MASSACHUSETTS INSTITUTE OF TECHNOLOGY.

PRESIDENT'S REPORT

FOR THE

Year ending Sept. 30, 1876.

BOSTON:
PRESS OF A. A. KINGMAN.
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Extracts from Acts of the General Court of Massachusetts, in relation to the Massachusetts Institute of Technology.

Act of Incorporation. "William B. Rogers [and others named], their associates and successors, are hereby made a body corporate, by the name of the MASSACHUSETTS INSTITUTE OF TECHNOLOGY, for the purpose of instituting and maintaining a Society of Arts, a Museum of Arts, and a School of Industrial Science, and aiding generally, by suitable means, the advancement, development, and practical application of sciences in connection with arts, agriculture, manufactures, and commerce."

Chapter 183, *Acts and Resolves of* 1861.

Grant of Public Lands. "When the Massachusetts Institute of Technology shall have been duly organized, located, and established, ... there shall be appropriated and paid to its treasurer, each year, on the warrant of the Governor, for its endowment, support, and maintenance, one third part of the annual interest or income which may be received from the fund created under and by virtue of the 130th chapter of the Acts of the 37th Congress, at the second session thereof, approved July 2, 1862 [giving Public Lands to the States in aid of instruction in Agriculture, the Mechanic Arts, and Military Science and Tactics]. . . . . . Said Institute of Technology, in addition to the objects set forth in its Act of Incorporation [as above quoted], shall provide for instruction in military tactics."

Chapter 186, *Acts and Resolves of* 1863.

Power to confer Degrees. "The Massachusetts Institute of Technology is hereby authorized and empowered to award and confer degrees appropriate to the several courses of study pursued in said Institution, on such conditions as are usually prescribed in universities and colleges in the United States, and according to such tests of proficiency as shall best promote the interests of sound education in this Commonwealth."

Chapter 247, *Acts and Resolves of* 1868.

CONTENTS.

PRESIDENT'S REPORT.

To the Corporation of the Institute: —

I deeply regret the delay in the issue of this report, which has been caused by the desire to include all matters relating to the International Centennial Exhibition held at Philadelphia during the year, and affecting the Institute. The particular cause of delay has been the time taken to prepare, in the midst of other absorbing duties, a full and accurate catalogue of the collections presented to us by exhibitors, which would have been practically useless without the systematic classification we have made, with the corresponding casing and catalogue. I shall touch upon some matters begun near the close of the year, which will be reported upon fully hereafter.

The various reports and matters herewith submitted will inform you of the condition of the several departments of the Institute for the year 1875–76. For information relating to departments not especially referred to, and in which no particular changes have taken place during the year, you will please consult the report of last year.

The changes in the corps of Instruction during the year have been the resignations of Lieut. E. L. Zalinski, Professor of Military Science and Tactics, Thomas E. Pope, A. M., Instructor in Quantitative Analysis, Frank B. Morse, S. B., Instructor in Free Hand Drawing, Francis T. Sargent, S. B., and J. Austin Knapp, S. B., Assistants in Mechanical Engineering, and William E. Nickerson, Assistant in General Chemistry and Qualitative Analysis. Lieut. Henry W. Hubbell, Jr., U. S. Art'y, was appointed Prof. of Military Science and Tactics, Thomas W. Robinson, S. B., Assistant in Quantitative Analysis, James B. Stanwood, S. B., and Clarence L. Dennett, S. B., Assistants in Mechanical Engineering.

Attendance. The aggregate number of students in attendance during the year was 299, an increase of 11 over the previous year. For classification and other items, see page 22 of the Secretary's report.

Graduates. The number of graduates for the year was 44, two of whom completed the course in 1872–73, with the exception of presenting a graduating thesis. This is the largest number ever graduated in one year. It will also be noticed that all but one of the ten departments are represented. The following table gives the aggregates in years and departments.

	1868	1869	1870	1871	1872	1873	1874	1875	1876	Total.
Civil Engineering . .	6	2	4	8	3	12	10	10	14	69
Mechanical Engineer'g	1	2	2	2	1	1	4	7	8	28
Mining Engineering .	6		2	5	4	2	1	6	7	33
Architecture						1	1	1		3
Chemistry		1	1	2	3	6		1	5	19
Metallurgy									1	1
Natural History . .									2	2
Physics								1	3	4
Science and Lit. . .	1		1			1	2	2	2	9
Philosophy									2	2
Total	14	5	10	17	11	23	18	28	44	170

Theses. Abstracts will be found on pp. 69–123. Mr. Galloupe's thesis has been published in full in the Journal of the Franklin Institute, and also a portion of Mr. Kilham's; those of Mr. Holman and Mr. Jacques in the Proceedings of the American Academy of Arts and Sciences; those of Mr. Barrows and Mr. Crosby have been accepted for publication in the

Proceedings of the Boston Society of Natural History; and those of Mr. Ware and Mr. Phipps, one published and the other accepted, by the Journal of Speculative Philosophy, St. Louis.

These facts are the only commentary I need make upon the general excellence of all the theses presented.

THE INTERNATIONAL CENTENNIAL EXHIBITION AT PHILADELPHIA, 1876.

The Institute's Exhibit at Philadelphia. Early in the year the question of the participation of the Institute in the Exhibition began to be agitated. There was a lack of unanimity in favor of so doing, and especially a lack of means to meet the necessary expense. These discouragements led to delay and decrease of interest, until late, and when the matter had about been given up, the State came to our aid in a small appropriation. We then hurriedly made such collections as were available, and represented as nearly as possible the current work of the school in the various departments. These collections were exhibited in the East Gallery of the Main Building, in one of the stair-ways leading to the Gallery, and in the Women's Pavilion, and were regarded by all as creditable to the school, and adding substantially to the credit and value of the State's exhibit of its educational resources and progress. The exhibit of the Lowell School of Design was thought worthy of a special award, as was also our exhibit as an whole. On application of Dr. David Murray, Commissioner of Education in Japan, the whole collection from the Lowell School of Design was presented to the Educational Museum of Japan. A recent letter from Dr. Murray speaks of these designs as a marked and interesting feature of the Museum. This Museum is mainly intended to illustrate the present condition of Industrial Art Education, and to serve in some degree to guide and stimulate such education in that country. The Catalogue of the Institute's exhibit will be found in the Appendix to this report.

The Institute's Centennial Excursion. From the beginning of our school, an important feature in the instruction of the higher classes has been the excursions to mining regions and manufacturing works relating to the various courses. This has been especially true of the mining department, which has for several years spent a portion of each long summer vacation in visits to the most important mining centres of the United States and Canadas. The students have been particularly prepared to profit by such excursions by their experience in the treatment of ores in our Mining and Metallurgical Laboratories. I may add here that these laboratories have grown from year to year in capacity and completeness of detail for doing almost all kinds of work, and on as large a scale as will ever be needed either for instruction or experiment; and they have, besides, demonstrated the feasibility of incorporating a large amount of practice in the curriculum of the school, and that, too, not only without curtailing the amount of purely scientific instruction, but by giving to this instruction point and definiteness. Contact with mines and mining operations, preceding such practical study, is of comparatively little value to the student or the mine; while the handling of ores by the ton in the laboratory particularly qualifies the student to rapidly profit by contact with the wider sphere and conditions of mining works. Besides, he begins by being an aid rather than an hindrance to the works, because he is not entirely ignorant of the elements of practice.

The success of these laboratories is beginning to show us more clearly the possibilities and advantages of such facilities in other engineering departments. There is a certain knowledge which can only come to the mind by the ability to handle the materials with which we deal, and if this training of the hand can be formulated into an educational system, and pursued by educational methods, we shall have engrafted upon our industrial education a very important and vitalizing element. The experience of the works must, as far as possible, be brought into the school in order that the training of the school may properly and most profitably react upon the works. All the sciences and arts which find their applications in industrial works should be thoroughly taught in the schools, and there is no more difficulty in teaching the arts in a practical way, when they have once been comprehended as such, as they will be when studied as a whole, and not through some special application, than there is in teaching the sciences as such, or in their applications. But the *manual* of an art can only be formulated and taught by an expert in this art, and it is only through such a course of instruction as a basis, that we come to see the vital connection between science and art in their relations and applications in the various industries. Our system of excursions naturally led us to consider the feasibility of a trip to Philadelphia during the Centennial Exhibition. But too many were anxious to go; none of the departments which had been in the habit of arranging and conducting excursions of small parties were willing to undertake one on so large a scale. At last the Military department came to our aid. The organization which had been found necessary for properly carrying on the instruction of the department, was found sufficient to maintain order and cohesion in a much larger body, and the Institute, as well as all the members of the party, owe a debt of gratitude to Lieut. Zalinski for the energy and efficiency with which the whole affair was conducted; and it gives me great pleasure to refer you to his interesting report, where you will find full details of all matters connected with the expedition, except the presentation to Lieut. Zalinski of a valuable watch and chain by the members of the party, in recognition of his aid in planning and conducting the expedition. This presentation was also made the occasion by members of the Corporation present, as well as by professors and students, to cordially thank him for what he had done for the school in the reorganization of the Military department, in the building of a proper drill hall. and gymnasium, and in the establishment of a restaurant where well cooked and well served meals could be had at a reasonable price.

I gladly take this opportunity to thank Lieut. Zalinski in behalf of the Corporation, and to wish him success in all his future duties and relations.

It was supposed that much special study would be done and reported upon by the students of the several departments. In this expectation we were to a considerable extent disappointed. While the heads of departments were able to aid their students in finding what related particularly to their work, and to guide them in a general way, the excitements and fatigue of each day left little power or desire to take full notes, and still less to write them out for the instruction or inspection of others at the end of the day. Notwithstanding this apparent, not real, failure to accomplish the result in a given way, the exhibition proved a grand lesson to all of us, and I am happy in believing that the Institute is only just beginning to reap the fruits which in succeeding years will reach greater maturity and value.

The Centennial Collections. When our party disbanded, I felt convinced that the Institute could reap an additional advantage if some one could be on the ground to gather up such materials as would in all probability be given to institutions, or sold at low rates, rather than packed and returned home at greater or less cost. Mr. A. D. Blodgett, one of the graduates of 1876, was selected for this duty. He began work July 1st, and remained in Philadelphia until the middle of December, after he had packed and shipped his collections to Boston. Since his return he has taken charge of the arranging and cataloguing the collections, the results of which you will find in the Appendix. These collections could have been made much larger and more valuable if we had had but a small sum to expend in this way. Not an article was purchased, our only expense being the packing and sending to Boston.

At the same time, Mr. Blodgett took charge of the Institute's exhibit, and distributed about 8000 copies of various catalogues and reports to individuals, and to foreign countries, through their Commissioners. It was by this means that many of the collections were obtained, and relations were established which can not fail of continuing to be of advantage to the Institute.

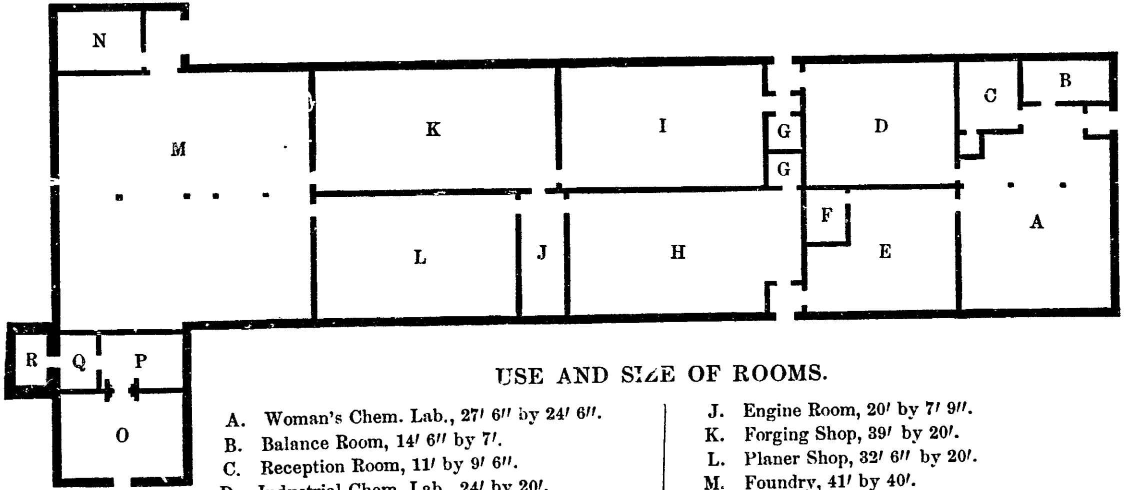
We have thus formed the nucleus of the Industrial Museum, which was a prominent feature of the Institute in its Act of Incorporation. With proper space and care this Museum would grow rapidly at a very inconsiderable annual cost. This matter deserves your serious attention.

THE NEW TEMPORARY BUILDING FOR SHOP-WORK AND ADVANCED CHEMISTRY.

The New Building. The plan of the building authorized by your vote of Aug. 17, 1876, is given on the next page. It is of one story, with 12′ brick walls, nearly flat tar and gravel roof, well lighted, heated, and ventilated, and covers 7500 sq. feet. The stem of the T, 150′×40,′ was first built, but finding greater demands upon the space than was expected, we afterwards made an addition of 75′×20′ parallel to Newbury St. Some changes in the details in the heating of the main building has given the heat and power needed in this building without any addition of boiler capacity. The funds for the erection, heating, and equipment of this building have been contributed by the Women's Educational Association, the Massachusetts Charitable Mechanic Association, and various individuals, details of which will be reported hereafter.

A. *Women's Advanced Chemical Laboratory.* With the exception of the years 1869–70 and 1872–73, chemistry has been among the Lowell Courses since their establishment in 1865–66. The instruction in this subject has been given mostly through laboratory work; and as the courses have been open to both sexes, quite a large number of women, residing in and about Boston, have been able to acquire a good knowledge of General Chemistry aud Qualitative Analysis. This fact led the Women's Educational Association of Boston to apply to this Institute to furnish advanced chemical instruction to women. By your vote of May 10, 1876, such instruction was author-

NEW TEMPORARY BUILDING FOR SHOP-WORK AND CHEMISTRY.



USE AND SIZE OF ROOMS.

A. Woman's Chem. Lab., 27' 6" by 24' 6".
B. Balance Room, 14' 6" by 7'.
C. Reception Room, 11' by 9' 6".
D. Industrial Chem. Lab., 24' by 20'.
E. Microscopical Lab., 24' by 20'.
F. Dark Room, Spectroscope.
G.G. Tool and Stock Rooms, 6' by 6'.
H. Lathe Shop, 37' by 20'.
I. Chipping and Filing Shop, 32' 6" by 20'.
J. Engine Room, 20' by 7' 9".
K. Forging Shop, 39' by 20'.
L. Planer Shop, 32' 6" by 20'.
M. Foundry, 41' by 40'.
N. Wash Room, 13' 6" by 9' 6".
O. Organic Chem. Lab., 19' by 14'.
P. Special Work Room, 13' by 9' 6".
Q. Store Room, 9' 6" by 6'.
R. Ice Chamber, 8' by 5'.

ized, provided the Association would aid in securing the funds to provide the proper laboratory and equipments. The Association promptly performed its part by raising for this purpose about $2000. The laboratory, balance and reception rooms, are devoted exclusively to women, and will accommodate about twenty students. The space devoted to this laboratory was placed in charge of Professor John M. Ordway, to whom we owe the excellent and commodious arrangements, and under whose personal supervision and instruction the department has realized the highest expectations of all concerned.

E. *The Microscopic and Spectroscopic Laboratory.* The theory and use of these instruments constitute a part of the general course in physics; but the need has long been felt for the proper facilities for applying them in other subjects of study. By an ingenious seating devised by Professor Ordway, the table supporting the instrument is so connected with the dissecting table that the student turns from one to the other without leaving his seat. Each table is supplied with gas and water. The laboratory accommodates ten students at a time, and is a model of convenience and compactness of arrangement. It is in charge of Prof. Ordway, is open to all students in the school requiring this instruction, aud is a valuable and interesting adjunct to our resources.

D. *The Industrial Chemical Laboratory.* For some years the chemical department has felt the urgent need of more room. This has been especially needed in Industrial and Organic Chemistry. The opportunity for providing temporarily for these wants has been offered in the new building. The kettles for dyeing are already set, and the various furnaces and other appliances will soon be in place.

O, P, Q, R. *The Organic Chemical Laboratory* is separated from the remainder of the building by a brick wall and is substantially fire-proof. The benches and hoods are of stone, and the floor of cement. It has been admirably arranged in all its details by Professor Wing, and was built and fitted at his own personal expense, assisted to some extent by a few friends. It will be noticed that the additions to the resources of the chemical department of the Institute, to which I have called your attention, are of a marked and substantial character, and I am happy to say that for breadth, thoroughness, and efficiency in all the details of the instruction we have every reason to be fully satisfied with the present condition of the department.

THE RUSSIAN SYSTEM OF INDUSTRIAL ART EDUCATION.

In the report which I had the honor to make upon this subject soon after my return from Philadelphia in July last, it was seen that the Russian Government had decided some years ago, that in the education of mechanical engineers and machinists, practice should be combined with theory, to the extent that the young engineer should be able to construct his own designs with his own hands. To this end large manufacturing works were connected with the Imperial Technical School of Moscow, which has solicited and executed orders to the amount of thirty-five to forty-six thousand dollars annually. These work were thoroughly organized, with competent engineers at the head of the various departments, with a sufficient number of skilled workmen, and conducted as a commercial establishment. To these large and well appointed works the students were admitted for the purpose of acquiring manual skill and professional practice without any preparation, until 1868. During these years the system of apprenticeship was tested as a part of an educational system under the most favorable conditions. It failed. Unskilled and intermittent labor was found prejudicial to commercial success, while it was also found impossible to develop the manual skill of the students in a systematic and progressive way, with the proper tests for thoroughness and efficiency at every step, with the greatest economy in teaching and supervision to the institution and of time to the student. Since 1868 that system of art teaching has been pursued which produced the surprising results exhibited at Philadelphia. Here then we have in the experience of this great school, gained through a number of years, a comparison of the two systems; the one of teaching the arts indirectly through their applications in the manufacturing works, and the other of teaching the arts directly as such, and as preliminary and preparatory to admission to these works.

It is indeed true that after the arts have been learned, the next logical step in a full course is to teach their applications through constructions, either in private works, or as is done in the Moscow school. In a government school, when the curriculum covers six years, and the young engineer is needed in the service immediately upon graduation, and has not the opportunity, for any reason, to learn the details of construction in private works, then the attaching of the works to the school may be justified.

I propose now briefly to call your attention to the shops which we have thus far been able to establish, reserving for my next report a full exposition of the system as we have applied it, giving cuts showing the blanks as they come to the student, and also the finished work, with tables of results, showing the percentage of accuracy obtained by each student on every piece of work in each course.

I. *The Vise Shop for teaching the Arts of Chipping, Filing, etc.* In the fitting of this shop I wish to express my great indebtedness to Professor Whitaker, whose practical experience enabled him to judge of the value of the system, and to work out the details of the instruction and supervision which have been so ably and satisfactorily carried out by Mr. Wallburg, who has had the immediate charge of this shop.

The shop contains four heavy benches, each 18 ft. long, 3 ft. wide and 2½ ft. high. To each bench eight vises are attached. It was supposed that one teacher could instruct thirty-two students at a time, and this has been found to be about the right number. At the beginning of the course it is quite enough, but later, when the students have acquired some skill and independence, a larger number might be successfully taught. As an experiment, we have adopted for this course thirty lessons of four hours each, giving three lessons per week, which is certainly enough for the mechanical engineers, and probably also for the class in the new "School of Mechanic Arts," at first called the new course in Practical Mechanism. At each vise there are four drawers, each large enough to hold all the tools needed by the student at any one time; so that four sections of thirty-two each can take the course simultaneously. This shop has, then, a capacity for teaching the course to 128 students every ten weeks, and to 640 in a year of fifty weeks.

The next step was to devise the proper series of designs to teach the use of the various forms of files and chipping chisels used in any branch of the art, and with a range wide enough to cover all probable applications. At this stage the services of an expert were needed, and we were most fortunate in finding in Mr. Valentine Wallburg, a man who had spent twenty-five years in applying his art skill in various trades, and who had, moreover, the ability to comprehend the unity involved in the details, which he had spent so many years in applying. Each piece is designed to teach a definite idea, and to be put into the course when the student has acquired the requisite skill to work it. As the class system is to be followed, the element of time must be the same for all. The teacher is required to solve each piece in advance of the class, to find the time it will take, having also to settle clearly in his own mind the best method of solution, with the reasons why. At the beginning of a lesson the teacher must be able to assign the time to be given to the class to solve this piece, to show them what it is intended to teach, and to give them the method of solution, with the reasons therefor. These points settled, and all needed directions having been given, all proceed to do the same work, and the teacher's time and energies are all devoted in directing and watching its progress. When the assigned time has expired, all the pieces are called in for inspection, in accordance with an analysis which has previously been posted, assigning marks to each element for perfect workmanship. These marks add up 100, the same given for perfection in other studies.

The student, by carefully studying the analysis, is able to work, not at a venture, but with knowledge, for the highest marks, and thus his capacity to judge of the quality of work fully keeps pace with his ability to perform it.

We are thus developing the mechanical judgment of the student by making in advance a careful study of the methods of solution, as well as the manual skill to perform, and the ability to judge of the quality of work at the same time. The course in mechanical drawing, which keeps pace with the shop work, and the parallel lecture-room course upon the same art, with its applications in construction, completes the instruction.

That so much skill of hand could be acquired in one hundred and twenty hours' practice has been quite as great a surprise to mechanics as to others, and I am glad to be able to say now from our own experience, and in which I am joined by all with hardly an exception, that the system is a triumphant success.

K. *The Forging Shop.* This shop is fitted with eight forges. The Sturtevant pressure blower, which furnishes the blast for the forges, is placed in the engine room. The hoods over the forges are connected with a 16′ pipe, which runs longitudinally near the ceiling of the shop, and enters a No. 4 Sturtevant exhaust blower just through the partition into room M, and thence through the embankment and foundation of the main building into a flue at its northerly end on Newbury St. This exhaust blower removes completely all smoke and dust, and much of the heat, making this shop one of the best ventilated and most comfortable rooms for work in the Institute.

As the acquiring of manual skill in the art is the principal aim, only such tools are furnished as are necessary to this end, but none of the appliances which are simply used to facilitate work. In establishing this shop it was supposed that two students could work at the same time at each forge, thus giving sixteen to a section. But in this we have been disappointed. It has been found that considerable skill in the management of the fire, and the use of all the tools, including the sledge, must be gained before two can advantageously be put at the same forge upon two-handed work. On this account the students have had thus far only half the time in the shop that was intended. But even this short time of sixty hours has fully demonstrated the value of the system in teaching this important art, both in the quality and amount of work. You may be interested in a brief statement of the analysis of the art upon which we have based our course of instruction. In the infancy of the art the forger was obliged to operate upon irregular shaped masses of metal and work them into the required form and dimensions. Now the manufacturing works furnish us with iron and steel bars of any given shape and size in cross-section, and with this material the forger has to deal.

Now it is found that the forger's art is substantially included in the six following elements: First, *the management of the fire*, and *degrees of heat*; second, *bending without changing the cross section*; third, *drawing-down*, or reducing the cross section; fourth, *jumping*, or *upsetting*, that is, shortening the piece and increasing its cross section; fifth, *building up*, or *welding*; sixth, *hardening* and *tempering*. Now while the class are studying the forger's art in the class room, under the direction of the professor, either through lectures or some text upon the subject, such as is found in the "Practical Metal Worker's Assistant," by Oliver Byrne, they are at the same time in the shop working out under the direction of an expert a sufficient number of graded examples under each of the above heads to become familiar with the theory, and acquire reasonable skill in the manipulations. I am satisfied that it is of comparatively little use to spend much time upon these subjects without the instruction can be based upon a reasonable amount of practice — but with such a sub-stratum upon which to build, the whole subject becomes permeated with light and life. For instance, it is of little importance for the student to know the fact that in tempering, certain tints accompany certain approximate temperatures, if he can not have the opportunity of studying these relations by actual practice, and learning at the same time how these facts are related to the uses of the tools he may be called upon to forge and temper.

While it may be true in general that for tempering steel tools for metal working, from 430 to 450 degrees of heat are needed, and that very pale straw yellow indicates about 430 degrees, and a shade of darker yellow about 450 degrees, it becomes especially and doubly true to the student who has once made and successfully tempered such a tool.

I must not close my brief account of this shop without expressing our obligations to Mr. B. F. Sturtevant of this city, who aided in working out the plan of this shop and fitted it at his own expense. He not only came to our aid with his large and successful experience as a skillful manufacturer of just what we needed to make the shop a perfect model of comfort and convenience, when such aid was of the greatest value, but he also expressed his confidence in the method of instruction we had adopted by this generous contribution, with a heartiness and cordiality which entitles him to my lasting gratitude and regard.

We were also fortunate in finding for the teacher of forging, Mr. James Bell, who has devoted forty years of his life to the practice of this art, and who by his skill, zeal and enthusiasm, and thorough comprehension of the system, and faith in its success made it such with every one of the fifty-one pupils who came under his instruction. That we should have found masters of two important arts, Mr. Wallburg and Mr. Bell, both so skillful, and at the same time having an apparently intuitive tact for teaching, is to me a matter of no less surprise than pleasure, and I gladly put on record my personal thanks to both of these gentlemen for the hearty and unfaltering support they have given me in all the details of instruction and discipline.

H. *The Lathe Shop.* In addition to the Vise and Forging Shops already mentioned, it is proposed as fast as the means can be secured, to furnish facilities for teaching the use of machine tools and foundry work, and thus complete the circle of the arts which apply particularly in constructions of iron and steel.

The lathe will be regarded as the fundamental machine tool, and after the student has become familiar with its construction and adjustments, and the tests for precision, he will be required to work out a series of designs, involving as a whole the entire capacity of the tool. All the other machine tools are to be regarded and used as supplementary to the lathe, and the lathe course is to be so designed as to include their use to the extent that experience may render necessary.

L. *The Planer Shop* is to be used for the supplementary tools, and it is thought that the shops H and L will furnish all the space needed for as many tools as one teacher can superintend successfully. American machine tools are now made of such variety and perfection that their skillful use is to be classed high in the scale of metal working arts, and it is only by personal familiarity with these tools that the engineer can ever acquire a tangible and exact knowledge of their capacity and their proper use by those under his direction. It is admitted that to-day there are far too few men in the shops who can use some of the more complicated tools with anything like the requisite skill, and still fewer who are able to adjust and test their accuracy within given limits. It is useless to ask for a degree ef accuracy which the tool can not give through faulty construction, or through incompetent handling. The work in these shops is to be made auxiliary to the class room instruction upon the theory and construction of these tools.

M. *The Foundery.* The founder's and the forger's arts are fundamental in all metal constructions. To these we look for the first close approximation to the forms we wish to construct, and in a complete system of art instruction in metal working, one is quite as important as the other. Nor is there any reason either on the score of space or expense, why the founder's art should be omitted. All the important manipulations in the art can be as well learned in the moulding and casting of a good variety of small forms, as of large ones; the difference consisting mainly in the handling, which usually depends upon special devices, and is not in any sense a part of the art.

When the proposed series of shops are fully equipped, it is easy to see how the instruction in the foundery and the forging shop can be connected with the courses of instruction in the vise and machine tool shops: and especially will the series be complete when we shall have the room and means to establish a pattern shop. Then the student will be able to take his own drawings into the shops and follow them up till the design is brought out in its finished state, either in cast or wrought iron. And further, all this can be done by rigorously following the class system of instruction, applying at each step the most rigorous tests for thoroughness of workmanship. But a comparatively small sum of money is still needed to carry out this plan fully, and I can not but feel that when the importance of this system of art-education is once clearly seen, not only in connection with technical schools, but as supplementing our present public school system, the means will not be wanting to enable us to work out the plan with care in all its details.

You will be pleased to learn that by a recent letter from the Director of the Imperial Technical School of Moscow, I am informed that the Russian Government has authorized him to duplicate the exhibit of that school at Philadelphia for the Institute of Technology.

The Lowell School of Industrial Design. The continued demand for the graduates of this school is the best evidence I can offer of its success. Each year is adding to its efficiency as a school of design; but there is beginning to be a demand made upon it which it has not yet been able to meet. These young designers can not put their designs upon the loom and exhibit them in the woven fabric, and this art is so closely allied to that of designing that it should be taught in close connection with it.

In foreign schools for teaching the arts employed in the textile manufactures, two phases of the weaver's art are usually kept in view — one that mentioned above, and the other the handling of the loom after the work has been properly mounted. This latter point, I am satisfied from the slight experience we already have, is not important for us to consider. We find that the students have no difficulty in running the loom after a few hours' instruction and experience. In a large manufacturing town I can see that it may be more economical to teach simple weaving in a school, than to be troubled with raw hands in the mills, but for us the question is simply the teaching the student how to make his weaving pattern from the design, and then put it properly upon the loom, and weave enough to show the design in the fabric; and for this purpose hand pattern looms are on many accounts better than power looms. The expense of running power looms is too great simply for pattern weaving, and besides the weaving of a pattern should be done slowly to give the student time to observe the working, and become familiar with the effects of each phase of the design as it appears in the fabric. It is important, however, that the school should be supplied with specimens of several of the more successful power looms of various construction, that they may be used and studied as machines, and some knowledge gained of the adaptability of each for the production of a certain class of goods. The theory and practice of dyeing and sizing come in the Department of Industrial Chemistry. Our wishes in this matter coming to the attention of the Lewiston Machine Co. of Lewiston, Me., we were kindly presented with one of their looms, which has been used for weaving quite a number of designs, and has given great satisfaction to teacher and pupils. We are also indebted to Mr. Edward A. Brigham of Boston, for an English loom, intended for the weaving of plain cotton cloth and to be run as high as 225 picks per minute; and also to the Bridesburg Manufacturing Co. of Philadelphia, for one of their manufacture; neither of which we have yet had time to set up and use. Other parties have promised to aid us in this way, and we shall have no difficulty in adding this art to our course in designing. Messrs. Mudge, Sawyer & Co. have kindly furnished us with all the yarns needed, from the Washington Mills at Lawrence.

Industrial Science and Art. In what precedes it will be noticed that some prominence is given to the matter of Industrial Art. It has been the spirit of our instruction in all departments to combine theory and practice, that is, science and art, just as far as was practicable in a school. Even in the study of science, the practice, or art side, has been made prominent through our laboratories; and our teaching has been successful almost in the exact proportion to the extent in which we have been able to build the instruction upon a manipulatory, or art basis.

This sort of science teaching is of comparatively modern invention; and this inversion of building the theory upon the practice, or the science upon the art, is only gradually working its way in the teaching of the purely industrial arts through practice shops as a foundation upon which to build, in the mind of the student, a knowledge of the theory or science, which pertains to each, and which is mainly the experience of its practitioners, growing out of all the varying conditions of the applications. As, however, there is a time when science grows out of its corresponding art, so also there is a time when the art grows out of its applications in the trades, or handicrafts; and it becomes a matter of the greatest importance as to which phase of this development we use as the foundation of our industrial education.

In the past, the higher industrial education has been based upon the science phase, and the lower upon the trades, or handicraft, phase. It seems to me that in the future we shall find it the wisest to build upon the art phase, as the firm and substantial foundation for both the engineer and the artisan, for both the theorist and the practitioner, no matter what the industry may be. Because if the student only acquires the art, he can apply it in the trades as a means of support, while upon the art as a foundation he may build a structure worthy of his highest aspirations.

Conclusion. I am glad to be able to say that the year's work has, upon the whole, been successful. There has been progress in all departments. We have only to regret the want of means to make the work still more successful. Not a single department has the means of meeting its necessary current expenses. In some a small appropriation is made to answer; in too many the minimum needs are made up by the professors; and the necessity for such contributions will last until a larger percentage of our income is derived from invested funds. There is no school or college in the country, so far as I know, whose students' fees constitute anything like such a large percentage of the total income; and I am sorry to know that our fees make it impossible for many young men to join our classes who would otherwise gladly do so. Nor have we the means for aiding needy students possessed by nearly all the older colleges. I refer to these facts here, hoping they may thus come to the attention of those who may be inclined to lend a helping hand.

JOHN D. RUNKLE, *President.*

SECRETARY'S REPORT FOR 1875–1876.

SOCIETY OF ARTS.

There have been held during the year fourteen meetings of the Society of Arts. The first two meetings were devoted to the discussion of the manner in which, if in any, the Society would coöperate with the School of the Institute in the Centennial Exhibition of 1876 at Philadelphia. Though the members consulted were all in favor of such representation, and a committee was appointed to consider the subject, the Society, as such, did not coöperate with the School in its exhibition, which proved of such great advantage to the students and an honor to the Institute — an account of which will be found elsewhere.

SPIRIT COMPASS, ETC.

At the meeting of *Dec. 9, 1875*, Mr. David Baker exhibited and explained the most important features of the so-called "Baker Compass."

The object of his invention was to remedy the defects of spirit compasses, the most prominent of which are: — 1. The liquid with which they are filled is liable to freeze in low temperatures, rendering the instrument useless for the time being. 2. The changing of the paint on the card and interior surface of the bowl from white to dark brown, making it difficult to distinguish the division marks. 3. The inconvenience and expense of taking the card to pieces in order to get at the needles to recharge them when necessary. 4. The leaking or bursting of a card float at sea, rendering the compass inoperative. 5. The inability of a floating card to turn in the liquid with a desirable degree of activity, in consequence of the friction produced by the float and needle casings. 6. The arrangement and movement of the lubber point.

These defects Mr. Baker claims to have overcome by the following corresponding remedies:—1. His compass is filled with a thin, transparent kerosene oil which cannot congeal under any temperature to which it is liable to be exposed. 2. His paint is very firm and durable, perfectly imperishable in the oil, and will not scale, crumble, nor wash off; neither will it change to a dark color by the lapse of time. 3. The oil prevents oxidation of the needles and pivot, permitting the construction of a very light card, consisting simply of a sheet of paper with open centre, supported by a thin and narrow rim of metal or other suitable substance, to which the needles are fixed. This permits the direct application of a magnet to the needles, without removing them from the card whenever it is necessary to re-charge them. 4. No float being used or required, the compass can not become inoperative by a card-float leaking or sinking down on one side. 5. The light and thin card, displacing but a small quantity of liquid, and having no weight of casings around the needles and no float to create friction, turns very easily on a steel pivot, maintaining or regaining quickly its position in the magnetic meridian. 6. The lubber point, as usually made, is very deceptive, misrepresenting the direction of the vessel, and has doubtless been the cause of many disasters at sea; it leads the mariner to suppose that he is sailing on a straight line when he is really making a zigzag course; it may appear from this that he is sailing on a particular course, when he is actually sailing some degrees off.

By a simple apparatus attached to his and the old form of compass, he showed that at sea the inaccuracy in the latter was great in proportion to the roughness; when the vessel mounts a wave the bow turns one way off from the course, carrying the lubber line with it; when it descends into the trough of the sea, it goes rapidly to the other side; so that this line, though indicating the long axis of the vessel, by its swinging motion constantly deceives as to the true course of the vessel; in fact, the experienced helmsman steers more by the direction of the waves and the sails than by the lubber line.

The whole secret is in this: In the old instruments, in every nation, the outer gimbal ring on which the compass swings is suspended on pivots on each *side*, so that any change in the elevation of the bow and stern of a vessel, except in an absolutely vertical plane, must be attended by an oblique motion, which carries the lubber line to one side or the other of the supposed course. He swings his compass on gimbals whose pivots are arranged in the longitudinal instead of the transverse axis of the ship, or *fore and aft*; this deviation of the lubber line thus becomes impossible, and the compass, instead of being an uncertain guide, becomes entirely trustworthy.

EXTINGUISHING OF FIRES ON SHIPBOARD.

Lieut. F. M. Barber, U. S. N., read a paper, illustrated by drawings on the black-board, on extinguishing fires on vessels laden with coal, cotton, or other combustible material. He utilizes the well-known properties of carbonic acid gas in the following way.

In some convenient locality on board, as the spardeck, he places one or more flasks, about three feet long and one foot in diameter, containing about one hundred pounds of the gas in a liquid condition; from the top of the flask runs a small iron pipe, just under the deck, the whole length of the ship; from this, at proper intervals, are branch pipes at right angles, passing to every store room and the hold; any one, or all the cocks, may be turned from the main deck, near the flasks.

On an alarm of fire the hatches are to be battened down, and the gas let on to the compartment where the fire is; the liquid gas, under a heavy pressure, passes in the form of vapor through the pipe, and is instantly driven to the compartment to which it is admitted; arrived at this point, being one and a half times as heavy as air, it fills the compartment from the bottom upward, without being diluted by the air, producing at the same time intense cold by its expansion, and driving before it through cracks and crevices every particle of air.

The liquid is non-corrosive, and the vapor is not injurious to the most delicate fabrics. It is probably the only substance which will permanently suppress the most advanced stage of combustion in a cargo of coal. One pound of the liquid is equal to over eight cubic feet of gas; it must be contained in vessels capable of sustaining the great pressure.

The objections to its use, viz.: the want of apparatus capable of producing a large quantity in a short time and at a low cost, and of suitable vessels to contain it, have now been removed. He described the apparatus, devised by Mr. W. N. Hill, which produces fifty pounds of liquid gas per hour, at a cost of only fifteen cents a pound. The containing flasks are made of steel, weighing a little over three hundred pounds, and tested to two thousand pounds per square inch, hydraulic pressure; tested to destruction, one gave way at three thousand one hundred and thirty-two pounds per square inch. The flasks are made of sheets of steel, rolled up like curl-papers, one within the other; the outer one is riveted, and all spaces between the sheets are filled with pure tin.

THE LIQUID COMPASS.

December 23. Mr. Edward S. Ritchie read a paper on the "Baker" or "liquid compass," replying to the statements made at the last meeting.

In his compasses he uses alcohol and water, the first of which has never been frozen; the mixture he uses he has never known to freeze when in use on board ship. On examining the "Baker" compass he found the liquid used was naphtha, a highly volatile and combustible liquid, vaporizing and burning at all temperatures. Though this will not affect the paint of the compass, nor congeal at any temperature to which it is likely to be exposed, it is, he thinks, very objectionable; it is very volatile and difficult to hold, very expansive when heated, requiring a compensation of much greater capacity than alcohol and water, and increasing the danger of bursting the bowl by heat or cold.

Placed as a compass generally is, in a close binnacle, with a lamp lighted inside, if from any cause a leak should occur, a dangerous explosion might result. The changing of the color of the paint is now practically corrected. The magnets are never charged until the cards are ready to be placed in the bowl, and it would be quite practicable to charge them in the bowl. The leaking of a card is possible, but extremely rare, as each one is severely tested under high pressure; his card bears but about forty-five grains on the pivot, while in the new compass it bears with a pressure of half an ounce.

