor Charles-Edward A. Winslow, Biologist in charge of the Sanitary Research Laboratory and Sewage Experiment Station.

Browntail and Gypsy Moths, their Life Histories, and Some Suggestions for their Suppression, by Mr. William Lyman Underwood.

Submarine Signalling, by Mr. Henry R. Gilson.

Recent Researches on the Canals of Mars, by Professor Percival Lowell, Director of the Astronomical Observatory at Flagstaff, Arizona.

The Treatment of the Black Sands of the Pacific Coast by the United States Geological Survey, by Professor Robert H. Richards, of the Institute.

The American Indian Folklore, by Professor Alexander F. Chamberlain, of Clark University.

Hydraulic Mining in British Columbia and Alaska, by Mr. Howard W. Du Bois, Mining Engineer of Philadelphia.

Causes and Effects of River Capture, by Professor Douglas W. Johnson, of the Institute.

Shoddy, or the History of a Woolen Rag, by Mr. Henry G. Kittredge, Editor of the *Textile American*.

The Chemistry of Cellulose as Applied to Textile Fibres, Mercerized Cotton, Artificial Silk, and Horse Hair, by Professor William H. Walker, of the Institute.

The American Bison: Our Grandest Native Animal, by Mr. Ernest Harold Baynes.

The Rationale of the Industrial Betterment Movement, by Mr. H. F. J. Porter, of New York.

Practical Operation of a Dynamometer Car in Establishing Locomotive Tonnage Rating, by Mr. Herbert O. Keay.

The membership of the Society has remained practically the same as last year. Fifteen members have resigned, two have died, and two have not been heard from, and the number of new members elected to associate membership has been fourteen, leaving the total membership three hundred and fifty-eight. The *Technology Quarterly* has continued to be published under the editorship of Dr. Robert P. Bigelow, with the advice and counsel of the Publication Committee of the Society. In addition to the Proceedings of the Society twenty-five papers and twenty-five book reviews have been published. Among the papers published the following were of special interest:—

Modern Language Teaching, with Special Reference to Pronunciation and Conversation, by Professor John Bigelow, Jr.

The Cruiser, and The Sea-going Battleship, by Professor William Hovgaard.

Submarine Signalling, by Mr. Henry R. Gilson.

Railway Telephone Service, the Cost of Line Construction, by Mr. F. F. Fowle.

Orientation of Buildings and Streets in Relation to Sunlight, by Mr. William Atkinson.

The different departments of the Institute have contributed papers as follows: The Biological Department, four papers; the Chemical Department, three papers; the Electrical Engineering Department, two papers; the Geological Department,

two papers; the Naval Architecture Department, two papers; the Modern Languages Department, one paper.

At the forty-fourth annual meeting of the Society, held on May 10, 1906, the following officers were elected:—

Executive Committee.—George W. Blodgett, James P. Munroe, Edmund H. Hewins, James F. Norris, C. J. H. Woodbury.

Secretary.—Walter S. Leland.

Board of Publication.—William T. Sedgwick, Dwight Porter, Harry E. Clifford, Robert P. Bigelow, Dana P. Bartlett.

Respectfully submitted,

WALTER S. LELAND, *Secretary.*

Publications.

CIVIL ENGINEERING.

G. F. SWAIN.—Report to the Massachusetts Railroad Commissioners on Steam Railroad and Street Railway Bridges in Massachusetts. In *Report of Railroad Commissioners*, 1905.

G. F. SWAIN.—Report to the Massachusetts Railroad Commissioners on Steam Railroad and Street Railway Bridges in Massachusetts. In *Report of Railroad Commissioners*, 1906.

G. F. SWAIN.—What is the Best Preparatory Education for the Civil Engineering Profession? *Transactions of the American Society of Civil Engineers*, 1906.

G. F. SWAIN.—Technical Training the Best Education for Executive Work. *Transactions of the American Society of Civil Engineers*, 1906.

F. P. MCKIBBEN.—Parts of "Concrete Plain and Reinforced," by Taylor and Thompson, New York. Wiley & Sons, 1905.

F. P. MCKIBBEN.—Distribution of Loads on Stringers of Highway Bridges carrying Electric Cars. *Engineering News*, April 12, 1906.

F. P. MCKIBBEN.—Tension Tests on Steel Angles with Various Types of End Connections. Read before the American Society for Testing Materials, June, 1906. *Engineering News*, July 5, 1906.

C. B. BREED and G. L. HOSMER.—The Principles and Practice of Surveying. New York, Wiley & Sons, 1906.

MECHANICAL ENGINEERING.

G. LANZA.—Memoirs of Deceased American Investigators who have contributed to the Advance of the Testing of Materials. *Proceedings of the American Society for Testing Materials*, 1906.

G. LANZA.—Report of Committee on Standard Methods of Tests. *Proceedings of the American Society for Testing Materials*, 1906.

G. LANZA.—Tests of Re-enforced Concrete Beams. *Proceedings of the American Society for Testing Materials*, 1906.

E. F. MILLER.—Notes on Power Station Design. Published by the Institute.

C. F. PARK.—The Testing of Shock Absorbers. *Horseless Age*, Nov. 7, 1906.

MINING ENGINEERING AND METALLURGY.

R. H. RICHARDS.—Progress in Gold Milling in 1905. *The Mineral Industry*, Vol. XV., p. 289.

R. H. RICHARDS. Progress in Ore Dressing and Coal Washing in 1905. *The Mineral Industry*, Vol. XV., p. 685.

H. O. HOFMAN.—Recent Improvements in Lead Smelting. *The Mineral Industry*, Vol. XV., p. 388.

H. O. HOFMAN.—Improvements in Sampling and Assaying. *The Mineral Industry*, Vol. XV., p. 647.

H. O. HOFMAN (with R. HAYDEN and H. B. HALLOWELL).—A Study in Refining and Overpoling Electrolytic Copper. *Transactions of the American Institute of Mining Engineers*, Vol. XXXVI., 1906.

H. O. HOFMAN (with R. G. REYNOLDS and A. E. WELLS).—Lime Roasting a Galena Concentrate with Special Reference to the Savelsberg Process. *Transactions of the American Institute of Mining Engineers*, Vol. XXXVI., 1906.

H. O. HOFMAN (with U. S. CAYPLESS and E. E. HARRING-

TON).—The Constitution of Ferro-cuprous Sulphides. *Transactions of the American Institute of Mining Engineers*, Vol. XXXVI., 1906.

H. O. HOFMAN.—Review of Vol. I. of Henry Louis' translation of the Handbook of Metallurgy by C. Schnabel. *American Chemical Journal*, Vol. XXXV., p. 473.

CHEMISTRY AND CHEMICAL ENGINEERING.

H. P. TALBOT.—Technical Chemistry in Technical Schools. *Technology Quarterly*, Vol. XIX., p. 83.

H. P. TALBOT.—The Training of a Chemical Engineer. *Proceedings of the Society for the Promotion of Engineering Education*, 1906.

H. P. TALBOT.—See A. G. Woodman.

W. H. WALKER.—An Instructive Laboratory Experiment in Applied Chemistry. *Proceedings of the American Electrochemical Society*, Vol. IX., p. 24.

W. H. WALKER.—Some Present Problems in Technical Chemistry. *Congress of Arts and Sciences*, St. Louis Exposition, 1904, Vol. VI., p. 686.

HENRY FAY.—Notes on the Determination of Phosphorus in Iron and Steel; on the Analysis of Spathic Iron Ore; and on the Determination of Potassium and Sodium in Silicates. Prepared for the use of students of the Institute.