Mr. Ritchie also stated that placing the lubber line in the line of bearing of the gimbal ring was not new, as the ships of the American and English navies had for many years been furnished with compasses whose lines were placed in this position; he had himself made hundreds in this way, and it is by no means certain that this is the best position.

METRIC SYSTEM OF WEIGHTS AND MEASURES.

Mr. Edmund H. Hewins read a paper on the "Metric System," which has been adopted by a majority of nations, including the United States. Standard metres are now deposited at Washington. England is almost the only important government which still withholds its approval.

It is so simple that any person of ordinary intelligence can readily be taught it in a few hours; and no one could pretend to master the old system of apothecary's, avoirdupois, and troy weights, and the inches, feet, yards, fathoms, furlongs, miles, perches, acres, pecks, bushels, gallons, quarts, pints, gills, etc., in many weeks — to say nothing of the general uselessness of the knowledge in any country but his own.

He dwelt on its advantage to mechanics, in enabling them to have a common standard where there is now so much confusion and arbitrary method of measurement, as in screws, taps, dies, etc., both in government and private shops.

Mr. J. P. Putnam continued the subject by reading a communication on the advantages of the system, and the means that had been taken to introduce it into various countries. That decimal division of weights, measures and money, is of the first importance in computation is shown by the praise generally bestowed on the federal currency; and that engineers share in this opinion may be seen by their using decimals of a foot where they can, although, by so doing, they are at variance with the general practice of the community.

The real difficulty is not with the proposed system, but with making the change. The cost of such a revolution, affecting so large a proportion of the transactions of life, must be enormous; but it is equally true, if not quite so obvious, that it is costing enormously to keep up the present confusion. It is already used in the mint and on the coast survey; men of science have used it for many years; it is used by analytical chemists, and will soon be used by many architects and constructors all over the country. To accomplish its introduction concerted action is necessary.

In the metric system, the weight and dimensions of every material thing, — whether solid, liquid, or gaseous, — whether on land or on water, — whether in the earth or in the heavens, — and whether determined by the scale, plummet, balance, barometer, or thermometer, — are ascertained by a method absolutely uniform, entirely simple and equally suitable to the use of all mankind, — resting upon a single invariable standard of linear measure, with multiples and submultiples, like those of our monetary system, — exclusively decimal, with appropriate names, similar in all languages — and itself secure against the possibility of change, or loss through carelessness, or accident, or design, by being constructed on scientific principles, and copied for distribution among the different nations of the world. The standard unit of length, the metre, is the ten millionth part of the quadrant of the meridian, equal to very nearly 39.37 English inches.

NEW METHODS OF TOPOGRAPHICAL SURVEYING.

January 13, 1876. Prof. E. C. Pickering made a communication on some new methods of topographical surveying among mountains, devised by himself, as distinguished from the old method of trigonometrical survey, which is very expensive as well as inaccurate, and from the plane table, which answers very well for the determination of a few points.

He exhibited a new instrument, with various modifications, for use among the mountains. His object was to dispense with the graduated circle, and its bulky and heavy stand, and to be able to make accurate observations without the necessity of ascending the mountains, thus saving much time, labor and expense. He brought to the notice of the meeting three different methods, each having its special applications.

The first was a new stadium, as a substitute for the one commonly used in the coast survey and elsewhere, which requires the services of two persons, and which is also inaccurate. He uses an ordinary small and portable telescope, lightly but firmly mounted, having a plane glass mirror in front of the object glass; by placing this mirror at the proper angle, the two images of an object are made to coincide. Two positions being taken on the same line, at right angles to the object seen, the measurement of the different angles from these different points enables the observer to measure the distance with a great degree of accuracy.

This instrument, used for measuring horizontal distances, being made to turn 90° on its longitudinal axis, may then be employed for measuring heights. He uses a good level firmly attached to it, and a spider-line micrometer, or eye-piece, containing a divided scale. It is practically, therefore, a zenith telescope, without vertical circle or heavy mounting, but with a rigid connection between the level and the instrument. Its liability to error is very small, and its use easy and satisfactory.

The third form of apparatus was for working out details, after certain main features had been determined by other means; it was specially valuable for making contour maps, which by ordinary processes are difficult and expensive. His device was a modification of the camera obscura, easily transported and managed. He explained how, by this simple apparatus, the height and velocity of clouds may be determined, the distance of a thunder-cloud, and the velocity of sound.

Attention was drawn to the simplicity and efficacy of these instruments, which would so diminish the cost, and increase the accuracy of topographical surveys, that no State need be deterred from authorizing such survey on the ground of the great expense of the topographical work.

NEW WIND VANE.

January 27. Prof. Pickering described a new form of wind vane, an invention of Mr. W. H. Pickering, now a student at the Institute.

It consisted of an ordinary vane, which had attached to the base of its pivot-socket two arms inclined downwards, one on each side of the vane. To the left hand arm was attached a ball, and to the right a piece of ground glass, of such a size that when viewed from the front it would present the same amount of surface as the ball, both about as large as the letters denoting the points of the compass. The object is to show the direction of the wind under all circumstances, especially when a person in the line of the wind might be unable to tell whether it was north or south, east or west; when the ball appears to the right of the pivot the vane is pointing toward you, and when to the left, away from you. The ball is the object judged by, as the glass would be invisible at a short distance, the use of the last being to counterbalance the weight of the ball and to counteract the action of the wind on it. The improvement is a very cheap one, and can be easily applied to any vane now in use.

INSTRUMENT FOR DRAWING CURVES.

Mr. John M. Batchelder, of Cambridge, sent for exhibition a new instrument, devised by himself, for drawing curved lines, such as are ordinarily made by the French curves.

A diagram of the various and graceful curves which may be drawn by this instrument was exhibited. The opinion was expressed that the flexibility of the steel bands was such that extreme care would be necessary to insure accuracy.

Mr. Moore spoke of the importance of preserving in some way the diagrams made in illustration of the papers read before the Society, in many cases indispensable for the permanent value of communications.

DIFFERENTIAL COMPASS.

February 10. Mr. S. W. Holman, a student of the Institute, in the Department of Physics, presented in behalf of the inventor, Mr. George Iles of Montreal, a new form of mariner's compass, called a "Differential Compass."

The instrument was designed to detect variations of the compass needle, due to the disturbing action of iron ships, and to give the mariner a means of correcting this error at any time, thus obtaining the magnetic north.

After explaining the effect of the iron mass of a vessel on the compass, illustrating the action by magnets, he described the model.

It consists of two compound needles pivoted one above the other. The upper needle is made up of a series of bundles of small steel magnets, held between two long strips of aluminum; the bundles are arranged with their like poles pointing in the same directions, the north pole of one bundle being placed toward the south pole of another. As each small bar magnet can be much more intensely magnetized in proportion to its bulk than a larger one, we can obtain by this arrangement a much more intensely magnetized needle than with an ordinary steel bar. The lower compass needle is an ingenious arrangement of similar small steel magnets across a bar of aluminum, like poles being all upon the same side of the bar. In this way is produced a compound needle, which sets with its length east and west; when pivoted one above the other, the needles set at right angles.

If a piece of soft iron, or an attractive magnetic pole, be introduced into any quadrant near the needles, the quadrant is diminished to an acute angle. Upon this fact is based the method of determination of the deviation of the compass and its compensation. The conclusion of the inventor was that any disturbing mass at any distance would cause the needles to deviate toward each other in some quadrant, forming an acute angle there; this acute angle was to be rendered a right angle again by the repellant pole of a compensating magnet under certain prescribed conditions.

Mr. Holman showed that, from experiments performed by him on this compass in the laboratory, the action of disturbing forces at a distance was not as Mr. Iles had expected,— that an acute angle was produced only when such force was at a small distance from the needle as compared with the length of the small magnets composing these needles,— and that the compass failed to show any variation from a right angle between its needles, when a disturbing magnet had moved them both through a very large angle from a true position.

He then showed, upon theoretical grounds, the reason for these two actions at different distances, making evident in this way the fallacy of the instrument, which had acquired a wide reputation.

NEW SYSTEM OF RIFLING CANNON.

March 9. Prof. E. L. Zalinski, U. S. A., read a paper, illustrated by numerous diagrams and models, on a new system of rifling heavy guns, devised by Mr. S. P. Ruggles, a member of the Society.

The following extracts embrace the principal points in the paper.

He sketched briefly the object of rifling guns, the various kinds of rifled projectiles, the principal methods in use at the present time, and the arguments of advocates of the uniform and variable pitch or twist of rifling.

The object of rifling guns is to give projectiles, not spherical, a rotary motion, which gives greater range and accuracy, and to impart the maximum projectile force to the shot with the minimum strain upon the gun. These projectiles are known as expansive, compressive, and flanged.

The expansive class are made smaller than the bore to facilitate loading, being used most frequently in the muzzle-loading cannon. The pressure of the powder-gas expands a soft metal cup or base so as to cause it to fill the grooves and rotate the projectile.

The compressive class are made larger than the bore, and used with breech-loaders, and are made to take the rifling by being compressed. They are made of iron or steel, with a thin soft metal coating, usually a compound of lead and tin. This system is gradually being abandoned, as it strains the gun, and reduces the velocity and accuracy.

The flanged class are made with flanges which correspond in position and inclination to the grooves of iron lined on the bearing side with a softer metal. While this class has given good results as to accuracy, range, and penetration, they strain the gun and the flanges are liable to break; they can not be used with a variable twist; they are used, however, by most European nations.

Mr. Ruggles's plan of rifling cannon and projectiles was shown by a model. It contains sixteen grooves of a serrated shape. The grooves used in United States cannon are rectangular, this Mr. Ruggles claims is unnecessary, as only one side of the groove is subjected to any strain or bearing in firing; consequently a number of serrated grooves, each having the same effective bearing surface as the rectangular groove, can be cut in the bore, doubling thereby the bearing surface without weakening the gun.

The projectile has an expansive sabot of soft metal, which is forced into the grooves by the powder gas, which thus gives the required rotary motion. From this kind of groove the sabot is able to expand, fitting closely the bore at every point, utilizing the entire force of the powder, and preventing the escape of the gas, which is not the case with the service groove. Around the front of the projectile, near the junction of the cylindrical and conical portions, is a soft metal hoop, which is to be expanded by the gas that must pass the base sabot at the first moment of explosion; this will cause it to expand sufficiently to centre the front end, although it may not have fitted the grooves. This band is put on loosely, so that it may turn.

Opinions differ as to the rate and kind of twist that should be given to rifling. There are two kinds of twist used, uniform and varying. The uniform twist is one which imparts the required rotary velocity upon starting the projectile; the increasing variable twist is one which causes the projectile to move straight forward at first, and then gradually acquire its ultimate rotary velocity at the muzzle.

Mr. Ruggles proposes to use an increasing twist, and considers that one based upon the law of gravitation will give the best results. By an ingenious device he has made the twist an exact copy of the law, as to progressive increments of pitch, giving the projectile one revolution in travelling the first 48′ of its flight.

Remarks by several experts in the science of gunnery and projectiles added to the interest of the meeting.

DEVELOPMENTS IN STEAM ENGINEERING.

March 23. Prof. Channing Whitaker read a paper on some "New Developments in Steam Engineering."

De Pambour thought that saturated steam expanding in a cylinder followed the laws of Mariotte and Gay Lussac, that the steam remained saturated during the expansion, and that the weight of steam in the cylinder was constant throughout the expansion; we now know that these ideas are inconsistent with each other.

Mariotte's law is that the pressure is inversely proportionally to the volume; this law he represented by a diagram on the board.

He gave the results of Regnault's, Rankine's, Zeuner's, Fairbairn's, and Tate's experiments, as represented by diagram curves.

After Dr. Joule had determined the mechanical equivalent of heat, it was ascertained that some of the steam in the cylinder would be condensed during expansion if no heat was communicated to it during that time, and hence, it was believed that the expansion line, instead of being a curve of a constant weight of saturated vapor, was a curve of a constantly decreasing weight of vapor. Rankine called this an "adiabatic" curve, and this has been generally accepted by engineers as the one coming nearest to that according to which steam should expand in the cylinder of an engine. It is supposed that the steam neither receives heat from, nor imparts heat to, any other substance during the expansion, but that as much heat as is necessary for the purpose is converted into the work done during expansion. The heat converted into this work is then obtained from the steam which is expanding, and a portion of it is therefore condensed, and the curve is one of a decreasing quantity of saturated vapor.

Prof. Whitaker stated that it is by no means certain that steam in a cylinder should be expected to expand along an adiabatic curve. The supposition that the steam neither receives heat from, nor imparts heat to, any other substance during expansion, is an untenable one, and the conclusion is in error to the extent that it is affected by this supposition. He laid before the meeting some facts which led him to believe that the conditions of ordinary expansion are not those of the adiabatic curve.

In almost all cases, indicator diagrams taken from unjacketed engines using saturated steam expansively, show a greater increase in the weight of steam during expansion than if the steam had expanded along a Mariotte's curve. During the winter of 1874–75 many experiments were made by the students in the Mechanical Engineering Laboratory of the Institute bearing upon the question of condensation and re-evaporation in the cylinder. He gave an abstract of the thesis of Mr.

J. H. Head, from which it appeared that in unjacketed cylinders the co-efficient of expansion of saturated steam, established theoretically by Rankine as $\frac{10}{9}$, is incorrect in ordinary practical usage; the co-efficient is not constant, varying in different engines, and even at different cut-offs in the same engine.

Two principal reasons have been assigned for the increase in the weight of steam in the cylinder during expansion: — leakage, and re-evaporation of water which entered as steam and condensed against its cool walls during the early part of the stroke, the re-evaporation being produced by heat returned to the steam during expansion by the walls of the cylinder. As to the first, it seemed to him reasonable to suppose that in most cases at least as much steam will leak out of as into the cylinder during the expansion. He thinks the results more likely due to condensation and re-evaporation.

BLOOD GLOBULES OF MAN AND MAMMALIA COMPARED.

April 6. Dr. Ephraim Cutter exhibited micro-photographs of the blood of man and of some of the mammalia, taken by himself.

The object of his researches was to ascertain what ground, if any, medico-legal experts had for saying that they could distinguish the blood of a child from that of an adult, or that of man from that of any other mammal.

The images thrown on a screen by the calcium light can be measured directly, and any observer can decide for himself whether such discrimination is possible, as size is the only morphological element of the red blood corpuscle taken into account by such experts.

The averages of the measurements were as follows:

Man	1-3100	to 1-3200	of an inch.
Dog	1-3200		“ “ “
Squirrel	1-3600		“ “ “
Rat and Rabbit . .	1-3400		“ “ “
Deer	1-3500		“ “ “
Ox	1-3900		“ “ “
Pig	1-4028		“ “ “
Horse	1-4200		“ “ “
Sheep	1-5600		“ “ “

All were taken with the same $\frac{1}{50}$ objective of Tolles at a distance of 26 inches, and reduced upon the glass positives at the same distance from the camera. The powers used are very much higher than have ever before been employed in microphotography.

Whether such small differences could be of any value in legal medicine, especially as in the same specimen the size varies considerably, he left for others to determine.

He also exhibited the appearances presented by diseased blood, in the various stages of consumption, showing characteristic changes in the outlines, appearance, and contents of the globules.

Dr. Cutter exhibited an invalid chair of his invention, in which all the parts have an independent motion in a vertical plane, corresponding to the movements of the natural divisions of the body.

Mr. H. P. Langley read a paper on windmills, and some of the wasted forces of nature. He described a cheap machine of his invention, useful for pumping and other domestic purposes.

ELECTRIC RAILWAY SIGNALLING.

April 27. Mr. William Robinson read a paper on his system of "Wireless Electric Railway Signalling, and the prolongation of batteries" — illustrated by a working model.

His invention shows that the intricate and expensive system of line wires is unnecessary, and that excellent conductors are found in the ordinary rails of the track, resting on the ties in the usual manner and without insulation, disproving the generally received opinion that the electric current would be speedily lost by passing to the earth, especially in wet weather, unless perfect insulation is secured. He gave a sketch of the various attempts to use the rails as conductors, from an English patent in 1848, to his own invention, which would hardly be intelligible without the diagrams.

He also read a paper on his new method of prolonging the duration of batteries, and gave what he believed to be the explanation of the facts.

MINING LABORATORY OF THE INSTITUTE.

Prof. Richards read a paper on the Mining Laboratory of the Institute, comparing its present with its former condition. In the improvements introduced, the idea has been constantly in mind that the Institute requires real machines, and not toys, to work on a small scale; he believes that any ore susceptible of washing can be practically treated in this laboratory. It connects the school practically with the mining interests of the country, by sending out students capable of putting into successful operation machines they are familiar with. It protects the public from imposition, and private individuals from delusive hopes of a fortune, by establishing a criterion of just and true treatment by disinterested and able experimenters. The future is full of promise.

EXPERIMENTS ON SOUND.

May 11. Mr. William W. Jacques, a student in the Physical Department of the Institute, read a paper, illustrated by diagrams and apparatus, on some new experiments on Sound made by himself.

They consisted of three series: the first was made for the purpose of testing the law of inverse squares; the second to show that the principles of Fresnel and Huyghens, announced for the ether waves, could be applied to waves of sound; and the third, for the purpose of measuring the velocity of sounds of considerable intensity.

There is every dynamical reason for believing that the intensities of light, heat, and sound diminish as the reciprocals of the squares of the distances from their origins. That this is true of light and heat has been demonstrated experimentally; his experiments proved that this law applies also to sound, the observed and calculated results agreeing almost exactly.

There seems to be no *a priori* reason why the principles of Fresnel and Huyghens should not be applied to our atmosphere, and the experiments of Mr. Jacques on the diffraction of sound show that they may be so applied. From his data we may calculate the length of a sound wave, the velocity of sound, and, in short, all of the quantities dependent upon the velocity of sound as well as acoustic quantities analogous to the optical quantities deduced from the diffraction of light.

Many eminent mathematicians and physicists have raised questions as to whether the velocity of sound is not affected by its intensity and pitch, by barometric pressure, hygrometric state, and by other supposed causes. Mr. Jacques's experiments had for their object the measurement of the velocity of sound near the mouth of a cannon. His method consisted of an automatic measurement of the velocity between the members of a series of membranes, placed at different distances from the source of sound, by causing the sound, as it passed each membrane, to register its passage, by means of suitable electric connections, on a chronograph. The experiments were carried on at Watertown arsenal by means of a six-pound cannon. He carefully described the manner of conducting the experiments, which showed that the velocity of sound in the vicinity of a gun is greater than at a distance, by several feet. This is in accordance with theory. The method, when perfected, will probably furnish the most accurate results of the velocity of sound yet obtained.

NEW FORM OF PLANE TABLE.

Prof. Pickering exhibited a simple and inexpensive form of plane table. He called attention to the gradual change in the instruments used by surveyors, the plane table gradually taking the place of the compass. The principal obstacle to its general use is its expense, which, as ordinarily made, is not less than that of a transit, amounting sometimes to nearly three hundred dollars. Its weight, also, is so great as to render its use difficult among the mountains, and the accurate fitting of some of the parts renders them very liable to injury.

He described and exhibited his instrument, which can be furnished for the sum of fifteen dollars. The cost of the proposed surveys of this and other States may be materially reduced, since the expense of the topography is generally a serious difficulty, and this could be very much lessened if large numbers of competent observers, like the Institute classes, could be provided with inexpensive instruments.

TELEGRAPHING MUSICAL SOUNDS.

May 25. Prof. A. Graham Bell read a paper, illustrated by several experiments, on "telephony" or the telegraphing of musical sounds.

It has long been known that an electro-magnet gives forth a sound when it is suddenly magnetized or demagnetized. When rapidly produced the effect upon the ear is that of a musical note. The discovery of galvanic music by Page in 1837 led inquirers in different parts of the world, almost simultaneously, into telephonic research.

As his researches will be published in full elsewhere, a brief abstract only of some of the principal points will be given here. [Proc. Amer. Acad. of Arts and Sciences. Vol. xii.

In the autumn of 1874, Prof. Bell discovered that the sounds emitted by an electro-magnet under the influence of a discontinuous current of electricity are not due wholly to sudden changes in the magnetic condition of the iron core (as heretofore supposed), but that a portion of the effect results from vibrations in the insulated copper-wires composing the coils. An electro-magnet was arranged upon circuit with an instrument for interrupting the current, — the rheotome being placed in a distant room, so as to avoid interference with the experiment. Upon applying the ear to the magnet, a musical note was clearly perceived, and the sound persisted after the iron core had been removed. It was then much feebler in intensity, but was otherwise unchanged,—the curious crackling noise accompanying the sound being well marked.

The effect may probably be explained by the attraction of the coils of the wire for one another during the passage of the galvanic current, and the sudden cessation of such attraction when the current is interrupted.

Very striking audible effects can be produced upon a short circuit by means of two Grove elements.

Loud sounds are emitted by pieces of iron and steel when subjected to the attraction of an electro-magnet which is placed in circuit with a rheotome. Under such circumstances, the armatures of Morse-sounders and Relays produce sonorous effects. He has succeeded in rendering the sounds audible to large audiences by interposing a tense membrane between the electro-magnet and its armature. The armature in this case consisted of a piece of clock-spring glued to the membrane. The instrument was connected with a parlor organ, the reeds of which were so arranged as to open and close the circuit during their vibration. When the organ was played the music was loudly reproduced by the telephonic receiver in a distant room. When chords were played upon the organ, the various notes composing the chords were emitted simultaneously by the armature of the receiver.

The simultaneous production of musical notes of different pitch by the electric current, was foreseen by him as early as 1870, and demonstrated during the year 1873. Elisha Gray, of Chicago, and Paul La Cour, of Copenhagen, lay claim to the same discovery. The fact that sounds of different pitch can be simultaneously produced upon any part of a telegraphic circuit is of great practical importance; for the duration of a musical note can be made to signify the dot or dash of the Morse alphabet, and thus a number of telegraphic messages may be sent simultaneously over the same wire without confusion by making signals of a definite pitch for each message.

If the armature of an electro-magnet has a definite rate of oscillation of its own, it is thrown bodily into vibration when the interruptions of the current are timed to its movements. For instance, present an electro-magnet to the string of a piano, it will be found that the string which is in unison with the rheotome included in the circuit will be thrown into vibration by the attraction of the magnet.

All the effects noted above result from rapid interruption of a voltaic current, but sounds may be produced electrically in many other ways.

The Canon Gottoin de Coma, in 1785, observed that noises were emitted by iron rods placed in the open air during certain electrical conditions of the atmosphere; Beatson produced a sound from an iron wire by the discharge of a Leyden jar; Gore obtained loud musical notes from mercury, accompanied by singularly beautiful crispations of the surface during the course of experiments in electrolysis; and Page produced musical tones from Trevelyan's bars by the action of the galvanic current.

When an intermittent current is passed through the thick wires of a Ruhmkorff's coil, very curious audible effects are produced by the circuit.

When a voltaic battery is common to two closed circuits, the current is divided between them. If one of the circuits is rapidly opened and closed, a pulsatory action of the current is occasioned upon the other. All the audible effects resulting from the passage of an intermittent current can also be produced, though in less degree, by means of a pulsatory current.

When a permanent magnet is caused to vibrate in front of the pole of an electro-magnet, an undulatory or oscillatory current of electricity is induced in the coils of the electro-magnet, and sounds proceed from the armatures of other electro-magnets placed upon the circuit.

The effect was much increased when a battery was included in the circuit. In this case, the vibration of the permanent magnet threw the battery-current into waves. A similar effect was produced by the vibration of an unmagnetized tuning-fork in front of the electro-magnet. The vibration of a soft iron armature, or of a small piece of steel spring no larger than the pole of the electro-magnet in front of which it was placed, sufficed to produce audible effects in the distant room.

Electrical undulations can be produced directly in the voltaic current by vibrating the conducting wire in a liquid of high resistance included in the circuit, as water, dilute sulphuric acid, or saturated solution of salt.

Sullivan discovered that a current of electricity is generated by the vibration of a wire composed partly of one metal and partly of another; and it is probable that electrical undulations were caused by the vibration. The current was produced so long as the wire emitted a musical note, but stopped immediately upon the cessation of the sound.

Although sounds proceed from the armatures of electro-magnets under the influence of undulatory currents of electricity, he has been unable to detect any audible effects due to the electro-magnets themselves.

The telephonic effects described above are produced by three distinct varieties of currents, which he terms respectively intermittent, pulsatory, and undulatory. Intermittent currents are characterized by the alternate presence and absence of electricity upon the circuit; pulsatory currents result from sudden or instantaneous changes in the intensity of a continuous current; and undulatory currents are produced by gradual changes in the intensity of a current analogous to the changes in the density of air occasioned by simple pendulous vibrations.

The experiments were novel and successful, and were witnessed by a large audience.

The meetings were then suspended for the season.

Mr. George W. Hammatt was elected an Associate Member. Messrs. A. T. Hall, George W. Pratt, and Thomas W. Pratt, have died during the year. Eight members have resigned, and four have been dropped for non-payment of fees. The list now comprises 63 life and 185 associate members.

SCHOOL OF INDUSTRIAL SCIENCE.

The attendance at the School of Industrial Science for the year has been 299, as follows: Resident graduates, 11; Regular students of 4th year, 43; of 3d, 43; of 2d, 30; of 1st, 66;—Students not candidates for a Degreee: 4th year, 15; 3d year, 14; 2d year, 21; 1st year, 19; Architectural Students, 23; Students in Practical Design, 25, of whom 12 were females—total 299, of whom 8 were graduates of other Institutions. Of these about two-thirds were from Massachusetts, principally from Boston and its vicinity; — from other New England States, 22; viz.: from Maine, 6; New Hampshire, 6; Connecticut, 5; Rhode Island, 4; Vermont, 1. From other States, there were from New York, 9; Ohio, 8; Illinois, 7; Indiana, 3; Pennsylvania, Iowa, Kentucky, Minnesota, California, 2 each; New Jersey, Michigan, Virginia, and District of Columbia, one each; from Japan, 4; from the Hawaiian Islands, Canada, and New Brunswick, one each.

Thirty-four professors and teachers have been connected with the school, and several advanced students have rendered assistance in the various laboratories and in surveying. The fees rom students have amounted to about $46,000.

The class in the School of Design has been full, and the work has been entirely satisfactory.

The Lowell Free Courses for the year were as follows:

I. *General Chemistry.* Twenty-four laboratory exercises, of two hours each, on Wednesday and Saturday afternoons, at 2½ o'clock, by Professor Nichols, beginning Nov. 3.

II. *Qualitative Analysis.* Twenty-four laboratory exercises, of two hours each, on Wednesday and Saturday afternoons, at 2½ o'clock, by Professor Nichols, beginning Nov. 3.

III. *Philosophy.* Eighteen lectures for beginners, on *Kant's Critique of Pure Reason*, on Monday and Wednesday evenings, at 7½ o'clock, by Professor Howison, beginning Nov. 8.

IV. *Physiology and the Laws of Health.* Eighteen lectures on Tuesday and Friday evenings, at 7½ o'clock, by Professor Kneeland, beginning Nov. 9.

V. *Heat and its Applications.* Eighteen lectures on Tuesday and Friday evenings, at 7½ o'clock, by Professor Ordway, beginning Nov. 9.

VI. *Perspective and the Perspective of Shadows, with Applications.* Eighteen lessons on Wednesday evenings, at 7½ o'clock, by Professor Ware, beginning Nov. 3.

VII. *Light in its Relation to Color.* Eighteen lectures on Wednesday and Saturday afternoons, at 3 o'clock, by Professor Cross, beginning Jan. 12, 1876.

VIII. *Elementary German.* Eighteen lessons on Monday and Wednesday evenings, at 7½ o'clock, by Professor Otis, beginning Nov. 22.

These were open to both sexes over eighteen years of age; applicants to apply in their own hand-writing, stating age, occupation, and previous preparation. These courses are always well attended by persons desirous of substantial teaching, and having a serious purpose of improvement.

MEETINGS OF THE CORPORATION.

The Corporation has held nine meetings during the year.

At the meeting of Oct. 13, 1875, it was voted to establish a dining room for the students in the gymnasium building.

At the meeting of May 10, 1876, it was voted that the Committee on the School be authorized to cause a laboratory to be constructed for advanced instruction in Chemistry and allied subjects to women, provided that the funds are contributed by the "Women's Educational Association."

At the same meeting the Committee were authorized to open such departments of the school as they see fit, to advanced special students of either sex, or to special classes, where it can be done without interfering with the regular work of the school—on payment of certain fees.

At the meeting of June 7th, it was voted to confer the Degree of Bachelor of Science on the following students who had complied with all the requirements therefor:

Thos. Aspinwall, Jr.	Brookline	Civil Engineering.
T. W. Baldwin, A. B.	Bangor, Me.	“ “
Joshua B. F. Breed	Louisville, Ky.	“ “
Harry T. Buttolph	Buffalo, N. Y.	“ “
Fred. K. Copeland	Winchester	“ “
John R. Freeman	Lawrence	“ “
Frank W. Hodgdon	Arlington	“ “
Arthur L. Mills	Everett	“ “
Henry Raeder, Jr.	Hyde Park	“ “
Henry M. Waitt	Nantucket	“ “
Henry B. Wood	Woburn	“ “
Charles L. Rich	Morrisville, Vt.	“ “
Wm. P. Jewett (72–3)	Cape Elizabeth, Me.	“ “
Henry L. Ripley (72–3)	Kingston	“ “
Aaron D. Blodgett	Boston	Mechan. “
Clarence L. Dennett	Beverly	“ “
Francis E. Galloupe	Lynn	“ “
Sumner Hollingsworth	S. Braintree	“ “
Alfred C. Kilham	Beverly	“ “
Theodore J. Lewis	Philadelphia, Pa.	“ “
Chas. T. Main	Marblehead	“ “
Chas. F. Prichard	“	“ “
Chas. F. Allen	Cincinnati, O.	Mining “
Alfred E. Hunt	Hyde Park	“ “
Sam'l James, Jr.	Cambridgeport	“ “
Thos. W. Robinson	Chicago.	“ “
Theo. E. Schwarz	Boston	“ “
Julius H. Susman	“	“ “
Walter D. Townsend	“	“ “
Wm. P. Atwood	Lowell	Chemistry.
Chas. R. Fletcher	Chelsea	“
Albert H. Low	Boston	“
Chas. N. Waite	Medford	“
Wm. E. Nickerson	N. Somerville	“
Robert H. Gould	E. Cambridge	Metallurgy.
Walter B. Barrows	Reading	Natural History.
Wm. O. Crosby	Washington, D. C.	“ “
John B. Henck, Jr.	Boston	Physics.
Silas W. Holman	Framingham	“
Wm. W. Jacques	Newburyport	“
Willis E. Davis	San Francisco, Cal.	Science and Literat'e.
Chas. A. Sawyer	Chicago, Ill.	“ “ “

David W. Phipps . . .	Boston	Philosophy.
Robert C. Ware, S. B. .	Marblehead	"

The subjects of the Theses, and the abstracts of the same, will be found in subsequent pages.

The progress of the School in the various departments will be found in the reports of the President and Professors.

At the meeting of Aug. 17th, it was voted to approve the plan for the new course in Practical Mechanism proposed by the President, and to construct a one story brick building for that and advanced and organic chemistry, the funds having been contributed by the Charitable Mechanic Association, the Women's Educational Association, and from sources unconnected with the funds of the Institute.

SAMUEL KNEELAND, *Secretary.*

Boston, Oct. 2, 1876.

DEPARTMENT OF PHYSICS.

BOSTON, JAN. 31, 1877.

Prof. J. D. RUNKLE,
President of the Mass. Inst. of Technology.

DEAR SIR: —

My official connection with the Massachusetts Institute of Technology, which has extended over a period of precisely ten years, terminates to-day. I therefore take this opportunity of presenting a statement of the work I have accomplished, and of comparing the condition of the Physical Department and the nature of the instruction with that of ten years ago. At that time instruction in Physics was universally given by lectures and recitations illustrated by experiments and diagrams. A student wishing to pursue this subject further, might aid his instructor in preparing these experiments, and thus become qualified in his turn to deliver the lectures. The first step towards the introduction of a new order of things seems to have been taken by Prof. Wm. B. Rogers, then President of the Institute, and Professor of Physics and Geology. In a pamphlet entitled "Scope and Plan of the School of Industrial Science of the Massachusetts Institute of Technology," published in 1864, the following paragraph headed "Practice in Physical and Chemical Manipulations" occurs on page 23: —

> "It will be the object of these exercises to make the student practically familiar with the adjustments and use of the apparatus and agents employed in the more important experiments and processes in natural philosophy and chemistry. With this view, the students, under the direction of their teacher, will be called, by small classes at a time, to execute with their own hands various experiments in mechanics, pneumatics, sound, optics, electricity, and other branches of experimental physics, and to exhibit chemical reac-

tions, to fit up chemical apparatus, to prepare gases and other products, and demonstrate their properties by suitable experiments, accompanying these manipulations, when required, with an explanation of the apparatus used, or of the process or experiment performed."

On page 24 the following paragraph occurs under the heading "Laboratory of Physics and Mechanics": —

> "In this laboratory, it is proposed to provide implements and apparatus with which the student may be exercised in a variety of mechanical and physical processes and experiments. Thus he may learn practically the methods of estimating motors and machines by the dynamometer, of experimenting on the flow of water and air, or other gases, and of testing the strength of the materials used in construction. He may become familiar with the adjustments and applications of the microscope; be practised in observing with the barometer, thermometer and hygrometer; and, in a room fitted up for photometry, may learn the mode of measuring the light produced by gas and other sources of illumination, and the value of different kinds of burners, lamps, and their appendages."

This appears to be the first clear statement of the desirability of teaching Physics by the Laboratory method, but owing to the pressure of other business and the lack of means, the matter stopped at this point, and no definite plan was formed for carrying it out.

Accordingly the first instruction in Physics at the Institute was given by the usual illustrated lectures, and this continued to be the case for the two following years. Meanwhile, my appointment in charge of the exercises in Physics led me to consider whether a plan for a Physical Laboratory might not be developed, and, accordingly, in April, 1869, a scheme was offered to the Government of the Institute and printed and distributed among them, under the title "Plan of the Physical Laboratory."

This plan was carried out the following autumn, and has been in operation ever since without sensible change, except in extending its scope. In fact, out of sixteen experiments published in 1870 all but one or two are still in use without alteration.

The cost of establishing this Laboratory was exceedingly small. The argument used was, "this is an experiment and may not prove a success, therefore we will begin on a small scale, and if it accomplishes its end the public will at once appreciate its value, and it will not be difficult to obtain a liberal support, while if unsuccessful, the loss to the Institute will be small." Here, if anywhere, the mistake was made; it accomplished far more than its projectors anticipated, but the public, seeing how much had been accomplished with so little, supposed that no more was needed. The great need of the Physical Laboratory at the present time is an independent endowment, by which, as regards apparatus, it may be placed on an equal footing with other Laboratories since established. Instead of an original expenditure of several thousand dollars, the cost to the Institute was little beyond that of fitting up the room adjoining the lecture-room with tables, and gas and water fixtures, and most of this was done by those already connected with the Institute. The apparatus was largely constructed in a similar manner, at small cost, and without regard to looks, the working being almost the sole consideration. Notwithstanding these adverse circumstances, the work of the Laboratory has been continually increasing. The space first provided proving insufficient, a portion of the long room at the end of the building was added, and soon after the whole of this room was appropriated to this purpose. Two large rooms, one nearly a hundred feet in length, were thus devoted to Laboratory work. But, as many small rooms were needed rather than a few of large size, two alcoves were partitioned off from the main room, one devoted to a chemical store-room, and the other fitted with tools for a workshop. Recently, a partition has been run along one side of the large room, by which small rooms are formed for electrical measurements, photometry and optical experiments requiring the exclusion of a portion of the light. The use of a portion of the closet adjoining the physical lecture-room has also been granted for a battery room, and for photographic work, and last year the room to the east of the front door has been darkened, so that it may be used for spectroscopic and other similar work. Notwithstanding this large amount of space, it is not of the kind best adapted to a Physical Laboratory. Accordingly last summer I presented a plan by which the same facilities could be obtained with a much more economical arrangement of space. I proposed that the present rooms should be given up to lecture-rooms, or some of the other purposes to which they are admirably adapted, and that a block of three small dwelling houses should be converted into a Physical Laboratory. One of these could be leased to the Director, and the other two would contain the large number of small rooms especially required for this work. Among the numerous advantages of this plan are the economy, considering the additional space gained, the means of erecting stone piers to secure steadiness for delicate instruments, the light for spectroscopic and photographic work, the easy access to the ground for out-door experiments, the comparatively unobstructed view for astronomical or meteorological observations, and the convenience for undertaking experiments requiring power.

The work of the Laboratory may be divided into three classes: that for the regular students, additional courses, and original investigation. The first of these has been fully described elsewhere, in previous reports, in the Catalogues of the Institute, and in the "Elements of Physical Manipulation." The latter work, in particular, gives in detail the work of the Laboratory, and is, in fact, based on the manuscript directions to students in performing their various experiments. It will therefore be sufficient here to state, in a general way, what would be the work of an average student in the third year in the course as now given. The actual experiments differ a little in each case, but the following list shows approximately what is done by every regular student in the third year's Class.

3. *Insertion of Cross-Hairs*, teaching the student to handle delicate objects.

11. *Calibration of Water*, for graduating vessels.

12. *Cathetometer*, measuring the height of columns of liquid.

14. *Spherometer*, measuring the curvature of a lens.

15. *Estimating tenths of a Second*, as in very accurate measurements of time.

23. *Composition of Forces*, illustrating the parallelogram of forces.

25. *Parallel Forces*, measuring their resultant and comparing with theory.

28. *Crank motion*, comparing the relative positions of a piston rod and fly-wheel with that given by theory.

35. *Deflection of Beams*, proving the laws of elasticity.

41. *Borda's Pendulum*, determining the force of gravity by the time of vibration of a pendulum, and measuring its length by (20) *Reading Microscopes.*

45. *Hydrometers*, showing how specific gravity is found.

46. *Specific Gravity Bottle*, for measuring specific gravities.

67. *Absorption Photometer*, measuring the light cut off by glass.

69. *Bunsen Photometer*, for testing the quality of illuminating gas.

76. *Spectroscope*, observing and measuring various spectra and analyzing by the spectroscope various unknown mixtures.

78. *Law of Lenses*, comparing their observed and computed foci.

79. *Microscope*, using various appliances, as reflected and oblique illumination, camera lucida, micrometers, etc.

88. *Opthalmoscope*, viewing the interior of an artificial eye, illustrating various diseases.

92. *Polarized Light*, illustrating a subject otherwise acquired by the student only with difficulty.

96. *Telegraph*, teaching the student to send messages.

98. *Law of Galvanometer*, or currents corresponding to various deflections.

102. *Wheatstone's Bridge*, measuring resistances with apparatus like that used on the Atlantic Cable.

103. *Resistance Coils*, making and testing resistances by the British Association Bridge.

105. *Electromotive Force and Resistance of a Battery*, or a complete test of a galvanic battery.

118. *Force of Magnets*, or their attraction measured at various distances.

125. *Expansion of Liquids*, with various temperatures.

132. *Law of Cooling*, or the connection between time and temperature.

133. *Pressure of Steam*, at various temperatures.

138. *Specific Heat*, measuring first that of water.

145. *Efficiency of Gas Burners*, measuring the number of units of heat generated with a given burner per cubic foot of gas burned.

Since this only represents about fifty hours' work, or two hours a week for twenty-five weeks, the apprehension that all the time would be spent on a few experiments, proved groundless. If the means were sufficient to keep the apparatus in perfect order, there is no reason that this amount of work should not be made the minimum required of all students. Several of the more advanced institutions of learning in this country have already successfully adopted our system in the form in which we use it, and at many others its adoption is strongly desired. The only other plan competing with it, is that in which every experiment shall be very exhaustively treated, which requires a long time to be devoted to each one. This system may have advantages for specialists (though even then I think it should follow that given above), but I doubt its advisability with large classes of students not particularly interested in physics as a profession. As a matter of general culture, the list of experiments detailed above would have greater value than any single experiment, however fully treated. The use of the course here described as a means of culture should not be overlooked, as it is with this object that its introduction into our larger colleges is to be expected. A student accustomed to learn merely from books acquires a new knowledge of physical phenomena, when he himself proves the correctness of theoretical laws by actual experiment. Facts thus learned are also far more readily remembered. An interesting feature of this method of teaching is the rapid improvement, especially with classes who have had no previous laboratory practice. Such a class, during their first hour, accomplish almost nothing, and almost discourage both themselves and their instructor; the next hour shows an improvement, and before many weeks, experiments are readily performed without question, which at first were quite unintelligible to them.

A good test of the character of the instruction, is the relation of teacher to pupil. My own relations, which have always been of the pleasantest character, I ascribe largely to the interest of the classes in their work. They remain beyond the hour, encroach upon their dinner-hour, and frequently ask, and are allowed, to work at other times which they might devote to amusement. With this condition of things disorder is almost unknown, and they are treated, and I believe regard themselves, as friends and guests, rather than as pupils. Of course the consequence shows itself in a largely increased amount of work, and a saving of much of the nervous wear and tear of a teacher's life.

These remarks apply with still more force to the work of the fourth year, which is largely of a professional nature. The students in Civil Engineering and Architecture devote two hours a week to work in the Physical Laboratory for half of their fourth year. The work during the present year serves as a type of that previously done. This year two students planned and built a truss of a form suitable for a roof, and measured its change of shape under various loads. It finally broke under three hundred pounds, while the bars of which it was formed would not have borne a tenth part of the weight. Others studied the laws of continuous girders, and compared the deflections with those given by theory; others tested a water-motor, measuring the flow, the pressure, the work done, the speed and other elements, and from these computed the efficiency. Others, again, measured the strength of wires, the force required to strip a nut off a bolt, and compared the effect of impact, as in a pile-driver, with a dead weight. In former years, several excellent models of bridges have been built by students, and these are now used for tests of change of form with varying loads and for other purposes.

Several other courses have also been given, mostly to students intending to make Physics their profession. Of these the following may be mentioned:—

Mechanical Engineering. Formerly the mechanical engineers spent four hours a week in their fourth year in the Laboratory. With the establishment of a Mechanical Laboratory this work has been given up, and the course is now given to the students in Physics only. It includes various mechanical measurements, as flow of water, strength of materials, velocity of shafting, friction and power (Phys. Manip., II, pp. 109–138).

Lantern Projections. To students in Physics only. The various methods of using the lantern as a means of instruction (Phys. Manip., II, pp. 212–253). Last year, when several students in the fourth year were devoting themselves to Physics, this course was supplemented by some exercises which proved most successful and useful. Some lectures were given by these students to pupils of some of the neighboring private schools, and illustrated by the lantern and the other lecture apparatus of the department. Thus our students acquired the very best experience to fit them as teachers. The course in Lantern Projections has sometimes been given by Prof. Cross, in connection with his own lectures.

Geodesy. Last year, finding that the students in Civil Engineering received little instruction in this branch of higher surveying, a course of lectures was given to the older students on geodesy and topography, with especial reference to the Geological Surveys now under consideration in many of the United States.

Practical Astronomy. This course, which has been given for the last two years in the form of lectures, promises, by its adoption, an excellent opportunity to some college, provided with the necessary instruments, for the establishment of an Astronomical Laboratory (Physical Manip., II, pp. 166–212).

Photography. This course, originally given by Mr. Whipple, is now given by Prof. Cross to students in Physics only.

Advanced Physics. One of the most successful courses for the special students in Physics is that bearing this name. The form of each exercise is that of a scientific meeting, different students being selected in turn as secretaries. The advantages of a student's society are attained, while the objections of irregular attendance, and that the work would fall mainly on two or three members, are obviated by requiring from all, attendance and the presentation of papers. Each student in turn presents papers, often illustrated by experiments, either on some original work, or a review of some recently published research, or of the latest scientific periodicals. Many of the standard researches in physics have been thus presented, and other matters of value to every scientific man, such as the character of various scientific societies and periodicals and other similar matters. This, with the lectures referred to above, qualifies each student to express himself clearly and composedly before an audience.

For the past two years instruction has been given in the Physical Laboratory to the students of the Boston University, with results highly satisfactory to us. The laboratory course has thus been successfully tested with a class whose previous preparation has been literary rather than scientific. The income derived could, moreover, have ill been spared in maintaining the Laboratory.

The great object to which my work for these last ten years has been directed, has been original investigation. This is the real goal to which the attention of a student in the Physical Laboratory is directed. The value of the course in physical manipulations is largely that it teaches a student to think for himself, and prepares him with methods by which he may solve any problem for himself experimentally. I have endeavored to impress on all our students in physics the principle that original investigation should be the great aim of every scientific man. In consequence, a great deal has been done in the laboratory that is new, but in many cases there has been neither time nor means for publication. The following articles have been published under the titles here given. Where I have aided the student largely in the work, my name appears; in the other cases the work has been done almost entirely by the student.

* On the Focal Length of Microscope Objectives. By Chas. R. Cross. *Journ. Frank. Inst.*, lix, 401 (June, 1870).

On the Relative Efficiency of Kerosene Burners. By Chas. J. H. Woodbury. *Journ. Frank. Inst.*, xcvi, 115 (Aug., 1873).

The Phonautograph. By Chas. A. Morey. *Amer. Journ. Sci.*, cviii, 130 (Aug., 1874).

I. Foci of Lenses placed obliquely. By Prof. E. C. Pickering and Dr. Chas. H. Williams. *Proc. Amer. Acad.*, x, 300.

II. Light transmitted by one or more Plates of Glass. By W. W. Jacques. *Proc. Amer. Acad.*, x, 389.

III. Intensity of Twilight. By Chas. H. Williams. *Proc. Amer. Acad.*, x, 421.

IV. Light of the Sky. By W. O. Crosby. *Proc. Amer. Acad.*, x, 425.

V. Light absorbed by the Atmosphere of the Sun. By E. C. Pickering and D. P. Strange. *Proc. Amer. Acad.*, x, 428.

VI. Tests of a Magneto-Electric Machine. By E. C. Pickering and D. P. Strange. *Proc. Amer. Acad.*, x, 432; *Electrical News*, i, 14, 54.

VII. Answer to M. Jamin's objection to Ampère's Theory. By W. W. Jacques. *Proc. Amer. Acad.*, x, 445.

VIII. An Experimental Proof of the Law of Inverse Squares for Sound. By Wm. W. Jacques. *Proc. Amer. Acad.*, xi, 265.

IX. Diffraction of Sound. By Wm. W. Jacques. *Proc. Amer. Acad.*, xi, 269.

X. Comparison of Prismatic and Diffraction Spectra. *Proc. Amer. Acad.*, xi, 273 (June, 1875).

XI. On the Effect of Temperature on the Viscosity of Air. By S. W. Holman. *Proc. Amer. Acad.*, xii, 41.

The following articles were published in the Report of the Physical Laboratory for the year 1871–72.

The first four are Reports of the Civil Engineers of the Fourth Year in the course referred to above.

Report upon Experiments on a Queen-Post Truss and its component parts. By Messrs. C. S. Ward and B. E. Brewster.

Measurement of the Angular Deflection of Beams fixed at one end. By Mr. C. F. Allen.

Apparatus for ruling lines with a Diamond. By Mr. C. F. Allen.

Coefficients of Efflux. By Messrs. W. B. Dodge and W. E. Sparrow.

Buoyant effect of a column of heated air from a Bunsen burner. By Mr. C. K. Wead.

Law of Lenses. By Mr. C. K. Wead. The focal length of two or more lenses separately and combined, were here measured.

Photometric Experiments. By Mr. C. K. Wead. The light cut off by 1 to 7 plates of glass was measured, also the absorption of ground glass. Another series of experiments gave the light of an Argand burner with various consumptions of gas.

To find the Refractive Formula (that of Cauchy) for any Substance. By Mr. F. W. Very.

Micro-photography. By Mr. C. S. Minot.

Saccharimetry. By Mr. F. A. Emmerton.

Of the unpublished papers may be mentioned the following: —

On Covering Steam Pipes. By several students, collated by Mr. B. H. Locke.

Magnetization by Frictional Electricity. By Mr. C. K. Wead.

Electricity generated by a Holtz Machine in absolute measures. By Mr. S. J. Mixter.

On the Density of the Earth. By Mr. J. B. Henck, Jr.

Measurements of Plateau's Soap-Bubble Films. By Mr. W. E. Nickerson.

Velocity of Air Currents at various distances from an Air-jet. By several students.

Resistance of Water in Pipes. By several students.

Measurement of curvatures and minute distances by Newton's Rings. By Dr. C. H. Williams.

Law of Vibration of a Tuning Fork. By Mr. S. H. Wilder.

Effect of the Intensity of Sound upon its Velocity. By Mr. W. W. Jacques.

It remains for me to speak of my own work, which I do without hesitation; first, since the reputation of the Institute is largely that of those connected with it; and, secondly, because the intellectual as well as the physical results of my work should be in the possession of the Corporation of the Institute.

As the entire work of building up the Physical Laboratory, making or having made the apparatus, and conducting the exercises has been in my hands, unaided by any assistant, I have had less time than I desired for original investigation. Besides this, I have given all the other courses described above, except where the contrary is expressly stated, and, in addition, have delivered four Lowell Courses of lectures. The first of these, on Sound, was in 1869–70; the second, on Experimental Physics, in 1871–2, gave a class composed mainly of teachers, an opportunity to learn the methods of our Laboratory; the third, on the Applications of Electricity and Magnetism, was given at the Lowell Institute in 1873–4; and the fourth, on Lantern Projections, in 1874–5, was especially designed to aid teachers in using this instrument. In 1872 the laboratory was kept open during nearly the entire summer, and instruction in its methods given to a class of half a dozen gentlemen, mostly Professors of Physics in Western colleges. Although the number of regular students in physics has been small, as was to be expected, there have been every year several special students, some of whom devoted almost all their time to physical investigation. To provide work for them, many of the researches I should otherwise have undertaken myself I have put in their hands, and this proved an additional drain on the limited number of subjects of investigation which will occur to a single individual. My principal work has been the publication of the two volumes entitled "Elements of Physical Manipulation," which embody the experiments performed in the current work of the Laboratory. During the summer of 1869, I accompanied the Nautical Almanac Expedition to Iowa to observe the total eclipse of the sun of August 7th. In 1870, through the liberality of the Government of the Institute, I was enabled to accompany the Coast Survey Expedition to Spain, to observe the total eclipse of the sun of December 22d. The summer of 1873 was largely devoted to observations, with a new form of polarimeter, on the light of the sky and that reflected and refracted by plates of glass. During the summer of 1876 several thousand observations were taken of the heights of the White Mountains with a micrometer level. The results, which will probably supply the most complete survey yet made of this region, are now in process of reduction. The following list gives the references to the published accounts of these researches, together with the more important of my other published papers: —

Dispersion of a Ray of Light refracted at any number of Plane Surfaces. *Proc. Amer. Acad.*, vii, 478 (April, 1868).

Essay on the Comparative Efficiency of different forms of the Spectroscope. *Amer. Journ. Sci.*, xlv, 301 (May, 1868).

Description of a Machine for Drawing the Curves of Lissajous. *Journ. Frank. Inst.*, lvii, 55 (Jan., 1869).

Plan of the Physical Laboratory. (April, 1869.)

A New Form of Spectrum Telescope. *Engin. and Min. Journ.* (July, 1869).

Report on the Total Eclipse of August 7th, 1869. *Journ. Frank. Inst.*, lviii, 281 (Oct., 1869). Trans. into French in *Les Mondes*, xxi, 573.

Observations of the Corona during the Total Eclipse. *Phil. Mag.*, xxxviii, 281 (Oct., 1869).

Note on the Supposed Polarization of the Corona. *Journ. Frank. Inst.*, lviii, 372 (Dec., 1869).

On the Diffraction produced by the Edges of the Moon. *Journ. Frank. Inst.*, lix, 265 (April, 1870).

Polarization of the Corona. *Nature*, iii, 52 (Dec., 1870).

Spectrum of the Aurora. *Nature*, iii, 104 (Dec., 1870).

List of Observations of the Polarization of the Corona. *Journ. Frank. Inst.*, lxi, 58 (Jan., 1871).

The Graphical Method. *Journ. Frank. Inst.*, lxi, 272 (April, 1871).

Photographing the Corona. *Journ. Frank. Inst.*, lxii, 54 (July, 1871).

On Dispersion, and the Possibility of Attaining Perfect Achromatism. *Proc. Amer. Assoc.*, xix, 62 (Aug., 1871).

The Eclipse of 1870. *Old and New*, iii, 634 (May, 1871).

Report of Observations of the Total Eclipse of the Sun of Dec. 22d, 1870. *U. S. Coast Survey Report*, 1870, 115, 229.

Report on the Physical Laboratory. 1871.

A Geometrical Solution of some Electrical Problems. *Journ. Frank. Inst.*, lxvi, 13 (July, 1873).

Applications of Fresnel's Formula for the Reflection of Light. *Proc. Amer. Acad.*, ix, 1 (Oct., 1873).

Measurements of the Polarization of Light reflected by the Sky and by one or more plates of glass. *Amer. Journ. Sci.*, cvii, 102 (Feb., 1874); *Phil. Mag.*, xlvii, 127 (Feb., 1874).

Applications of the Graphical Method. *Proc. Amer. Acad.*, ix, 232 (May, 1874).

Graphical Integration. *Proc. Amer. Acad.*, x, 79 (Oct. 1874).

Mountain Surveying. *Proc. Amer. Acad.*, xi, 256 (Jan., 1876).

Height and Velocity of Clouds. *Proc. Amer. Acad.*, xi, 263 (Jan., 1876).

Comparison of Prismatic and Diffraction Spectra. *Proc. Amer. Acad.*, xi, 273 (June, 1875).

Elements of Physical Manipulation. In 2 Vols. Vol. I, 1873, pp. 225. Vol. II, 1876, pp. 316.

Allow me now to compare the present condition of the Physical Department with that of ten years ago. Then we had only a single room, with a second unfurnished, very little apparatus, and the entire instruction consisted of one course of lectures. Now, besides the lecture-room, we have two large laboratories, one subdivided so as to give five small rooms, and, in addition, rooms for the spectroscope and for photography. The lecture course has been for some years ably administered by Prof. Cross, and a course of lectures on Descriptive Astronomy has been added to it. The apparatus is in good condition, and contains a large collection of slides for the lantern. A large Physical Laboratory has been built up, which now accommodates a hundred students a year. The course has been extended into the fourth year, giving technical experiments to the architects and civil engineers, and to our own students in photography, lantern projections and practical astronomy. Original investigation is encouraged, and numerous articles have been published by our students in the scientific periodicals of the day. The principles on which our work is conducted are few and simple. First, use is of the first importance, appearance, secondary. All our apparatus is based on this fact. Polish and lacquer are dispensed with, and the money saved is expended on the working parts. Secondly, originality on the part of the student is encouraged to the uttermost, and he is taught that, as a scientific man, original research should be his highest aim. Thirdly, there are no secrets in science, and accordingly every aid has been extended to other institutions desiring to adopt our methods, by giving them the results of our experience.

Of the present needs of the Laboratory the principal one is an endowment to cover running expenses; in this way only can it be placed on a permanent foundation. The apparatus is of the simplest kind, and comprises but few instruments of precision in the modern sense of the term. It has never received the large sum usually expended on original equipment. For the older students, especially in the course in Advanced Physics, a working library of the standard works in physics, and a few of the later scientific periodicals, are much needed. This last need has been in part supplied by the liberality of a friend of the Institute, but where the journals are to be divided among so many departments, each gets but little. Another generous friend has twice given a large sum to the Laboratory, once for a spectroscope, the most powerful ever made at the time of its completion, and, again, by a timely gift, enabled a large sum to be expended on original investigation Several of the most important papers that have issued from the Laboratory resulted from this gift. The Department is also greatly indebted for a most liberal gift for acoustic apparatus. Two large sums have been given for this purpose, and have furnished the lecture course with an excellent collection of instruments to illustrate the laws of sound.

I cannot close this report without an acknowledgement of the aid I have received from you, Mr. President, in bringing our Laboratory into its present state of efficiency. Your confidence in its success from the very beginning, your encouragement and enthusiasm regarding its extension, and the interest you have shown in every detail, have helped, more than we have realized, to such success as we have attained.

My thanks are also due to Prof. Cross, whose work as student, assistant and professor, has been wholly devoted to the interests of our department. To his unwearied efforts the present high efficiency of the lecture course is very largely due.

With hopes that the next decade may witness as great advances as that which is just completed, I remain,

Very respectfully yours,

EDWARD C. PICKERING,

Thayer Professor of Physics.

DEPARTMENT OF PHILOSOPHY.

To the President: —

I have the honor to present the subjoined account of the work done in my department during the past year.

I. WORK WITH REGULAR STUDENTS OF ALL DEPARTMENTS.

During the first half-year, there were given, to the Fourth Year's class, three lectures a week on the Philosophy of Science; to the Third Year's class, two lessons a week on the Rudiments of Political Economy; and to the First Year's class, two lectures a week on the Structure and Analysis of the Sentence.

The course of the Fourth Year's class, on the Philosophy of Science, included discussions of the nature and essential conditions of Science; the distinction between Pure (or Rational) Science and Empirical Sciences; the Classification of existing sciences as belonging to the one or the other of these two heads; the comparative claims of the so-called Pure and Empirical sciences to the character of strict sciences; the exact logical character of the professed "Inductive Logic"; the proper scientific province of all Empirical Investigation; the Observative and Experimental Methods, and their Canons; the restriction of their use to the formation of a Natural History, properly so-called, and their futility as methods of establishing Universal Laws; the formal imperfection of the existing expositions of the Pure Sciences as contrasted with the speculative truth of their contents; the reduction of the various Mathematical Sciences to one logical system; and the Logic of the Infinitesimal Calculus, with the history and criticism of the several theories of the same.

I take pleasure in reporting the excellent character of the work done by the class upon these subjects. The examination-paper used at the last Semi-Annual is herewith submitted, as indicating better than any general account, such as the above, the nature of the instruction.

FOURTH YEAR.—PHILOSOPHY OF SCIENCE.

SEMI-ANNUAL EXAMINATION, JANUARY 20, 1876.

I.

1. Prove, from the conception of Science as the Ideal of the Reason, that its form consists in the possession by its component judgments, of the three characters of Certainty, Universality, and Unity.

2. In order to establish man's actual possession of *science*, what is it necessary to show? And what, in order to prove that, in any field, he is on the *path* to science, so far as his experience can indicate the path?

3. What is the distinction between Rational and Empirical science? What three other pairs of titles may be given to these groups of human knowledge, and for what reason?

4. Since, by the very conception of Empirical science, it lacks the two most significant characters of the ideal of science, on what rational grounds can we call it science, at all?—what are its claims to scientific character on the ground of certainty, and what on that of universality and unity?

5. Distinguishing between Universality and Generality, state the Final Problem of all empirical science whatsoever. What are the limits of *certainty* in such science? Why does not the process known as Verification change the logical character of empirical science, and raise its method into one of absolute certainty—of real prediction?

6. How many possible Rational sciences are there, and by what titles are they known? Do they actually exist in man's conscious possession? Is the actual form of their exposition consistent with their logical ideal? Why is the number of possible empirical sciences indeterminate? Mention the principal ones thus far developed, in the order (from the highest down) of their degree of scientific developement.

7. Show that Induction, whether in the strict sense or in the modified sense that Mill gives it, is necessarily illusory as a method of certainty.

8. Show that even the introduction of the Principle of Causality

while it substitutes the Deductive for the Inductive form of arguing to the future, fails to bring empirical judgments into the region of certainty.

9. What is the strict province of Mill's so-called Methods of Empirical Science? Into what two Canons are they all at last resolvable? In what natural illusion do these two Canons logically originate?

10. Estimate the Four Methods in respect to comparative strength for determining the problem on which alone they strictly bear.

II.

[Regulars of Departments V, VI, VII, and IX, may omit this part.]

1. State the General Problem of the science *actually* called Mathematics.

2. Give the two grand divisions of this science, with the object of each, and the three subdivisions of the first, with their objects.

3. Distinguish ordinary Algebra from Arithmetic, and Higher Calculus from ordinary Algebra. What different systems of Higher Calculus are actually in existence? What is the distinguishing character of the system called Diff. and Integ. Calculus?

4. By the combination of what two conceptions is the logical justification of this calculus alone possible? What principle alone justifies the neglect of infinitesimals? Does it merely *justify* this?

5. What doctrine regarding the relations between limits is implied in every operation peculiar to the Diff. and Integ. Calculus? To what class of problems is the application of this calculus restricted?

The course to the First Year's class, on the Structure of the Sentence, differed in no material respect from that which has now become habitual in the first half of that year. By a vote of the Faculty after the Semi-Annual, the instruction of this class in the rudiments of Formal Logic was postponed from the second half of the first year to the second half of the third, and this arrangement adopted for subsequent classes. I cordially approve the change. The course of study in logic and cognate branches required of candidates for any degree, will hereafter be as follows: —

First Year, first half, 30 lessons on the Analysis of Sentences.

Third Year, 7 weeks of second half, 21 lessons on Elementary Formal Logic.

Fourth Year, first half, 45 lectures on the Philosophy of Science.

II. WORK WITH STUDENTS OF PHILOSOPHY.

In the department proper of Philosophy, we have had seven students this year — three regular, and four special. Two of the latter were women ; and the presence of all four deserves particular mention, as the result of a recent vote of the Government, opening single courses of lectures, in various departments, to students of either sex who might wish to receive instruction without being subject to examination for admission, promotion, or a degree. It is not unlikely that others, and in greater number, may hereafter avail themselves of the opportunity thus afforded ; especially, if some public notice should be given of the existence of such courses.

The regular students have continued their historical and critical work upon the modern philosophical systems, following, to such an extent as thoroughness would allow, the course laid down in the catalogue. The year has been occupied, mainly, with a minute study of Kant's *Critique of Pure Reason*, and of Hegel's *Logic*. They have read all the essential portions of these works, and I believe I do not go too far in saying that they have mastered the principles of them. The four special students joined them in their study of that part of Kant's *Critique* known as the *Deduction of the Categories* — its most important and difficult division. The examination-papers used with the regulars during the year, are annexed.

KANT : — CRITIQUE OF PURE REASON.

SEMI-ANNUAL, JANUARY 19, 1876.

I.

1. In what sense does Kant call his principal works *Critiques* of Reason ? What does he mean by " criticism " as distinguished from " dogmatism " and " skepticism " ?

2. What *historical* connexion is there between Kant and Hume ? between Kant and Leibnitz ? What is Kant's *logical* relation to these two men respectively ? What, to Locke ?

3. What innovation did the *Critique of Pure Reason* introduce into the theory of knowing ? Show the revolutionary character that Kant

attributed to the innovation, by quoting the substance of his remarks about the "Copernican point of view" in philosophy.

4. What is Kant's prevailing usage, in the *Critique*, in regard to the term *Reason*? In what other sense does he sometimes use it? What does he mean by *pure* reason? In the expressions "theoretical reason," and "practical reason," what still wider (or deeper) sense does he give to the term *Reason*?

5. In what three questions does Kant sum up the whole problem of philosophy? How, in effect, does he answer each of these?

6. What is the purpose of the First Preface to the *Critique*, and what are the successive points brought out in it? Answer the same questions in regard to the Second Preface.

7. On what distinction between the Two Beginnings of knowledge does Kant rest his case against Empiricism? State the distinction, with clearness and fullness. How would you state it in terms of the notions of Sequence and Cause?

8. Has the foregoing distinction any connection with that between Matter and Form, which plays so large a part in Kant's thinking? Justify your answer to this question at length.

9. State Kant's distinction between the *a posteriori* and the *a priori* in knowing. What two other pairs of terms does he use to mark it? What noteworthy difference in his use of the noun *experience* and of the adjective *empirical*? What two meanings given to the adjective *pure* must be carefully discriminated in reading Kant?

10. Starting from the primary distinctions between Object and Subject, and Matter and Form, trace Kant's whole theory of the upbuilding of cognition; show all the elements that he thinks must enter into cognition, the part he supposes each of them to play, and the logical order in which he represents them as acting. Give his criteria for the *a priori* in knowledge, and vindicate, against Hamilton, his doctrine that each of these carries the other and is therefore adequate by itself. Distinguish between Analytical and Synthetical judgments, justify the distinction against the objections of Lewes, show its bearing upon the Problem of Pure Reason, and state that problem in its universal form, giving its three specializations.

II.

1. In how much, with reference to the distinction between Analytical and Synthetical judgments, had Kant been anticipated by others, especially by Locke; and in what consists his contribution to philosophy in connection with this distinction? Illustrate his new view, in connection, particularly, with the Principle of Causality. What new doctrine, referring to this distinction, does Kant establish respecting mathematical judgments?

What are the respective bearings of these two discoveries upon the establishment of the "critical" standpoint?

2. What is your estimate of Kant's attempts, in § 2 and § 5 of his Introduction, to establish our actual possession of some *a priori* cognitions and some syntheses *a priori*? What is the nature, and what the value, of the proofs of these points furnished by the *Æsthetic* and the *Analytic*?

3. Why does the *Critique* contain an *Elementology* and a *Methodology*? Why, an *Æsthetic* and a *Logic*? Compare Kant's view of the twofold in cognition with that of Locke, showing exactly wherein they agree and wherein they differ. Compare Kant's view of Experience with Locke's.

4. Give Kant's "Graduated Scale of Representations," defining its terms as you go on.

5. What does Kant mean by "immediacy" in cognition? State, as comprehensively and as accurately as you can, what the fact of Intuition *is*, so far as concerns the Object (Thing in Itself). What, in general, is an "Empirical Intuition"? What does Kant mean by "phænomenon"?

6. Distinguish, after Kant, between *Sense*, *The Senses*, *sensation*, and *empirical intuition*. Is either of these, or is *pure* intuition, an intelligible whole? How is it that we speak of them separately, and apparently define them? To what mental process alone are they conceivable? Make a critical estimate of Kant's theory about the "immediacy" of intuition.

7. In what does the *a priori* faculty (or "Form") of intuitions at last consist? Sketch Kant's attempted proof of this, noticing its waverings from the point, and other defects.

8. Why a "metaphysical" and a "transcendental" exposition of the Pure Forms of intuition? Give the exact distinction between them, taking pains to clear up Kant's peculiar use of the word "transcendental"; and explain the peculiar Method of Proof that signalizes the *Critique*.

9. What remarkable ambiguity is there in the Kantian doctrine concerning the Pure Forms of intuition? [What *should* the doctrine be, for exact consistency with the "critical" principle; and what *is* it, as Kant usually and deliberately states it?]

10. Why is there, in the *Logic*, an *Analytic* and a *Dialectic*? What, in the *Analytic of Conceptions*, corresponds to the distinction between the Metaphysical and Transcendental expositions in the *Æsthetic*? Give the "Logical Table of Judgments" as determined by the Categories, and the "Transcendental Table" of the corresponding Pure Concepts (the Categories themselves).

Make any criticisms that suggest themselves to you upon Kant's so-called "Faculty of Conceptions," and show in what sense only are that and its Categories intelligible. In other words, show the truth and the error involved in Kant's view about the Pure in all cognition, whether intuition or conception.

KANT:—CRITIQUE OF PURE REASON.

ANNUAL, MAY 25, 1876.

1. Make the following distinctions according to Kant:—(1) Between General logic and Special logic. (2) Between Pure logic and Applied logic. (3) Between General logic and Transcendental logic.

2. What are the two main divisions of his *Transcendental Logic*, and what is the object of each?

3. To what in the *Æsthetic* does that part of the *Logic* correspond in what Kant makes out his so-called transcendental table of the Pure Categories? What would be the name of this part, in the terminology adopted in the *Æsthetic*? With what purpose does Kant precede his "Transcendental" table of the Forms of Judgment by his "Logical" table?

Show the inconsequence of this step on Kant's part, and its inconsistency with the principle from which he sets out upon his investigation of the Categories.

4. Show clearly the bearing of your last answer upon the claim of Kant's final table to the title of "transcendental."

Illustrate, by accurate examples, all the distinctions contained in the Logical Table of judgments.

5. Point out, with proofs, Kant's misconceptions about the subdivisions of the Four Fundamental Categories, (1) as to their mutual dependence; (2) as to the distinction between Negation and Limitation; (3) as to the professed "Pairs" in the sub-categories of Modality.

6. What is the exact object of the so-called *Deduction* of the Categories? To what part of the *Æsthetic* does this part of the *Logic* correspond, and what name might accordingly be given to it? What difficulty presents itself, on undertaking the *Deduction*, that did not arise in the corresponding part of the *Æsthetic*?

7. Why is this difficulty inevitable, with Kant's general presuppositions? What does its necessary existence prove, not only in regard to his *prime* presupposition, but in respect to his hypothesis of the difference in *kind* between the "two main sources of knowledge"?

8. Give Kant's attempted distinction between the Intuition-Object and the Experience-Object;—between the two meanings of "Nature."

9. What, in the most general terms, is Kant's offered solution of the problem of the *Deduction*? Is the minor premiss of his syllogism valid or not? Give your reasons.

10. In arguing for this minor, what is the special form of treatment that he adopts in his *Prolegomena to any Future Metaphysic*?

11. What is the treatment most prominent in the First Edition of the *Critique*?

12. And what the one most prominent in the Second Edition?

13. Explain Kant's doctrine of the "Synthetical Unity of Apperception," and its supposed bearing upon the problem of the *Deduction*.

14. What equivoque presents itself in Kant's dealing with this "Synthetical Unity"? Which side of the dilemma ought he to assume, to make the said "Unity" valid for the purposes of *Deduction*? Why can he not consistently assume this side?

What is the bearing of the whole situation respecting the "Synthetical Unity" upon the real character of his "transcendental" in cognition?

10. Show the rise of "The Three Ideas" — Absolute Subject, or The Ego; Absolute Cause, or God; Absolute Total, or The World — out of the analytic of the Three Forms of Inference, viz., the Categorical, the Hypothetical, and the Disjunctive.

16. Into what three corresponding parts is Kant's *Dialectic* divided, and what is the line of its movement in each part?

HEGEL.

ANNUAL, MAY 30, 1876.

1. Distinguish and illustrate the Three Attitudes of Thought toward the Objective World.

2. Summarize Hegel's critiques, (1) of Dogmatism, (2) of Skepticism, both Empirical and Transcendental, (3) of Intuitionalism.

3. State the Hegelian distinction between a *Beginning* and a *Principle*. How many possible distinct Beginnings are there in Philosophy, and why? What is Hegel's *First Principle*? Under what conditions only can this be made a philosophic beginning?

4. What are the general divisions of Philosophy, according to Hegel, whence deduced, and what writings of Hegel's correspond to them respectively?

5. What is meant by *Dialectic*? Point out the truth and the defect in Kant's view of dialectic.

6. Illustrate the universality of dialectic, as shown in the processes of the Objective World, (*a*) of Nature, and (*b*) of Spirit — man's works, the institutions of Reason.

7. Illustrate the same as shown in the Subjective World, (1) in the growth of the individual mind, (2) in the History of Philosophy.

8. State Hegel's doctrine of the *Notion* as the unit of empirical thought, and trace the dialectical rise of this doctrine out of Kant's "Analytic."

9. State the doctrine of the Immediacy and the Mediation of the Notion, and show the origin of this from the dialectic of Kant's "Æsthetic and "Analytic."

10. In what element of Hegel's general philosophy does the truth of Kant's "Transcendental Unity of Apperception" and "Ideas of the Pure Reason" come to light? Define this element as thoroughly as you can.

11. What are the exact subject and purpose of the *Logic*? What error in regard to them must be carefully avoided?

12. What is the *Method* of the Logical Process, according to Hegel, and what are its "moments"? Into what parts does the *Logic* divide itself in accordance with this method, taken at its origin in the "moments" of the IDEA?

13. What is BEING, in its total finitude or determinateness, in terms of Absolute Idealism? What is THOUGHT — empirical *thinking* — in terms of the same? And what, in like terms, is REALITY — the Concrete Universal of Being?

14. Discriminate between this doctrine of the ABSOLUTE IDEA and (1) The Pantheism of Spinoza; (2) the Pananthropism of Fichte; (3) the Nihilism of Schelling's earlier writings.

15. Illustrate the dialectical process of the *Logic* by sketching the movement through the first triad — Being, Nought, Becoming.

In addition to the study of Kant's and Hegel's text, the class have completed those portions of Schwegler's *History of Philosophy* which cover the period from Kant to Hegel inclusive, and also the parallel portions of Ueberweg. They have also read Mahaffy's rescript of the *Æsthetic* and the *Deduction*, and considerable portions of Stirling's *Secret of Hegel*. One member of the class made, besides, an extended study of Fichte, reading the English translations of his *Science of Knowledge*, *Sun-clear Statement*, *New Introduction*, *Criticism of Philosophical Systems*, and *Vocation of Man*, together with sundry commentaries and his biography.

Theses have been presented by the class, at various times during the year, on the Life and Writings of Kant, the Influence of Kant upon subsequent Philosophy, and the Derivation of Fichte's System from Kant's.

At the Annual Examination in May last, two of the class — Messrs. David Warren Phipps, of Boston, and Robert C. Ware, of Marblehead, completed their course and received the corresponding degree. The third member passed his examinations, but was prevented from completing his thesis by severe illness. The subjects of the theses by the two graduates, were "Kant's *Æsthetic*: a Restatement of it, with Criticisms," and "The Historical and Logical Relations between Fichte and Kant." In the former, some new points, of apparently permanent significance, are made in the criticism of Kant. Abstracts of both theses will be found on the appropriate pages of the President's report.

Respectfully submitted,

GEO. H. HOWISON.

Boston, *Sept.* 11, 1876.

DEPARTMENT OF MODERN LANGUAGES.

REPORT FOR 1875–6.

President Runkle,

DEAR SIR: — Permit me to present herewith the report of the department of Modern Languages for the school year 1875–6.

FRENCH REQUIREMENT FOR ADMISSION.

The following table exhibits the results of the entrance examinations in French for the four years that the same has been one of the requirements for admission to the school, the autumn examination of 1876 being included.

1873	1874	1875	1876	
70	41	71	43	No. of students in First Year.
53	49	53	57	Average mark at Entrance Examination.
15	5	3	0	No. admitted without French.
49	26	51	25	No. admitted without conditions.
81	66	61	65	Average mark.
21	15	20	18	No. admitted with conditions.
10	19	32	33	Average mark.

From this it appears that there has been a gradual improvement in the manner in which the requirement has been fulfilled, as indicated in the following particulars:—

1. The average mark of the whole class has slightly increased.

2. The number admitted without any French has constantly diminished, until the present year, when there were none.

3. The average mark of those admitted under condition has constantly increased.

It is to be mentioned moreover, that there has been twice a small increase in the amount required. The requirement at present is; in grammar, "through regular and irregular verbs," that is the more prominent and essential principles of the same; and in reading, "the first two books of *Charles XII*," that is about sixty pages. As will be seen from the last examination paper for admission published in the annual catalogue, and also from the statements and suggestions regarding the preparation in French also contained there, it is only the prominent and essential facts of the language that are required of the candidate. But it is expected that he will know these facts well and have them at ready command.

Each candidate is also examined in pronunciation, in so far as to pronounce a short passage, and his performance of the same is noted with reference to three or four facts of French pronunciation, and judged accordingly. Deficiency in fluency, general style of pronunciation, and minor matters are not counted against him. But, as the marks show, the performance of candidates on so moderate a test, falls considerably below that on the written paper. A fair understanding of and familiarity with the prominent facts of pronunciation can be obtained without great difficulty, and the matter is one of considerable practical importance in the farther prosecution of the study.

At present, the amount of French which students have on entering, can hardly be said to represent a year's work, and it would seem to be more advisable to insist upon greater thoroughness in what is now required, than to add to the amount of the same.

It may be interesting to notice, that of the fifty-eight candidates, as regular and special students, for the FIRST YEAR at the last examination, forty-four stated that French was a regular study in the school where they prepared, and, thirty-five that Latin also was, while thirty-eight reported that they had studied Latin.

WORK OF THE PAST YEAR.

The number of exercises per week in the department were 31 the first term, and 28 the second. The following view shows what was read and the amount:

FRENCH.

First Year. "Bôcher's Reader," 100 pages. "Les chemins de fer"— Guillemin, 100 pages.

Second Year. Mérimée —"Lettres d' Espagne," 50 pages. Taine— "Notes sur l' Angleterre," 150 pages. This class had French exceptionally the first half of the year, in consequence of the omission of one of their courses in another department.

Fourth Year (first half.) "Bôcher's Reader," 100 pages. About—"Roi des Montaignes," 50 pages.

GERMAN.

Second Year. "Whitney's Reader," 34 pages. Grimm's "Märchen," 67 pages.

Third Year. "Whitney's Reader," 55 pages. "Wind und Wetter" —Lommel, 25 pages. "Eigensinn"—Benedix, 22 pages. "Die Braune Erika"—Jensen, 55 pages.

Fourth Year. (students in Sci. and Lat. and Philosophy.) Portions of Schiller's "Wallenstein," and two easy comedies.

Exercises in composition, written and oral, and on the forms and principles of the languages in question, have accompanied the above work in translation.

During the second half of the year, the students in Science and Literature, and Philosophy, pursued, as indicated in the catalogue, a course in the *Science of language*, using as text book Whitney's "Language and the study of language." During this half also there was an optional class of three students, that commenced Italian.

Certain students of the FIRST YEAR, who were admitted on condition in French, and who were much behind the other members of the class, were formed into a class by themselves, reciting oftener than the rest. This Elementary class numbered seventeen, and was united with the regular FIRST YEAR at the Semi-Annual.