A. H. GILL.—Engine Room Chemistry. *Power*, New York, December, 1905–July, 1906.

A. H. GILL.—Gas and Fuel Analysis for Engineers. Fourth Edition. New York and London, Wiley & Sons, 1906.

A. H. GILL.—Examination of the Contents of a Mycenæan Vase found in Egypt. *Archæological Institute of America*, Vol. X., p. 300.

A. H. GILL.—The Determination of Rosin in Varnishes. *Journal of the American Chemical Society*, December, 1906.

F. L. BARDWELL and P. S. BURNS.—Laboratory Experi-

ments in Inorganic Chemistry. For the use of students of the Massachusetts Institute of Technology. Boston, 1906.

F. H. THORP.—The Technology of Boric Acid. *Proceedings of the New England Association of Chemistry Teachers*, 1906.

F. H. THORP.—Review of Current Literature upon Industrial Chemistry. *Journal of the American Chemical Society*, 1906.

F. J. MOORE.—Piperonal and Hydrogen Chloride: A Two-component Three-phase System. *Journal of the American Chemical Society*, Vol. XVIII., p. 1188.

F. J. MOORE and A. M. CEDERHOLM.—Benzoyl-p-Bromphenylurea: A By-product in the Preparation of Benzbromamide. *Journal of the American Chemical Society*, Vol. XXVIII., p. 1190.

E. H. RICHARDS.—Food Materials and their Adulterations. Third Edition. Boston, Whitcomb & Barrows, 1906.

E. H. RICHARDS.—The Cost of Shelter. New York and London, Wiley & Sons, 1905.

E. H. RICHARDS.—Source and Significance of Nitrites in Streams. *Reports of American Public Health Association*, Vol. XXXI., Part II., p. 241.

E. H. RICHARDS.—Wanted, A Test for "Man-power." *Clarkson Bulletin*, Vol., III. No. 3.

E. H. RICHARDS.—Air Supply Examination. *Report of American Public Health Association*, Sanitary Section, 1906.

E. H. RICHARDS.—Co-operation between Water Boards and Health Officials. *Proceedings of the American Water Works Association*, 1906.

E. H. RICHARDS.—The Present Status and Future Development of Domestic Science Courses in High Schools. *Proceedings of the Society for the Scientific Study of Education*, 1905.

E. H. RICHARDS and CHARLES W. MOULTON.—Ten Years' Experience with Broad Irrigation at Vassar College. *Journal of the Association of Engineering Societies*, Vol. XXXVI., p. 148.

P. S. BURNS.—See F. L. Bardwell.

G. W. ROLFE.—See W. T. Hall.

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A. G. WOODMAN (with G. P. SHINGLER, Jr.).—Analysis of American Malt Vinegar. *Technology Quarterly*, December, 1906.

W. T. HALL and G. W. ROLFE.—Beet Sugar Manufacture. Dr. H. Claassen. (Translation) New York and London, Wiley & Sons, 1906.

W. T. HALL.—Analytical Chemistry. F. P. Treadwell. (Translation of second German edition.) Second English Edition. New York and London, Wiley & Sons, 1906.

C. H. MATHEWSON.—Ueber Natrium-Aluminium, Natrium-Magnesium und Natrium-Zink Legierungen. *Zeitschrift für anorganische Chemie*, January, 1906.

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RESEARCH LABORATORY OF PHYSICAL CHEMISTRY.

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No. 8.—Concerning Silver Oxide and Silver Suboxide. By G. N. Lewis. *Journal of the American Chemical Society*, Vol. XXVIII., pp. 139–158, 1906.

No. 9.—The Potential of the Oxygen Electrode. By G. N. Lewis. *Journal of the American Chemical Society*, Vol. XXVIII., pp. 158–171, 1906.

No. 10.—An Elementary Proof of the Relation between the Vapor Pressures and the Composition of a Binary Mixture. By G. N. Lewis. *Journal of the American Chemical Society*, Vol. XXVIII., pp. 569–572, 1906.

No. 11.—On the Applicability of Raoult's Laws to Molecular

Weight Determinations in Mixed Solvents and in Simple Solvents Whose Vapor Dissociates. By G. N. Lewis. *Journal of the American Chemical Society*, Vol. XXVIII., pp. 766–770, 1906.

No. 12.—The Ionization of Fused Salts. By H. M. Goodwin and H. A. Wentworth. *Physical Review*, Vol. XXIII.

No. 13.—Equilibrium in the Deacon Process. By G. N. Lewis. *Journal of the American Chemical Society*, Vol. XXVIII.

No. 14.—A System of Qualitative Analysis for the Common Elements. By A. A. Noyes and W. C. Bray. *Technology Quarterly*, Vol. XIX., No. 3, pp. 191–290.

Other Publications of the Research Staff.

W. C. BRAY.—Beitrage zur Kenntnis der Halogensauerstoffverbindungen, I.–IV. *Zeitschrift für physikalische Chemie*, Vol. LIV., pp. 463–497, 569–608, 731–749, 1906.

W. C. BRAY.—Einige Reaktionen des Chlordioxyds und der chlorigen Säure. *Zeitschrift für anorganische Chemie*, Vol. XLVIII., pp 217–249, 1906.

H. T. KALMUS.—Electrical Conductivity and Viscosity of Some Fused Electrolytes. Inaugural Dissertation, Zürich, 1906.

G. N. LEWIS.—Ueber Komplexbildung, Hydratation und Farbe. *Zeitschrift für physikalische Chemie*, Vol. LVI., pp. 223–224.

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H. E. CLIFFORD (with L. B. MARKS).—Flame Arc Lamps. *The Electrician* (London), Oct. 5, 1906.

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F. A. LAWS (with F. L. BISHOP and P. MCJUNKIN).—A Method for Determining Thermal Conductivity. *Proceedings of the American Academy of Arts and Sciences*, Vol. XLI., No. 22, p. 457.

G. C. SHAAD.—Report of Convention of A. I. E. E. at Milwaukee for *The Western Electrician.*

G. C. SHAAD.—Set of Lesson Papers for an Elementary Course in Electrical Engineering, for Highland Park College Correspondence School, Iowa.

BIOLOGY, AND SANITARY RESEARCH LABORATORY AND SEWAGE EXPERIMENT STATION.

W. T. SEDGWICK (with THEODORE HOUGH).—The Human Mechanism: Its Physiology and Hygiene and the Sanitation of its Surroundings. Boston, Ginn & Co., 1906.

W. T. SEDGWICK (with C.-E. A. WINSLOW).—On the Present Relative Responsibility of Public Water Supplies and Other Factors for the Causation of Typhoid Fever. *Journal of the New England Water Works Association*, Vol. XX., No. 1, March, 1906.

W. T. SEDGWICK.—The Experimental Method in Sanitary Science and Sanitary Administration. Address of the Vice-President and Chairman for 1905 of Section K, American Association for the Advancement of Science. *Proceedings*, New Orleans meeting, Vol. LV., 1906, pp. 497–505; *American*

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W. T. SEDGWICK.—The Readjustment of Education and Research in Hygiene and Sanitation. *Proceedings*, Boston, meeting, September, 1905, American Public Health Association, 1906. *American Medicine*, Vol. XI., No. 5, pp. 159–161, Feb. 3, 1906.

W. T. SEDGWICK.—Pavements for Residence Streets. *Good Housekeeping*, March, 1906, pp. 275–278.

W. T. SEDGWICK.—Comments upon a Report by Theodore Horton, M. Am. Soc. C. E., on the Prevalence and Causation of Typhoid Fever in Washington, D.C., with a Discussion of the Typhoid Fever Situation in the District of Columbia. *Engineering News*, Nov. 8, 1906, p. 488.