TECHNICAL READING.

As indicated above, popular works of a scientific nature have been used to a considerable extent for reading in both French and German. These seem to interest the students more than works of a purely literary nature, and convey practical information, bearing more or less directly on the special profession of the same. Strictly professional and technical reading would hardly be practicable in a class made up of students pursuing different professional courses, and where the main object is to obtain a knowledge of the language. Exercise in such technical reading would be in place in each special department.

Following are the examination papers at the Annual, of the FIRST YEAR in French and THIRD YEAR in German, with the average mark of the whole class on the same.

Respectfully submitted,

CHARLES P. OTIS.

October, *1876.*

[EXAMINATION PAPER OF THE FIRST YEAR AT THE ANNUAL.]

Number of students 62. Average mark 64.

I. *Translate.*—Il s'agissait d'ouvrir entre Modane et Bardonèche une galerie souterraine qui, partant de la vallée de l'Arc, allât déboucher en Italie, sur le versant opposé, dans la vallée de la Dora. 12,220 mètres à franchir, voilà pour la longueur du tunnel; une épaisseur de 1800 mètres de roches, voilà pour la profondeur. Vous rendez-vous compte, maintenant, des difficultés de tous genres que rencontre le percement? Avant que les deux têtes du souterrain puissent être reliées par une galerie de 12,000 mètres et qu'un courant d'air s'y établisse, l'air pur manquera mille fois aux ouvriers, dans un milieu vicié tout à la fois par leur respiration, par la combustion des lampes et par celle de la poudre. GUILLEMIN.

1. Indicate the relation to the verb of all nouns and pronouns in "*Vous rendez-vous compte des difficultés que rencontre le percement.*"

2. Point out and explain any instance of the subjunctive you see in the translation above.

3. Account for the ending of the participle in *puissent être reliées* and render in French "*the difficulties which we have met up to this day.*"

4. Explain the forms *s'agissait*, *partant*, *allât*, *puissent*, giving the principal parts of each.

5. Conjugate in full the present subjunctive of *ouvrir*, *allât*, and imperfect subj. of *rencontre* and *puissent*.

Translate. — The engineers fear that the workingmen may suffer from want of air. Unless a current of air is established, the men will not be able to work. Is it true that they are to build an iron bridge over the Hudson.? I think they will build one.

II. *Translate.* — Puisque je vous ai dit un mot du choix de l'eau c'est le moment de parler de celui du coke.

Une seule question, interrompis-je, ne brûlez-vous donc jamais de houille, ni de bois.—

— De bois, cela ne m'est pas arrivé. J'ai ouï dire toutefois qu' à l'étranger, en Amérique, en Allemagne, on chauffe les machines au bois. Quant à la houille, si elle est un peu grasse, elle gêne le tirage, dans tous les cas, elle donne trop de fumée. On la réserve pour la conduite des trains de marchandise. Jadis on nous donnait des cokes de médiocre qualité, aujourd' hui les compagnies s'attachent à nous fournir les meilleurs combustibles: ce n'est pas nous qui nous en plaignons, demandez plutôt à mon chauffeur.

GUILLEMIN.

1. Why the compound of present in "*je vous ai dit*," the preterit in "*interrompis-je*," and the imperfect in "*on nous donnait*," etc.
2. What is the English equivalent of "*on chauffe les locomotives*;" give this sentence another construction without changing the meaning.
3. Give the principal parts of the verb *plaignons.*
4. Explain the form of the demonstrative pronouns *celui* (*du coke*), *c'* (*est le moment*), *cela* (*ne m'est pas arrive*).

Translate. — We used to heat our house with coal, now we heat it with steam. Rails are being laid rapidly. He complained of the poor quality of the coal that was given him.

III. (*Passage not translated in class*). — Un certain jour d'automne, Mattéo sortit de bonne heure avec sa femme pour aller visiter un de ses troupeaux dans une des clairières du mâquis. (1) Le petit Fortunato, son fils, voulut l'accompagner, mais la clairière était trop loin. D'ailleurs, il fallait bien que quelqu'un restât pour garder la maison; le père refusa donc. On verra s'il n'eut pas lieu de s'en repentir.

Il était absent depuis plusieurs heures, et le petit Fortunato était tranquillement étendu au soleil, regardant les montagnes bleues, quand il fut soudain interrompu dans ses méditations par l'explosion d'une arme à feu. Il se leva et se tourna du côté de la plaine d'où partait ce bruit. D'autres coups de fusil se succédèrent, tirés à intervalles inégaux et toujours de plus en plus rapprochés; enfin, dans le sentier qui menait de la plaine à la maison de Mattéo parut un homme; ——— il venait de recevoir un coup de fusil dans la cuisse. (2)

MÉRIMÉE.

(1) glade; (2) thigh.

1. Explain the forms *restât*, *fut interrompu*, *se succédèrent*.

2. What is the force of the preposition *à* in *arme à feu*, of *de* in *coup de fusil* and in *venait de recevoir*.

3. Point out in the translation one or two instances of an infinitive not preceded by any preposition and give the rule for it.

4. Give the compound of present of *aller*, *verra*, *se succédèrent*.

5. Conjugate the present indicative of *voulut* and *se repentir*, the future of *parut* and the present subj. of *venait* and *recevoir*.

Translate. — Setting out in the morning he went to the town to buy gunpowder. He has just left, but he will return after having done his work. On rising he saw a man coming.

IV. *Translate 8 of the following sentences.* — 1. While running, one of the wheels of the carriage was broken. 2. Although this book does not describe all the methods, it gives a good idea of them. 3. I am very glad that you take a trade. 4. We believe that God made the world. 5. It is said that he will be put to death. 6. We wish to know what these workmen are doing. 7. Here the track will have to pass over a river. 8. What direction is to be chosen for that railroad? 9. Could you reach the depot in time? 10. No! when I reached it the train had left. 11. The man whose vanity dies is dead. 12. I shall remember the Sundays that I spent with them.

First Year. May, 1876.

[EXAMINATION PAPER OF THE THIRD YEAR AT THE ANNUAL.]

Number of students. 43. Average mark, 61.

I. Und ſo wuchs ſteigend die Bewegung nach allen Seiten, und neben Bußen, Gebeten, Klagegeſängen und Faſten traf man die allgemeinſten, die umfaſſendſten Vorbereitungen zu neuen Zügen. Bald fragte man nicht mehr, wer mitgehe, ſondern wer zurückbleibe? Und die Zurückbleibenden wurden als feige und weibiſch verlacht und verſpottet, während Mütter ihre Söhne, Weiber ihre Männer befeuerten und klagten, daß die Schwäche ihres Geſchlechtes ſie von Heldenthaten zurückhalte. Kaum ſchien es der Reizmittel zu bedürfen welche die Kirche aus der Fülle ihrer Macht den Pilgern bewilligte: Ablaß, Befreiung von Zinszahlungen, Schutz für die Güter der Abweſenden, u. a. m. Raumer.

II. Außerdem brach ein ſolcher Mangel ein, daß man ſogar Pferdefleiſch aß und Pferdeblut trank. Aber ungeachtet dieſer ſchrecklichen Lage hielt Friedrich ſtrenge Mannszucht und beſtrafte, ſelbſt nach dem Zeugniſſe ſeiner Feinde, jeden Frevel und jede Unzucht an den Geringeren, jeden Mißbrauch der anvertrauten Gewalt an den Vornehmen. So ſtrenge Mittel kamen indeß nur gegen wenige in Anwendung; im allgemeinen zeigten die Pilger in Noth und Gefahr eine faſt unglaubliche Geduld und Ausdauer. Einzelne’ welche verzweifelnd zu den Türken übergingen und dem Chriſtenthume entſagten, galten für keinen wahren Verluſt. Raumer

III. M. Geſchwind! Geſchwind!
Rette dein armes Kind!
Fort! immer den Weg
Am Bach hinauf,
Ueber den Steg,
In den Wald hinein,
Links, wo die Planke ſteht,
Faß es nur gleich!
Es will ſich heben,
Es zappelt noch!
Rette! Rette!
F. Beſinne dich doch!
Nur einen Schritt, ſo biſt du frei!
M. Wären wir nur den Berg vorbei!
Da ſitzt meine Mutter auf einem Stein,
Es faßt mich kalt beim Schopfe!

Göthe.

IV. 1. Case and construction of Reizmittel (I); Chriſtenthume (II); Weg (III); of mir, in „folge mir;“ of Sinnen, in „umſonſt, daß trocknes Sinnen hier die heil’gen Zeichen dir erklärt;“ of Mondenſchein, den and Mitternacht, in „O ſähſt du, voller Mondenſchein, zum letztenmal auf meine Pein, den ich ſo manche Mitternacht an dieſem Pult herangewacht!“

2. Construction of ſteigend and feige (I). Is Feinde (II) Subjective or Objective Gen., and why? Geſchwind and immer (III) modify what? To what does es (nur) (III) refer? Decline ihre Söhne (I) and keinen wahren Verluſt (II).

3. Principal parts of ſteigend, fragte (I); galten (II); ſitzt (III). Inflect Pres. Indic., Active and Passive, of aß (II).

4. Analyze Bewegung, Klagegeſängen, Vorbereitungen, bewilligte (I); unausbleiblich, Wiedervergeltungsrecht, Unentſchloſſenheit, Nothwendigkeit, Waſſerſtoffgas, Wiederbelebung

5. What is meant by Primitive words? In accordance with what three principles are derived words formed? State four ways in which compound adjectives are formed.

6. Explain the subjunctives mitgehe, zurückhalte (I); wären (III); möchte in „es möchte kein Hund ſo länger leben;“ wären, in „er behandelte die deutſchen Geſandten ungebührlich, als wären ſie ſeine Unterthanen.“

7. Give the English *historically* connected with Theil, Würde; the endings =heit, =niß, =ſchaft, =thum; fangen, Dach, bleiben, dringen, treten, wachſen, fahren, heben, ſchlagen.

8. *a.* State what you known about the Hohenstaufen. Which crusade was this, and when did it take place? *b.* From what two points of view can we look at the Faust drama? *c.* State what is said about the Monsoons and Etesian winds.

9. Translate: 1. He told me day before yesterday that he always rose at half past five, was in very good spirits, and worked the whole forenoon.

2. Many houses in our city have been destroyed by the storm, two of which belonged to my uncle. 3. If the farmer had worked over his garden early in the Spring, he would have had much finer vegetables.

V. Hastily she tore[1] herself away from Raymond, and flew out of the door. The gigantic dog sprang after her with a merry[2] bark. At the same moment all weariness returned[3] into the eyes of the Professor as if *poured out*[4] in a stream. His head fell sleepily upon the hay, and in a few seconds fast sleep had overpowered[5] him.

Erica sat outside under the firs,[6] and sang a soft[7] melancholy song, the commencement of which he heard.[8] But farther and farther did it sound,[9] and strange dream pictures took captive[10] his senses. In his study every thing began to grow animate,[11] and rustled[12] about the arm chair on which he sat.

[1] reißen. [2] heiter. [3] zurückkehren. [4] ausſchütten. [5] übermannen. [6] die Föhren. [7] leiſe. [8] vernehmen. [9] klingen. [10] gefangen. [11] lebendig. [12] raſcheln.

VI. (Passage not read in class.) Die Frage, ob das Waſſerſtoffgas athembar ſei oder nicht, hatte urſprünglich zwei ganz entgegengeſetzte Antworten erhalten. Prieſtley und ſeine Partei behaupteten, dieſe Luft ſei irreſpirabel, während Scheele und ſeine Anhänger gerade das Gegentheil verſicherten. Das veranlaßte Fontana, den Verſuch an ſich ſelbſt zu wagen. Er vermiſchte Waſſerſtoffgaß mit atmosphäriſcher Luft zu gleichen Theilen und fand kaum eine Spur von Unbequemlichkeit bei dem Einathmen dieſer Luftmiſchung, im Gegentheil wollte es ihm ſcheinen, als wenn er dadurch eine gewiſſe Leichtigkeit im ganzen Körper verſpürte, die ihm wohlthat. Dies gelang auch noch, wenn er abwechſelnd reines Waſſerſtoffgas und atmosphäriſche Luft einathmete. Sobald er aber verſuchte, das Waſſerſtoffgas ganz unvermiſcht und ohne Wechſel einzuathmen, ſo ſtürzte er bewußtlos zu Boden und wäre ſicher ein Opfer des Todes geweſen, wenn ſeine Umgebung nicht raſch zu Hülfe geſprungen wäre und die paſſendſten Mittel zur Wiederbelebung angewandt hätte.

Birnbaum.

[1] Hydrogen gas.

Third Year. *May*, 1876.

LOWELL FREE COURSES FOR 1875-76.

Department of Physics.

To President Runkle.

MY DEAR SIR:—In response to your request, I would state the following facts regarding the lectures given by me in the Lowell Free Courses for 1875-6.

These lectures were designed to furnish a somewhat extended discussion of the topic of light in its various relations to color and to vision in general, the subject being considered both from a physical and physiological point of view. Much of the matter concerning the physiological side of the phenomena under consideration was not, at that time, accessible to the general reader, no reliable English works upon the subject having been published, and only a very limited portion of it had been treated in any public course of lectures in the country.

The attendance upon the lectures (eighteen in number) varied from a minimum number of fifty to a maximum of one hundred and ten, the average number being about sixty.

The following is a list of the principal topics discussed in each lecture.

I. Light considered objectively. Propagation of Light. Undulatory Theory, and recent suggestions regarding it.

II. Reflection, Refraction, Dispersion.

III. Polarization.

IV. Anatomy and Physiology of Human Eye.

V. Sensation of Light. Müller's Principle of Specific Action of Senses. Modality of Sensations.

VI. Constitution of Luminous Spectrum. Theories of Color of Newton, Brewster and Young. Experiments of Maxwell and Helmholtz.

VII. Color Blindness. Field's Chromatic Equivalents.

VIII. Physical Causes of Color. Colors of Luminous Bodies. Colors of Non-Luminous Bodies. Production of Color by Absorption and Internal Reflection.

IX. Production of Color by Metallic Reflection and Dispersion. Turbid Media. Goethe's Theory of Color. Fluorescence and Phosphorescence.

X. Colors Produced by Interference of Light. Phenomena of Thin Plates and Diffraction.

XI. Chromatic Phenomena of Polarized Light.

XII. Compounding of Colors. Modes of Studying Complementary Colors.

XIII. Geometrical Systems of representing color-variations in Hue, Tint and Shade.

XIV. Measurement of Intensity by Photometers. Effect of variations of Intensity on Saturation of Colors. Irradiation.

XV. Persistence of Sensation. Laws of Duration of Impression. Stroboscope and applications.

XVI. Modifications of Excitability. Positive and Negative After-Images. Rate of Excitation of different color-sensations.

XVII. Successive Contrast, its Phenomena and Laws. Simultaneous Contrast. Contrast of Colors of same hue.

XVIII. Simultaneous Contrast concluded. Contrast of Colors of different hues. Chevreul's Law. General Law of Simultaneous Contrast and Explanation of Phenomena.

An examination of the preceding summary of topics will show that Lectures I. — III., inclusive, were devoted to a brief description of the principal facts of Physical Optics, which was a necessary introduction to the matter afterwards discussed.

In this connection I wish to call your attention to an experiment which I was enabled to carry into effect through the generosity of a member of the Corporation of the Institute. In previous similar courses there had seemed to be a great need of some concise statement of the principles of the subject under consideration, to which the audience might be referred. It appeared that a very brief series of printed notes, comprising one or at most two printed pages for each lecture, and containing a brief summary of the results finally attained, without attempting any description of apparatus or experiments, would greatly enhance the value of the lectures to those in attendance. The result of the trial more than justified the expectation, and from the general desire on the part of the audience to keep a complete set of the notes, together with the expressions of many persons as to their service, I am very certain that the value of such notes can hardly be over-estimated. It would be a very considerable addition to our work for the public if this method could be generally adopted in our Lowell Courses.

All of which is respectfully submitted,

CHAS. R. CROSS.

Kant's Critique of Pure Reason. Eighteen lectures for beginners.

President J. D. Runkle:—

The attendance on the first four of these lectures, given Mondays and Wednesdays at 7½ P. M., commencing Nov. 18, which were of an introductory and general character, was about fifty, nearly half of whom were women. The remainder of the course, devoted to instruction upon the details of Kant's text, was of necessity less interesting to many, and the attendance was at once reduced to some twenty-five, who continued however, to the end. Four of the attendants afterwards joined the class in the Department of Philosophy, as special students of the course on Kant there.

GEO. H. HOWISON.

Physiology and the Laws of Health. Eighteen lectures.

At the Lowell Lectures on Physiology and the Laws of Health, at the Institute, in the winter of 1875-76, there was an average attendance of fifty, principally female teachers. The lectures were illustrated by the skeleton, separate bones, models, life-size engravings, diagrams, and tables on the blackboard.

As the main object of these lectures was to teach the few and simple rules of health, so easy to violate, so difficult to return to without great inconvenience and suffering, only so much technical anatomical detail was introduced as was necessary for understanding the laws of physiology and hygiene. Under the bones were dwelt upon the deformities of civilization, distortions of the spine, chest, hips, and limbs, frequently produced by parents and nurses in the child, confirmed by improper attitudes in school, and uncorrected by teachers, from ignorance or carelessness. Under muscles, the natural correctors of the above deformities, the evils of sedentary habits and the dangers of excessive muscular exertion, the latter of which is, in the present mania for athletic sports, productive of great physical injury, were considered at length.

The phenomena of nutrition, beginning with digestion, from the taking in of food to its conversion into blood, were then examined; — including the composition and uses of the various kinds of food, their nutritive qualities, digestibility, and adaptibility to age, season, climate, and occupation, — the chemical, mechanical, and vital processes carried on by the vessels, glands, muscles, and secretions of the different parts of the alimentary canal — absorption of nutritive materials and their conveyance to the heart — their purification in the liver and lungs — the circulation, pulmonary, systemic, and portal — respiration and animal heat — and the final purifications effected through the lymphatic and other glands, the kidneys, and the skin.

The dangers attendant upon abuse of these various organs, their most common diseases, and nature of the means of cure, were then explained from the standpoint of elementary physiology, not of medical science.

The course ended by a description of the brain, nerves, and special senses, showing how this complicated body is regulated, and may be preserved from danger, if attention be paid to their timely warnings. SAMUEL KNEELAND.

General Chemistry. Twenty-four laboratory exercises.
Qualitative Analysis. Twenty-four laboratory exercises.

The usual laboratory facilities have been afforded this winter to persons of both sexes who desired to study either General Chemistry or Qualitative Analysis, the text books and methods of instruction being the same as employed in previous years, and as described in the last Annual Report.

W. R. NICHOLS.

Heat and its Applications. Eighteen lectures.

President Runkle,

DEAR SIR: — In the Lowell course of eighteen lectures on Heat and its Applications, the principal topics considered were as follows: —

I. Older and newer theories respecting the nature of heat. How heat makes itself known. Correlation of forces. Distinction between accepted theories and positive knowledge.

II. Sources of heat. Resisted motion. Rumford's, Joules and Hirsch's experiments on friction and the mechanical equivalent of heat.

III. Conduction of heat by solids, liquids and gases. Nonconductors and their uses. Clothing. Spheroidal state of liquids. Convection. What are suitable carriers of heat.

IV. Radiation. Good and bad radiators. Resistance to radiation. Transcalence. Melloni's experiments on transmission. Tyndall's experiments on the intercepting power of gases and vapors.

V. Absorption, destruction, or conversion of heat. Expansion of bodies. Differential expansion. Thermometers of various kinds.

VI. Pyrometers. Thermomultiplier. Specific heat. Expansion by mechanical means as compared with expansion by heat. Determination of mechanical equivalent by the expansion of air.

VII. Absolute zero. Thermometric scales. Latent heat. Calorimeters. Freezing mixtures.

VIII. Boiling points. Superheated liquids. Nature of vapors and gases.

IX. Solution of gases in water. Distillation. Fractional distillation and fractional condensation. Analytic condensation.

X. Tension of vapors. Superheated steam. Occlusion of gases by metals, charcoal, and coal. Combination of bodies by volume.

XI. Production of heat by chemical action. Fermentation. Respiration. Combustion in air. Combustion in oxygen.

XII. Fuels. Sulphur and sulphides. Combustibles produced by plant life in different geological epochs.

XIII. Progressive changes of vegetables to form peat, brown coal, bituminous coal, anthracite. The manufacture of charcoal.

XIV. Artificial fuels. Gaseous fuels. Siemen's regenerative furnace.

XV. Fireplaces. Altars. Forges. Kilns. Reverberatory furnaces.

XVI. Heating dwellings. Hot water circulation. Steam heating, direct and indirect. Hot air furnaces. Open grates. Stoves.

XVII. Heat as a motive power, or the conversion of heat into motion. Hot air engine. Wind power. Steam power. Water power. Gunpowder engine. Carbonic acid engine.

XVIII. Cosmic heat. Utilizing the sun's heat. Conversion of heat into light. Origin of all force.

Experimental illustrations were introduced as far as possible, but in giving two evening lectures a week in addition to my ordinary daily duties, I could not make as much preparation as was desirable in the way of demonstrative experiments. Whenever lectures require such aids for elucidation I believe it would be better both for the audience and the lecturer to let the course extend over a greater length of time and have but one exercise each week.

Respectfully yours,
JOHN M. ORDWAY.

Elementary German. Eighteen lessons.

President Runkle,

DEAR SIR: The Lowell course of eighteen lessons in "Elementary German" assigned to me was commenced Monday, Nov. 22, and continued Monday and Wednesday evenings until finished Jan. 19. The average attendance was forty-five, the number at the beginning being a little larger, that at the end a little smaller than this, the number present varying but little from evening to evening. About a third, I should think, of those attending were men, mostly young men.

The object of the course was to present in a concise and clear manner the *more essential facts of the German language*, with *writing and oral exercises* for the sake of practice. It was found necessary to arrange the course and treat the subject quite differently from what would have been practicable with a class of students, at the Institute for instance, of about equal age and attainments and with time at their disposal for preparation and outside work. For, the class of persons who presented themselves for the knowledge in question differed widely from such students in all of these respects. Some were advanced in life, some were young, some had studied German before and were desirous of reviewing the subject, others were beginners, some had time for study outside of the lecture hour others had not, some had had previous training in language others none. It was desirable therefore to pursue a course requiring as little previous knowledge and training as possible, and little or no outside work, while at the same time the instruction was to be of a systematic and thorough character. The especial features of the method pursued for accomplishing this object were the use of the *blackboard as text-book*, with regular exercises in *German composition and reading.*

Before the hour for the lecture, such essential grammatical *forms and rules* as were embraced by the subject to be studied during the evening were written on the blackboard, in a concise form and one best adapted to catch the eye and impress itself upon the memory. These the class were requested to write down in note books, as also such things in the exposition given of the subject as might seem necessary. After the exposition of the subject for the evening, followed the writing of sentences involving particularly the principles and facts just presented. Such sentences were written by all in blank-books provided for the purpose. At the end of the hour the majority handed in their books, which were examined and returned at the beginning of the next lecture with the errors indicated.

The only trouble in such a mode of working is the difficulty persons, who have not had practice, find in *taking notes* that are reliable in point of accuracy and completeness. This might, however, be obviated by having the class provide themselves with a short manual containing the essential facts of German grammar, to which they could refer for the forms and so much as might be necessary of what was presented in the exposition. In spite, however, of this drawback the class worked with reasonably satisfactory results, as shown by the exercise books and the continued interest in the subject.

Following is given an outline of the lectures, showing the topics treated at each one. It will be seen that, with the exception of the verb, each topic was taken up and finished by itself. Eight of the eighteen lectures were devoted to the *verb*, as being of much more importance in German than the other parts of speech. In the case of the verb alone the treatment was interrupted, the more essential part being presented first, and the subject afterwards resumed, partly for the sake of introducing earlier other topics demanding attention, and partly in order to give variety to the work. The *order* in which the subjects were presented was different, it will be seen, from that usually adopted in grammars, but one which seemed most natural and most favorable for unfolding the facts of the language, as also for showing in the proper light the *more important* as distinguished from the *less important.*

I. *Pronunciation.*
II. *Articles. Possessive Pronouns.*
III. *Verb*: simple tenses of a verb of the *New conjugation.* (*Demonstrative and Relative Pronouns.*)
IV. *Verb*: simple tenses of a verb of the *Old conjugation.* (*Use of the tenses.*)
V. *Verb*: compound tenses of the new and old conjugations. (*Use of the tenses.*)
VI. *Verb*: *separable verbs.* (*sein* for *haben* as tense auxiliary).
VII. *Order of the German sentence.* (*Inseparable verbs.*)
VIII. *Personal Pronouns.*
IX. *Adjective*: I and II declensions.
X. *Adjective*: "mixed" declension.
XI. *Adjective*: comparison.
XII. *Adjective*: numerals.
XIII. *Noun*: I declension.
XIV. *Noun*: II declension.
XV. *Verb*: passive voice.
XVI. *Verb*: passive voice.
XVII. *Verb*: reflexives.
XVIII. *Verb*: impersonals.

In order to present to the class at the outset, and keep constantly before them the *actual language*, a small selection of very short selections in poetry and prose, the easiest things to be found, were printed and distributed. These served at each meeting as exercises for pronunciation and translation.

Respectfully submitted,
CHARLES P. OTIS.

The Elements of Perspective. Eighteen lectures.

This course consisted of nine lectures and nine lessons, the lessons being taken up with explanations and the examination and correction of drawings made by members of the class, which consisted of about forty persons, men and women. A printed syllabus containing the propositions to be explained was furnished at each exercise.

The instruction differed from that generally given and from that contained in the text books in several particulars, much greater prominence being given to the phenomena of parallel planes than is usual, and use being made of the laws established to determine the perspective of shadows, a subject that has hitherto received but little attention.

In the course of this discussion it was shown that the paramount importance commonly assigned to the horizontal plane and to the horizon line is unnecessary, and that the practice of referring everything to that plane is productive of needless inconvenience. It was shown that every plane has, so to speak, its own horizon, in which all the lines that lie in the plane have their vanishing points.

The well-known method of points of distance, also, which is generally treated as an auxiliary method of but limited serviceability, was shown to be of universal application, and to suffice for the solution of all problems. The developement of this method was shown to lead to the construction of a perspective plan, taking the place of the orthographic plan by the aid of which perspective drawings are commonly made.

The first part of the course was given to the study of the phenomena with the representation of which the art of drawing in perspective is concerned, and to what may be called a *qualitative* discussion of the subject, as distinguished from the *quantitative* discussion which followed, in which the representation in perspective of exact dimensions was explained. This first part of the course was addressed especially to artists and amateurs, to assist them in sketching.

This discussion involved the subject of the so-called errors of perspective and of the discrepancies that are always found to exist between drawings made from nature and those made by the rules of plane perspective. It was shown that drawings made from nature are in fact made in accordance with the rules not of plane but of cylindrical perspective, — what is sometimes called curvilinear or panoramic perspective, — and the principles and methods of this system were explained and shown to concide in their result with drawings made directly from objects. The relative advantage of the two systems was discussed, the cases pointed out in which each was to be preferred, and the devices and accommodations explained by which the disadvantages of each may be palliated in practice.

The course closed with brief review of other systems, especially of the system of coördinates and of the *Système Adhemar*, to which was added an investigation into the perspective of reflections.

Throughout the course it was maintained that a problem in perspective cannot be considered to be entirely solved unless the solution gives the vanishing point of every line that is drawn, and the vanishing trace, or horizon, of every plane, a solution which the commonly received methods fail to supply.

WILLIAM R. WARE.

ABSTRACTS OF THESES PRESENTED BY GRADUATES OF 1875–76.

DEPARTMENT OF CIVIL ENGINEERING.

Providence Water Works. Abstract by the author, T. Aspinwall, Jr., May, 1876.

The water supply of the city of Providence is taken from the Pawtuxet river. The main pumping station is situated close to the river, on low land, and is called, from the Indian name of the place, Pettaconset.

The machinery for pumping consists at present of two pumping engines, a Cornish and a Worthington Duplex. The latter is only intended for temporary use here. It has a capacity of 5,000,000 gallons, pumped 180 feet high in twenty-four hours. The Cornish engine, however, is permanent and has a capacity of 9,000,000 gallons. The engine house is designed to contain four Cornish engines of like-dimensions. The Cornish engine pumps into a standpipe 182 feet high, connecting with Sockanosset reservoir. The latter has a capacity of 51,156,544 gallons. Its construction, together with that of its gate chambers was described.

The main to the city was then described, particularly at the crossing of Pochasset brook by a triangular truss, and at the Pawtucket river, which the main crosses on iron screw piles.

The reasons for the construction of Hope reservoir were then stated, the construction of the gate chambers described, and their action explained.

Hope pumping station was next taken up. The engines here are two in number, each being of the capacity of 5,000,000 gallons in twenty-four hours. One is of a pattern designed and built by Geo. H. Corliss, Esq., and the other of a form designed by A. F. Nagle, M. E., of the Providence Water Works and built by the Providence Steam Engine Company.

The paper concluded with a short account of the pipes used in the mains, giving the formula by which the thickness was calculated and a table containing the results of those calculations for every diameter.

Merrimac River Bridge at Nashua, N. H. Abstract by the author, T. W. Baldwin.

I have commenced this thesis with a full description of the abutments, piers and superstructure of the bridge. Next I have calculated analytically and graphically the stresses arising from a uniform live load of 2500 lbs. per foot. Then follows a calculation of the web stresses when the bridge is partially loaded. Having found all the maximum stresses I have calculated the necessary dimensions of the girders and compared them with the actual dimensions. Next I have made calculations to see whether the factor of safety necessary to be used, in order that the working strength of the posts and braces shall be sufficient to withstand the stresses brought to bear upon them, is of proper size. I have finished by inserting a "Bill of Timber and Iron" together with the weight of each piece, in order to compare the actual weight with the weight assumed in the calculations.

I have made two drawings, one of the plan, side and end elevations of one span of the bridge, and one giving on a larger scale some details of the bridge and masonry.

West Chester Park Bridge over B. & P. R. R. in Boston, Mass. Abstract by the author, J. B. F. Breed.

This is a wrought-iron through highway bridge with three roadways and two sidewalks.

It consists of six girders, four of which are lattice girders and two are plate girders.

I have first given a detailed description of the bridge and then proceeded to calculate the maximum stresses in the diagonals and chords of lattice girders and in the flanges and webs of plate girders. This is followed by the determination of the net area of cross-section and the number of rivets required in the different pieces.

The stresses on the floor-beams and stringers are next considered and the requisite size and form of these fixed. Finally I have computed the total weight of the bridge and thus determined the true dead load.

The thesis is accompanied by plates of drawings representing elevations, sections, plan and details of the bridge.

The Buffalo Water Supply. Abstract by the author, H. T. Buttolph.

The city, first supplied by a private company in 1852, bought the works in 1868. There was much need of improvement, in order to fill the wants of the rapidly growing city, and it was thought they could be more fully carried out under the city government.

The improvements to be made, were to furnish the city with a *plentiful supply of pure water*; to supply a district higher than the level of the existing reservoir; and to lay the pipes low enough to avoid the effects of frost, the freezing of the pipes as then laid being a great inconvenience to the people during the winter season.

The first improvement was made by excavating a tunnel under Erie Canal, Black Rock Harbor and under Niagara River to a point 1020 feet from the pumping station on shore; where was erected an inlet pier with the requisite gates to control the supply.

The pier is 30 feet high, 114,662 feet long, 18 feet wide at the base, and the platform is 15.5 feet wide, battering planes intersecting it, which narrow it at the ends. This platform from end to end is 37 feet in length. The shaft in the pier is 6 feet in diameter and extends down to the tunnel, nearly 60 feet. The tunnel is at an average depth of 17 feet below the bed of the river, and has a section 8 feet square. The tunnel was five years in building; many obstacles being met, the principal of which were the great leaks of sulphur water. These leaks were encountered at two separate times; the first about 500 feet from Black Rock Harbor, where the water came up through the bedrock, which is a very soft limestone, at the rate of 3500 gallons per minute.

By putting in a wrought iron shield, 6 feet in diameter and 24 feet long, the flow of water was nearly stopped; and the work was carried about 89 feet farther where the second and more disastrous leak was met with. Here the water came in at the rate of 4500 gallons per minute, and the leak delayed the progress of the work nearly fifteen months. During this time the contract of the work passed into other hands.

Ten Blake pumps were put into the bottom of the shaft on shore. Five were put into operation with a capacity greater than the flow of water and by this means the water was kept out of the tunnel, so that the work was carried on. Above the strata through which the water flowed there were harder ones, and after overcoming the second leak the tunnel was raised three feet, top and bottom, in order to carry it through the harder rock.

The formal announcement of the completion of the work was made November 6th, 1875; the work was begun on the 12th of May 1870.

In 1870 the Holley System was introduced to supply the higher district. And in the spring of 1874 over three miles of pipe was taken up and relaid, the bottom of the new trenches for the pipe being six feet below the grade of the streets.

The pumping is at present done by a Compound engine, Shepard engine, and Worthington duplex engine; each of the capacity of 10,000,000 gallons in twenty-four hours. The last named engine does the principal part of the pumping, the Compound doing the least and in the place of which there is being built a Worthington duplex engine of 15,000,000 gallons capacity. The Holley pump takes its supply from the main, through which the engines at the pumping station force the water to the reservoir.

During the winter of 1872–3 the city was twice left without a supply of water, once for nearly forty-eight hours. A protracted east wind forced the water out of the harbor and left the waters in the pumping wells below the reach of the pumps. When the wind changed the water rose again. This trouble can not come up, under the present condition of the works.

The Bridge over Front St., in the Viaduct at Worcester, Mass.
Abstract by the author, Fred'k K. Copeland.

After a short description of the bridge and the conditions under which it was built, the dead load was approximately calculated.

The stresses in the web members were calculated for both live and dead load and the results combined. Having obtained the stresses in the trusses, the area of the cross-section required was compared with that actually provided, which showed at once any deficiency in strength of any part. The rivets and pins were calculated both for shear and bearing; the number of rivets used, in all cases, was largely in excess of the number required.

The posts were calculated by "Gordon's formula"; their area being given, their ultimate strength, and from this the factor of safety used was calculated, the smallest value of the latter being over four. The floor beams are plate girders hung from the trusses by suspending straps. These beams were very heavy as the bridge carries three tracks, and it was not possible to have more than two trusses.

The amount of iron used was found to be sufficient in all but a few parts and in these the deficit was not large. The weight of iron was calculated and proved the dead load to be less than the dead load first assumed.

The Broadway Draw Bridge, Boston, Mass. Abstract by the author, John R. Freeman.

The first part of this thesis is mainly descriptive, the general form of the pier and superstructure and the form and dimensions of the more important members being explained with reference to the accompanying drawings, and the manner of building the foundation for the centre pier and of depositing the concrete in the depth of water there existing being briefly described. Some of the more important requirements of the specifications as to character of work and quality of materials and the results of tests made to determine the strength of the wrought iron used, are also given.

The maximum load assumed in the specifications is then discussed and next the conditions of loading producing maximum stress in a continuous girder of two spans are investigated. Then starting with the "Theorem of the Three Moments" as given by Weyranch, a formula for the end reaction for this case is derived.

The method used for the determination of the stresses in the different members is that known as "Ritter's Method of Sections". The maximum intensity of stress in each member is then found, and compared with the limit fixed by the specifications.

The remainder of the thesis is taken up by a calculation of the stresses in floor beams, etc.

Accompanying the thesis are three sheets of drawings, showing the whole structure in plan and elevation and the more important parts in detail.

The Albany Street Bridge in Boston. Abstract by the author, F. W. Hodgdon.

The thesis begins by giving a general description of the bridge which is to replace the old iron lattice bridge on Albany Street.

It is to have four trusses 10 feet high and of spans varying from 102 feet to 83.7 feet. They are double Warren girders and the floor beams rest directly on the lower chords. The trusses are held in position by angle bar stays. The roadway is 32.5 feet wide, and each sidewalk is 8′ 9″ wide, making a total width of 50 feet. It is calculated for a load on the roadway of 80 lbs. per square foot live load, and 90 lbs. per square foot dead load, on the sidewalk 100 lbs. per square foot live load, 50 lbs. per square foot dead load.

Then it takes up the calculations, explains the method, and finds the stresses in all the parts.

Using 9000 lbs. per square inch for compression and 8000 lbs. per square inch for tension, it finds the sectional area required for each piece, and compares it with the actual area used, and gives the sizes and shapes of all the iron used in making up each cross section. Everything is reduced to tabular form where possible.

Finally it takes up the subject of riveting, explains the principles and shows its application in the case of this bridge.

The drawings which accompany it show, I. Elevations of each of the four trusses; II. A cross section of the bridge, a skeleton plan and the principal details.

Iron Bridge over the Merrimac River, at Tyngsboro, Mass. Abstract by the author, A. L. Mills.

In this thesis, I have first given a short description of the bridge and its foundations. I have then given a statement of the loads for which this bridge was calculated, which I obtained from the Engineer, Mr. C. H. Parker.

I then calculated the greatest stresses that could occur on the members from different positions of the live load, giving an explanation of the method used in the calculations. I have found the actual stress in pounds per square inch of section and compared it with the breaking stress per square inch, showing the factor of safety that is in actual operation in the different parts of the bridge. In all cases of compression members I have used Mr. Gordon's formula for the breaking stress in pounds per square inch. For the tension members I have taken the tenacity of wrought iron rods between 60,000 and 70,000 lbs. per square inch, as given by Rankine. For wrought iron plates I have used, on the same authority, between 50,000 and 60,000 lbs. per square inch as the breaking stress.

I have treated the floor beam, which is a "Pratt" truss of six panels, in the same way that I have treated the main truss.

I have found the stress per square inch on the wooden stringer which lies between the floor beams, and have found it amply strong enough to sustain the load it was intended to bear. Lastly I have calculated the weight of the iron work and planking in the bridge, showing that the dead load was estimated but a trifle too large.

Design for a double track Wrought Iron Post Truss. Four Girders. Abstract by the author, Henry Raeder.

In the introduction of my work I have given a general description of the form of a Post Truss, followed by the conditions under which I designed this special case of that kind of truss.

I then explained the method of calculation I employed, which fundamentally consists in dividing one of the four trusses into two primary trusses and afterwards combining the results of the calculations for the two girders.

The chord stresses I found by Ritter's method of sections, and the maximum web stresses from the corresponding shearing forces, when the girder is most disadvantageously loaded for the section in question. I checked the chord stresses by finding them a second time from the horizontal components of the web-stresses under a uniform live and dead load.

Having found the maximum stresses, I designed the pieces which are to sustain them, using for limit of stress in a tie 50,000 lbs. per square inch and employing Gordon's formula $\left[p = 40{,}000 \div \left(1+\frac{e^2}{\underset{40{,}000}{(10{,}000)}}\,r^2\right)\right.$ to find the limit of stress in the struts. I employed five for the factor of safety. In the remainder of my work I discussed the details of the structure, and finally calculated the entire weight of one girder, and comparing this *calculated* weight with the dead load *assumed* in the calculations, I found it was smaller.

West Boston Draw. Abstract by the author, C. L. Rich.

This pivot bridge consists of two equal Pratt girders of wood and iron, span of 68.5 feet each; width, including sidewalks, 50 feet, and twelve panels in each span. It is continuous over the three level supports, with a uniform cross-section. Two plate iron girders at the centre carry the weight of the bridge to the pivot. A live load in addition would bring the ends of these girders to bear upon the wheels of the turn-table, so that the centre support always acts through the iron girders at the middle. The ends of the bridge when open are supported by hog chains, passing over Samson posts erected over the centre. These rods, by a pin joint in the upper chord, continue to the lower chord, at the same points as the end support.

The dead load is taken as 45 lbs. per square foot; the live load, 80 lbs. The hog chains and the girders of the turntable are calculated for the open condition. The working strength of wrought iron in tension is 10,000 lbs. per square inch; in compression, 8,000 lbs.; in shearing action, 8,000 lbs.; in bearing on rivets, 10,000 lbs. per square inch. The flanges are assumed to resist the bending; the web, the shearing forces. The girders are of uniform strength. In discussing the trusses, the factor of safety of each part has been determined, which shows the relative strength of the parts. This factor may be smaller here, than in case the maximum load is often obtained.

As a check on the chord stresses, a diagram of the moments was drawn, by representing the positive moments by parabolas whose middle ordinates are $\frac{1}{8}$ Wl, where W is the total uniform load on either span, l, the length of span; and the negative moments by triangles, whose altitudes in a total uniform load, are $\frac{1}{8}Wl$; when the live load covers only one span, the altitude is $\frac{(W + W^1)l}{16}$, where W and W^1 are the loads uniformly distributed over each span. The ordinates between parabola and triangle in terms of the moments, divided by height of truss, give chord stresses.

In calculating the stresses, the dead and live loads are taken separately. The first thing is to find the reactions, then shearing forces, chord stresses, or the diagonal stresses.

In the bending action, the loads are considered uniform. Moments tending to produce compression in the upper chord, are called positive; those tending to produce tension, negative. The supporting forces or reactions at the left, right and centre are called R_A, R_B and R_C respectively. R_C and therefore the negative moment at centre are maximum under a full load. $R_A = R_B = \frac{3}{8}W$. $R = \frac{5}{8}W$. A half panel load must be deducted from these reactions for shearing forces in the end panels. R_A and therefore the positive moment in the left span, are maximum, and the negative moment extends farthest from the centre, when the left span only contains the live load. Then $R_A = \frac{1}{16}W$, $R_B = \frac{1}{16}W$, $R = \frac{10}{16}W$, W being the uniform live load in the left span, while the reactions resulting from the dead load are those in the preceding case.

Shearing forces, which act upward at the left of any section are called positive; downward, negative. The shearing action of the dead load still remains the same. The live load is treated as concentrated at the 11 apices of the lower chord, and the reaction caused by each is separately calculated by three formulas.

$$R_A = \frac{P}{4}[4 - k(5 - k^2)], \quad R_B = -\frac{P}{4} \cdot k(1 - k^2),$$

$$R_C = \frac{P}{2} \cdot k(3 - k^2).$$

where P is an apex load, and k, the ratio between the distance from left support to the load, in the left span, and the whole span.

By supposing the apex loads attached as we wish, and taking the sum of the reactions of each, as calculated in the 11 cases, we can get any desired condition. The maximum positive shearing force in any bay of the left span occurs, when the live load extends from the centre support bay; the maximum negative shearing force, when the right span is fully loaded and the live load extends from the left support to that bay.

There are trussed floor beams 12 feet apart carrying two longitudinal beams, which support two intermediate floor beams, extending under the sidewalks. The greatest stress in the sidewalk beams occurs under a heavy wagon load; as 20 tons. The trussed beams carry the greatest load, when under the uniform full load.

A prominent advantage of this bridge is its complete rotation.

The Eastern Avenue Swing Bridge in Boston. Abstract by the author, Henry M. Waitt.

This thesis opens with a short statement of the dimensions of the truss, and the extent of loading. Next in turn comes the calculation of stresses. The bridge was considered as continuous over "Four Level Supports". The dead load was considered to produce the same effect on the truss when shut, as when open. The live load in every case, as acting continuously over the four supports. The four reactions, for each individual panel load, were calculated by the formula given in "Dubois' Graphical Statics", pp. 184–5, Art. 122. Having thus obtained the reactions of every panel weight, the stresses were calculated for various loading, both with, and without snow, and the maximum stresses obtained for all cases. The method of Sections was used exclusively in this work. The method furnishes a ready means of ascertaining the position of counters, and the character of stresses.

Comparison was made with the amount of material in the structure, and, as a general thing, was found to agree well with the calculations. There was, however, one marked exception to the above, and this occurred in the middle bay, where the upper chord was considerable in excess, and the diagonal ties one half the requisite size. The floor-beams were tested for the maximum moments and shears, and found to contain sufficient material.

The maximum intensity of shearing stress on the web was calculated, and compared with the safe working intensity, given by Gordon's formula. The floor-beam hangers, and the intensity of stress on the wooden stringers, were also calculated. Lastly the weight of the bridge was computed, the result proving somewhat smaller than the assumed dead load. Two sheets of tinted drawings accompany this thesis, the one showing plan and elevation, the other showing end view and details of construction.

On the Haverhill Highway Bridge. Abstract by the author, H. B. Wood.

The bridge consists of five spans in all; one pivot draw of about one hundred and twenty-five feet span; three spans of about one hundred and seventeen feet each; and two spans of about one hundred and two feet each. Each span consists of two principal trusses built after the "Pratt" model.

The roadway is twenty-five feet wide in the clear, and is supported by "built up" cross girders, each of which projects by the vertical posts, so as to form supports for the two sidewalks, which are six feet wide in the clear.

These cross girders are bolted to the vertical posts, and rest upon plate-iron brackets rivetted to the same. The upper chord is built of wrought iron plates and angle-irons, forming a rectangular cross section, open and latticed at the bottom, so as to be easily painted. The lower chord consists of flat bar iron of uniform depth, and increasing in thickness toward the centre of the span. The posts are I-beams rivetted to the upper chord and resting in bearing blocks on the lower chord. The diagonals consist of square and round bar iron with screw ends, and fastened with wrought iron forged nuts, which rest upon cast iron bearings or angle blocks on the top chords, which abutt against the thrust plates. The "effective" section for use in calculating stresses is taken at the foot of the threads. The cross girders camber six inches in the centre, to form a water shed for the roadway, and are four feet deep at the centre. The cross bracing consists of the cross girders as compressive members, and diagonal tie rods.

Stringers of southern pine (3″ x 12″) are placed upon the cross girders about sixteen inches from centre to centre, and upon these rests a planking of yellow pine two inches thick, and running transversely. Upon this is laid a course of white oak plank, also two inches thick, and butted on the centre line of the driveway, and thence running 45° each way right and left, with this centre line.

The sidewalks have but one course of planking, and are four inches higher than the driveway. The draw is built upon the pivot plan, in which nearly the whole weight is thrown upon the centre pintle, which is adjustable. It has a spider wheel and radial rods, with coned cast-iron wheels upon their ends, running between two coned surfaces on the pier and bottom of turn-table. It is opened by means of a turning bar which fits upon the vertical shaft at the centre.

The bridge is designed to carry a moving load of twenty-six hundred pounds per foot of span, without straining it more than one-sixth of its ultimate strength.

Counters are put in where it is necessary to resist the action of partial loads.

A complete calculation of the stresses in each piece of the first span is given, also the areas of cross sections required, and the actual areas given.

Direct measurements of the structure itself were made, to obtain the latter data.

DEPARTMENT OF MECHANICAL ENGINEERING.

A Mechanical Laboratory. Abstract by the author, A. D. Blodgett.

In this thesis I have endeavored to call attention to the following points, viz.: 1. The necessity for a more extensive Mechanical Laboratory in the city of Boston. 2. Why it is a necessity. 3. What class of people would be benefitted by such an institution. 4. What Institutions in this country and abroad already have in this direction. 5. What they hope to have in the future. 6. What the Massachusetts Institute of Technology already has toward a Mechanical Laboratory. 7. What I think would be a good direction for the development of our Laboratory. 8. Why?

The above points it will be observed are taken up in more or less detail as it has been thought necessary, and I would say that I have copied freely from works on engineering both in our own land and abroad, always making a note of the same and giving the authority for the information in the margin opposite. I have illustrated the thesis with wood-cuts and photographs kindly furnished by the manufacturers of such machinery as will be found mentioned in the text.

Reference has been made to the views whenever it was thought necessary. In the basement room at the Institute represented on Plate II, I have thought it advisable to arrange machinery as there represented. This machinery will be found to consist of Lathes, Planers, Milling Machine, Saws, Drills, Emery wheel, Grinding apparatus, Testing machine, etc.

The power necessary to drive the machinery would be supplied by a belt from the Harris-Corliss Engine described and represented in the thesis.

The width of the belt is also calculated. It passed from the fly wheel of the engine to a large pulley on the main shaft which enters the room above and near the door parallel to Boylston St.

The power would be carried to each machine as represented on Plate II by a belt from the main shaft to a counter shaft for that machine. The speed of each machine would be adjusted to the speed of the main shaft by the relative size of the pulleys. There is also for each *lathe* a set of cone pulleys which allows certain variations from the main speed.

In reference to the drawings it may be well to state that the scale for Plate I is 1½ inch = 1 foot for all parts of the calorimeter except the figures A and B, these are not drawn to scale. The scale for plate II is ½ inch = 1 foot.

Steam Boilers. Abstract by the author, C. L. Dennett.

The writer's idea in the selection of the subject was, that by giving it the study required in order to present it in thesis form, he would gain a knowledge of the subject that would be practical and useful, and which should be first possessed by the steam engineer, since the subject of steam generation naturally precedes that of steam using.

Various works have been examined in order that the best information on each point might be obtained. Personal observation has also been a material aid.

Among the works consulted may be mentioned, Burgh on "Steam Boilers," Isherwood's Experiments, Wilson on "Steam Boilers," Trowbridge's "Heat and Heat Engines," Bournes' "Catechism of the Steam Engine," Rankine's "Steam Engine," C. Wye Williams on "Combustion and the Prevention of Smoke," W. R. Johnson on the "Practical values of American and Foreign Coals," "Journal of the Franklin Institute," "Master Mechanics' Reports" and others, besides numerous pamphlets on boilers and boiler tests.

The different parts of so extensive a subject are, in the thesis, necessarily presented very briefly. The general heads are as follows. 1. The requirements with which boilers should comply. 2. General form. 3. The natures and strengths of the different materials entering into boiler construction. 4. The strength and construction of the component parts, as the shell, flues, rivets, stays, tubes, etc. 5. The boiler fittings, as grates, furnace doors, pressure gauges, safety valves, blow-off pipes, gauge cocks, manholes, mudholes, etc. 6. The testing is considered. 7. The boiler setting and general proportions, including chimneys. 8. Boiler management, and injuries to which they are especially liable. 9. The circulation. 10. The subject of incrustation is taken up more fully than any of the previous subjects. The most common injurious ingredients of water are mentioned and different methods of preventing their action upon the plates explained. 11. The subject of combustion is also quite fully taken up. The process of combustion is analyzed; the causes and the waste of imperfect combustion, and the importance of air admission above the fuel are explained. These divisions are more or less fully illustrated by drawings, tracings, and wood cuts. 12. Land Boilers — A — the factory horizontal tubular, the vertical tubular, the fire-engine boiler, the locomotive boiler, and one of the boilers of the Hope Pumping Station at Providence, R. I. These boilers are illustrated by practical examples and the best authorities are cited as to their leading dimensions. B — sectional boilers are illustrated by cuts of the Root, Allen, Phleger, Lowe, Blanchard, Harrison, Wiegand and Exeter. 13. Marine boilers. The results of Isherwood's comparison of the Martin vertical water tube and the English horizontal fire tube boiler are illustrated by outline drawings of these two classes. A complete tracing of a boiler of the U. S. Steamship Vandalia is given and the principal data of its design. Two boilers, one of the U. S. Steamer "Jacob Bell," and one of the U. S. Steam Battery "Monitor" are illustrated by tracings, as being boilers of high efficiency, and the results of Isherwood's experiments on each are given.

Certain Points in the Development and Practice of Modern American Locomotive Engineering. Abstract by the author, Francis E. Galloupe.

In the study of the Locomotive Engine the subject divides into what are called the theoretical and practical aspects. I may therefore in its treatment first view the practical division and state what has been accomplished before applying the theoretic principles by which to criticise what the latter has done. In the treatment of the former, an investigation of the efficiency of the locomotive as it exists, has been made. The locomotive is throughout an exhibition of Dynamics, a moving structure. It begins with receiving power as the motion of heat, from the combustion of the coal, and ends with imparting force and producing visible motion of masses of matter. In the fuel from which this is derived, the energy is stored. The primary moving force in the locomotive, heat, is first considered and the manner and amount of its generation in the combustion of coal. The efficiency of the working fluid to which this energy is transferred, succeeds. The efficiency of the apparatus by which this is effected is next ascertained, and that of the mechanism by which the portion of energy utilized in the former is converted into its final form of motion against resistance at the circumference of the wheels. The subject is therefore considered under the following heads: —

In a historical sketch are traced the successive improvements in the development of the Locomotive and the Railway, and the practice with regard to the former from Darwin's "Fiery Chariot" and Cugnot's first actual running locomotive machine, in 1769, to the present time. The performance of these early engines is given and the most important improvements and principles developed in them are stated.

Part 1. The Production of Heat and the Laws of Combustion. The various sources of heat, mechanical, physical and chemical are mentioned, and that of Chemical Attraction, the action of which between elementary substances in the fuel and the oxygen of the air produces combustion, considered. The natural and artificial solid combustibles are stated, and three typical substances employed in locomotives, viz.: — Anthracite Coal, (Lackawanna), Semi-Bituminous Coal, (Cumberland), and Wood, (Dry Pine), considered. Tables showing their composition are given and calculations made of one, Cumberland coal, as follows: — its total heat of combustion, equivalent carbon in one pound, evaporative power from 212° and 62° Fah., equivalent foot-pounds of work, weight of air necessary to be supplied for complete combustion and for dilution, and the temperature of the fire. In this part it was found just what the fuel that is burned in the fire-boxes of locomotive boilers is, by theory, capable of doing.

Part 2. Water and the Properties of Steam. Of the two distinct operations common to all heat engines, heat making and heat expanding, in the former of these the facts having been ascertained, the latter is here considered. Water is treated chemically, physically and dynamically. The physical properties of steam are enumerated and the subject discussed with reference to three circumstances which determine its condition, its density, pressure and temperature. One pound of saturated steam at atmospheric pressure, at 120 pounds and 140 pounds above the atmosphere, is treated in its generation under constant pressure, and also under volume, its motive power, expansion, condensation and efficiency.

Part 3. An American Passenger Locomotive. The ultimate object of the locomotive-engine is to draw a train of a certain number of cars, upon a specified maximum up-grade, at a certain velocity. In this part a bituminous coal burning passenger engine, built at the Hinkley Locomotive Works in October, 1875, for the Eastern Railroad, was selected, illustrated by five detail drawings and a complete specification given. Its parts were classified and its details and action discussed under the following heads: —

A. The Boiler. 1. The shell, description, construction, material, strength, factor of safety. 2. The Heating Apparatus, the furnace and the tubes. The efficiency of the heating surface and furnace is found and other calculations made concerning its evaporative power. 3. The Feed Apparatus for the supply of water to the boiler consists of the pump and injector. These are described, illustrated by tracings, and the principle of the latter explained. 4. The Safety Apparatus which forms a large part of the locomotive boiler fittings, is mentioned in detail, and the Steam Gauge and Safety Valves illustrated, described and their mode of construction and principles upon which they operate given. 5. In the Transmission Apparatus by which the power is distributed to the engine, the steam and exhaust pipes are treated and the velocity of steam through them determined.

B. The Engine. In the engine the parts and topics are mentioned as 1. The Cylinder and its proportion; 2. The Valve Gear; 3. The Action of Steam in the Cylinder and the Blast; 4. The Transmission of Power to the Wheels by means of the Cranks and Connecting Rods; 5. The Running Gear; and 6. The balancing of the engine.

In this part the object was to apply theoretic principles to this particular engine and determine what its performance should be. In the succeeding part it is ascertained how nearly it does approach to this theoretic excellence and its actual efficiency determined.

Part 4. Trial of an American Passenger Locomotive. On March 14–18, 1876, trips were made upon the engines of two of the fastest passenger trains of the E. R. R. On the first and last of these days I rode from Boston to Rockport, a distance of thirty-six miles, and return, upon engine No. 36 ("The John Howe"). Upon the three intervening days trips were taken to Portsmouth, N. H., a distance of fifty-six miles from Boston, upon the 8.30 A. M. Bangor train, and data taken upon them concerning the actual running of the engine.

The engine was No. 55, being the same as that whose parts are discussed in Part 3. Six tables give in full the data taken upon the latter and results obtained. The observations made were the times of passing all the stations, the steam pressures, the point of cut-off, the coal consumed, the depth of water in the tank, the speed at different portions of the road upon levels, up-grades, curves and against head winds, and miscellaneous notes of the time of stopping, the action of the air-brake, the oiling of the engine, the weather, condition of the rails, direction of the wind and number of cars. In all, records of four hundred and ninety-five miles run were obtained, and of the engine under consideration three hundred and thirty-six miles. In brief, it was the aim to note every occurrence that took place with regard to the engine. The carrying of a train from Boston to Portsmouth means so many gallons of water and pounds of coal consumed. The tables state what these amounts are. From them other results are calculated, such as the equivalent horse power exerted and the train resistance. The record of the direction and velocity of the wind during these three days was obtained from the Weather Signal Office in Boston, so that the extent of the resistance from this cause could be approximately ascertained at any part of the road. The method of correcting the times for the rate of the watch is explained, the action of the safety valves and method of determining the coal record and of the speed. The capacity of the tank is calculated both from the measurements upon the detail drawings and from actual measurements with a steel tape, of all the accessible parts. A drawing of the tank and its internal staying is given.

Succeeding is a discussion of the peculiar facts shown by these records, and a table is given of the performance of eight engines of the E. R. R., including No. 55, for the month of January, 1876, by which any deviation from the records of ordinary locomotives is plainly seen. The power exerted by this locomotive on a part of the road is next calculated; its weight and tractive power ascertained. The extent of the train resistance is partially discussed. Finally, the efficiency of the mechanism is approximately found.

To sum up, the efficiency of the locomotive is the product of the three factors found and is stated as follows:

1. Efficiency of Furnace and Boiler, ...557
2. Efficiency of Steam, ...071
3. Efficiency of Engine or Mechanism, ...80

Efficiency of the Locomotive Engine, .557×.071×.80 = .326 or three and two-tenths per cent.

The projects of improvement in the boiler, the mechanism, and in the use of steam are mentioned, and statements made as to the effect of gauge upon economy in locomotive use. Narrow gauge roads, having the United States Standard gauge of three feet, are rapidly being opened in our State, and to them we look for cheap passenger transportation, rapid speed and economical working.

Paper Mills and Machinery. Abstract by the author, S. Hollingsworth.

After a brief history of the first paper mills in Europe and America, the subject is divided into, and taken up under two principal heads: First the Machinery, and second Mills.

First. The various machines are treated under the heads of the different processes they aid. The processes themselves however are treated only so far as concerns the engineer who designs the mill.

The manufacture of paper from the most commonly used material generally requires the following.

1. To form the pulp from the raw material. Thrashing, sorting, dusting, boiling, washing, draining and beating are generally necessary, and under all these heads, the machines and apparatus are described and shown in sketches, etc. The speed and power required by the most important of them is given. The general arrangement of foundations and rooms that contain them is spoken of. And in the case of the boiling process, results are given of an experiment by the author to find the amount of steam used that the engineer may know what boilers must be used.

2. To form the pulp into paper. The old process of making the paper by hand or from the vat is still practiced in Europe, and is therefore described and a sketch given of some of the apparatus used.

Paper is now formed from the pulp by the so called "paper machine" in some form. Of these there are two kinds in common use, the Fourdrinier and the cylinder machines. The history of the development of the Fourdrinier machine is quite interesting, and is therefore briefly given. The two machines are described and illustrated, their comparative merits are spoken of; and the questions of amount of steam used in drying the paper by an experiment by the author; the foundation of machine; the room; ventilation; felt-washers; roll-grinders, etc., are brought up.

Second. Under the head of Mills the question of location brings up the questions of communication with the markets; the use of steam or water for power; the quality and quantity of water used in the manufacture; building materials, etc. The whole power required by a mill of a given capacity is given, and also something about the general arrangement of the mill, repair shop, etc.

Pumping Engines. Abstract by the author, Alfred C. Killham.

Dividing pumping engines into two classes, according as they pump into a reservoir or directly into the distribution, I have first described several engines under each head. Under the head of Engines pumping directly into the distribution, I have taken the Corliss and the Holly engines and the new engine recently erected at Providence, according to the designs of Mr. A. F. Nagle of that city, and have endeavored to give some idea of their size and character, together with their advantages and disadvantages as regards economy and liability to accident. Under this head are also compared the advantages and disadvantages of the two systems.

Under the head of Reservoir Engines are taken, first, the Cornish; second, the Leavitt, as an example of a beam and fly-wheel engine; third, the Worthington. These are described like those under the first head, the advantages and disadvantages of each variety of engine being pointed out, and a table of the duties attained by each kind of engine being given.

Under the head of Cornish Engines is described "Davey's Differential Valve Gearing," which has been quite extensively ntroduced in England both for Horizontal and Cornish pumping engines. Its object is to make the valve motion not entirely dependent on the piston, but partly on the load, and so to change the point of cut-off that the speed of the piston shall not be very much accelerated or retarded by a change in load, and thus to ensure freedom from accident.

Having described engines under both heads, a comparison is drawn with regard to ultimate economy between the two systems and between the different engines in the same system. From calculation the engines pumping into the distribution are decided not to be economical except for places where not more than 2,000,000 gallons per day at the utmost are required.

From a similar calculation of the first cost and duty of different engines, it is decided that the Leavitt beam and fly-wheel engine is the most economical engine in this country, it having given both the highest special test duty and the highest annual duty of any engine in this country. On the special test the duty was 103,923,215 foot pounds per 100 pounds of coal consumed, and an annual duty of about 90,000,000 foot pounds per 100 pounds of coal consumed, including coal used for banking, has been obtained.

The Worthington engine, which has been largely introduced throughout the United States, is much valued on account of the apparent ease and quietness with which it performs its duty and its freedom from liability to serious accident; but although it gives good results compared with most pumping engines, it does not approach the Leavitt engine in economy.

Shafting and its Fittings. Abstract by the author, Theo. J. Lewis.

In my thesis I have endeavored to give an account of a research which I have made into the subject of Shafting and its fittings. In this research I have read such books and essays as were at my command, and have taken from them what seemed to me to be the most important facts connected with the subject.

The sources from which the information contained in the thesis is chiefly drawn are the following: Rankine's "Machinery and Mill work," Weisbach's "Mechanics of Machinery," Fairbairn's "Mills and Millwork," Box's Mill Gearing," Barlow's "Strength of Materials," Anderson's "Strength of Materials," Essays upon Shafting by Messrs. Allen, Hussey, Burke and Francis in the Report of the New England Cotton Manufacturer's Association, Essay upon Shafting by Mr. Coleman Sellers, "Fittings for Line Shafts" in the Engineering.

The subject is treated of in the following manner: —

1. The older forms of shafting and the various improvements which have been made upon them, as the introduction of lighter shafts and pulleys and the general adoption of belting as a mode of transmission of power.

2. The materials from which shafting is constructed and their adaptability to the purpose; giving a series of tables collected from various sources, showing the transverse and torsional strengths of the metals, steel, wrought iron, both hot and cold rolled, and cast iron. Also showing the methods by means of which these strengths are calculated.

3. The size of shafting, showing the demonstration of the general formula for the diameter of a shaft, and giving the values of the constants in those formulæ as used by different practical men. Stating the arguments for and against the use of very light shafting, and some examples of sizes which have been or are now in daily use.

The fourth general division of the subject comprises the fittings for shafts. The fittings discussed are, — Couplings; one of the first requirements that a line of shafting may run well being that the various sections shall be firmly coupled together. The requirements of a good coupling are given, and also examples of various forms in use.

Bearings; giving examples of the best forms of hangers and pillow blocks. Treating of the proper distance between two bearings, and of the metals of which they are made, and the proper pressure per square inch of bearing surface. In this connection the proper speed for shafts is spoken of.

Pulleys ; the forces which act upon them ; the shape and number of arms ; rules for the crowning. Belting ; the materials of which it is commonly manufactured, mode of fastening. The strength and the proper speed at which to run belts.

Efficiency of Marine Engines. Abstract by the author, Chas. T. Main.

The steam engine is a machine in which heat is converted into work with a certain amount of efficiency. During this conversion there are successive losses. 1. The whole of the heat from the fuel is not utilized in producing steam. 2. All the heat in the steam is not converted into work on the piston. 3. There is loss by the friction of the mechanism. The *second* and *third* factors are developed in the thesis.

1. On the different methods of using steam.

Although in some engines the expansive working of steam does not indicate a gain, yet in the modern engines the gain is worthy of notice. And the allies of the use of steam expansively are "Superheating," "The Steam Jacket," "Compounding," "High Steam Pressure" and "High Piston Speed." As a general thing now-a-days, too much expansion is attempted, and thus the results are not so economical as they ought to be. With the steam jacket and superheated steam the expansion can be carried on to a much greater extent than without, for these agents are preventions of surface condensation which is the great evil of the expansive use of steam, and the gain from their use is well worth studying. As far as the theoretical working of the steam goes, it makes no difference whether the expansion takes place in one cylinder or in a succession of cylinders; but as the size of the parts depends upon the *greatest*, and not the *mean* strain, the more expansively the steam is used the less is the *mean* pressure. Now to avoid the making of the parts so large as to increase the expense and friction, the compound engine was invented, and it has truly fulfilled the object aimed at. The parts connected with the low pressure cylinder are of more slender construction than when a single cylinder is used. It is well known at present that high pressures, and high piston speeds are conducive to economic results.

2. On the Various Combinations of Mechanism.

The size and proportion of the engine is governed by the work which it has to perform and the instrument by which it does it. In the case of paddle wheel engines, a long piston stroke and a short arm crank on the same shaft with the wheel is conducive to speed, power, and durability. For paddle wheel engines, probably the old fashioned working beam and its connections is as satisfactory as any method of transmitting the power from the piston to the crank. It has stood the test for many years, and is now much used for river and coasting purposes. The side lever engine has been used with success for ocean steamers, but its bulk and heaviness requires it to give way to the smaller and lighter engines, such as the oscillating, the trunk, and other engines having direct connection; the oscillating engine is to be preferred to the trunk on account of its lightness, strength and durability, and its accessibility for repairs; it has come into universal favor.

But the greater economy and greater convenience of the screw vessels have caused the paddle wheel to become almost extinct for ocean and war purposes. There are various types, the most common of which are, the geared, the oscillating, the horizontal, the vertical and the inclined. The shaft of the geared engine is divided in a clumsy way, and since it is now known that high speed is economical, and for other reasons, the direct acting engine is considered as the *screw engine proper.* All the other forms have been used to good advantage, according to the purpose to which they were applied.

Whatever form is used there is a great saving by the use of the surface condenser instead of the jet condenser, and all the other details should be arranged with reference to their simplicity, durability, and access for repairs. Of course in selecting an engine judgment must be used, and attention paid to the efficiency, the location, price of fuel, etc.

In writing this thesis, the author has gathered information from all the experiments at his command, and which he deemed sufficiently accurate to make use of. Under "Expansion" experiments of Isherwood, and those made at the U. S. Navy Yard in Boston, on the "Rush," "Dexter" and "Dallas," also those made at Baltimore on the "Bache" were referred to, and results given. Under "Superheating" those experiments made by Mr. Isherwood on the "Georgianna," "Adelaide," and "Eutaw" are given in synopsis. In studying the effect of the steam jacket, the experiments on the Brooklyn Pumping Engine, and those at the Navy Yard were referred to and results given. In determining the effect of compounding, and the gain of high steam pressure these last named were also used. A synopsis of the experiments made on the U. S. steamers "Spencer" and "McLane" to determine the relative efficiency of the screw and paddle wheel is given.

The Screw Propeller. Abstract by the author, C. F. Prichard.

Although spoken of and suggested by various authors it was not until 1836 that any extensive attempt was made to use the helicoidal or screw surface as a means of propelling vessels; then the idea was taken up in England simultaneously by Mr. F. P. Smith and Capt. John Ericsson. The exertions of either of these would have achieved a success, but the rivalry which existed hastened its introduction. Smith's form consisted of a single threaded screw of two convolutions, and was the same in principle as the true screw now in use. Ericsson's form consisted of two hoops revolving in opposite directions having short blades placed upon their circumference. The thesis contains detail drawings and descriptions of both these forms and short descriptions of numerous other forms.

The rapid rise of the propeller into general use is due principally to its power of being combined with sails, its form and the arrangement of its engine being such that it does not interfere at all with the working of the sails, while it is almost impossible to combine steam with canvas in the paddle wheel vessel; beside this reason there are many others which are given, with contrasts between the speed of the two classes of vessels.

Under the head of the generation of the helix and helicoidal surfaces are given the definitions of, and the manner of describing and drawing the various forms of true, axially expanding, and radially expanding screw surfaces. The radially expanding, and what is called the bent back form of blade, have for their object the overcoming of the centrifugal action of the screw. A particle of water struck by a straight bladed screw is acted upon by two forces, a centrifugal force tending to drive the particle radially, and the propulsive effort resulting from the oblique action of the blade; the resultant of these two tends to drive the water from the screw in the shape of a frustrum of a cone. If this body of water could be driven aft in a cylindrical column we should utilize all the force, and to do this the blade is radially expanded or more commonly bent back. This question is discussed and a formula for the true curve deduced.

The proper form of the screw depends entirely upon slip or the recession of the water, for it is evident if there were no recession of the water we should have the case of a screw working in an immovable nut, and provided the blades were strong enough, it would make no difference whether we have one blade or four, short or long length, large or small diameter; if the pitch and number of revolutions were the same the propulsive effort would be the same; but the water does recede and hence slip must be taken into account, and it becomes necessary to choose the particular dimensions which will reduce slip to a minimum. Slip cannot be entirely done away with owing to the nature of water; the pressure of a surface against the water puts it in motion, and this motion is a measure of the resistance, accordingly although slip is an evil and occasions losses from many sources, it is a necessary one and should be regarded as a purchase of power rather than an entire loss. After discussing slip the proper dimensions of the screw are given with the reasons for choosing them, as deduced from experiments by Isherwood, Mall & Bourgois, and others.

When steam is used as an auxiliary power it is often advantageous to proceed under sail alone; in this case the screw must either be hoisted or must drag in the water. This dragging causes an important resistance, and I have given the experiments of Isherwood upon the resistance of dragging screws as determined by dynamometrical measurement.

When sailing for some time this resistance becomes a considerable amount and may be obviated by the methods of hoisting the screw out of the water; several of these methods are described and illustrated.

The two methods of making a casting of a screw, that by sweeping up a mould, and that of making a wooden pattern are described.

The principal forms of screws in use in this country are the True Screw, the Griffiths, the Hirsch and Isherwood's form; these forms are described and working drawings given, taken from actual examples now in use in the English and American Navies. The Griffiths screw is a tracing of the form of screw applied to the Great Eastern.

The Mungin and Lowe-Vansittart propellers are described, though they are used more particularly in France and England.

The resistance of a vessel is composed of Head and Skin Resistances; a method of determining this resistance is given, with the manner of finding the power of engines necessary to drive the propeller, and several methods of receiving the thrust.

DEPARTMENT OF MINING ENGINEERING.

The Port Henry Iron Industry. Abstract by the author, C. F. Allen.

Part 1. Geographical location and description of the region. Geology of the country. Discovery and development of the mines. Growth and progress of the iron industry. General situation and its advantages.

Part 2. The mines. Their number, location, history and remarks. The Cheever bed — a detail description of the mine, showing location, situation, giving manner of working, winning ore, hoisting, lighting, ventilating, materials used, drainage, pumping, timbering, tramways, inclines, surface works, machinery, railroads, sorting, dumping, labor, yield, wharves, shipment, etc. Other beds — their history and brief descriptions.

Part 3. The blast furnaces; their history and growth. The Bay State Iron Company's Furnace, with detail description of the works and working of the furnace. Statements of the amounts of different materials which go in and come out of it, and the relative proportions of charges, fluxes, ores, fuel, etc. Analyses of the ores, fuel, fire-brick, limestones used at the furnaces, and of the slag and pig produced. Table of analyses of five different pigs and the results deduced, etc. The description, in brief, of the Cedar Point Furnace.

Part 4. Comparison of this with other regions, particularly that of Lake Superior, and the cost of mining and shipping ore. Comparison of these and other furnaces. Advantages and disadvantages of the region.

Part 5. Chemical Work. Methods of analysis. Stating the method used with brief description. The reasons for so doing and results obtained.

The Metallurgical Treatment of an Argentiferous Galena from Burleigh Tunnel, Colorado. Abstract by the author, S. James, Jr.

The subject is treated as follows:

1. Position of the tunnel and purpose of working. Progress of work and number of lodes cut. Geology of the tunnel.

2. Composition (both mineral and chemical) of the ore worked.

3. Crushing, sampling and weighing of the ore.

4. Roasting. Effects of zinc blende and chemical changes the ore undergoes. Roasting furnaces. Time and coal used, and losses in lead, sulphur and silver.

5. Trial of the Flintshire process.

6. Separation of the lead from the ore by the blast furnace. Analysis of the tap cinder used for fluxingwith a calculation of slag and charging mixture. Size of blast furnace used, and the construction of the hearth. Working of the operation and blast. Tables taken of the charging and tapping. Amount of coal used. Regulating the amount of coke. Sorting and working over the products of this run to be used in a second run, or for getting the lead ready for refining. Changes before second run, new tuyeres in the furnace, and a forehearth used. Action of metal matte and slag. Tables of the charging and tapping at the second run. Separation of the lead in the forehearth, but no slag sample. Loss of lead in the whole operation and amount of fume.

7. Getting a slag sample by fusion. Manner of using a plumbago crucible.

8. Refining of lead under charcoal. Tables of the running of the furnaces, coal used, and loss of lead.

9. Sweating to get rid of copper and impurities in the lead. Description of the heater and manner of working.

10. Smelting of the copper and impurities with galena to get the copper into a matte. Time, and coal used.

11. Zincing. Parke's process. Zincing and sweating three times with one per cent. of zinc each time, by which means the amount of silver in the lead was reduced to .001 per cent.

12. Distilling off the zinc from the silver lead.

13. Cupelling. Tables of losses in the different operations.

The Richmond Blast Furnace. Abstract by the author, Thos. W. Robinson.

After a brief history of the furnace the details were considered under the following heads.

1. The Construction.

2. The Accessories and Machinery.
3. The Manner of Working.
4. The Results of Chemical Analysis.

An Investigation and Report on The Pomeroy Iron Works at West Stockbridge, Mass. Abstract by the author, Theo. E. Schwarz.

I visited the Pomeroy Iron Works last September, spending one week in studying the works and mines in the vicinity, and in collecting samples for analysis, and obtaining data for this thesis. The works consist of an anthracite blast furnace and accessories. I have considered the subject under the three following heads:—

1. The Works.
2. The Process of Manufacture.
3. The Manufacture Economically considered.

Under the first head, I have described, with drawings, the blast furnace, blast heating stove, engines, incline, etc., and the mines of brown hematite ore situated in Berkshire county, from which the furnace derives part of its ore supply.

Under the second head, I described first the process of washing the limonites, as practised in Berkshire county. The apparatus, of which I have given a drawing, consists of three revolving cylinders, through which the ore passes with water. The apparatus sizes the ore into three different products according to the sizes of the perforated plates composing the cylinders. I then described the five ores; the sampling; preparation for analysis; method of analysis, and the analyses of the ores, flux, and coal.

The following are the analyses:—

PORT HENRY MAGNETITE.		ANDREWS-BROWN HEMATITE.
Insoluble Residue	3.54	14.16
Binoxide of Manganese	.88	.36
Alumina	1.20	1.46
Ferric oxide	90.01	73.80
Phosphoric acid	2.82	.49
Sulphur	tr.	—
Loss on Ignition	—	9.72
Lime		tr.
	98.45	99.99

	CALEDONIA RED HEMATITE.	LEETE ORE ("WHITE HORSE").
Insoluble Residue	10.57	20.80
Binoxide of Manganese	.23	2.96
Alumina	2.22	.76
Ferric oxide	72.15	56.30
Phosphoric acid	.43	.25
Loss on Ignition	8.09	16.80
Lime	4.49	
Magnesia		.42
Sulphur	—	—
	98.18	98.29

CHESHIRE BROWN HEMATITE.	
Insoluble Residue	15.43
Binoxide of Manganese	1.13
Phosphoric acid	2.13
Alumina	2.13
Ferric oxide	68.67
Loss on Ignition	10.00
Sulphur	—
	99.49

LIMESTONE FLUX.	
Silica	2.92
Protoxide of Iron	.40
Lime	42.83
Magnesia	9.65
Carbonic acid	44.235
	100.035

LEHIGH ANTHRACITE. (Very pure specimen.) The ASH contained: —

Volatile matter	11.16
Ash	6.85
Fixed carbon	81.98
Sulphur	.0062
	99.9962

Alumina	3.59
Silica	3.28
Lime	tr.
	6.87

I next gave descriptions of the operations of charging, drawing slag, casting, etc. The analysis of the slag is as follows: —

SLAG.	
Silica	37.62
Alumina	12.84
Ferrous oxide	tr.
Lime	39.16
Magnesia	6.98
Protoxide of Manganese	.65
Sulphide of Calcium	2.16
Alkalies	1.11
Phosphoric acid	tr.
	100.52

The three grades of pig iron analyzed as follows: —

	I.	II.	III.
Carbon combined	.53	.585	.395
" graphitic	3.38	3.49	3.36
Phosphorus	.84	.875	
Manganese	.89	1.13	.62
Sulphur	.016	.015	
Silicon	3.24	2.16	4.44 = Silica.
Slag	.20	.116	
Iron (by difference)	90.904	91.629	

Then follows a general statement and description of one week's run of the furnace, and comparative results deduced from the analyses and actual working data of the furnace. Under this head the following points were considered: —

1. Calculation of the theoretical slag from the analyses, with its formula.
2. Calculation of formula of slag actually obtained.
3. Weight of obtained slag.
4. Calculation of amount of pig iron expected in one day, from the analyses of the ores, and comparison with amount actually obtained.
5. Composition of the most desirable slag.
6. Comparisons with other furnaces.