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S. C. PRESCOTT.—The Production of Clean Milk, from a Practical Standpoint. *Charities*, Vol. XVI., No. 18, pp. 488–493.

S. C. PRESCOTT.—Farmers' Guide to Clean Milk. pp. 24. Deerfoot Farm Co., Boston, 1906.

S. C. PRESCOTT.—Review of E. F. Smith's "Bacteria in Relation to Plant Diseases." *Cent. für Bakt.*, 2d Abt., Vol. XVI., Nos. 17–19, pp. 565, 567.

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C.-E. A. WINSLOW (with EARLE B. PHELPS).—Experiments on the Purification of Boston Sewage, 1903–05. *Proceedings of the American Public Health Association*, Vol. XXXI., 1905 meeting, p. 16.

C.-E. A. WINSLOW (with EARLE B. PHELPS).—The Trickling Filter at the Sewage Experiment Station of the Massachusetts Institute of Technology. *Engineering News*, Vol. LVI., No. 7, p. 168.

C.-E. A. WINSLOW (with EARLE B. PHELPS).—Investigations on the Purification of Boston Sewage, with a History of the Sewage-disposal Problem. *Water Supply and Irrigation Paper*, No. 185, United States Geological Survey, Washington, D.C.

C.-E. A. WINSLOW (with E. E. LOCHRIDGE).—The Toxic Effect of Certain Acids upon Typhoid and Colon Bacilli in Relation to the Degree of their Dissociation. *Biological Studies by the Pupils of William Thompson Sedgwick*, Chicago, 1906, p. 258.

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EARLE B. PHELPS.—The Inhibiting Effects of Certain Organic Substances upon the Germicidal Action of Copper Sulphate. *Biological Studies by the Pupils of William Thompson Sedgwick*, Chicago, 1906, p. 283.

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GENERAL STATEMENT

OF THE

RECEIPTS AND DISBURSEMENTS BY THE TREASURER

FOR THE YEAR ENDING SEPT. 29, 1906

STATEMENT OF THE TREASURER.

The Treasurer submits the annual statement of the financial affairs of the Institute for the year ending Sept. 29, 1906.

Substantial savings have been effected in various items of expenditure, notably in those for fuel, water, gas, and electricity. The charts at the end of this report will show in the matter of electrical work a striking increase of power with decrease of cost. Less has been spent for the publication of notes, and in the matter of general expenses there would be a decided saving were it not for certain large and unusual expenditures.

Important changes and improvements have been made in the mechanical laboratories and in the architectural department, and the Rogers Building has been put in good condition. The final payments on the new gymnasium have been made, and the building has proved satisfactory and well suited to the purposes for which it is intended. The report of the Engineer shows that in his department our plant is in good condition, although some expenditures will have to be made before very long.

There has been an increase in expenses and a decrease in receipts from students' fees and the net result, comparing current expenditures with current receipts, is a deficit of $3,896.21. In this account is taken of one of the most interesting features of the year, namely, the results of the devoted and efficient work of the Income Committee. This Committee has paid over to the Institute during the year $42,583.61 free from all conditions. The collection of this sum shows the good will of the alumni, as well as the good work of the Committee.

Apart from the above the Institute has received through the generosity of Mr. Nathaniel Thayer $25,000, to be added to the permanent endowment fund. A similar amount has been received from the executors of the will of the late Charles Choate, and a like sum from the executors of the will of the late Macy S. Pope.

Charles G. Weld, M.D., has generously given $15,000 to be added to the permanent endowment fund, and in addition to this has given $1,600 for the Department of Naval Architecture.

From the same generous but anonymous donor, who has contributed a like amount in previous years, we have received $5,000 for the Sanitary Research Fund.

Dr. A. A. Noyes has given $3,000 for the Physico-Chemical Research Laboratory.

Dr. W. W. Jaques, $1,000 for the Department of Physics.

The estate of the late William E. Hale has contributed $1,000 for the Physico-Chemical Fund.

Mrs. William B. Rogers has again given $225 for the purchase of periodicals for the Library.

From the estate of the late Ednah D. Cheney we have received a further payment of $180.

From the B. F. Sturtevant Co. a motor of the value of $150, and from Prof. Henry M. Howe $100.

The net result of the whole year is an addition to the property of the Institute of $86,865.85.

The Walker Memorial Fund now amounts to $107,557.06.

SECURITIES SOLD OR PAID, GENERAL FUND.

$1,000 Bur. & Miss. River non-ex 6s	1918	$1,000.00
65 000 Boston & Maine R.R. 4½s	1944	74,181.25
5,000 Ozark Equipment Co. 5s	1910	5,000.00
50 Sh. Union Pacific R.R. pref.		4,886.50
80 Rights Ch., Mil. & St. Paul R.R. pref.		1,430.00
		$86,497.75

SECURITIES SOLD OR PAID, ROGERS FUND.

600 Republican Valley R.R. 6s	1919	600.00

SECURITIES BOUGHT OR RECEIVED AS LEGACIES, GENERAL FUND.

20,000 American Tel. & Tel. Notes 5½s	1907	20,000.00
20,000 Louisville & Nashville 4s	1923	19,750.00
25,000 Mass. Electric Co. Notes 4½s	1910	24,500.00
75,000 Lake Shore & Mich. So. R.R. deb. 4s	1931	75,000.00
5,000 Wabash Equipment 4½s	1907	5,000.00
25,000 Wabash Equipment 4½s	1912	24,360.00
		$168,610.00

SECURITIES BOUGHT, ROGERS FUND.

1,000 Wabash Equipment 4½s	1916	$961.00

GIFTS AND BEQUESTS FOR SPECIAL PURPOSES.

Increase Scholarship Funds	2,790.82	
" Austin Fund	410.00	
" Teachers' Fund	2,470.00	
Ednah Dow Cheney Fund, additional	180.00	
Susan E. Dorr Fund, additional	684.06	
Charles Choate Fund	25,000.00	31,543.88

GIFTS AND BEQUESTS FOR GENERAL PURPOSES.

Nathaniel Thayer Fund	25,000.00	
Macy S. Pope Legacy	25,000.00	
Thomas Gaffield Legacy	43.18	50,043.18

GEORGE WIGGLESWORTH, TREASURER, *in account with*
GENERAL STATEMENT OF RECEIPTS AND DISBURSEMENTS

Dr.

Cash balance, Sept. 30, 1905		$23 215.40
RECEIPTS FOR CURRENT EXPENSES.		
Income for funds for salaries	4,324.00	
" " " " Fellowships	1,400.00	
" " " " scholarships (students' fees)	10,175.00	
" " " " Joy "	100.00	
" " " " W. B. Rogers Scholarships	625.00	
" " " " Library	480.00	
" " " " general purposes	26,438.67	
" " Rogers Memorial Fund	10,845.75	
" " Charlotte B. Richardson Fund	1,495.15	
" " Rotch Prize Funds	400.00	
" " Rotch Architectural Fund	1,000.00	
" " Edward Austin Fund, Scholarships	8 577.50	
" " " " " Awards	5,312.50	
" " Teachers' Fund	1,530.00	
" " Ednah Dow Cheney Fund	.448.43	
Students' fees	313,816.25	
State Scholarships	4,000.00	
United States Act of 1862	5,306.68	
United States Act of 1890	8,333.34	
Gift of State of Massachusetts	25,000.00	
Laboratory supplies and breakages	11,936.36	
Rents, per Table (page 12)	10,757.68	
Gifts	1,825.00	
Interest	4,176.04	
Sale Printed Lecture Notes	3,624.04	
Income Fund Committee	42,583.61	504.511.00
GIFTS AND BEQUESTS FOR SPECIAL PURPOSES. (Page 3)		31.543.88
GIFTS AND BEQUESTS FOR GENERAL PURPOSES. (Page 3)		50,043 18
SECURITIES SOLD OR PAID.		
General Fund, page 3	86,497.75	
Rogers Fund, page 3	600.00	87,097.75
SUNDRIES.		
Income credited to Bond Premium Acc't	4,199.25	
" " " Rogers Bond Premium Acc't	636.00	
Copley Society of Boston, on acc't	666.67	
Walker Memorial Fund	4,075.00	
Naval Architecture Fund	1,667.13	
Letter Box Fund	37.25	
Sanitary Research Laboratory Fund, additional	5,000.00	
Physico-Chem. Research Fund	4,000.00	
Students' Notes	125.00	
Students' Fees paid in advance, Increase a/c	99,327.50	
Students' Deposits " " "	8,850.00	
Accounts Payable	5,973.23	134,557.03
		$830,968.24