Under the third division of the subject, I have added up the expenses and receipts for the week ending Sept. 9th, '75, and balanced accounts, showing a loss of $ per ton of iron made. The question of greater economy of production, as affected by the ores used, has also been discussed, and whether it would be well to attempt the production of Bessemer pig. In which case, what would be advisable ores to use?

On Newburyport Silver Lead Mines. Abstract by the authors, J. H. Susmann and W. D. Townsend.

This abstract is made to embrace two theses on the same subject, which was too extensive for one person to do justice to it in the limited time.

We have given in our theses general accounts of the history, development, mineralogy, and geology of the Newburyport district; in addition to a description of the treatment by us of two ores from the Chipman lode, a rich float ore, and a poor third grade ore.

Our first experiments were on the concentration of 3d grade ore. For this purpose 1628 pounds of ore, yielding to analysis 9 per cent. of lead, .03 per cent. of silver, worth all told $18 to the ton, were taken and treated in the wet way by a system of spitzlutten, jigs, side and end bump tables, and cones. We obtained a concentration of 233 pounds, containing 73½ per cent. of all the lead, and 54.7 per cent. of all the silver in the ore, together with a slime containing 10 per cent. of all the silver. These products were both of them ready for smelting. The concentration yields to analysis 46 per cent. lead, .115 per cent. silver, worth $94 to the ton. Silver being valued at $1.15 currency and lead at 6 cents per pound.

For the metallurgical treatment we took 774 lbs. float ore, which was a little poorer than the present first class ore. It yielded to analysis 44.30 per cent. lead, .15 per cent. silver. This was treated for the lead, silver and copper by roasting, agglomerating, and subsequent smelting in the blast furnace; yielding a crude lead containing silver and some copper, and a copper matte.

As a result of the smelting, we obtained products (lead and matte), containing 234 lbs. lead, 16 oz. of silver, 0.256 oz. gold, and 5 pounds copper.

The silver and gold were subsequently extracted by Parke's process, followed by cupellation. The copper was left in the matte, from which it can be readily extracted by wet processes.

The details of this work are fully given in the theses.

DEPARTMENT OF CHEMISTRY.

Action of Tungstic Acid upon Gelatin. Abstract by the author, Wm. P. Atwood.

I have considered the subject of my thesis under the following heads:

1. Object of thesis.
2. Gelatin.
3. Tungstate of soda.
4. " acid.
5. Method of determining Wl_3 and analyses of tungustate of soda.
6. Method of preparing the substance produced by the action of tungstic acid upon gelatin.
7. Properties of substance so produced.
8. Method of analysis.
9. Results of analysis.
10. Comparisons and conclusions arrived at.

On Anthracene and Associated Hydrocarbons. Abstract by the author, Chas. R. Fletcher.

This consists:—

Part 1. A digest of published papers on anthracene, anthraquinone, alizarine, phenanthrene, and their derivatives.

Part 2. Experiments made to determine the value of the various methods proposed for the quantitative determination of anthracene;

Experiments on the quantitative determination of phenanthrene.

The Action of Chloride of Sulphur upon Spirits of Turpentine. Abstract by the authors, Albert H. Low and Charles N. Waite.

The subject is treated under the following heads:

PART FIRST, BY ALBERT H. LOW.

Chapter I. 1. The action of chloride of sulphur upon certain oils, etc.

2. Extract from Parke's patent for the vulcanization of caoutchouc.

3. Treatment of the spirits of turpentine with chloride of sulphur, and separation of the products by distillation.

Chapter II. 1. Separation, purification and analysis of a substance having the composition $C_{10}H_{16}HCL$.

2. Determination of the composition and physical properties of other products.

3. Summary of the results of the investigation.

PART SECOND, BY CHARLES N. WAITE.

Chapter I. General remarks on the methods employed in obtaining the various products.

Chapter II. Purification and analysis of a sulpho compound and speculations as to its molecular structure.

Practical Estimation of the Value of Tanning Materials, together with Points on Tanning. Abstract by the author, Wm. E. Nickerson.

The work done may be divided as follows:

1. Collecting together some of the more available methods for the estimation of *tannic acid*, which have been published in foreign and American scientific works.

2. Consideration and trial of some of the more promising of these methods, by which one was found which can be used quickly, and by persons possessing but very little chemical skill. The method used, although essentially like the original, is somewhat simplified.

3. The determination of the value of various liquors from tanneries, of a number of the more common tanning materials and commercial extracts, by the selected and modified method, and the comparison of the results with those obtained by other chemists, with other methods.

4. The methods used by tanners, to test the strength of their liquors and tanning materials.

5. Investigation of the supposed loss of considerable quantities of tannic acid during tanning, by oxidation to gallic acid.

6. A partial analysis of an exhausted tan liquor.

DEPARTMENT OF METALLURGY.

A Report on the Vershire Copper Mine and Ore. Abstract by the author, R. H. Gould.

The first part of this thesis is devoted to a description of the mine and the method adopted for working the ore at Vershire. The second part describes the working of about 500 pounds of the ore at the Institute.

I. The ore mined at Vershire is a sulphide of copper and iron (Chalcopyrite) which occurs associated with a large amount of pyrrhotite and quartz. The method adopted for extracting the copper consists of the following operations. 1. Cobbing the ore to a uniform richness of about 9 per cent.; 2. Roasting the ore in large heaps to expel a portion of the sulphur; 3. Fusing the roasted ore in blast furnaces to obtain a matte containing from 30 to 35 per cent. of copper; 4. Roasting the matte in kilns to expel the remaining sulphur; 5. Fusing the roasted matte in blast furnaces to obtain pig copper containing 95 to 96 per cent. of metallic copper.

II. The working of the ore at the Institute is divided as follows:

1. Preliminary Treatment. The ore was first examined for the various minerals which it might contain. Those found were, chalcopyrite, pyrrhotite, quartz, blende, garnet, feldspar and mica. The first three make up about 95 per cent. of the ore.

The ore was next crushed to lumps of half inch diameter, and sampled. The ore on analysis gave the following:

Copper	12.18
Iron	34.93
Zinc	0.76
Lead	0.17
Sulphur	27.59
Silica	16.88
Ferric oxide	0.36
Alumina	1.90
Magnesia	1.54
Water	0.03
Undetermined	3.66
	100.00

2. Roasting of Ore. The ore was roasted in reverberatory furnaces for four hours, during which it lost over one half of its sulphur.

3. Fusion for Matte. The roasted ore was fused in a blast furnace, puddle cinder and limestone being used for fluxes.

The main products were, a matte containing about 25 per cent. of copper, and a perfectly fusible slag of the following composition:—

CuO,	0.56
PbO,	0.29
SiO_2,	35.97
FeO	41.90
$Ab_2O_3 + P_2O_5$,	8.55
CaO,	8.56
MgO,	1.14
Undetermined,	3.03
	100.00

4. Roasting of Matte. The matte was roasted in four charges, of 56 lbs. each, for about six hours.

5. Fusion for Black Copper. The roasted matte was fused in a blast furnace. Revere acid slag and sand being used as fluxes. The main products were:

1. Black Copper very highly charged with iron;
2. Matte containing about 44 per cent. of copper;
3. Slag which was perfectly fusible, and on analysis was found to contain no copper.

DEPARTMENT OF NATURAL HISTORY.

Catalogue of the Alcidæ in the Museum of the Boston Society of Natural History; with a review and proposed classification of the family. Abstract by the author, W. B. Barrows.

In this paper the family is first located and then briefly defined; its prominent characteristics, as shown in the various specimens in the Museum, being simply enumerated, and the more critical notice of specific and generic differences left for the descriptions of Genera and Species which immediately follow.

The descriptions are all original and are made from actual specimens in the Museum. Twenty-one species are included in the family and twelve of these, representing every Genus, are contained in the Museum. No descriptions of species have been given where actual specimens have not been handled, but each species is assigned its place in such a manner as to make a connected series which seems to best represent the natural relations of the members. One feature of the work is the reduction in the number of Genera usually admitted, only seven being here accepted; while the exclusion of sub-families is a parallel feature. These two points, involving the whole relation of species to species, are somewhat fully, though not exhaustively, discussed in the concluding third of the paper, where the grounds for every step have been carefully considered.

Two plates, containing figures of thirty beaks (both plan and elevation) conclude the paper.

The whole classification differs widely from those most generally in use; but the writer has been largely guided by such facts in the embryology of the group as have been within his reach and ability; and these facts, which have thus far been too generally overlooked, have made many of these changes imperative.

Geology of Eastern Massachusetts. Abstract by the author, W. O. Crosby.

This essay is prefaced by some remarks on the general structural features of the eastern United States.

Attention is called to the existence, during Paleozoic time, of a great gulf on the western side of the Appalachians, forming part of the interior Continental sea.

In this Paleozoic gulf is found a probable cause for the greater thickness of the Paleôzoic sediments in the Pennsylvania region as compared with any other part of the Continental basin.

The general absence of Paleozoic strata from the Atlantic slopes of the Appalachians is noted, and the fact pointed out that the Paleozoic rocks of eastern North America were deposited about the western and northern sides of what is now a long and narrow belt of land stretching from Maine to Georgia. Much evidence is adduced to show that this limited area had a greater extension to the east and south-east in ancient times than now; that there must have been during Paleozoic time, where now lies the basin of the Atlantic thousands of fathoms deep, a great continent, from which were derived the detrital materials forming the Paleozoic sediments of both Europe and America.

It is shown that our Atlantic coast line exhibits two grand deflections or bays, — the Gulf of Maine lying between Cape Cod and Nova Scotia and the large nameless deflection of the middle portion of the coast between Cape Cod and Cape Hatteras. The latter, which has been christened the Alleghanian Gulf, is proved to date from the beginning of Mesozoic time and to owe its existence to the great accumulation of sediments forming the Alleghany Mts.

The Gulf of Maine, on the contrary, is shown to be far older, having been, like the Gulf of St. Lawrence, with which it formerly communicated, in existence during the whole of Paleozoic time. Its origin is found in the erosion of an anticlinal of old crystalline rocks.

The age and relations to the Paleozoic sediments on the west and the Metazoic on the east of the rocks forming the long and narrow belt of land, before adverted to, stretching from Maine to Georgia, are discussed at some length, shown to be, with small exceptions, chiefly crystallines, and to probably ante-date in their origin the earliest Primordial.

Coming to the proper subject of the paper, the relations of Massachusetts to this Eozoic belt are defined and the rocks of the State divided into two principal groups: (1) the crystalline, and (2) the uncrystalline.

The crystallines are further divided into the Norian, the Huronian and the Mont Alban. Then follows at considerable length, forming the major part of the essay, an account of the lithology, distribution and probable origin of the various rocks forming each of these formations.

The rocks referred to the Norian are identified with the Norian of other regions, and, although occupying but a small area in the Eastern part of the State, are shown to be of great scientific importance, since they are the oldest rocks in Massachusetts and perhaps in New England, and afford a key to the geology of this whole region.

The stratigraphical relations of the Norian of this vicinity to the rocks of the same and of Laurentian Age in New Brunswick is pointed out.

The rocks of the Huronian Age are divided lithologically and chronologically into several groups, which, stated in their order of sequence, are granite, felsite, diorite, and stratified rocks including limestone. These are minutely described, their lithological and stratigraphical relations pointed out, showing that they are strictly members of one and the same series, and the law governing their distribution indicated.

The derivation of the compact felsite from conglomerate is briefly treated, old views discussed and new ones advanced.

General sections across this formation from north to south are given, showing that there is a repetition of the strata which can be accounted for only by a gigantic fault which must extend from the shore in Ipswich south-westerly through Essex and Middlesex counties. It is conceived to die out near Westborough, and a reason is found here for the existence of the peculiar band of Huronian rocks extending south-west from Concord and piercing the Mont Alban formation.

The existence of many minor faults is rendered probable, and it is proved that the diorite area of Salem, Swampscot and Marblehead has been thrown down thonsands of feet by a great fault which brought up the Norian rocks of Salem.

The Mont Alban formation is treated in a similar manner, but with less detail. The rocks of this age are shown to form, like those of the Huronian period, a complete chemical and lithological series, a rounded cycle of sedimentation.

Particular attention is given to the distribution and stratigraphical relations of the rocks of the Nashua and Merrimac valleys; and general sections across these valleys are given which show that the peculiar relations of the rocks are due to faults never before noticed.

The Mont Alban rocks are found, in their general distribution, to lie concentrically about the Huronian as the Huronian do about the Norian ; and it is pointed out that these formations sustain precisely the same inter-relations in Maine, New Brunswick and Nova Scotia that they do in Massachusetts.

In this manner is established the existence of the great Eozoic Anticlinal, the erosion of which produced the gulf of Maine. The occurrence of Primordial and later sediments at various points in the Gulf of Maine, is appealed to as evidence that the erosion of this Anticlinal was completed before the beginning of Paleozoic time. Preceding the systematic account of the Palezoic rocks, two general sections are introduced showing the probable form of the valleys in which they were deposited.

The slates in the vicinity of Boston are chiefly referred to the Acadian period, while the great mass of the conglomerates is regarded as synchronous with the Carboniferous conglomerates of Bristol County and Rhode Island, which they closely resemble.

The conglomerates and sandstones forming the Norfolk county belt are referred, on stratigraphical grounds, to the Devonian Age.

The paper is concluded by an account of the disturbance closing Paleozoic time, wherein is traced the origin of many of the more prominent geological and topographical features of this region.

DEPARTMENT OF PHYSICS.

On the Mean Specific Gravity of the Earth. Abstract by the author, J. B. Henck, Jr.

1. General principle of all methods of finding the mean specific gravity of the earth.
2. First hint of an actual experiment by Sir Isaac Newton.
3. First actual attempt to determine the deviation of the plumb-line by the attraction of a mountain, as suggested by Newton, made by Bougner and others in 1738.
4. Maskelyne's experiments in 1774, Hutton's calculation of the results, and subsequent lithological survey of the ground by Playfair, with remarks on the use of the terms "quantity of matter" and "density."
5. Experiments by Col. James in 1856.
6. Experiments by Airy in 1826, 1828, and 1856.
7. Experiments by Pierce in 1874.
8. A second class of experiments, to be performed in the laboratory.
9. First experiments of this class, by Cavendish in 1797–98.
10. Experiments by Reich in 1837.
11. Experiments by Baily in the same and following years.
12. Second series of experiments by Reich in 1852.
13. Experiments by Cornu in 1873–74.
14. My own attempted experiments the past season.
15. Recapitulation of results.
16. References.

There are several sketches in the text, and a photograph of my own apparatus.

The Atomic Theory as Applied to Gases; with Some Experiments on the Viscosity of Air. Abstract by the author, Silas W. Holman.

This thesis is a result of a study of the "Atomic Theory" of the constitution of matter, especially in its application to the explanation of the phenomena of gases. A review of the theory, from its rise in the speculations of Democritus and others more than five centuries before the Christian era, to the most recent development in its application to the phenomena of gases by Clausius, Maxwell and many more, has been outlined in the first portion of the paper. The methods of application of the hypothesis of a gas made up of rapidly moving particles to the explanation of the relation between the pressure, temperature and density of a gas is next considered. This leads to a comparison of the results obtained by different investigators from the time of Boyle (1650) to the present. Such a comparison shows the uncertainty which still remains as to the nature of the derivation of gases from the law of Mariotte, and the desirability of a more thorough discussion of all the results yet obtained, as well as the need of more accurate observations at high pressures.

Another class of the phenomena exhibited by gases, namely, those due to their viscosity or internal friction, is one quite well adapted to test the conformity of theoretical deductions with the results of experiment. From the hypothesis of perfectly elastic spherical molecules (or their equivalents) acting upon each other by impact after moving over a rectilinear path, Maxwell has deduced the law that the viscosity of a gas is independent of the pressure upon it and increases proportionately to the 0.5 power of the absolute temperature. The experiments of Meyer, Maxwell, Puluj and von Obermayer on dry air have given, instead of 0.5, values of 0.75, 1.0, 0.66 and 0.75 respectively. These various results are discussed by a special application of the graphical method which shows a great discordance in the case especially of Meyer's extensive investigations. These give in fact almost all values of the power from a negative one to +2.3, which shows that they entirely fail, even when their best values are selected, to establish any law for this variation. Maxwell's published results seem insufficient. Those of Puluj are more concordant. Only the conclusions of von Obermayer as published in a short notice have yet been attainable.

The apparatus which I have used in my experiments in the Physical Laboratory is dependent upon the law of Poiseuille as applied to the transpiration of gases through capillary tubes. This law is based upon the assumption that the viscosity of a gas is independent of the pressure upon it; a law which I consider as verified for variations not exceeding two or three atmospheres by the experiments of Graham, Meyer, and Maxwell. In this apparatus the same volume of gas is transpired successively through two capillaries of glass into a receiver continuously exhausted by means of a Richards' aspirator. The pressure of the gas at the entrance and exit of each tube is measured by means of two mercury gauges and a barometer. The capillaries may be at the same or at different temperatures. From the reading of the gauges when both are at the same temperature the constants of the apparatus may be determined, which must undergo a slight correction for variations of temperature since they depend on the dimensions of the capillaries. When the tubes are at different temperatures, the effect shows itself in the guage readings. From these and the previously determined constants, the effect of the known variation of temperature upon the viscosity is determined. The errors of measurements of volumes of air are thus eliminated, and the accuracy of the results depends only upon the measurements of temperatures and columns of mercury. As a mean of nine measurements I get the power 0.770, the extremes being 0.738 and 0.782. The greatest variation obtained with the apparatus was in the value 0.881 which was one of two observations rejected at the time of making. This form of apparatus does not furnish absolute values of the coefficient of viscosity, but may be readily extended to accomplish this by measuring the volume of gas transpired in a certain time. The superior concordance of these preliminary results warrants the expectation of absolute values surpassing in accuracy those of previous investigations.

The deviation of all experimental data upon this law from the theoretical value of the 0.5 power of the temperature indicates, probably, a false hypothesis with regard to the mode of action of the molecules at impact. Maxwell has rëinvestigated this subject upon the hypothesis of a repulsive force between the particles varying inversely as the fifth power of the distance, which makes the viscosity proportional to the first power of the absolute temperature. This is probably not the law however, and it would seem that it would be necessary to establish the experimental law with certainty before giving ourselves to any theoretical deductions from it.

New Experiments in Sound. Abstract by the author, William W. Jacques.

The experiments consisted of three series. The first was made for the purpose of testing the law of inverse squares; the second to show that the principles of Fresnel and Huyghens, announced for the ether waves, could be applied to waves of sound; and the third, for the purpose of measuring the velocity of sounds of considerable intensity.

First Series — There is every dynamical reason for believing that the intensities of light, heat and sound diminish as the reciprocals of the squares of the distances from their origins. That this is true of light and heat has been demonstrated experimentally. The case of sound, however, has hitherto received no experimental demonstration. The following experiments furnish us with a proof of this law for the case of sound.

If two resonators be placed equally distant from an organ pipe, and connected by tubes with two prongs of a forked tube in such a way that the waves from the two resonators shall arrive at the fork in opposite phase, they will neutralize each other, and if the stem of the fork be connected with the ear no sound will be heard.

If, for one of the resonators, we substitute a pair, we may, by moving the single resonator nearer to the organ pipes and properly changing the length of its tube produce the same complete interference. If the law of inverse squares holds good, the distances of the single resonator and the pair from the pipe should be as one to the square root of two.

The observed and calculated results agree almost exactly, so that we are now warranted in assuming the law for sound on as valid experimental grounds as for light and heat.

Second Series — There seems to be no *à priori* reason why the principles of Fresnel and Huyghens should not be applied to our atmosphere. The following experiments on the diffraction of sound show that they may be so applied. It is well known that when light, diverging from a centre, passes by a sharp edge, an interference is produced, so that, if a screen be placed just behind the edge, we shall see upon it alternate light and dark bands. The experiments which we have made in sound are analogous to these. In the path of rays of sound diverging from an organ pipe, an edge, consisting merely of a wide board, was interposed. In the rear of this edge alternate bands of maximum and minimum intensity of sound were observed, corresponding, in their positions, to the theoretical bands calculated by formulæ essentially similar to those used in the case of light.

From the data furnished by these experiments, we may calculate the length of a sound wave, the velocity of sound, and, in short, all of the quantities dependent upon the velocity of sound, as well as acoustic quantities analagous to the optical quantities deduced from the diffraction of light.

Third Series — Many eminent mathematicians and physicists have raised questions as to whether the velocity of sound is not affected by its intensity and pitch, by barometric pressure, hygrometric state and by other supposed causes. The following experiments, which form one of several series being made for the settlement of these questions, have for their object the measurement of the velocity of sound near to the mouth of the cannon. If the velocity varies with intensity, these results should be larger than those obtained by other methods.

The method consists of an automatic measurement of the velocity between the members of a series of membranes, placed at different distances from the source of sound, by causing the sound, as it passes each membrane, to register its passage, by means of suitable electric connections, on a chronograph.

By the kindness of Colonel Laidley, commander of Watertown Arsenal, the experiments were carried on at that place.

The gun used was a six-pounder. From the mouth of the gun a series of three membranes was set up at intervals of thirty feet. These membranes were made of thin rubber stretched over a hoop nine inches in diameter. To the centre of the membrane was attached a polished brass shelf, upon which rested a polished steel spring. The shelf was connected with one wire, and the steel with the other running to the chronograph. When the spring rests upon the shelf it completes a circuit, which is the primary coil of an inductorium. The passage of the sound wave by a membrane breaks this circuit, and so causes a spark to pass between the terminals of the the secondary coil of the inductorium. The chronograph used was a Schultz, which consists essentially of a rapidly revolving polished silver cylinder, upon the lampblacked surface of which a tuning fork is allowed to draw its curve, and so to furnish a scale of times. One terminal of the inductorium is led to near the cylinder through a glass tube; the cylinder itself forms the other terminal. The breaking of the primary circuit at the membranes, then, causes a spark to pass from the wire to the cylinder, which is registered by a dot in the lampblack. An arrangement was attached to each of the membranes, by means of which the current, after being broken at it, could be sent through the next one before the sound wave arrived at it. The experiments which have been made show that the velocity of sound in the vicinity of a gun is greater than at a distance by several feet. This is in accordance with theory. The method will, probably, when perfected, furnish the most accurate results of the velocity of sound yet obtained.

There is also a chapter describing some experiments made in a section of the new Sudbury River Conduit to test the effect of a very great variation of pitch upon the velocity of sound; and a final chapter describing a method to be used in the study of the effects of barometric pressure and hygrometric state of the atmosphere on the velocity of sound.

DEPARTMENT OF SCIENCE AND LITERATURE,

Australian Colonies of Great Britain. Abstract by the author, Chas. A. Sawyer.

Under the above title are included the following: New South Wales, Victoria, Tasmania, New Zealand, Queensland, South Australia, Western Australia, Fiji Islands.

Occupying, as they do, a position second only in importance to that of India, the colonies of Great Britain in Australasia demand something more than a merely general treatment as a group. In this thesis therefore I have entered somewhat into the details of each colony in its relation to the others of the group, paying also particular attention to their relations, commercial and political, with the mother country, and not only as a group but individually. In order to do this to better advantage and to systematize the treatment of the subject as much as possible, I have divided it into two parts as follows. In the first part I have briefly sketched the general and more important points in connection with the early discovery and history of Australia, this being common to all the colonies of the group, New Zealand alone excepted; I have also indicated their present relative positions as regards commerce, industry, and general prosperity, and verified my statements as far as possible by means of statistics and quotations from books and papers of authentic publication. This part of the subject is treated under the following heads: History and Discovery; Climate and Physical Features; the Natives; Government, including the colonial system of land tenures; Trade, Commerce and Industry. In the preparation of the pages devoted to this first part the following authorities were consulted:

"Australia and New Zealand," (3 Vols.), by A. Trollope.
"Australia," by Wm. Westgarth.
"Discovery and Exploration of Australia," (2 Vols.), by Rev. J. E. T. Woods.
"Life and Growth of Language," by Whitney.
"Queensland, Australia," by Rev. J. D. Lang.
"Colonial Constitutions," by Sir Edwd. Creasy.
Stateman's Year Book (1876), by Martin.
Edinburgh Review (1865).

In the second part I have taken up the colonies separately in the order of their commercial importance, and entered into a more detailed account of each and with special reference to its commercial relations with others of the group and Great Britain.

New South Wales, though at present occupying a second place in the list as thus arranged, is the oldest and parent colony of all those that have grown up about her, and for this reason therefore I have given her the preference to Victoria in the order of their treatment. Comparisons of the colonies have been made, under the different heads into which the treatment of each is divided, in order better to show the kinds of industry, agricultural, pastoral or manufacturing, characteristic of it, and to which the natural resources of each seem best adapted. The divisions under each colony are as follows:

Area; Discovery and History; Climate; Geology and Mining; Natural History; Laws and Government; Population; Education and Religion; Revenue and Expenditure; Trade and Commerce; General Items. The same scheme is not followed in the treatment of each colony, however, though varying but slightly throughout the list, one topic being necessarily included perhaps in another and not requiring a separate discussion or admitting of it in some cases.

Statistics have been given the preference to more interesting facts in connection with the history and present condition of the colonies, of which many have been reluctantly passed over and omitted. More space has been devoted to Victoria as the most important, and less space to Western Australia as the least important, of the colonies of the group.

The authorities referred to in this division of the subject include those already mentioned together with the following: Accounts and Papers of the Colonial Government, 1852–3; Greater Britain, by C. W. Dilke; What we saw in Australia (1875); The colony of Victoria, by Wm. Westgarth; Victoria and Tasmania by Trollope; Dublin Univ. Magazine, Jan. 1876; Journal of the Statistical Society, Dec. 1875; Goldfields of Victoria, by R. Brough Smith; Victoria and the Australian Gold mines, by Westgarth.

DEPARTMENT OF PHILOSOPHY.

Concerning Kant's Transcendental Æsthetic. Abstract by the author, D. W. Phipps.

I.

EXPOSITION OF KANT'S IDEA OF A CRITIQUE OF THE PURE REASON.

1. Mutually independent Mind and Thing assumed.

2. The assumed hypothesis (to be proved) that the qualities of the object pertain only to the Mind.

3. In consequence of the assumed duality of Mind and Thing; together with the apparent element of universality in experience, the theory arises that

(*a*). There are two sources of knowledge, viz., Sense and Understanding.

(*b*). And hence the problen of the Critique: How are synthetical judgments possible *a priori*?

4. The Sense-cognition, as distinguished from the cognition of the Understanding, has an element which is contributed by the spontaneity of the Mind; hence,

5. The necessity of a Transcendental Æsthetic; which is a critique of the spontaneity in the sense-object, as distinguished from the spontaneity of the Understanding; the critique of the latter being named Transcendental Logic.

6. What we shall expect Kant to prove in the Æsthetic, in view of the foregoing notion of its purpose.

II.

REMARKS CONCERNING THE PLAN OF THE ÆSTHETIC; AND NOTICE OF SOME OF ITS DEFECTS.

III.

AN ATTEMPT TO RESTATE THE ÆSTHETIC SO AS TO AVOID SOME OF THE NOTICED DEFECTS.

1. *Definitions:* Sense; Intuitions: pure, empirical, external and internal; Phenomenon; Sensation, Space and Time; Matter, Form.

2. The Æsthetic a critique of Space and Time.

(*a*). Space and Time to be explained Metaphysically and Transcendentally.

3. *Metaphysical Exposition:*

(*a*). What a Metaphysical exposition is.

(*b*). Space and Time are not general concepts.

(*c*). They are not concepts of any sort; and as an intuition can be given by a single object only, so Space and Time are like intuitions, for they are each only one.

(*d*). Space and Time give rise to synthetical propositions *a priori*; but a conception contains only a unity of certain marks or characteristics, which may be discovered by analysis, and does not contain anything beyond those marks; hence a conception cannot give synthetical propositions *a priori*; hence Space and Time are not conceptions; hence they must be intuitions.

4. *Transcendental Exposition:*

(*a*). What a transcendental exposition is.

(*b*). What "transcendental" means.

(*c*). An object cannot be cognized as extended and enduring unless there be the representation *a priori* of Space and Time, in which the object may extend or endure.

5. The exposition of Space as a representation *a priori*, makes possible the conception of mathematics as a synthetical science *a priori.* And motion, the change of place of an extended object in Time, can be understood, and explained *a priori*, only on the ground of the representation *a priori* of Space and Time.

6. *Conclusions:*

(*a*). Space and Time are subjective, only, but universal.

(*b*). Sensation is subjective, only, but singular.

7. *Elucidation:*

(*a*). Change is real for us.

(*b*). Space and Time are only elements of a Transcendental Æsthetic.

8. The bearing of the completed Æsthetic upon the solution of the main question: How are synthetical judgments possible *a priori*?

IV.

QUERIES.

1. How did Kant discover that the Sense-object was *occasioned* by the thing-in-itself?

2. Has he proved that Space and Time are *a priori;* that is, universal and necessary, but independent of sensation?

3. Has he proved that Space and Time are intuitions?

4. If Space and Time are independent knowledge of *one* sort, and Sensation is independent knowledge of *another* sort, how can the two sorts be united?

5. Is the so-called *a priori* from the *human* reason or from *Reason*? that is, do we not know the Absolute?

6. Has Kant's theory of cognition provided for Transcendental reflection?

Historical and Logical Relations between Fichte and Kant. Abstract by the author, R. C. Ware.

Fichte's adoption of the philosophic standpoint of the absolute validity of reason, through his researches in theology. His adoption of a fatalistic determinism. His subsequent conviction of the freedom of the will by Kant's new theory that the nature of liberty is subjective. Fitche's hearty acceptance of Kant's doctrine. Fitche's visit to Kant. The "Critique of all Revelation," an application of the "Critical" Principle. Development of Fichtianism by reflection on the contradiction of Kant. Development of the theory of intellectual intuition by reflection on the implications of the "Transcendental Logic." Derivation of the Ego as ground of the universe, and of the one fundamental principle of thought (the Principle of Identity), from Kant's "Synthetical Unity of Apperception." Development of Fichte's theory that will is a necessary part of real thought, out of the adoption of Kant's practical philosophy. The real character of the revolution wrought by Kant in philosophy.

THE RUSSIAN SYSTEM OF SHOP WORK INSTRUCTION.

To the Corporation of the Mass. Institute of Technology:

GENTLEMEN: — It must be admitted that technological education is still in the experimental state. The methods in use, even in our primary schools, do not pass unquestioned, and upon the best methods of teaching the ancient languages, and the pure mathematics, subjects which have constituted the main elements in all high and generous culture for ages, the most learned doctors disagree. We could hardly expect, then, that the best methods of teaching the modern sciences should already have been found; and particularly the best way of working them out practically in the industrial arts. Ten years ago, when the courses in this Institute began, some valuable experience in teaching science had been gained. It had been found that simple text-book instruction in Chemistry, unaccompanied by corresponding laboratory work by the pupil, was comparatively useless; that a small professional laboratory, while good for an advanced specialist, was no place for a beginner; and, in short, it was too expensive to teach each pupil singly. Hence there had grown up, as a necessity, large and well arranged laboratories, especially adapted to the instruction of pupils in as large classes or sections as one or more teachers could instruct well at the same time. This step of teaching laboratory work to large classes of pupils, and all in about the same state of progress, was found to be most economical for both parties, and the only system by which this element of instruction could be maintained with a large number of pupils. It has also been found by experience that general chemistry, quantitative and qualitative analysis, and the various departments of applied chemistry, can best be taught in laboratories adapted to each. Such are the steps which have been taught us by experience in a single department. But unfortunately, in hardly another department have we the same experience, and an equally well defined and systematic method of instruction. In architecture, in laboratory instruction in physics as a part of the required course of each candidate for a degree, in the mining and metallurgical laboratories for the working of ores in quantities, and in the laboratory for teaching the nature and use of steam, this Institute has the honor of having led the way. But in these cases each year's experience serves to suggest improvements in details, which add materially to the amount and quality of the work done.

While we have been gaining experience in these directions, other technical schools have also been working out, more or less fully, other phases of the same great educational problem upon which we are all engaged; each doing its work under such limitations and conditions, and in such main directions, as its location and other controlling circumstances have dictated. Each, therefore, owing to a great extent to these varying circumstances and conditions, has its lesson to teach to all the others; and it was with the expectation that the opportunity of learning some of these lessons would offer, that our Professors and Students made their recent visit to the International Centennial Exhibition at Philadelphia.

The Act of Congress of 1862, giving lands to the States for educational purposes, while not excluding other subjects, laid particular stress upon the two great industries upon which the well-being of any great community must always mainly depend, agriculture and the mechanic arts. While all the sciences having a direct application to these arts should be taught, there can be no doubt that it was also the intention that the arts themselves should be taught in the most practical and fundamental way; and accordingly, we find farms in several of the States, used in one or two cases, simply as experimental stations, but in most cases conducted as model farms, and depending to a considerable extent upon the labor of the student, which is regarded as instruction, and is made a required part of the curriculum of the course in agriculture.

In like manner many of these schools have already established shops for the instruction of their students in the mechanic arts.

As this Institute was selected by the State to represent the mechanic arts, for which we receive one-third of the income derived from the national grant, we have watched the experiments in this department, which the various schools have been making with the deepest interest; believing, that the time would come, when the best solution would be reached, and trusting that when it was reached we should be in a condition to take advantage of the experience. In the meantime the steam laboratory is all we have been able to furnish of a practical character to our students in mechanical engineering, beyond what could be gained by a good locality for manufacturing, and the particular kindness of the directors.

We went to Philadelphia, therefore, earnestly seeking for light in this as well as in all other directions, and this special report is now made to ask your attention to a fundamental, and, as I think, complete solution of this most important problem of practical mechanism for engineers. The question is simply this — Can a system of shop-work instruction be devised of sufficient range and quality, which will not consume more time than ought to be spared from the indispensable studies?

This question has been answered triumphantly in the affirmative, and the answer comes from Russia. It gives me the greatest pleasure to call your attention to the exhibit made by the Imperial Technical Schools of St. Petersburg and Moscow, consisting entirely of collections of tools, and samples of shop-work by students, illustrating the system which has made these magnificent results possible.

In all constructions a certain limited number of typical forms are found, these forms being more or less modified, to adapt them to special constructions. These forms will also fall into groups each to be worked out in a certain way and with special tools. If, then, the student can be taught to work out these forms, each in the best way, and with the tools best adapted to the work, he will be far advanced in the skill which will make him available and useful in construction. The ideas involved in the system are, first, to entirely separate the *instruction* shops from the *construction* shops; second, to do each kind of work in its own shop; third, to equip each shop with as many places and sets of tools, and thus accommodate as many pupils, as a teacher can instruct at the same time; and fourth, to graduate the samples to be made in each shop according to some scale, that of difficulty being probably the best in practice. In short, in these preliminary instruction shops, the *arts*, which find their applications in construction, are systematically taught.

It will be seen, then, that the problem thus far is simply one of systematic instruction, given by an expert in each shop, and having the same end in view as instruction in any other subject or department. The aim is to give sufficient skill in each specialty in the shortest possible time, and to give the instruction to as many at the same time as the teacher can well instruct, thus securing the greatest economy of time, and therefore money, to both teacher and pupil. After the student has finished his course in the several instruction shops, he may then be transferred to a construction shop, which may still be used simply for instruction as in the St. Petersburg school, no orders being taken, and all constructions being made simply to give variety to the instruction; the machines and tools made being sold at the end of the year if wanted.

Or he may be transferred to a construction shop, which takes orders and depends largely upon the work of the pupils, as at the Moscow school, the construction shops being in each case owned and controlled by the school.

With this preliminary exposition, I propose now to ask your attention to details, mainly in connection with the statements which these schools make in explanation of their exhibits at Philadelphia.

And first, the statement of the St. Petersburg school:

"The Practical Technological Institute of St. Petersburg is one of the highest technical schools now existing in Russia, and has capacity for five hundred students. It is divided into two departments; Mechanical and Chemical.

The Mechanical Department prepares technical men for the management of mechanical work-shops, and of the rolling stock on railroads. Owing to this the Mechanical Department is divided into two special sections; one of them graduates engineers for the workshops, and the other for the railroads.

Before entering the Institute as student the young man must be graduated in one of the middle schools (gymnasiums), and must undergo a competitive examination.

The whole course of instruction in each department of the Institute is arranged for five years, and is divided into five yearly courses.

In the Mechanical Department the course of instruction includes: Mathematical analysis, natural philosophy, theoretical and practical mechanics, mechanical technology, the art of construction, and the art of mechanical drawing. Besides this, a part of the time is employed by the students in manual labor in various workshops and mills belonging to the Institute.

During the full five years of the course of studies, six hundred and forty-eight hours are devoted to the manual labor in workshops. There the students, under the management of experienced masters, begin to exercise in the most simple works, gradually passing to more complicated, and at last finishing with construction and joining of all the parts of an engine.

The collection of practical works exhibited in the Machinery Hall by the Institute is composed of articles manufactured by the students during the year 1875, and represents the systematical course of practical studies adopted by the Institute.

The system introduced with this purpose is as follows: The practical studies are divided into three courses; for the first course each student is induced to work with a chisel and file upon the cast-iron, performing six consecutive tasks exhibited under the No. I. of the collection.

For the second course the students begin by working upon wrought-iron, fulfilling nineteen consecutive tasks represented under the No. II. of the collections. Thereafter they are removed to the fitting shops, where they are obliged to perform fifteen tasks, exhibited under the No. III. of the collection, occupying themselves with turning, cutting screw-threads and soldering.

The last course is intended for the construction and joining of different engines. The samples of machine tools built by the students of this course are exhibited under the No. IV. of the collection."

I am indebted to Dr. August Peters, Mechanical Engineer, and Director of the shops of this school, for the following details: The filer's shop, No. I, has about sixty places, each fitted with a vise, and the tools necessary to do the work of the course. The forging shop, No. II, is fitted with ten places, and the turning shop, No. III, with sixteen places, the students working in these shops in alternating sections. The lathes are all run by the foot, and the only power used in any of these instruction shops is for the blast in the forging shop, which each student takes from the main pipe. Even here power could easily be dispensed with by attaching a hand blast to each forge. The shop work, which, it will be noticed, takes but six hundred and forty-eight hours for the four courses, is obligatory, and graduates are able to construct their own designs with their own hands.

The quality and variety of the work exhibited, and all done by the students during the year 1875, furnish the very highest evidence of the value and entire success of the system.

And second, I beg you to particularly notice the able and instructive presentation of this important subject by Victor Della-Voss, Director of the Imperial Technical School of Moscow, together with a brief preliminary statement of the general features of the school. I am indebted to Professors Aeschlimann and Petroff, the gentlemen in charge of this exhibit, for polite attentions.

"The Imperial Technical School of Moscow is a high class Special School, principally intended for the education of Mechanical Constructers, Mechanical Engineers and Technical Engineers.

The School consists of two divisions, general and special, each of which has a course of three years. The special division is divided into three branches: Mechanical Construction, Mechanical Engineering and Technological Engineering.

The three years' course of the general division embraces the following subjects: Religion, Free Hand and Linear Drawing, Descriptive Geometry, General Physics, Zoology, Botany, Mineralogy, Chemistry, Geodesy, Analytical Geometry, Higher Algebra, Differential and Integral Calculus, General Mechanics, Drawing of Machine-parts, the French and German Languages, *i. e.*, all Scientific subjects, the previous knowledge of which is required from the pupils of all the three following branches.

In the special department, the three years' course of the three branches contains the following subjects: Organic and Analytical Chemistry, Metallurgy, Practical Physics, Mechanical and Chemical Technology, Technics of Wood and Metals, Analytical Mechanics, Construction of Machines, Practical Mechanics, Railway Construction, Engineering and Constructive Art, Projecting and Estimating of Machines, Works and Mills, Industrial Statistics, and Book-keeping.

Every one of the appointed sciences is taught fully, or in a condensed form, according as it is considered a fundamental or collateral subject of the given branch. The students of all the classes are occupied during a stated time in practical work in the laboratories and mechanical workshops.

The School has also a preparatory division, of three classes, with the same curriculum as the higher classes of commercial schools, and is intended for such pupils as, by any reason whatever, have not been enabled to pass through the full course of the commercial or of the classical schools.

Admission into the School as boarder or day scholar is obtained by competitive examination, in accordance with the ordained programme.

Pupils who have passed through the full school course of the Gymnasiums may be admitted without further examination to the lectures of the second general class of the School, but pupils of the last class of the Gymnasiums, who have not passed their final examination, are admitted only to the first general class of the School.

The pupils wear the appointed half-military uniform.

Pupils who have obtained in the school the appointed grades, receive acknowledged rights in the service of the government.

The School is maintained by funds from the following sources: percentage on funded capital,[1] fees of private boarders and foreign hearers, and profits received from the Mechanical Works.

The annual receipts of the School amount to 160,000 dollars.
" " expenses " " " " 140,000 "

The Technical School is under the immediate patronage of *Their Imperial Majesties.*

Auxiliaries to Instruction. The School possesses a special library, containing more than six thousand volumes of works on specialties, a cabinet of physics, two chemical laboratories, a cabinet of mechanical models, a cabinet of natural history, extensive mechanical works with separate smithy and foundry, and also school work-shops.

Almost the whole of the collections exhibited by the School at the exhibition at Philadelphia, are immediately connected with the school workshops, and we shall therefore endeavor to give a few details concerning the latter.

No one will deny that a close acquaintance with hand labor, and, in general, practical experience in mechanical works, are matters of the utmost importance to every engineer.[2] The drawings of an engineer thus trained will always be distinguished by solidity and that practical judgment, which is the result not only of the study of scientific truths, but also of the acquirement of a

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[1] The School capital amounts to about 2,030,000 dollars.

[2] We speak here of Mechanical Engineers and Constructers.

certain familiarity in their application to practice. That the knowledge of hand labor is of extreme importance to a young man devoting himself to technical activity, and that it is considered an absolute necessity to him, we are convinced by the circumstance that the greater number of the polytechnical schools of western Europe demand from the students who enter them either a previous stay, of a certain duration, at some works of industry, or issue to them a diploma, attesting their accomplishment of the course, after they are in position to show that they have been occupied practically for a definite period at some such works on their leaving the school.

If we contemplate the matter itself more profoundly, and acquaint ourselves more closely with the circumstances of the practician at private works and mills, we must, disregarding exceptional cases, since it is not those which form the rule, arrive at the sad conclusion that a young man, desiring to acquire practical experience in a short time, and without the aid of an experienced guide, loses, at private works, nine-tenths of his whole time entirely unprofitably. As we are at present addressing persons well acquainted with this matter, we do not consider it necessary to bring forward arguments in support of our statement. The practical information, acquired in works by a young man before entering a polytechnical school, is very inconsiderable, and therefore does not possess the desired significance.

Such information is, on account of its defectiveness, of little assistance in promoting the study at school of Practical Mechanics, the construction of machines or the drawing up of plans and estimates for mills and works.

A young man on leaving a polytechnical school should endeavor to carry on his practical education; should fix upon some mill or works in which, being, in the majority of cases, of course, left to his own initiative, he may find place and opportunity for his further self-education.

At this moment, so critical in the career of the youthful engineer, the insufficiency of material resources is the cause that the majority take service, at a very low rate of remuneration, as draughtsmen in the drawing office of mechanical works, or in the drawing offices of railway companies; others more fortunate enter works in the quality of artizans; but even they are hardly to be envied, simply from the fact that in the majority of cases the specialty of the first works, which they happen to enter, becomes their own specialty through life. An experienced observer will find no difficulty in perceiving all the inconveniences to a technical education, which arise as the result of such an order of things. Let us explain this by examples. A young man, having received thorough scientific preparation in a polytechnical school, has entered as artizan practician some extensive joiner works, and in a year or two begins to serve in the capacity of a workman, receiving pay from the works. If, from any circumstance whatever, he becomes deprived of his place, he finds it necessary to seek another in a similar joiner works, or else to enter again as practician in another specialty, for instance, a locomotive, boiler or other works. The material resources of young men preclude, in the majority of cases, the possibility of their deciding on the latter alternative.

If the observant Directors of Polytechnical Schools should take upon themselves the work of following the industrial career of the contingent of their pupils, who on leaving school enter a drawing office, they would easily perceive that those young people experience extreme difficulty when they are once engaged there in leaving such an office, and in the majority of cases remain draughtsmen all their lives. In such offices a young man acquires but very inconsiderable technical information, neither can they in any way serve him as practical schools for his further self-instruction. And we must here observe, also, that the more extensive the works, and consequently the drawing office attached, the fewer are the advantages offered to the young practician, since he has to do with an institution in which division of labor, forming an essential principle, will not admit of his becoming speedily acquainted with the general progress of work. We cannot but add that this principle having become latterly extensively applied in all large works and mills, though on the one hand bringing considerable material advantages to the proprietors, has, on the other, greatly influenced the depreciation of the level of technical knowledge among the workmen, by confining that knowledge within the limits of narrow specialization.

The technical education afforded to young men in almost all the Polytechnical Schools of Europe leaves, theoretically speaking, little to desire, but is exceedingly imperfect practically, and demands the particular attention of those persons who are entrusted with such instruction.

The peculiar circumstances, by which the young people who have finished the course of the Polytechnicums find themselves surrounded, do not admit before their entering upon an active life, of the acquirement of even a superficial general practical education, but place them in the necessity of devoting all their activity from the first day of their leaving school, and often their whole life, to a narrow specialty. The attention of the Directors of Polytechnical Schools has often been drawn to this, and attempts have frequently been made to familiarize young people at school with the practical work of mechanics, but all these endeavors have proved to be unattended with success from the following reasons:

1. The school workshops for the practical occupation of the students were constructed on a very miniature and inconsiderable scale.
2. The consequent want of room in these workshops did not admit of all the students being occupied at the same time, and therefore their attendance was not obligatory, while the majority of the professors and masters expressed their disapprobation of such employment.

3. There existed no systematical method of practical instruction in the workshops similar to that which had been applied to the practical teaching in the chemical laboratories.
4. The material resources assigned for the maintenance of the school workshops were very inadequate.
5. The time allowed for the full course of study in the Polytechnical Schools was insufficient to admit of the combination, in that course, of theoretical with practical instruction in technology.

Though there have appeared some literary articles against the introduction of practical instruction with workshops into the higher technical schools, yet it is our subjective opinion that those articles appeared only in defence of the existing order of things, and to justify a certain lukewarmness in introducing advantageous measures, but no demonstration of the results of trial were afforded among the arguments against such a mode of instruction, for the simple reason that excepting feeble attempts, no serious experiments have been made. Even those attempts themselves were made without any particular energy and due observativeness.

We do not here take into calculation some of the at present existing technical schools of France, which possess sufficiently extensive school workshops,[1] because those schools belong rather to the lower class technical institutions, and do not give to the world mechanical engineers and constructers, but only foremen (contremaîtres).

The slight acquaintance of learned technologists with practical work in mechanical workshops, entails the unfortunate consequence that in the greater number of even very extensive works the practical part remains in the hands of routined artizans who have received no scientific instruction, but who have attained their exceptional position by accustoming themselves during the course of many years to the most obsolete methods of practice in the mechanical art.

Seldom do the rays of science penetrate that unenlightened sphere of labor, and, meanwhile, it has so long demanded scientific guidance.

The Imperial Technical School of Moscow, the course of which, from the theoretical subjects taught therein, equals the course of many of the Polytechnical Schools of Western Europe, combines theoretical with practical education, and consequently is enabled to present real proofs of the possibility and advantageousness of such combination, since the trial of this combination has been made on an extensive scale, and during a considerable length of time.

Every thing that we have exhibited at the international exhibition relates exclusively to this, in our opinion, important question, and was exhibited in the desire of sharing with specialists in the

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[1] These are the schools of Chalons, Aix and Angers.

work of technical education in the New World, all those results which have been attained by the School in the independent investigation of this special question.

For the practical education of young men in the two branches,—mechanical engineers and mechanical constructers[1]—the school possesses large mechanical works with hired workmen, accepting and carrying out orders from private individuals, and on a commercial footing, for the construction of steam engines, working engines, pumps, transmissions, agricultural machines, etc.[2]

The works consist of the following shops: Joiners' shop, Engineers' shop, Erectors' shop, Painters' shop, a large Forge with steam hammer and fan blast, iron foundry with furnace for 3000 kilogr. of metal, and brass foundry; the works have also a drawing-office and counting-house attached to them.

A steam engine of thirty horse-power is used for the working of the place, while the foundry with fan blast and coal pulverizing-mill are worked by an engine of ten horse-power.

The works are under the management of the head mechanical engineer (vacant) and his assistant, Platonoff, mechanical engineer.

The drawing-office is in the charge of Petroff, mechanical engineer. All the mentioned persons have passed through the course of our school.

These works being within the walls of the institution itself, and managed by well-instructed technologists, would be of important assistance in the instruction of young people, even if the young people took no active part in the practical working of them.

But in order that the pupils may derive the greatest possible advantage from such auxiliaries, the school possesses, apart from the mechanical works, and intended solely for the use of the pupils, school workshops: joiners' shop with turning lathe, pattern shop, metal turning, fitters' shop, smithy and moulding shop.

Every one of these shops is under the management of a technologist — specialist,[3] or of a skilled workman, and their duty is to instruct the pupils in the rudiments of mechanical labor.

Every young man becomes acquainted, by fulfilling the obligatory programme, with all the work of mechanical art, namely: turning, fitting, carpentering and forging, in the school workshops, and only then is admitted to the mechanical works.

We shall endeavor to speak further, on the system of teaching the arts in the mechanical workshops of the school.

Up to the present time throughout the world, the workmen at industrial works and mills are usually self-taught. Any one who

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[1] Young men studying the technological engineering branch are admitted to the laboratories instead of the mechanical workshops.

[2] These works execute private orders to the sum of from 35,000 to 46,000 dollars annually.

[3] The wood turners' shop is in charge of Mr. Adelmann, the smithy — Mr. Bouroff, carpenters'— Mr. Michaeloff, metal turners'— Mr. Markoff, moulders'— Mr. Koumenius, and the fitters' shop—Mr. Sovetkin, mechanical engineer.

has himself been employed at works, and is familiar with the daily life of the workman in the different countries, must have perceived that the acquirement of knowledge and skill in any trade is to him a process much similar to the following: a boy of thirteen or fourteen years of age having entered a mechanical works to learn his trade, is put during the first few years, to work of an entirely unproductive kind, and which has not the slightest relation to technics. He is made to carry water, sweep the workshop, crush emery, grind colors, etc. Only after the lapse of a few years, and probably, thanks to accidental circumstances, a chisel or a file is put into the hands of the youth, and he is set to perform the rudest and simplest kind of work.

Then, also, if he happen to have neither father nor brother among the workmen around him, he begins learning his trade without a guiding hand, and thus commences acquiring practical knowledge and skill in his trade by observing those about him in the workshop, and by his own thought and calculation, and impelled by the sole desire of attaining in as short a space of time as possible the position of a paid hand in the works. There can be no doubt that under such circumstance the acquirement of skill by the new generation of workmen takes place in an extremely irrational manner, and without any system; the amount, of knowledge obtained depends upon accident, and the time thus employed is of disproportionate length. Besides this, there is yet another inconvenience, namely, that of specializing labor to too fractional a degree. The young workman, placed accidentally either to a drilling or planing machine, or a self-acting lathe, endeavors to remain as long as possible at his machine, encountering, it will be understood, no objection on the part of the heads of the workshops, since such specialization of labor redounds to the advantage of the proprietors, owing to the abundance of hands.

This order of things has the deplorable result, that notwithstanding the long continued stay of the young workmen at mechanical works, and which is sometimes prolonged through the major part of the years of their manhood, well-taught and skilled fitters are almost everywhere rarely to be met with. This will be confirmed by all those constructers who demand skilled labor for the erection of models, and of the more or less delicately constructed instruments, machines and apparatus.

During the past few years endeavors have been continually made to open schools for the instruction of the workmen at all works of any considerable extent. The subjects taught in these schools are free hand and linear drawing, arithmetic, and many others, in the supposition that practical knowledge of works will be acquired in the works themselves.

From this it is impossible to conclude otherwise than that society, while taking measures to civilize the working classes, gives, at the same time, no attention whatever to the manner in which the young workmen acquire practical experience in their trades at the works; no endeavors have been made in that respect, and, meanwhile, as is our subjective opinion, the question is worthy of particular attention.

The conclusion, however, forces itself upon us that this question can hardly be entered into until the young well-taught technologists, leaving Polytechnical Schools, shall themselves possess rational experience in practical hand labor. In order that their education as specialists shall be full and ample, such knowledge is indispensable in the highest degree, though until the present time, it has unfortunately presented a prominent deficiency in their instruction. Who will not admit that the knowledge of the manner of executing given work is a necessity to one who has to issue the project of such work?

Acting on the principle that mechanical engineers and mechanical constructers, whose future activity will be devoted preeminently to mechanical works, should have practical experience in the mechanical arts, the imperial Technical School has employed every necessary measure for the solution of this difficulty in the best possible manner.

In 1868 the School council considered it indispensable, in order to secure the systematical teaching of elementary practical work, as well as for the more convenient supervision of the pupils while practically employed, to separate entirely the school workshops from the mechanical works in which the orders from private individuals are executed, admitting pupils to the latter only when they have perfectly acquired the principles of practical labor.

By the separation alone of the school workshops from the mechanical works, the principal aim was, however, far from being attained; it was found necessary to work out such a method of teaching the elementary principles of mechanical art as, firstly, should demand the least possible length of time for their acquirement; secondly, should increase the facility of the supervision of the gradationary employment of the pupils; thirdly, should impart to the study itself of practical work the character of a sound, systematical acquirement of knowledge, and fourthly, and lastly, as should facilitate the demonstration of the progress of every pupil at every stated time. Everybody is well aware that the successful study of any art whatsoever, free hand or linear drawing, music, singing, painting, etc., is only attainable when the first attempts at any of them are strictly subject to the laws of gradation and successiveness, when every student adheres to a definite method or school, surmounting, little by little, and by certain degrees, the difficulties to be encountered.

All those arts, which we have just named, possess a method of study which has been well worked out and defined, because, since they have long constituted a part of the education of the well-instructed classes of people, they could not but become subject to scientific analysis, could not but become the objects of investigation, with a view of defining those conditions which might render the study of them as easy and regulated as possible.

This, however, cannot relate to those arts which have been hitherto pre-eminently followed by the common and imperfectly educated class of workpeople, but a knowledge of which appears at the present moment, to be of importance to the educated technologist.

These arts are: wood-turning, carpentering, metal-turning, fitting and forging. From what we have already said, it will not be difficult to arrive at the reason of the absence of a strictly systematical method for the study of them, nor why the active working out of such a method, without the aid of enlightened minds, may long remain deferred.

Meanwhile the necessity of such a method, more particularly for technical educational establishments, admits not of the slightest doubt, and the filling-up of this want promises evident advantages, not only in the matter of scientific technical education, but also with regard to the practical instruction of the work people, and consequently, the perfection of mechanical hand labor itself, which, from the introduction of specially adapted machinery is, year by year, perceptibly deteriorating.

If we except the attempts made in France in the year 1867 by the celebrated and learned mechanical engineer, A. Cler, to form a collection of models for the practical study of the principal methods of forging and welding iron and steel, as well as the chief parts of joiners' work, and this, with a purely demonstrative aim—no one, as far as we are aware, has hitherto been actively engaged in the working out of this question in its application to the study of hand labor in workshops. To the Imperial Technical School belongs the initiative in the introduction of a systematical method of teaching the arts of turning, carpentering, fitting and forging.

To the knowledge and experience in these specialties of the gentlemen entrusted with the management of the school workshops, and to their warm sympathy in the matter of practical education, we are indebted for the drawing-up of the programme of systematical instruction in the mechanical arts, its introduction in the year 1868 into the workshops, and also for the preparation of the necessary auxiliaries to study. In the year 1870, at the exhibition of manufactures at St. Petersbourg, the school exhibited its methods of teaching mechanical arts, and from that time they have been introduced into all the technical schools of Russia.

The auxiliaries of education employed in teaching mechanical arts were exhibited at the international exhibition of Vienna, and now at Philadelphia, in order that specialists in these matters might become acquainted with them.

The auxiliaries of education appointed for the teaching of any mechanical work whatever, for example— fitters' work, are classed in three categories; to the first of these belong the collections of instruments employed in fitters' work, with which the beginner must make himself perfectly familiar before entering upon work, and afterwards to use these instruments during the execution of the work itself.

To this category relate all those collections of models indispensable to the teacher of fitters' work, for the purpose of demonstration: the collection of instruments most in use for measuring, full size; the collection of instruments, full size, for drilling metals; the collection of instruments, full size, for finishing, from the smithy to the fitting shop inclusive.[1]

Models of files, increased to 24 times the ordinary size, for the purpose of demonstrating the surface of the incision; the collection of models of instruments employed in cutting screws and nuts, increased six times ordinary size, for the study of the direction of the angles of incision; the collection of models of drills, increased six times, for the practical study of the cutting angles; and lastly, the collection of instruments and apparatus for teaching the tracing of yet unworked metal articles. We consider it our duty to draw the attention of specialists to this last collection, for the organization of which we are indebted to our skilful instructor of fitters' work, Mr. Sovetkin, mechanical engineer.

To the second category belong the collections of models appointed for the systematical and gradationary study of hand labor in the fitters' art. These collections have the same signification with regard to the work of fitting as is allowed to scales and exercises in instruction in music. They are so ordered that the beginner may be enabled to overcome by certain gradations the difficulties which present themselves before him. It will be sufficient to glance at the adjoined detailed list of objects contained in these collections, and to examine attentively every object exhibited, to be convinced, that if the pupil, under the guidance of the teacher, carefully fulfils the study of all the numbers embraced in the collections, or rather the educational programme of the art of fitting, he must inevitably, and in the most rational manner, render himself familiar with all the known practical hand labor of this art.

Hence we arrive at the conviction, without any difficulty, that with such a system of teaching art, the supervision of the teacher over the pupils, and his observation of their progress, become exceedingly easy. He need only remark that every number of the programme is executed satisfactorily by the pupil, and putting the following one before him, give the requisite explanations for the succeeding work.

In such a case, the fact of a great number of pupils being occu-

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[1] This beautiful and ample collection could not be sent to the Exhibition in consequence of the limited space allotted to us.

pied at the same time will present no great disadvantage, nor will it increase the arduousness of his duty to any considerable degree. And further, it will be a matter of impossibility that a pupil who has been working during a few years in the workshop, should fail to be able to use the drill, or to trace a part to be worked, though he handle satisfactorily the chisel or the file.

To the third category belongs the collection of such articles, or parts of machines, as in the execution of which all the practical hand labor of the fitter's art is successively repeated, having been acquired during the studies of the previous course.

What we have said in relation to the manner of study of the work of fitting, must be accepted also with regard to the other branches of labor, namely, wood-turning, carpentering, smithy and foundry work. We exceedingly regretted that the limited space allotted to us in the exhibition did not admit of our exhibiting all those collections of auxiliaries to instruction which the School has produced.

In conclusion, we consider it our duty to observe that eight years have already elapsed since the programmes of instruction in the mechanical arts were introduced into the workshops of the School, and they have been found to attain in the most brilliant manner the aim proposed in their introduction.

VICTOR DELLA-VOSS,

Director of the School, and Ex-Professor of Practical Mechanics at the Agricultural and Forest-Academy Petrofsky-Rasoumofsky.

Next I include a condensed catalogue of the exhibit of this School, showing the collections of tools pertaining to each kind of work, and the number of samples which each student must make in each shop. Attention is particularly called to the admirable series, N, O, P, of enlarged models for the practical study of the construction of cutting instruments, in the "School Fitting Shop."

SCHOOL WORKSHOPS.

I. WOOD TURNERY.

MASTER F. ADELMANN.

A. Collection of tools (about 150) for turning wood.
B. Part I. Samples (13) for the successive learning of turning in wood.
Part II. Casting-mould models of details and Machines (30).

II. MODEL JOINERY.

MASTER A. M. MICHAELOFF.

C. Collection of tools (34) for joinery.
D. Collections of tools (46) for joinery. Second series.

E. Samples (25) for the successive learning of joinery and pattern making.
F. Collection of models (25) of usual wood-joinings.
G. Collection of patterns (18) for iron castings.

III. FORGING.

MASTER S. BOUROFF.

H. Collection (60) of forging tools.
I. Samples (79) for the successive learning of blacksmith's manipulations.

IV. METAL-TURNERY.

MASTER A. M. MARKOFF.

J. Collection of tools (55) for turning metal.
K. Collection of tools (75) for turning metal. Second series.
L. Samples (38) for the successive learning of turning metal.
M. Samples (21) for the successive learning of turning metal. Second series.

V. SCHOOL FITTING SHOP.

MODELS FOR THE PRACTICAL STUDY OF THE CONSTRUCTION OF CUTTING INSTRUMENTS.

MASTER D. K. SOVETKIN, MECHANICAL ENGINEER.

Taking into consideration the importance of a knowledge of the proper construction of instruments, and the difficulty which has to be overcome in explaining to a whole mass of pupils the minutest details in connection with the direction and the angles of the incisive portions of instruments, we, already in the year 1872 endeavored to construct wooden models, representing instruments on a considerably increased scale. Part of these models was exhibited by us at the Polytechnical Exhibition of Moscow, in the year 1872.

Models of instruments on an increased scale present the advantage of rendering it possible for the student to see clearly all the minutest details of the construction of the instrument. The direction of the cutting edges, and also the shape and direction of the level surfaces which form the working part of an instrument, should be studied in the most detailed manner, and how is this possible when these portions of an instrument are hardly to be seen by the unaided sight. Let us take for an example the cut of a smooth-file; is it possible to form a clear comprehension of the shape and direction of the teeth without the aid of the lens? Certainly not. If, then, we form the tooth of the file, increased to twenty-four times the ordinary size, all the surfaces around it will be presented as practically clearly, as will enable one not even engaged in the special study of the matter, to form a clear idea of the shape of the tooth of the file. At the present moment we submit to the appreciation and judgment of the interested public models of the cutting parts of files, drills and instruments for the cutting of the screw, outside as well as inside.

The three following lists will serve as the basis of the entire range of the collections, which represent all the instruments employed in work.

N. Models of drills and countersinks increased six times the ordinary size.

1. Model of cutting edges of a drill (double cutting) for drill-bow.
2. Model of cutting edges of a drill (one cutting) for drill-bow.
3. Model of cutting edges of a drill for crank-brace.
4. Model of cutting edges of a center-bit with long point.
5. Model of cutting edges of a center-bit with short point.

> *Remark.* In models No. 1–5, are clearly shown the shapes of the cutting edges, and also the angles of the working surfaces. From an examination of these drills it will be easily seen the work of such instruments cannot be called good by reason of the irregular direction of the working surfaces.

6. Model of cutting edges of a drill, which edges have the favorable angles for the work.
7. Model of cutting edges of an American spiral-drill, distinguished by stability and exact work.
8. Model of cutting edges of a drill for boring turning-joints.
9. Model of cutting edges of a drill for half-ball borings.
10. Model of cutting edges of a fashion drill.
11. Model of cutting edges of a cone-countersink for wrought-iron and cast-iron.
12. Model of cutting edges of a cone-countersink for brass.
13. Model of cutting edges of a hemisphère countersink.
14. Model of a drill-stock with the cutter, showing its cutting edges and fastening.

O. Cutting parts of files increased twenty-four times ordinary size.

1. Tin-file.
2. Rasp-cut for lead and soft allayage of metals.
3. Sample of the first-course of files for hard metals, in order to show the angles of the working surfaces and cutting edges.
4. Sample of the first course and the second course, in order to show the beginning of file-teeth.
5. Sample of the first course of a smooth-file, in order to show the angles and form of the working surfaces.
6. Sample of the second course for smooth-files.
7. Sample of the second course of a fine cut rasp, in order to show the proportions of teeth.
8. Sample of the second course of an armfile, in order to show the proportions of teeth.

> *Remark.* The three last samples show clearly and practically the size of the teeth of the most used files.

P. Screw-cutting tools, increased six times ordinary size.

1. Model of a screw-tap with conical nucleus and thread.
2. Model of a screw-tap with cylindrical nucleus and conical thread.

3–6. Models of screw-taps for nuts having holes not going through (complete assortment).

7. Model of part of a screw-plate for cutting external screw-threads.
8. Models of screw-dies with obtuse cutting angles.
9. Models of screw-dies with right cutting angles.
10. Models of Whitworth's screw-dies.

Q. Collection of instruments (about 90) employed in making apertures of various shapes.

R. Collection of instruments of measurement (43) used in studying the art of fitting.

S. Course I. Time for study, 240 hours. Samples (28) for the successive learning of the filer's trade.

T. Course II. Time for study, 240 hours. Samples (23) for the successive learning of the filer's trade.

U. Course III. Time for study, 240 hours. Samples (24) for the successive learning of the filer's trade.

Remark. The method of systematically teaching the art of fitting was first worked out in the Imperial Technical School of Moscow in the year 1868, and after eight years' trial has proved of immense advantage to the School itself, as well as to those of the Russian technical schools which borrowed that method of the Moscow Technical School at the time of the Petersburg exhibition of the year 1870.

In attestation of the utility of the proposed systematical method of teaching, we may observe that immediately after its being presented to the public in the year 1870, the Imperial Technical School received orders for similar collections from technical schools in Moscow, Petersburg and Odessa.

V. A bench, instruments and apparatus (13) for marking and lining machine-parts to be worked.

W. Collection of models (11) for the demonstrative instruction in the marking and lining; the red lines represent the geometrical axis, and the lines according to which the work must be carried out.

In all that precedes, I have endeavored to set forth, as clearly as I could, the general considerations upon which this system of shop instruction is based; to show that the solution of the problem has been approached from the instruction side, and not from the construction side, and in this consists its fundamental and thoroughly practical character, as part of a system of education. The system presupposes the student's ignorance, and begins at the foundation, both in theory and practice. Every step well taken from such a beginning is a clear gain, and the successive steps have only to be taken to arrive at the goal of success. The complete demonstration, however, is seen in the results exhibited at Philadelphia — results which no mixed, or less systematic system could possibly produce.

Another value of the system is, that it is equally well adapted to the wants of each class, or grade, of students. If one wishes to be a mechanical engineer, and finds that he has the ability to master the highest theoretical questions involved, the amount of shop work will be graded to meet his needs; if, on the other hand, the student looks forward to the rank of a first class machinist, he will need more mechanical dexterity, and will therefore work out a larger number of examples, and be required to do less in the higher mathematical and theoretical studies.

It is also an exceedingly important feature of this system that the instruction shops are the least expensive to equip and maintain — and further, it is not necessary for the highest success of this instruction, that construction shops should also be immediately connected with the school, either as at St. Petersburg or at Moscow. The young engineer, or machinist, after graduating in such a course, will find no difficulty in completing his practical education in great manufacturing works, and probably under circumstances quite agreeable to those who have already spent all they could borrow to complete their chosen course of study. Further, the system applies equally to all industrial arts needing manual skill.

Even, now, the Department of Industrial Design, established in this Institute four years ago by the Trustee of the Lowell Institute, and which has in this short time attained such marked success, needs that its course of study should be materially widened and enlarged before it can take rank as a school of technical education in the textile manufactures. Practical instruction in weaving, the study of the textile materials used in the various fabrics, with the operations of spinning, scouring, fulling and finishing, should be added. Systematic school instruction in such specialties has so long existed abroad as to have become a recognized element in the quality of their textile manufactures. If Massachusetts expects to keep the lead in the quality of her industrial work, it must be done by the establishment of technical schools for teaching the manipulations, with such other special knowledge as each particular art requires. In each case the details must be worked out simply as an educational problem, and the instruction put in charge of an expert specialist, who understands theoretically and practically the particular manipulation. With the same skill, energy and perseverance, as are needed to command success in the teaching of any subject, we shall not fail of corresponding success in the teaching of practical industrial art. With the ability to make will come the desire to create, to those who have the capacity to rise into the higher realms of their chosen art.

In the light of the experience which Russia brings us, not only in the form of a proposed system, but proved by several years of experience in more than a single school, it seems to me that the duty of the Institute is plain. We should, without delay, complete our course in Mechanical Engineering by adding a series of instruction shops, which I earnestly recommend. The whole matter turns upon getting the proper rooms. It is already clear that there are no other difficulties which can not readily be surmounted. With such shops once established, we shall also be prepared to offer instruction to those who wish to become constructers, rather than engineers, and especially to the large class of pupils to whom such a systematic training, properly supplemented with other studies, would prove a valuable foundation for further study, or for business. For these classes of students I propose the following outline of a

TWO YEARS' COURSE IN PRACTICAL MECHANISM.

To be admitted to this course the applicant must be at least fifteen years of age, and must pass a satisfactory examination in the following subjects: — Arithmetic, Geography, Spelling, Punctuation, English Composition, English and American History, and Algebra through simple equatious.

FIRST YEAR.

		No. of Exercises	Hrs. per week
Shop Instruction		120	12
Algebra	1st half	45	3
Plane Geometry.	2d half	45	3
Rhetoric and Composition		90	3
Mechanical and Free Hand Drawing . .		90	3

SECOND YEAR.

		No. of Exercises	Hrs. per week
Shop Instruction		120	12
Algebra finished	1st half	45	3
Solid Geometry	2d half	45	3
English Literature		60	2
French		90	3
Mechanical and Free Hand Drawing . .		90	6

With the sets of samples of shop-work which will come to us at the close of the exhibition at Philadelphia, and the averages of the times needed to make each, taken from the shop records, and other information kindly promised by Dr. Peters, we shall be able to start with reliable data upon which to build.

JOHN D. RUNKLE, *President.*

Mass. Institute of Technology,
Boston, July 19, 1876.

SUPPLEMENTARY STATEMENT.

Since the issue of my report upon the Russian system of shop-work instruction for engineers and machinists, so many persons who have read it have asked me if I would give them a simple, concrete illustration of the system, that I fear I may have failed to make the matter entirely clear, and I will try, in a simple way, to present the idea, which would be entirely unnecessary if I could only show the series of instruction-samples made in the several shops, now on exhibition at the Centennial.

Clearly, the first step in practical mechanism is to teach the use of tools. Suppose that we have, say, fifty young men to teach. Now we can put the same tool or set of tool into the hands of each, and teach all together, as a class, or we can put a different tool or set into the hands of each, in which case the instruction becomes special to each, or individual instruction. In the first case, one teacher can systematically teach the whole class, and in the second case, to give each pupil equally good instruction, it will need as many teachers as pupils, without some of the teachers happen to be experts in the use of more than one set of tools; and at best it would clearly require in the second case several teachers. It must be plain that on all accounts it will be best to follow the class system, and teach all the use of the same tool or set of tools at the same time. It follows, then, that our shop must be fitted with fifty sets of tools, if this happens to be the number of students which can be well taught at once.

Now, it is plain that, to learn the use of the set of tools selected as the beginning of the course, a certain number of forms must be worked out, the number being determined by the amount of skill which it is important the particular class under instruction should acquire. Next, what should guide us in the selection of the forms to be worked out? If we examine a certain number of constructions, say machines made entirely of metal, we shall find that some of the parts are made or finished with the set of tools under consideration. Now, it is not necessary that we should select these exact forms, but the whole end will be gained by devising and working out a series of typical forms, each of which will only vary from the actual ones to a limited extent, according to the special construction in which it may be needed. When the course in the first shop, say the filers' shop, is finished, the class is put into a new shop to learn the use of another set of tools, and so on until the use of all the tools used in the construction of wood and the metals is learned. It will be seen, then, that the samples made in each shop are made simply and only for instruction, in order that no conditions may enter to interfere with the system best adapted for this end. Next, it must be remembered that while the class is learning the manipulations of each set of tools, and thus learning at the same time to construct a *typical alphabet of mechanism*, the theory involved in the construction of the tools is systematically taught, — that is, the reason why each tool is so made and how it must be kept in order. Besides, each sample is made from drawings which the student has previously made, thus making this instruction also conform to actual practice.

Thus far the whole aim has been to give the student skill in the use of all the tools pertaining to the course, and now, and not before, he is prepared to be transferred to a construction shop. The Russian system is then a fundamental analysis of the problem of practical mechanism, and consists in teaching the theory and use of tools to classes of students in the same orderly and progressive way in which any other subject is taught, with the same supervision and instruction of a specially qualified teacher, holding each student to the same account and giving him the same credit as in other studies. In this way of teaching it the study of practical mechanism also becomes a discipline of positive value in a system of instruction. The theories involved in the construction of machinery have nothing to do with learning the use of tools, and the entire aim in a construction shop is the production of results based on the skill of the workmen engaged.

In addition to the foregoing analysis it will hardly be necessary to extend this letter, by showing in what ways a shop arranged for construction is unfitted for the class system of instruction in the use of tools, even if such a shop could be devoted to this purpose. I hope I have now made the Russian system plain to all who will take the pains to give the subject a little thought, and particularly from the educational point of view. As a system, it is fundamental, applicable to all industries needing manual skill, easily manageable as an element in a systematic course of instruction, economical of the time of the student, and of the funds of the institution. When the manual skill of the student has a commercial value, as it will have when he has thoroughly mastered the course upon the use of tools, then he will be of value in a construction shop; and it only remains to ask whether this shall be a school-shop or one of the great manufacturing establishments with which our country abounds. I presume that but little time need be spent upon the answer.

The students' skill is worth more to a manufacturing establishment than it could be to a school, even if manufacturing was one of the proper functions. Besides, under the best supposable circumstances, all the economic conditions upon which success in manufacturing depends could never be realized in a school-shop. Therefore our aim will be to build up the instruction-shops authorized by the Corporation of this Institute, and leave the young engineer or machinist to enter at once upon the broad field of his chosen career, for which he should be well fitted if he and his instructors have faithfully done their duty. It is not necessary for a school to operate a railroad to teach its civil engineers, nor work a mine to teach its mining engineers, nor maintain a menagerie to teach natural history.

JOHN D. RUNKLE.

Massachusetts Institute of Technology,
Boston, August 21, 1876.

NOTE.—INDUSTRIAL ARTS IN THE PUBLIC SCHOOLS.

Extracts from "A Report of the Committee on Education, made to the House of Representatives of Rhode Island, at its January session, 1877, by Henry H. Fay, Chairman."

The subject is considered under the following heads:—

1st. The proper limit of free education.
2d. The importance of the High School in the system.
3d. The variety and kind of instructions in the schools.
4th. Industrial Art Education.

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INDUSTRIAL ART EDUCATION.

Recognizing the fact that our public school system is not perfected beyond criticism or improvement, and that it is progressive in its nature, as well as elastic in its adaptation to the wants of the people, we must take cognizance of the sentiment quite prevalent in the community, that the results are not fully commensurate with the expenditure of money, and that the element of "practicality" is not as large a factor as it should be, in the great educational problem of the period. The importance of this opinion is acknowledged by the warmest friends of public education, and the popular demand has become so urgent, that at last it has found expression in that part of the resolution before us, requiring a consideration of the question of industrial art education in the public schools.

The subject of industrial education is by no means new, and were it only the *general* subject, referred to us, the task would be easier than now, since we are confined to the specific consideration of its aspect as an integral part of our present established system, or at least a supplement of it. We find that we are not the only inquirers upon this subject, as our investigations have developed the fact that, in all parts of our country, the subject has recently risen to prominence, and school-boards, educators, and legislators, are seeking for information. The National Board of Trade of the United States has interested itself in this matter, and in January last, sent a memorial to this General Assembly, as to each of the legislatures of the other States, reading as follows:—

"Your memorialists, representing merchants and manufacturers of the United States, beg leave respectfully to represent unto your Honorable body, that the interference and dictation of Trades Unions, and similar organizations, with the system of apprenticeship in earlier times prevailing in this and other countries, the active competition of foreign manufacturers with American industries in both home and foreign markets, and the increased attention being given by governments abroad, to the development and improvement of skilled labor, by instruction in science and art, as applied to mechanics and manufacturing, renders it in the opinion of this Board of great importance to our material progress, that suitable provision be made for the establishment of Art and Science schools in each of the several States, where workmen and their children may receive such technical instruction as will improve and create skilled labor, to the end that the poorer classes of society may become better fitted for a higher development of industry, and our mechanical and manufacturing interests be enabled more successfully to compete with those of other countries; therefore, your petitioners would respectfully pray that your Honorable body will adopt measures for the establishment of such a school, or schools, as is herein indicated, within the State of Rhode Island.

Respectfully submitted, by order of National Board of Trade,

FREDERICK FRALEY,
President."

JANUARY, 1877.

NEGLECT OF INDUSTRIAL EDUCATION, A NATION'S WEAKNESS.

The Universal Exhibition in 1851 at London, bringing together, for the first time, so extensive a collection of the industrial products of all nations, enabled each one to obtain a correct view of its own condition compared with that of others. The succeeding exhibitions in 1856, 1861, and 1867, furnished valuable lessons to all of the European countries, but especially to England, whose utter discomfiture at the Paris Exhibition in 1867, led to systematic inquiries as to the reasons for the more rapid progress made in other nations in many of those industries in which, everything else being equal, the English ought to excel. Government commissioners, composed of representatives of the educated professions, applied sciences, engineering, education and manufactures, were sent to the Paris Exhibition, and a deputation of over fifty skilled artisans, also, whose reports all concurred in the statement that the superiority of other nations in industrial products was due entirely to the greater interest given to the industrial education of their people.