MASSACHUSETTS INSTITUTE OF TECHNOLOGY.

FOR THE YEAR ENDING SEPT. 29, 1906.

Cr.

EXPENSES.

Salaries, per Table (page 12)	$368,504.55	
Fellowship paid from Savage Fund	650.00	
" " " Dalton Grad. Chem. Fund	200.00	
" " " Swett Fund	150.00	
" " " H. Saltonstall Fund	400.00	
Edward Austin Fund, Awards	5,312.50	
Teachers' Fund "	1,530.00	
Prizes, Rotch Funds	400.00	
Repairs to Buildings, per Table (page 13)	16,843.91	
General Expenses, per Table (page 13)	14,261.99	
Fire Insurance	2,919.26	
Fuel	15,413.96	
Water	3,014.40	
Gas	2,394.24	
Electricity	425.67	
Printing and Advertising	5,768.41	
" Lecture Notes	2,215.32	
" Annual Catalogues and Reports	4,311.44	
Physico-Chemical Research Fund	3,000.00	
Department Supplies and Repairs, per Table (page 12)	58,853.69	
Society of Arts	1,389.44	
Margaret Cheney Reading Room	448.43	508,407 21

(Expenses more than Income, $3,896.21.)

SECURITIES BOUGHT OR RECEIVED AS LEGACIES

General Fund, page 3	168,610.00	
Rogers Fund, page 3	961.00	169,571.00

SUNDRIES.

Cabot Medal Fund	8.03	
Naval Architecture Fund	1,330.83	
Sanitary Research Laboratory Fund	6,267.84	
Physico-Chem. Research Fund	3,464.93	
Dormitory Fund	696.94	
Walker Memorial Fund	12,246.20	
New Gymnasium	8,650.17	
Supplies Acc't.	1,459.30	34,124.24
Cash balance, Sept. 29, 1906		118,865.79
		$830,968.24

E. and O. E.

GEORGE WIGGLESWORTH,
Treasurer.

The following account exhibits the property held by the Institute, as per Treasurer's books, Sept. 29, 1906:—

INVESTMENT OF THE W. B. ROGERS MEMORIAL FUND.

31,000.00	N.Y. Central & H. R. R.R. Deb. 4s,	1934	30,225.00	
6,000.00	Baltimore & Ohio R.R. 3½s . . .	1925	5,310.00	
27,000.00	Kansas City Belt R.R. 6s	1916	27,000.00	
3,200.00	Republican Valley R.R. 6s	1919	3,200.00	
4,000.00	Cin.,Ind.,St. Louis & Chicago R.R.6s,	1920	4,000.00	
4,000.00	Kansas City,Fort Scott & Gulf R.R.7s	1908	4,000.00	
1,000.00	Lincoln & Northwestern R.R. 7s .	1910	1,000.00	
1,000.00	Atchison & Nebraska R.R. 7s . .	1908	1,000.00	
35,000.00	Fort Street Union Depot 4½s . . .	1941	34,825.00	
24,000.00	Rome, Watertown & Ogdensburg R.R. 5s	1922	24,000.00	
37,500.00	Detroit, G. Rapids & Western R.R.4s,	1946	37,500.00	
25,000.00	Atchison, Top. & St. Fé R.R. 4s .	1995	24,470.00	
7,000.00	Chesapeake & Ohio R.R. 5s . . .	1939	7,000.00	
38,000.00	Chi. Junc. & Union Stock Yards 5s	1915	38,000.00	
1,000.00	Wabash Equipment 4½s	1916	961.00	
	Advances to Bond Premium acc't .		6,107.00	
				248,598.00

INVESTMENTS, GENERAL ACCOUNT.

5,000.00	Bur. & Mo. River (Neb.) R.R. 6s, non-ex.	1918	5,000.00	
2,000.00	Bur. & Mo. River (Neb.) R.R. 6s, exempt	1918	2,000.00	
5,000.00	Chicago, Burlington & Quincy R.R.4s	1922	4,100.00	
3,000.00	Hannibal & St. Joseph R.R. 6s . .	1911	3,000.00	
26,000.00	Am. Dock & Improvement Co. 5s .	1921	26,000.00	
3,000.00	Illinois Central R.R. 4s	1951	3,000.00	
8,000.00	Chi. Junc. & Union S. Yards 5s .	1915	8,000.00	
2,000.00	New England Tel. & Tel. Co. 6s	1907–8	2,000.00	
100,000.00	West End Street Ry. 4s	1917	100,000.00	
50,000.00	Utah & Northern R.R. 1st 7s . . .	1908	50,000.00	
120,000.00	Illinois Steel Co., non-conv. 5s . .	1913	119,586.25	
43,000.00	Chesapeake & Ohio R.R. 5s . . .	1939	43,000.00	
100,000.00	Long Island R.R. 4s	1949	96,137.50	
7,000.00	K. C., Clinton & Springfield R.R. 5s,	1925	6,289.21	
8,500.00	K. C., Mem. & Birmingham R.R. 4s,	1934	8,287.50	
13,000 00	K.C., St. Jo. & Council Bluffs R.R. 7s,	1907	13,000.00	
50,000.00	Kansas City Stock Yards 5s . . .	1910	50,000.00	
25,000.00	Atchison, Top. & St. Fé R.R. 4s. .	1995	25,000.00	
50,000.00	Rio Grande & Western R.R. 4s . .	1939	49,180.00	
50,000.00	Oregon R.R. & Navigation Co. 4s,	1946	50,090.00	
50,000.00	Union Pacific R.R. 4s	1947	50,000.00	
100,000.00	Chi. & W. Michigan R.R. 5s . .	1921	100,000.00	
105,000.00	American Tel. & Tel. Co. 4s . . .	1929	104,700.00	
50,000 00	New England Tel. & Tel. Co. 4s .	1930	50,000.00	
50,000.00	Chi. Junc. & Union S. Yards 4s .	1940	49,250.00	
50,000.00	K. C., Fort Scott & Memphis R.R.6s	1928	50,000.00	
25,000.00	Southern Ry., St. Louis Div. 4s . .	1951	24,875.00	
9,000.00	Ozark Equipment Co. 5s	1910	9,000.00	
50,000.00	Northern Pac. Gt. Northern Joint 4s,	1921	48,500.00	
34,000.00	Baltimore & Ohio R.R. 3½s . . .	1925	30,090.00	
30,000.00	Chi., Mil. & St. Paul R.R. 7s . . .	1910	30,000.00	
52,000.00	N.Y. Cent. & H. R. R.R.(L. S.) 3½s,	1998	46,046.65	
50,000.00	Oregon Short Line 4s	1929	48,500.00	
5,000.00	Terminal Asso. St. Louis 4s . . .	1953	5,000.00	
3,000.00	Lake Shore & Mich. Southern 4s .	1928	3,000.00	
	Advances to Bond Premium acc't .		29,405.00	
	Carried up		1,341,947.11	
	Amount carried up			$248,598.00

Amount brought up $248,598.00

INVESTMENTS, GENERAL ACCOUNT,—*Continued.*

	Brought up			1,341,947.11	
20,000.00	American Tel. & Tel. notes 5½s . .		1907	20,000.00	
20,000.00	Louisville & Nashville 4s		1923	19,750.00	
25,000.00	Mass. Electric Co. notes 4½s . . .		1910	24,500.00	
75,000.00	Lake Shore & Mich. So. deb. 4s .		1931	75,000.00	
5,000.00	Wabash Equipment 4½s (Notes) .		1907	5,000.00	
25,000.00	Wabash Equipment 4½s		1912	24,360.00	1,510,557.11

STOCKS.

Shares.					
172	Boston & Albany R.R.	par	100	34,456.50	
80	Chi., Milwaukee & St. Paul R.R. Pf.	"	100	8,478.00	
12	Cocheco Manufacturing Co.	"	500	6,000.00	
56	Hamilton Woolen Co.	"	100	5,390.00	
31	Great Falls Manufacturing Co.	"	100	3,472.00	
2	Dwight Manufacturing Co.	"	500	1,600.00	
17	Pepperell Manufacturing Co.	"	100	2,789.50	
27	Essex Co.	"	50	3,780.00	
64	Boston Real Estate Trust	"	1000	68,605.64	
1	Boston Ground Rent Trust	"	1000	900.00	135,471.64

INVESTMENT OF THE JOY SCHOLARSHIP FUND.

	Massachusetts Hospital Life Insurance Co. . . .	5,000.00	
	Deposits in Savings Banks	5,346.31	10,346.31

INVESTMENT SWETT SCHOLARSHIP FUND.

	Massachusetts Hospital Life Insurance Co.		10,000.00

INVESTMENT OF RUSSEL FELLOWSHIP FUND.

2,000.00	Conveyancers Title Ins. Co. Mortgage 4s	1908	2,000.00	
	Amount carried up			$1,916,973.06

Amount brought up			$1,916,973.06

REAL ESTATE.

Rogers Building		200,000.00	
Walker "		150,000.00	
Land on Garrison Street	50,840.00		
Mechanic Arts Building	30,000.00	80,840.00	
Land on Trinity Place	76,315.69		
Engineering Bldg. A, Trinity Place	90,000.00	166,315.69	
Gymnasium Building		12,603.43	
Engineering Building, B		57,857.10	
Engineering Building, C		47,561.08	
Lot No. 2, Trinity Place		137,241.60	
Lot No. 3, " "		282,286.35	
Henry L. Pierce Building, Trinity Place		154,297.05	
Boiler and Power House, " "		26,916.74	
Clarendon St. Land and Building		142,762.94	
Real Estate, Massachusetts Ave., Cambridge		16,154.38	
Real Estate, Brookline, Mass.		112,964.32	
Aug. Lowell Lab. Elec. Eng. Bldg., 1902		121,790.93	1,709,591.61
Equipment, Engineering Building		16,555.24	
" Mechanical Laboratories		20,628.56	
" Elec. Eng. Building		87,282.24	124,466.04

SUNDRIES.

Notes Receivable		12,000.00	
Loans to Copley Society of Boston		6,333.32	
Students' Notes		570.50	
Cash balance, Sept. 29, 1906		118,865.79	137,769.61
			$3,888,800.32

The foregoing property represents the following Funds and Balances, and is answerable for the same.

The income of the following is used for the general purposes of the Institute:—

William Barton Rogers Memorial Fund	250,225.00	
Richard Perkins Fund	50,000.00	
George Bucknam Dorr Fund	49,573.47	
Martha Ann Edwards "	30,000.00	
Nathaniel C. Nash "	10,000.00	
Sidney Bartlett "	10,000.00	
Robert E. Rogers "	7,680.77	
Albion K. P. Welch "	5,000.00	
Stanton Blake "	5,000.00	
McGregor "	2,500.00	
Katharine B. Lowell "	5,000.00	
Samuel E. Sawyer "	4,764.40	
John W. and Belinda L. Randall Fund	83,452.36	
James Fund	163,654.21	
George Robert Armstrong Fund	5,000.00	
Arthur T. Lyman Fund	5,000.00	
Charles Choate Fund	25,000.00	
Nathaniel Thayer Fund	25,000.00	736,850.21
Amount carried up		$736,850.21

Amount brought up		$736,850.21
The income of the following is used towards paying salaries:—		
Nathaniel Thayer, for Professorship of Physics .	25,000.00	
Jas. Hayward, for Professorship of Engineering.	18,800.00	
William P. Mason, " " Geology .	18,800.00	
Henry B. Rogers, for general salaries	25,000.00	
George A. Gardner, " "	20,000.00	
Sarah H. Forbes, salaries	500.00	108,100.00
SCHOLARSHIP TRUSTS.		
Richard Perkins Fund	53,398.15	
James Savage "	14,226.71	
Susan H. Swett "	10,582.95	
William Barton Rogers Fund	11,704.70	
Joy Fund	10,408.81	
Elisha Thatcher Loring Fund	5,416.78	
Charles Lewis Flint "	5,321.29	
Thomas Sherwin "	5,000.00	
Farnsworth "	5,000.00	
James H. Mirrlees "	2,884.06	
William F. Huntington "	5,263.59	
T. Sterry Hunt "	3,247.04	
Elisha Atkins "	5,000.00	
Nichols "	5,000.00	
Ann White Vose "	60,910.33	
Ann White Dickinson "	40,778.14	
Dalton Grad. Chemical "	5,768.65	
Willard B. Perkins "	7,196.05	
Billings Student "	50,000.00	
Henry Saltonstall "	10,000.00	
Isaac W. Danforth "	5,616.00	
Charles C. Nichols "	5,408.00	
Richard Lee Russel "	2,163.43	
Lucius Clapp "	5,096.00	335,390.68
OTHER TRUSTS.		
Charlotte Billings Richardson Ind. Chem. Fund,	37,378.78	
Susan Upham Fund	1,307.95	
Susan E. Dorr "	18,848.08	
William Hall Kerr Library Fund	2,000.00	
Charles Lewis Flint " "	5,000.00	
Rotch Architectural " "	5,000.00	
Rotch Architectural Fund	25,000.00	
Rotch Prize "	5,200.00	
Rotch "Special" Prize Fund	5,200.00	
Edward Austin "	376,886.72	
Teachers' "	108,870.00	
Saltonstall "	42,248.52	
Ednah Dow Cheney "	14,066.19	
Letter Box "	57.75	647,063.99
Aug. Lowell Lab. Electrical Eng. Fund		68,000.00
George B. Upton Legacy, 1905		5,000.00
Macy S. Pope Legacy, 1906		25 000.00
Thomas Gaffield Legacy, 1906		43.18
M. I. T. Stock Account		1,821,924.71
Amount carried up		$3,747,372.77

Amount brought up		$3,747,372.77
MISCELLANEOUS.		
Cabot Medal Fund	198.22	
Walker Memorial Fund	391.76	
Roentgen-Ray Experiment Fund	981.50	
Sanitary Research Laboratory Fund	1,585.73	
Dormitory Fund	1,997.26	
Physico-Chem. Research Fund	9.79	
Naval Architecture Fund	336.30	
Students' Fees received in advance	116,187.50	
Deposits for Breakages and Supplies	587.25	
Deposits for Breakages and Supplies received in advance	8,850.00	
Accounts Payable	10,302.24	141,427.55
		$3.888,800.32

COMPARATIVE STATEMENT OF FUNDS, ETC.

	Sept. 30, 1905.	Sept. 29, 1906.
Trusts for general purposes	686,850.21	736,850.21
" " Salaries	108,100.00	108,100.00
" " Scholarships	333,114.29	335,390.68
Other Trusts, per page 9	642,759.25	647,063.99
M. I. T. Stock Account	1,816,645.92	1,821,924.71
Aug. Lowell Lab. Electrical Eng. Fund	68,000.00	68,000.00
George B. Upton Legacy	5,000.00	5,000.00
Macy S. Pope Legacy		25,000.00
Thomas Gaffield Legacy		43.18
Miscellaneous, per page 10	38,534.04	141,427.55
	$3,699,003.71	$3,888 800.32

Increase,		
Consisting of:		
Bequests for Special Purposes, etc. (See page 3)	31,543.88	
Gifts and Bequests for General Purposes. (See page 3)	50,043.18	
Net gain on Bonds sold	9,175.00	90,762.06
Less Expenses more than Income		3,896.21
		$86,865.85
Increase in Miscellaneous		102,930.76

INCOME FROM GENERAL INVESTMENTS, AND APPLICATION THEREOF.

Applied to Salaries	4,324.00	From Bonds	64,597.82
" " Scholarships	10,800.00	" Dividends, Railroad Stocks	2,165.00
" " Fellowships	850.00	" " Manufacturing Stocks	1,580.00
" " Charlotte B. Richardson Fund	1,495.15	" Real Estate Stocks	2,915.00
" " Teachers' Fund	4,000.00		
" " Edward Austin Fund	14,400.00		
" " Rotch Prize Funds	400.00		
" " Rotch Architectural Fund	1,000.00		
" " Cheney Fund	551.33		
" " Library	480.00		
" " General Purposes	26,438.67		
" " Samuel Dorr Annuity	1,000.00		
" " Increase of Funds	1,319.42		
" " Advances to Bond Premiums	4,199.25		
	$71,257.82		$71 257.82

INCOME FROM WILLIAM BARTON ROGERS MEMORIAL FUND, AND APPLICATION THEREOF.

Paid Massachusetts Institute of Technology	10,845.75	Received Income from Railroad Bonds	11,481.75
Credited to Advances Bond Premiums	636.00		
	$11,481.75		$11,481.75

DETAILS OF SOME ITEMS IN TREASURER'S CASH ACCOUNT.

Rents.

Huntington Hall, for Lowell Lectures	3,500.00	
Land and Building, Clarendon St., on account	6,500.00	
Use of Rooms and Gymnasium	609.14	
Cambridge Real Estate	148.54	$10,757.68

Department Supplies and Repairs.

Applied Mechanics	1,891.77	
Architecture	4,558.30	
Biology	1,317.90	
Brookline Athletic Field	600.00	
Chemistry	14,089.36	
Civil Engineering	3,342 12	
Drawing	1,130.35	
Economics	419.46	
Electrical Engineering	6,897.21	
English	215.56	
General Library	2,233.85	
Geology	1,855.46	
Heat Measurement	1,444.60	
History	653.80	
Mathematics	257.35	
Mechanic Arts	2,279.61	
Mechanical Engineering	3,234.20	
Military	508.46	
Mining	3,643.21	
Modern Languages	244.37	
Naval Architecture	785.63	
Physical Culture	122.16	
Physics	7,128.96	$58,853.69

Salaries.

Instruction	286,039.37	
Administration	39,196.79	
Labor	43,268.39	$368,504.55

Repairs to Buildings.

Rogers Building	2,699.36	
Walker "	934.37	
Engineering Buildings, A and B	805.33	
Pierce Building	364.57	
Engineering Building, C	180.23	
Lowell Building	1,399.01	
Gymnasium Building	28.47	
Mechanical Laboratories	9,030.42	
Boiler and Power House	1,154.44	
Sundries	247.71	$16,843.91

General Expense.

Window Shades		98.35	
Furniture		436.02	
Stationery and Office Supplies		2,284.39	
Postage		727.62	
Sundries		1,666.24	
Express		259.41	
Janitor's Supplies		1,409.34	
Examinations		520.00	
Diplomas and Commissions		957.40	
Washing		827.49	
Telephone Service, Installing Stations, Rentals, Repairs, etc.		1,105.94	
Engine Room Supplies:			
Oil	408.20		
Waste	226.19		
Sundries	107.53	741.92	
Ice		394.15	
Graduation Exercises		146.48	
Removing Ashes		295.50	
Glass		25.35	
N. E. Trust Co. Deposit Vaults		75.00	
State St. Trust Co. Deposit Vaults		75.00	
Union Safe Deposit Vaults		25.00	
Legal Services		242.80	
Taxes, Brookline		1,948.59	$14,261.99

EXPLANATION OF CHARTS.

Cost of Water.

In January, 1905, the condensing water discharged from all the condensers was turned into the cooling tower. Previous to this time the cooling tower had been used for the power plant only, and the other condensers were supplied with hydrant water which went to waste after leaving the condensers. The same water is now cooled and used over and over again.

The saving in the cost of water is quite apparent, beginning in February, 1905.

The saving from this source is even greater than the curve shows, for the amount of water required by the boilers has increased steadily.

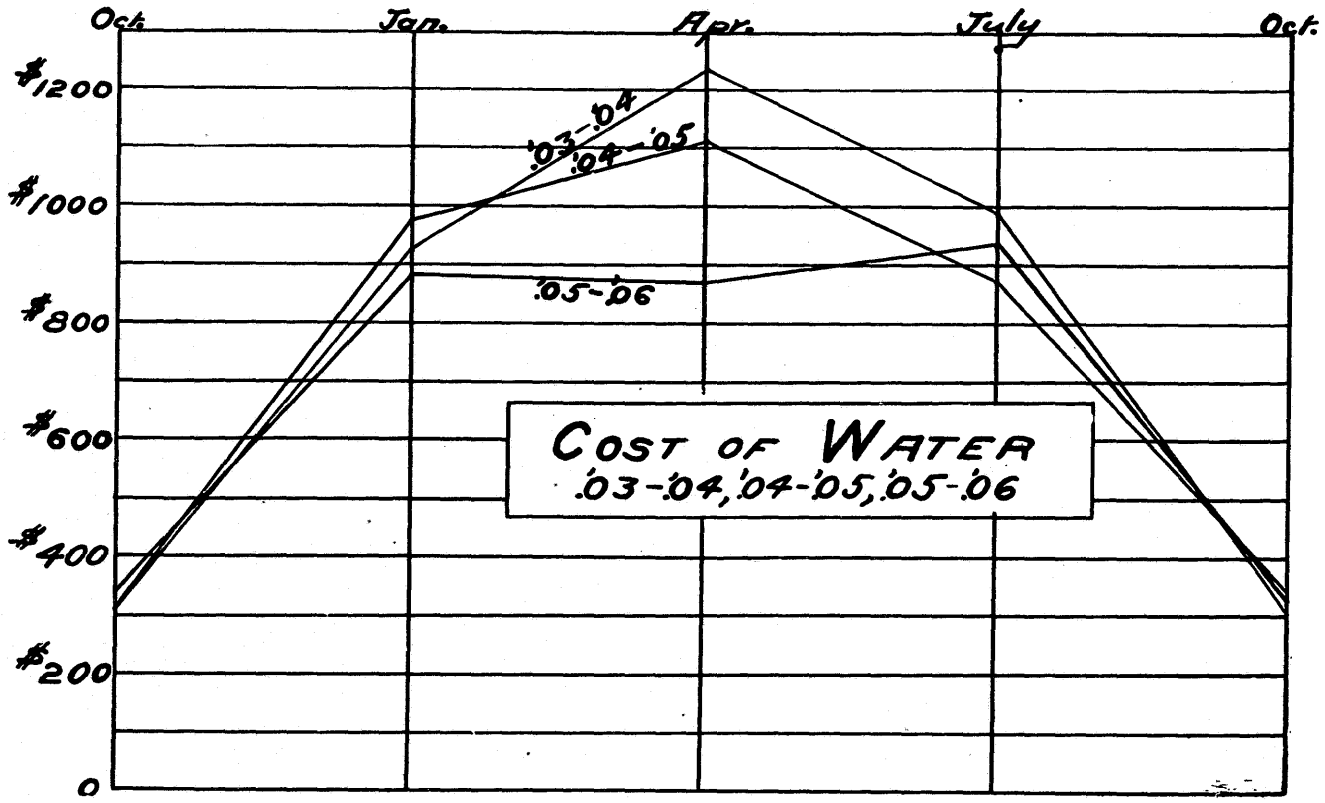
Cost of Coal.

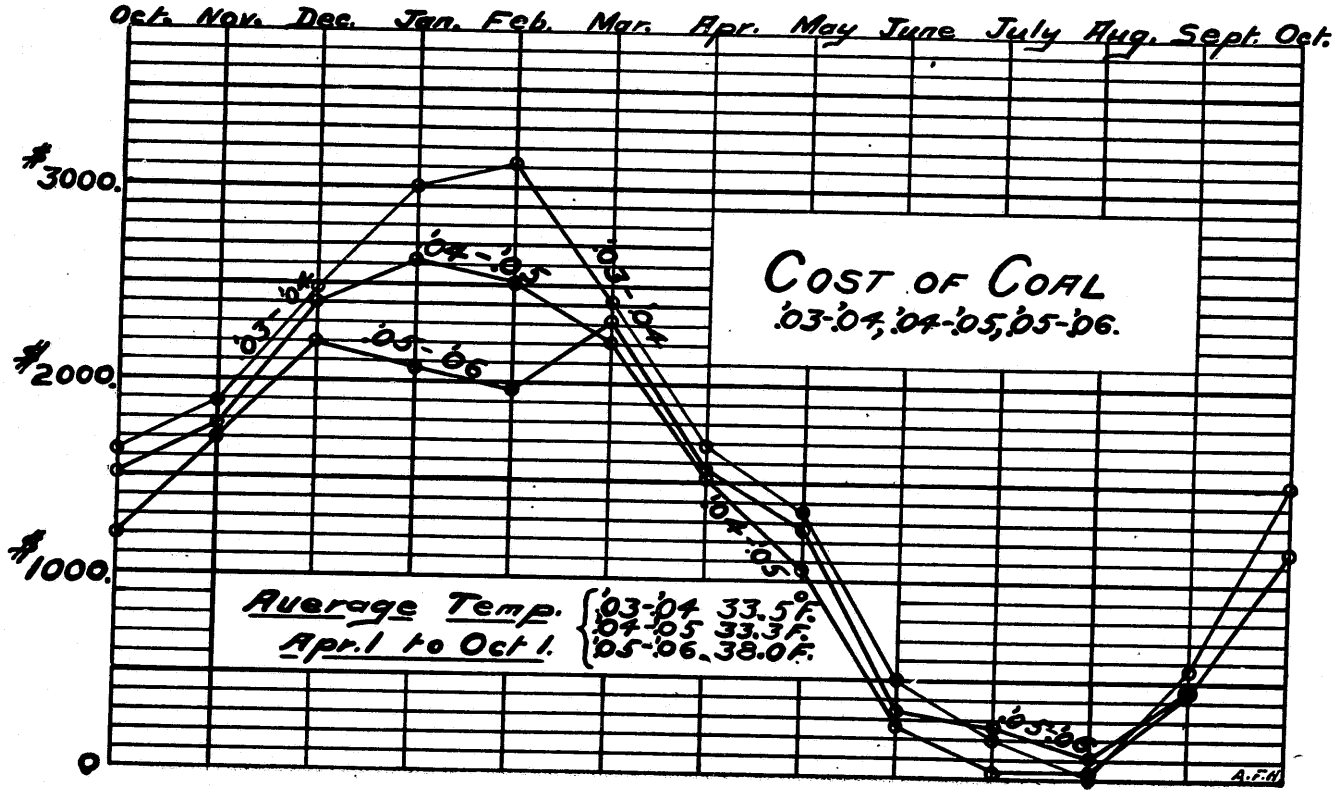
The cost of coal for 1905–06 shows a marked saving. The saving beyond February is not apparent from the cost curve alone, but becomes evident when the curve giving the kilowatt output of the plant is considered.

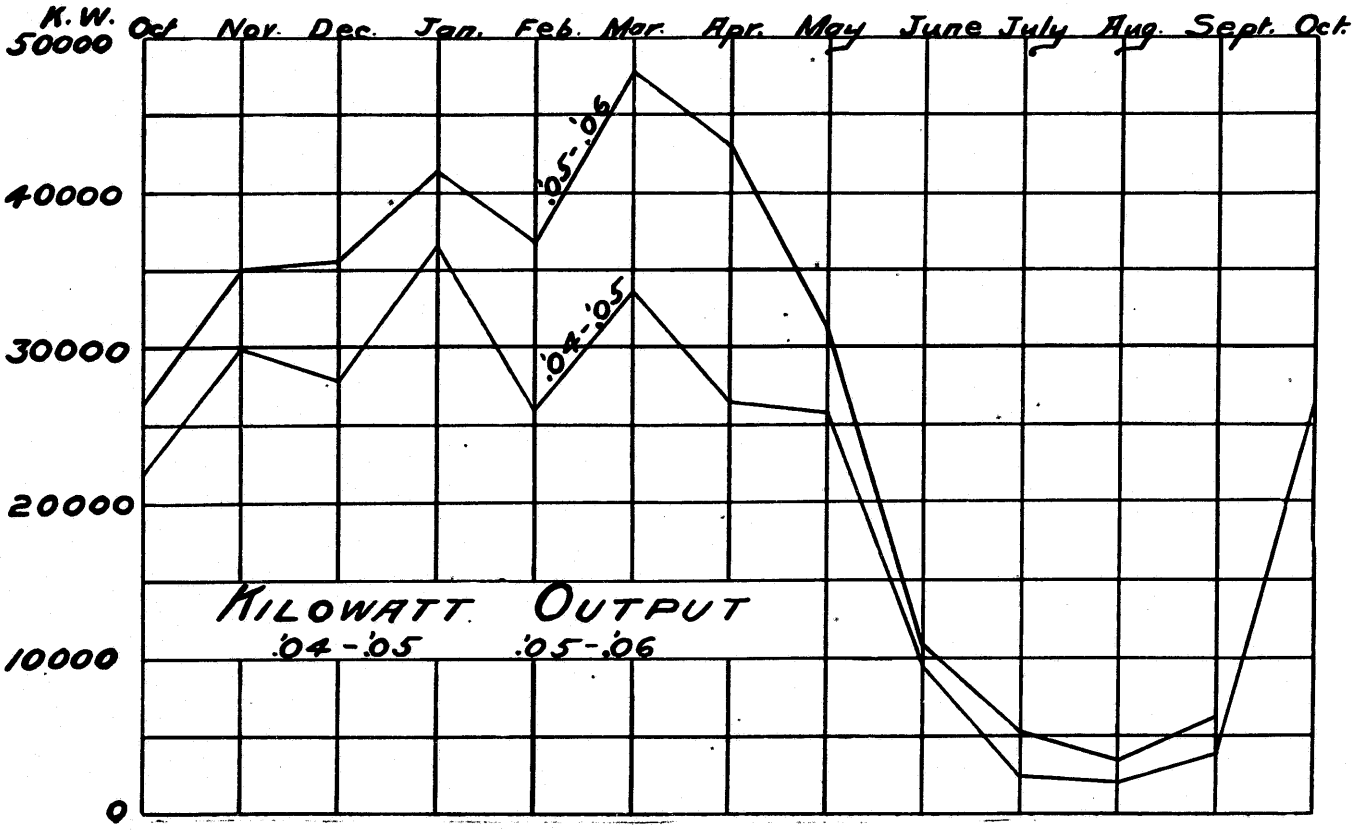
The average output is about 10,000 K.W. greater for February, and 15,000 K.W. greater for March and for April than in the year previous, in spite of which the cost of coal for this period is about the same as in the previous year.

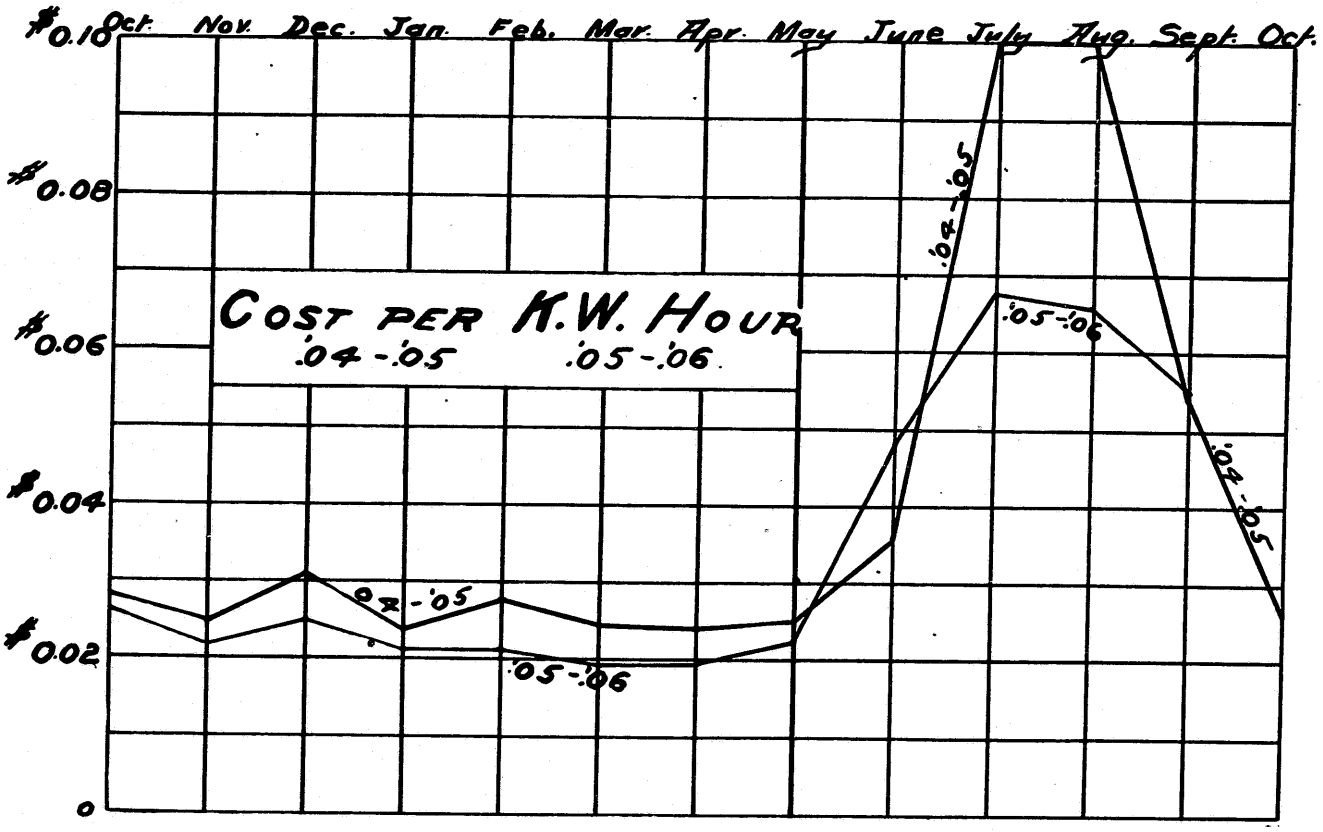
Cost per K.W. Hours.

The cost per K.W. hour is figured on the basis of four pounds of coal per K.W. hour, this figure having been obtained from tests of a week's duration, and of thirty pounds of water per K.W. hour. It includes both the cost of labor of all firemen, coal-passers and engineers of the power plant, and also that of waste, oil and all ordinary repairs.


Oct.
Jan.
Apr.
July
Oct.
$1200
$1000
$800
$600
$400
$200
0
'03-'04
'04-'05
'05-'06
COST OF WATER
'03-'04, '04-'05, '05-'06


Oct. Nov. Dec. Jan. Feb. Mar. Apr. May June July Aug. Sept. Oct.
#3000.
#2000.
#1000.
0
COST OF COAL
'03-'04, '04-'05, '05-'06.
'03-'04
'04-'05
'05-'06
Average Temp. Apr. 1 to Oct 1.
'03-'04 33.5°F.
'04-'05 33.3°F.
'05-'06 38.0°F.
A.F.H.


K.W.
50000
40000
30000
20000
10000
0
Oct
Nov.
Dec.
Jan.
Feb.
Mar.
Apr.
May
June
July
Aug.
Sept.
Oct.
'05-'06
'04-'05
KILOWATT OUTPUT
'04-'05
'05-'06


$0.18
$0.08
$0.06
$0.04
$0.02
0
Oct. Nov. Dec. Jan. Feb. Mar. Apr. May June July Aug. Sept. Oct.
COST PER K.W. HOUR
.04 - .05
.05 - .06
.04 - .05
.05 - .06
.04 - .05
.05 - .06

BOSTON, Nov. 26, 1906.

Mr. Edward L. Parker, a public accountant, employed by this committee, has examined the accounts of the Treasurer of the MASSACHUSETTS INSTITUTE OF TECHNOLOGY for the year ended September 29, 1906, and has verified the Students' Notes and the cash at office and in banks, and his report is hereto annexed.

We have verified the list of securities held by the Institute.

CHARLES C. JACKSON, } *Members of the*
JAMES P. TOLMAN, } *Auditing Committee.*

BOSTON, Nov. 26, 1906

To the Auditing Committee of the
Massachusetts Institute of Technology:

GENTLEMEN,—I have audited the accounts of Mr. George Wigglesworth, Treasurer, for the year ended September 29, 1906.

They are correct, payments duly vouched, and the receipts from students' fees and all other income duly accounted for. The cash at office and in banks, according to the deposit books, is correct, and the Students' Notes are on hand. The account of property held by the Institute and the funds, and balances, as shown in the Treasurer's report of September 29, 1906, is in accordance with the books.

Respectfully submitted,

EDWARD L. PARKER,
Public Accountant.