These statements, admitting inferiority on their own part, noting the rapid advancement of other countries since previous exhibitions, and attributing it solely to the one cause, were most startling, and thoroughly alarmed all Englishmen who had patriotic pride in maintaining for their country precedence in manufacturing and mechanical industries.

They examined continental systems of industrial education, published elaborate reports, and at once adopted such educational measures as were deemed useful to them. During the last ten years since the Paris Exhibition, England has made wondrous efforts in this direction, and her advancement in the industrial arts was made manifest by the many exhibits of her productions at the Centennial Exhibition last year. Meanwhile, other European countries, taught by experience, had also improved upon the industrial schools, which had given them the advantage of at least one generation of workmen, and were determined to continue in the lead.

The French manufacturers did not fail to note the extraordinary exertions England was making to contend for precedence in industrial arts. They called the attention of the Government to the matter, and demanded increased educational advantages, in addition to those already in existence. A government commission, upon full investigation, learned that their system was very defective in comparison with that of Germany, and the result was an energetic movement on the part of the State and of parties interested, which has, long ago, worked a great improvement in every branch of industry.

Switzerland, Germany, Austria, Russia, and other countries, were alike stimulated by the necessity of the case, to renewed interest in all that pertains to the advancement of the arts of industry, and their schools, which had been good, were made better, while those which had been best of all were advanced to a still higher standard. The process of improvement is still going on, and will continue to receive the utmost attention in each country that hopes to compete in the markets of the world with the products of her industry.

However satisfactory may be the present development of Rhode Island mechanical and manufacturing industries; whatever there may have been of inventive genius, artistic skill or business enterprise, to arouse feelings of pride in our achievements in the past, we must not lapse into a spirit of self-complacency, but rather take to ourselves the lesson from the experience of other countries, that no State can secure and maintain pre-eminence in mechanics and manufactures except by the systematic and thorough training of the young in the industrial arts; that the palm of superiority, by an unfailing law, will surely go to that country where the *hand of the laborer is guided by a cultivated taste and a scientifically trained intellect.*

From the last census of this State, we learn that in every 1,000 of our population, 560 are engaged in manufacturing or mechanical industries, and this fact in itself is sufficient to give us an interest in the great question of industrial education, and should lead us to the adoption of any measures that furnish a prospect of success in solving this great problem.

It will be interesting to briefly note what has been done in European countries, where, as we have stated, the interest in this subject has become synonymous with their self-interest, and where the competition of different countries has compelled attention to it, under penalty of banishment from the best markets of the world.

Industrial Education in Germany.

The system of general education in Germany is well known as being most comprehensive, and as having been successful in reducing illiteracy toward its minimum, but in its arrangements for industrial education it is equally broad and systematic. The proportion of the population engaged in mechanics and manufactures is less than in Rhode Island, but there is no place of any considerable size wanting in some sort of instruction having in view the various industries.

" Improvement " schools, " Real " schools, " Trade " schools, " Weaver's " schools, and special schools of many kinds, are found thickly scattered over the entire country, affording facilities not only for general, but for special, technical instruction that are unsurpassed. In the lower order of these institutions, there is a similarity to our elementary schools, with the distinction that, *invariably*, the strictest attention is given to instruction in *drawing.* Of the secondary schools, we give the curriculum of one of the best, styled the " City-trade School of Berlin." It was founded " to give a more appropriate education for the mechanic arts and higher trades than can be had through the courses of the other schools," and has the city of Berlin as its patron. The subjects of instruction are Religion, German, French, English, Arithmetic, Algebra, Geometry, Geography, History, Natural History, Physics, Chemistry, Technology, Writing, Drawing and Vocal Music.

The school is provided amply with laboratories, apparatus, and all the paraphernalia of instruction, and technology is taught by describing and illustrating the different arts and trades by models and visits to workshops of which there are none connected with the institution. Pupils enter after they are twelve years of age, and remain five years to complete the course. Higher than this in order, and forming the summit in the grade of industrial schools, is the Royal Trade Academy at Berlin, which embraces in its course far more advanced mathematical studies, and has extensive workshops connected with it, where various branches of practical mechanics are taught. The pupil begins with the making of a screw, and proceeds in regular order to the most difficult mechanical operations.

An Industrial Drawing School in Berlin, also, trains designers of patterns for printing silk, woolen and cotton tissues, and paper hangings, together with all the theoretical and practical branches of weaving.

Among the large number whose organization we have noted, the Royal School of Machinery at Augsburg, in Bavaria, is interesting, devoting, as it does, more time to the practical side of mechanics. The requisites for admission are a thorough knowledge of Algebra and Geometry, and a certain amount of practice in linear drawing. The pupils, who must be fifteen years old, pursue a theoretical course in higher Mathematics, Mechanics, Physics, Drawing, etc., but devote an average of three hours daily to the workshops.

The scholar is placed at a vise, and a coarse file and a piece of iron are given him. He practices first in filing planes at right angles, and then parellel to one another, then he does the same with a finer file. Nothing can be done superficially, and no one can go on to other work until he has been thoroughly successful. Next, he is practised in boring, cutting screws and in making faucets. Then comes the turning of round surfaces and of screws, smoothing off, etc., all of which is done with simple pieces of iron, out of which paper-weights, etc., are made. Other simple operations follow until the end of the course, when scholars are generally able to support themselves by work in any factory.

Enough examples have been furnished to show the general scope and variety of industrial schools in Germany, and while from the hundreds of them in operation, covering very many special trades and occupations, we might select some of unusual interest, we have not space for the details in this report.

In Austria, the agencies for the education of skilled labor are of various kinds, and increasing in number. They have, as in Germany, the "improvement" and the ordinary technical schools, but the great impulse which the art-industrial movement has received during the last twenty-five years, has called into existence new establishments of a similar nature, but largely devoted to special trades and industries.

These comprise theoretical schools and school shops, in which the practical and theoretical teachings are combined. The number of these schools has increased in the last five years from *ten* to *one hundred and thirty.* In the highest of the industrial schools, nearly one-third of the time is devoted to free-hand and geometrical drawing.

FRANCE.

France is equally aroused with her continental neighbors to exertions for increased facilities for industrial-art education, and has rapidly augmented the number of schools for the elementary training of the young in this respect. While perhaps, failing to equal Germany in the universality of the system, she compares quite favorably in certain localities, and in the higher class of technical schools.

In 1805, when Napoleon was First Consul, he visited one of the government institutions and was extremely dissatisfied with the answers of the pupils about to graduate, as to their intentions for the future. These, he said. unless they entered the army, would become a "burden rather than an aid to their families." He had observed workmen in the manufacturing establishments who were experts in the manual labor of their trades, but deficient in the theoretical part, and hence he determined to change the course at this institution, so that it should be devoted to "the study of trades, with so much theory as is necessary to their progress." This was done by an order soon after published, and the result has been one of the most successful institutions in the world for this purpose, at Chalons.

The plan has been modified during the last few years, so that instead of teaching a number of trades, it is devoted to general mechanical industries for which theoretical knowledge is indispensable. The shops connected with it are the Pattern shop, Smithy, Foundry and Fitting shop The pupils, who must be fifteen years of age, devote five hours or more daily, to the workshops, in which the general plan of instruction and practice is very similar to that previously described at Augsburg.

The general principles are, to make only one piece of the same kind, and to do all work, as far as practicable, by hand, and with the simplest tools. The school curriculum embraces Mathematics, Drawing, and the elementary branches.

Paris has numerous industrial schools of every grade, and throughout the country are found local institutions, often under the patronage of industrial societies, or established by individuals from philanthropic motives.

Notwithstanding all that had been done previously, a government report after the exhibition of 1867, states that "additional efforts must be put forth to maintain French industry at the level which it has reached, and enable it to meet the rivalry of other countries in fields, once by universal confession, exclusively their own."

The result has been, as in other countries, a period of remarkable activity in this direction during the last ten years, the beneficial results of which were seen in the display of industrial products at our Centennial, and will be far more evident at the next exhibition in 1878, on their own soil.

It would be a pleasing labor, if our time and space allowed, to note in detail the progress of other countries of Europe, and to give comparative views of their advance in industrial art education.

England, Holland, Italy, Sweden, Russia, and the other countries, have been actively working, and in each of them we find much to interest and instruct, but enough has been written to demonstrate the fact that in all of them the problem of industrial education is considered of vital importance, and that in its solution they are many years in advance of our own country.

OUR OWN COUNTRY.

We have had in this country a few technical schools of a high order, whose pupils were instructed in the theory but not in practice, unless we except the chemical laboratory work. A prominent educator, connected with one of the best of them, remarked not long since: "Our graduates go out into the world with their brains well stocked with theories, but *with their hands tied behind them.*"

In occasional instances, institutions have been established where theory and practice were conjoined, as in the Worcester school, and the "Illinois Industrial College," with good results. The latter institution was established by the State of Illinois, in carrying out the intention of the act of Congress in 1862, giving grants of the public lands and prescribing, in return, the promotion of the "liberal and practical education of the industrial classes in the several pursuits and professions in life," as conditions accompanying acceptance. The State of Illinois has added liberally to the original fund, and the university now has property valued at nearly a million dollars, including a system of mechanical workshops and other paraphernalia for a complete industrial training.

In the State of Massachusetts much attention has been given to the subject, and throughout the State drawing has been taught in the public schools, being correctly deemed the true foundation of industrial art.

In Philadelphia, an association of private gentlemen organized the Pennsylvania Museum of Art, early in 1876, and took advantage of opportunities offered at the Centennial Exhibition to secure a large collection of industrial masterpieces to form the foundation of the museum, which like its prototype, the South Kensington Museum, in England, which within twenty years has revolutionized many branches of industry and created new ones, is expected to become an important aid to industrial education and culture.

The teaching of specific trades has often been urged, but the objections are so numerous, and the experience of the past so decidedly in opposition to such a plan, that aside from the difficulties arising from the option as to the particular trades to be taught, the expense of any general system would condemn it.

What is desired, is some system that will teach *the arts which underlie many industrial occupations*; something that will educate the hands and eyes; something that will furnish such a course of manual training as will enable our children, when they complete their course in the public schools, to secure some kind of employment, and not feel that they are incompetent to live, except "*by their wits.*"

If we can secure this, without limiting or abridging the usefulness of the system of education we now have in operation with such great success, we shall succeed in achieving for our day and generation and posterity, a blessing comparable in value with that which the founders of free public schools handed down to us.

In a careful study of very many systems of industrial instruction in Europe, we have found that all agree in one respect, namely, that *Drawing is an indispensable basis.* From the primary grades to the highest institutions of technology, Drawing is invariably a prominent feature of the curriculum. In all of these schools the same general principles are followed in uniting manual and mental instruction, and in familiarizing scholars with the use of tools. The details of instruction in the scores of schools we have studied, have differed more or less, but in nearly all of them the plan of manual instruction involved the methods of the apprentice system. In the school at Chalons, and also in that at Augsburg, there is an advance upon the old methods, but in Russia, at the Imperial Technical School at Moscow, they have taken an entirely "new departure" in manual education, by conforming it strictly to the system and well established principles which have proved successful in developing skill in other arts and sciences. By this system, they *analyze the processes requiring manual skill, and teach each process by itself to a class.*

The first principles are taught, and exercises in practice accompany them, leading the pupil on from the simplest to the most difficult manipulations. Just as in teaching one to play upon the piano, the "scales" and simple exercises come first and receive entire attention, rather than set tunes, which are tried only after months of preliminary practice; or, as in Drawing, the pupil first practices upon straight lines and their various combinations, and then after long exercise, attempts anything requiring skill; or, as in penmanship, the first efforts are upon lines, curves and parts of letters, before writing words; so, in manual instruction at this institution, the systematic progress of the pupil is the paramount consideration.

The collection of implements and pieces of machinery contributed by the Russian government to illustrate the work done at that school, formed an interesting exhibit in Machinery Hall, at our Centennial Exhibition, and furnished to interested observers a definite idea of the plan, system and results obtainable from it.

MASSACHUSETTS INSTITUTE OF TECHNOLOGY.

In response to the polite invitation of President Runkle, who had been informed of the inquiry of this Assembly in regard to industrial education, we spent a day with him, for the purpose of receiving a full explanation of the plan, and of having ocular demonstration of the results thus far achieved. The pupils, since the commencement of the lessons, had completed the course in "filing," and we saw, in the results of only *eighty hours* of practice and instruction, such exquisite workmanship as could not be surpassed by an apprentice of two years' experience in an ordinary shop. We found a class of thirty-two boys at work on a "chipping" exercise, with hammer and chisel, under the instruction and constant supervision of an expert mechanic, employed as teacher of practical mechanics, and it was easy to perceive that the class instruction in this branch of education was as systematic and simple as the teaching of a class in Arithmetic or Grammar in one of our best public schools. Our attention was directed to the fact that these shops are for *in*struction, and not for *con*struction. The object of the labor performed is not to produce salable articles, but to impart mechanical skill, and hence the student can here receive systematic instruction, proceeding from first principles to difficult manipulations, while in ordinary construction shops an apprentice is taught only those things which accord with the convenience and profit of his employer. The fact that the instruction is given to so many pupils at a time, in class, is a marked economical feature, carrying out, as in so many other respects, the analogy with our general system of mental training.

Our space forbids a full description of the many interesting details which came under our observation, as well as any account of the testimony already given by practical and expert mechanics, as well as by thoughtful and skilled educators, as to the wonderful results already secured in this experiment of an altogether novel method of industrial training, but we are fully satisfied that enough has been shown, in the few months of trial, to warrant us in the opinion, that in this well-tried system, at once so simple and so economical, we can find a way to the solution of the great question of the *adaptation of industrial education to our existing system of mental training in the public schools.*

DEPARTMENT OF MILITARY SCIENCE AND TACTICS.

President J. D. Runkle,
Mass. Institute of Technology: —

Sir: I have the honor to render the following report of the status of the military instruction at the Institute during the school year of 1875–6.

The changes, made at the end of the last school-year, were based upon experience of the past, and the desire on my part to fix its status before leaving the Institute so that it should be satisfactory to all connected with it and, at the same time, give useful results. The experience of the year has justified the changes made; so far as the drill alone is concerned, it seems now to be placed so as to be satisfactory both to Faculty and students, based upon the premiss that military instruction shall, *must* be given in good faith. The end of the school year has found the battalion in an increased state of efficiency of drill and discipline. The instruction to the second year class, by lectures and recitations, was incomplete for lack of time to do even the minimum amount of work necessary, productive of a result that can be at all satisfactory. I most earnestly request that the time allotted to the second year work be increased by six exercises, making only thirty in all during the year.

The officers of the battalion during the year were as follows:

Staff Officers ranking as First Lieutenants.

Adjutant: E. F. Williams.
Quartermaster: I. Kirk.
Signal and Ordnance Officer: W. O. Bradford.

Line Officers.

Captains: J. Rich, D. Pierce.
First Lieutenants: L. O. Towne, E. S. Draper, E. C. Miller.[1]
Second Lieutenants: R. Austin Robertson, Jr., Herbert Jaques,[2] F. P. Bronson.[3]

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[1] Promoted previous to Centennial trip, vice Draper not accompanying the battalion.

[2] Vice Miller promoted.

[3] Vice Robertson not accompanying the battalion.

Each and all of these officers performed the duties of their respective stations in a remarkably efficient and satisfactory manner; conscientious and impartial in the execution of their duties, they displayed great tact and judgment in their rather delicate relation with fellow students when assuming, *at stated times only*, the duties and relation of officers to subordinates. More than ordinary capacity was here required, and their ability to successfully perform the duties of their office at the school is a guarantee of their ability to perform similar or even duties of a *higher grade* in actual service.

CENTENNIAL TRIP TO PHILADELPHIA.

Many students were desirous of visiting the Centennial Exhibition, as it would present a vast field for study. On account of the expense involved, a large proportion would necessarily be prevented from attending, if only able to go individually. This objection would be obviated in a great measure if a number would unite in the movement. Enquiries were made to ascertain the cost, and it was found that if three hundred went, the expense of transportation to and from Philadelphia, board and lodging for two weeks would probably not exceed $25.00 per capita. The Corporation and Faculty therefore determined that the trip should be made.

The Corporation of the University of Pennsylvania courteously tendered the University Campus for a camping site. Efforts to get the necessary tents and camp equipage from the United States having failed, an act was passed in the State Legislature authorizing the loan of camp equipage to such schools as are, by the law of the State, required to give military instruction. We were thus enabled to procure the necessary outfit for camping. Through the intervention of Mr. Enoch Lewis, Mr. Phelan of Philadelphia kindly tendered us the use of sufficient lumber to floor the tents and for other purposes. Mr. Lewis procured for us, also, some engine head-lights to illuminate the Campus. Efforts were made to procure reduced rates of admission to the Exhibition, but they were unavailing.

Hon. Geo. B. Loring offered to us the use of the Massachusetts State Building as a place of rendezvous. Mr. and Mrs. Thomas Webster of Philadelphia were untiring in their efforts to secure for the Institute every facility which might be required. Professor Stillé, Provost of the University, placed at our disposal certain facilities which the University building afforded. Prof. Haupt, Prof. Richards and other Professors of the University aided us in many ways to perfect our arrangements.

Professor Robert E. Rogers, with the concurrence of the Medical faculty of the University, gave the use of a large room in the basement for a dining room, as also a number of other rooms for the use of such of the members of our Faculty as were accompanied by their wives. Prof. Ward and Messrs. Ross and Chamberlain did much, previous to and during our stay, to insure us every facility afforded in the building. Medical attendance and many courtesies were extended to us by Dr. Hammell, Superintendent of the Hospital of the University of Pennsylvania. A camping party, consisting of students, left for Philadelphia on June 1st. These laid out the camp, making the tent floors and pitching a large proportion of the tents. The labor performed by this party was severe. Arrangements were made for purchasing provisions and other necessary supplies, as also for the preparation and service of food.

On June 8th, at 4 P. M., the party, numbering something more than three hundred and seventy, started from the N. Y. & N. E. R. R. depot, in a special train for Norwich. The party consisted of members of the Corporation, Faculty, Graduates, former students, students and friends of members of the Institute. We were favored with being accompanied by a few ladies. At Norwich the boat was taken for Jersey City where the party arrived next morning at about 6 A. M. After some vexatious delay at this point, a special train conveyed the party to Philadelphia, arriving at about 10 A. M. The following regulations indicate the routine which was essentially followed during the encampment.

REGULATIONS.

1. The first three days will be devoted to a general inspection of the Exposition.

2. Thereafter the special subject of each day's investigation will be assigned by the head of the department in which the student is enrolled; and each student will be expected to conform to such directions as he may receive from the head of his department in the matter of his special work.

CAMP AND SANITARY REGULATIONS.

3. I. The daily routine will be as follows, viz.:

First Call for Reveille, at 6 A. M.
Reveille Roll-Call at 6.15 A. M.

At this hour every person, unless specially exempted, will be required to fall into ranks and answer his name unless sick. Bedding and blankets will be aired when weather permits.

Sick Call at 6.40 A. M.
Breakfast at 6.45 A. M.
Police Call at 7.30 A. M.

All persons will be required to aid in policing the grounds of the camp, and to put their respective tents in order.

Battalion Drill at 8.15 A. M.
(For the Institute Battalion only.)
Guard Mounting at 9 A. M.

The detail for the daily guard will be inspected and assigned to reliefs. The guard posted during the day will be detailed from the Battalion, and will be in four reliefs; each relief will stand guard three hours and fifteen minutes (in two tours), during twenty-four hours. Members of the guard will not be required to remain in camp, except while posted as sentries, and for one half-hour previous to their respective tours. *They must not, however, allow any chance to prevent their being in camp at the designated time for duty.* The guards posted at night will be detailed from students not in the battalion. Only one relief of the night guard will be permitted to go beyond the limits of the University grounds. The grounds will be thoroughly lighted, and a less number of sentries will be required at night; each relief will probably be posted only once during the night for not exceeding two hours.

Lunch at 12.30 P. M.
Dinner at 6 P. M.
Tattoo Roll-Call at 9.45 P. M.

All *Students* will be required to fall into ranks and answer their names, unless specially excused by the President. Applications for such absence must be made previous to 6 P. M. Blank forms may be procured of the Chief of Squad.

Taps at 10.15 P. M.

At this call all lights must be put out and perfect quiet observed in the camp. Whilst Graduates will not be required to answer their names at tattoo roll-call, nor to apply for permission to absent themselves from camp, they will be required to enter camp and retire noiselessly.

The before-mentioned hours may be changed if occasion requires. If it is found that the Exposition is open at night, the hour for tattoo roll-call will be so fixed as to permit students to remain until it is closed, and have ample time to return to camp. The hour for Reveille will, in that case, be also changed so as to allow at least eight hours for sleep.

4. All students will be required to perform a due proportion of guard, or such other camp duty as may be found necessary. These duties will be so arranged as to cause the least possible inconvenience and labor.

It is expected that the burden of each individual will be comparatively slight.

5. Failures to comply with the above regulations or any modifications of the same, or conduct reflecting upon the good name of the student, or of the Institute, will be met with dismissal from the camp, in which case the funds deposited will be forfeited.

To secure the uniformity of action necessary to avoid confusion, for purposes of police and cases of emergency, a Chief of Squad will be appointed for the members occupying each section of tents. An Assistant Chief of Squad will also be appointed to aid the C. of S in the performance of his duties, and to act for him in case of his absence. The Captains commanding Companies will act as C.'s of S. for sections A. and B.

DUTIES OF THE CHIEF OF SQUAD.

To call the roll at designated times and report unauthorized absence therefrom.

To superintend the police of the grounds in the immediate vicinity of the tents of his section.

To see to the proper arrangement of the tents, ventilation, airing of the bedding, proper disposals of debris, and necessary provisions against fire.

To report any needs for the comfort and well-being of his squad.

To ascertain if any members of his squad are unwell, and to cause them to report to the surgeon at sick call; in case of the patient's inability to move, the C. of S. will report the circumstances to the surgeon in order that the proper attention may be given.

To distribute at stated times the permits given each day for absence.

To aid at all times in the execution of such regulations as may be from time to time considered necessary.

The routine for Sunday will be as follows:

Reveille, Breakfast and Police calls, one hour later than during week days.
Battalion drill will be omitted.
Guard mounting at 9 A. M.
Dinner at 1.30 P. M.
Supper at 7 P. M.
Other calls same as week days.

One or two tents in each section will be assigned for bathing purposes, and tubs will be placed therein. If it is found that any waters in the vicinity can be used for swimming purposes, arrangements will be made to have a boat or other appliances for use, in case of emergencies. All are cautioned not to bathe immediately before or after eating, especially the latter.

A wagon was sent daily to the Exhibition Grounds with a luncheon which was served at the Mass. State building between the hours of 12 M. and 2 P. M. Every aid was given us by Gen'l Oliver, in charge of the building, and he was ever on the alert to add to our comfort and pleasure. Mrs. Vinton freely permitted us to use her kitchen with all its appurtenances. This arrangement enabled our students to enter the Exhibition Grounds in the morning and remain until evening without being put to any extra expense for a mid-day meal.

Hon. John Cummings, of the Corporation, who was in Philadelphia, aided us materially in getting permission from the authorities for the entrance of the wagon and servants, as also in other matters.

The matter of feeding so large a number with but improvized appliances and with persons inexperienced in such work, was one of great difficulty. Many of those to be served were not able themselves to perceive the difficulties inherent in the work, and expected as much as if the party consisted of but twenty or thirty. The difficulties were overcome in a measure and only the most fastidious remained dissatisfied with the commissariat. With the experience derived from this, great improvements now appear to be feasible. All however was done that was possible under the existing circumstances and considering the pecuniary limits no complaint can be reasonably made of the fare. Messrs. Blodgett and Knapp of the Institute, attended to the purchase of the provisions and superintended the management of the dining room.

Considering the great change involved, and the experience of strangers generally in Philadelphia during the exhibition, the health of the party was exceptionally good. We were favored in having with us Dr. Sabin of Brookline, who, acting as surgeon of the expedition, was devoted in the performance of his duties, not sparing himself, treating with such skill that in most cases twenty-four hours sufficed to produce a radical cure. His pleasing, cheering, tender ways did quite as much in producing the desired results as the medical prescriptions given.

In establishing regulations for, and enforcing the discipline of the camp, it was the aim to have the minimum restriction and military work consistent with maintaining good order and securing the proper sanitary conditions necessary for the health and comfort of all. As the object of the expedition was to study the exhibition, as the change of locality, climate, water, and mode of life were in themselves trying, every effort was made to enable the students to economize their vital energies for the work in hand. The military work and display was reduced to the minimum, and in every case was made to yield to the foregoing considerations. The conduct of the students was exceptionally good and the subject of general commendation. I do not think it is possible to gather from any other college or school in the United States, so large a body of young gentlemen who would so earnestly enter into the spirit of their work, accomplish the object of the expedition and have conducted themselves with the same degree of propriety and consideration. As the members detailed for daily guard were not obliged to remain in camp, but report for duty in time to be posted on a specified relief, reliance was placed entirely on their sense of honor and duty.

The adjutant of the battalion, Mr. E. F. Williams, aided by the Sergeant Major, Mr. F. R. Loring, performed the duties of their office in the issuing of orders and making details, etc., most efficiently. This involved no little labor and responsibility, requiring great judgment and tact on the part of the Adjutant.

The Signal and Ordnance Officer, Mr. W. B. Bradford, aided the commandant materially as a staff officer in the execution of many details of the camp.

In the management of the camp and in the execution of all necessary regulations, efficient aid was given by the chiefs of sections, their assistants and the commissioned officers of the battalion. The following is the list of the chiefs of sections and assistant chiefs of sections, viz.:

			Chief of Section.		*Assist. C. of Section.*
Section	A,	Capt.	Pierce.	1st Lieut.	E. C. Miller.
"	B,	"	I. Rich.	"	L. O. Towne.
"	C,		C. F. Lawton.		J. P. Gray.
"	D,		T. E. Schwarz,		C. T. Main.
"	E,		J. B. Gardner,		A. Austin.
"	F,		W. H. Shockley,		C. A. Church.
"	G,	Adjt.	E. F. Williams.		

For the entertainment of the students, a piano was rented and a number of musicians were hired to play every evening. The dining room was cleared and hops were held therein. The students of the University attended bringing their lady friends. Many lady friends of the students, present in the city also attended. All this added very much to the pleasure of our students and caused a larger proportion to remain in camp at night than would have otherwise been the case. The students of the University displayed a kindly and hospitable disposition to our students, exerting themselves to add to their comfort and pleasure in many ways. In recognition of this, a reception was given to them and their friends on the night of June 21st. We were favored by the presence of a large number of ladies. The camp was illuminated and some tent floors having been placed together, out of doors, dancing took place on these and in the dining room. The camp was enlivened until after midnight by the presence of nearly twelve hundred ladies and gentlemen. The entertainment was eminently successful as such.

On the 22d of June a number of the party left for their homes, and on the 23d the larger proportion left returning by the same route they came. Supper and breakfast were served on board the boat by servants returning to Boston with the party. They arrived in Boston somewhat fatigued but in good health and spirits, none regretting having made the trip.

As it was impossible to break up the camp at once, and it was necessary to keep up a portion of it, whilst the rest was being removed, camp equipage packed and grounds cleared, about fifty professors and students remained until June 29th and 30th. A small camping party remained until July 5th, when they finally departed.

In the preparation for the expedition and encampment, in the labors pertaining to his office as Quartermaster during the encampment, in the closing up its affairs and return of the large amount of camp equipage and other property, Mr. E. H. Gowing displayed marked ability and business capacity. The duties were laborious and difficult and their satisfactory execution deserves more than a passing notice. He was assisted by Messrs. W. B. Fisher and Jas. H. Tibbits.

To the gentlemen mentioned not connected with the encampment, thanks are due for the interest and kindness shown. I wish to express my warm appreciation of the efficient and unselfish manner in which the students occupying the various offices of the encampment performed their laborious and sometimes otherwise thankless duties. These were of such nature that in many cases the casual observer would not know of their existence nor of their real necessity and importance. Without this unselfish devotion to their duties the encampment could not have been successful; they therefore deserve the thanks of the Institute. As to the results of the expedition to the school from an educational point of view, you, Mr. President, are more capable of speaking.

The expedition to the Centennial Exhibition will undoubtedly be considered a noteworthy event in the history of the Massachusetts Institute of Technology, and I am pleased that I should have been able to take part therein.

As this is my last report to you previous to severing my official connection with the Institute, you will pardon me for adverting to matters not within my field of work, but which I am impelled to mention by my interest in the welfare of the Institute. In my report of last year, I referred at length to the subject of physical culture, its especial necessity to students, the aid given thereby to mental culture and the great benefits derived from its introduction at Amherst College. I cannot advance any new arguments in the matter. I am most strongly convinced of its importance in all schools. Especially is it necessary at the Institute. Any time and money devoted to this, as a regular part of the curriculum of the school, will produce more than commensurate results and will add much to the future success and reputation of the school, — the spirit of earnest work which now pervades all who enter it will not so frequently reduce their physical strength — they will add to it, do more vigorous mental work and live long enough to accumulate and increase the knowledge and mental vigor necessary for the attainment of success; the Institute will be more likely to be decorated by laurels won by its Graduates. I most earnestly entreat a careful consideration of this subject, being, as it is, of such *vital* importance.

During my tour of duty at the Institute I have observed that a large number of its Graduates, without influential friends, find great difficulty in securing professional employment soon after graduation. With these especially, this is a matter of prime importance. It is always the most difficult step to get the *initial* employment. The Graduates of the Institute are so well prepared, graduation necessarily conveys with it such capacity and preparation, that no doubt can be felt as to the future of the largest proportion. The prosperity of the school is inseparable from the prosperity of its Alumni. The sooner these become prominent in the Engineering and Scientific world, the more quickly will the Institute acquire the reputation which is its due, and the material prosperity which will be brought to it by the aid of its Alumni. It will be enabled by them to enlarge and improve its field of work and to increase its attendance.

This may be brought about primarily, by the efforts of the members of its Corporation and its Faculty, by using the influence and interest which many of them possess in the business and educational world. Secondarily and finally this work may be taken up and carried on by the Alumni Association. Each Graduate will feel it his duty to the school to endeavour to secure employment for other Graduates. No one can be so placed but that opportunities will present themselves; a strong esprit de corps will be created. They will not so often feel that their interest in the Institute closes with their immediate connection, and both the school and its students will be benefitted.

I am extremely desirous of seeing the work, which I have endeavored to shape so as to give the best results within its circumscribed limits, carried on successfully. In order that it may attain the highest degree of success possible within those limits, it is absolutely indispensable that it should receive the ungrudging, unqualified, hearty support of the Faculty. Let it be considered that the military instruction is inevitably in the Institute as a necessary part of its creation and existence — that experience has shown that it is not detrimental to its interests as a scientific school if properly managed and circumscribed — that it is desirable to make this portion of its curriculum as thorough, within its apportioned limits, as other work of the school — that it will be of benefit to the nation in the emergency of a war — that it is the desire to cause this work to be carried on in good faith with the Government — that it will be considered less a hardship by the students if they observe that the work is inevitable and it receives the hearty support of the Faculty. For these reasons, therefore, I most earnestly make the parting request not alone to accord the Military instruction a passive but an active and generous support — that efforts be made to make it absolutely attractive to the students. A careful consideration of this subject will surely indicate that such a course is the only one open, in order to give stability to the department of military instruction, prevent its being detrimental and a source of constant irritation.

In parting from you officially let me express my appreciation of your unfaltering support and the courtesy with which I have been almost invariably treated by the members of the Corporation, Faculty and Students of the Institute, during nearly four years of duty, which necessitated, on my part, a course absolutely distasteful and obnoxious to many. Amongst the students I have found a very large proportion, who, if life is spared them, will take a high standing in any field of work which they may undertake — I have found that the general moral tone of the students, as a body and as individuals is higher than in any other school that has come under my observation. In reviewing the time spent by me at the Institute, I can not help but feel that, balancing all things, it has been both pleasant and profitable to myself. I will always feel an interest in its welfare, and will endeavor to further it and the interests of its Students and Graduates whenever the opportunities to do so can be seized.

I am Sir,

Very sincerely and respectfully,

E. L. ZALINSKI,

1st Lieut: 5th U. S. Artillery.

LOWELL DEPARTMENT OF INDUSTRIAL DESIGN, FOR 1875–76.

President J. D. Runkle:—

At the close of the fourth year of my department, I have the honor to submit to you the following report of the progress attained by my pupils. Of the entire number of graduates, twenty-four, twenty-two have received situations as designers and finishers in different mills in the New England and Middle States. During the past year the school has had two public exhibitions, one in Boston, the other in Philadelphia, at the Centennial Exhibition. At both places the exhibitions were well attended and a large and varied collection of patterns was displayed. At Philadelphia we were awarded two diplomas, one by the Women's Department; the other by the General Commissioners. The reasons assigned by the latter for their bestowal are as follows: "For the beauty, and general merit of the drawings exhibited; for their useful effect on various important industries and especially for their bearing upon technical education in general." The advanced pupils have the privilege of exhibiting their designs to manufacturers and frequently succeed in disposing of their patterns.

I would suggest the necessity of more materials as samples of the style of the season, such as novelties in oil cloths, prints, laces, cretonnes, carpets and fancy woolen goods. From these we obtain ideas of the prevalent style and thereby are enabled to suit the market. At present we have only the sample patches from Claude Frères of Paris. After long exertions I have succeeded in obtaining a loom, on which I propose to teach weaving to my pupils. By the aid of the loom, I am enabled to supply a deficiency which has long existed in my department; I can now furnish designers for silk and woolen goods. Without a loom such a thing is impossible; as a designer for silk and woolen goods must thoroughly understand weaving, and the art of putting a design on the loom. During the last few months I have introduced ceramic painting and the decoration of pottery; the young ladies are much interested, and bid fair to make a gratifying success in this branch of art. The following is a list of the pupils in situations, and the place of employment of each.

James L. Folsom . .	Hartford Carpet Co., Thomsonville, Conn.
Alex. Johnston . . .	Pacific Mills, Lawrence.
Sam'l Hudson . . .	“ “ “
Everett Authes . . .	Manchester Print Co., Boston.
Mary Jefferson . . .	“ “ “ “
Elizabeth Mendum . .	“ “ “ “
Carroll S. Faunce . .	Hamilton Woolen Co., New York.
Chas. H. Cowdrey . .	Oriental Print Co., Boston.
William Schroeder . .	“ “ “ “
Howard G. Hinckley . .	Merrimac Print Co., Boston.
S. R. Eaton . . .	“ “ “ “
Edgar Eames . . .	“ “ “ “
Minnie Ricker . . .	Hamilton Print Co., Boston.
Harriet A. Parker . .	Roxbury Carpet Co., “
Henry P. Mabille . .	American Print Co., New York.
Annie D. Stimers . .	Sprague Print Co., “ “
John H. Tarbell . . .	Donnell Manufac. Co. “ “
Kate T. Simonds . . .	David Browne & Co., Philadelphia.
Edward Williams . .	Lithographer, Boston.
Henry Morse . . .	Carpet Mills, Maine.
Ernest Pierce . . .	Pacific Mills.

Respectfully submitted,

CHARLES KASTNER,

Director.

DEPARTMENT OF ARCHITECTURE.

President Runkle,

Dear Sir: — The department under my charge was fully described in your Report for the year 1875, and but little change has since taken place in it. The only unusual event during the year 1876 has been the exhibition of the work of its students at the International Exhibition at Philadelphia. No drawings were made expressly to be exhibited, the instruction following its usual course, but in addition to those made by students still in the school a certain number were obtained from students of previous years, so that we were able to make a very fair presentation of the work of the Department. The result was unexpectedly satisfactory, and the drawings attracted a great deal of favorable attention especially on the part of visitors from abroad. They were quite unlike anything else in the Exhibition, the American schools not undertaking to cover the ground that we go over, and the foreign schools of similar grade not exhibiting their work. Towards the close of the Exhibition the American Institute of Architects held its annual Convention in Philadelphia, and a valuable opportunity was thus offered of making known to the profession the real issue of our undertakings. At about the same time information was received from Col. J. J. Marin, Commissioner from the King of Spain, that the splendid collection of casts of Moorish and Spanish architectural detail which formed a chief point of interest in the Spanish Pavilion was to be distributed among the educational museums in different parts of the country, and that in addition to those sent to the Museum of Fine Arts in Boston a portion of them would be sent to augment our own collections.

After the close of the Exhibition, accordingly, about fifty pieces of Saracenic and Renaissance detail were delivered to our agent in Philadelphia and are now hung upon our walls. Col. Marin was also good enough to accede to my suggestion, and send us a very interesting set of drawings made in the Municipal Schools of Madrid. At the same time we received from the agents of MM. Dûcher et Cie, of Paris, through M. Albert Levy of New York, six screens, covered with examples of their architectural publications, of great interest and value, and from Messrs. Galloway & Graff, of Philadelphia, a large vase in red terra-cotta, from an original in the British Museum.

Almost all the students then belonging to the Department, with as many as a dozen former students, joined the expedition organized by the authorities of the Institute and encamped for a fortnight on the grounds of the University of Pennsylvania. The points of professional interest proved too numerous to admit of systematic study during so short a period, and in respect of tangible results the undertaking so far as concerns this Department disappointed my expectations. But it was none the less a success, and the young men found that although they had not much to report in regard to the special topics assigned to each, it saved them from wasting time to have their attention thus definitely fixed upon special points of real interest.

Besides the gifts above mentioned a number of volumes of professional interest have been received from Mr. Geo. B. Emerson, from Mr. E. C. Cabot, and from Mr. G. J. F. Bryant, and the Royal Institute of British Architects in London and the Société Centrale des Architectes in Paris continue regularly to send us their publications. We are also indebted to Messrs. Hartwell & Swasey for a large and interesting model of a church erected by them at Fall River. No other important additions have been made to the library or collections, but a good deal of work has been done in re-arranging and cataloguing, and in binding and re-binding books, and the number of diagrams used in the lectures has been considerably increased.

The collections, though thus deficient in new material and without the means of supplying old deficiencies which become daily more apparent, prove more and more serviceable as the work of the department is so adjusted as to bring them into more constant use. As their character and value become better known in the community and as interest in such subjects increases, their range of service becomes every year more extended, the books, drawings and photographs being freely lent to responsible persons when this can be done without inconvenience to ourselves.

But in this respect as in every other the usefulness of the department is greatly impeded by the limitation of its resources.

The number of students, both Regular and Special, has been larger than ever before and of better quality, the two years Special Course affording opportunities for young men who have already had an office training to come and get the training that an architect's office cannot give, of which an increasing number of such students from various parts of the country show a disposition to avail themselves.

I am, very respectfully, yours,

WILLIAM R. WARE.

MINING EXPEDITION TO PENNSYLVANIA.

President Runkle,

DEAR SIR: —Though the long study of the Centennial Exhibition had made considerable drafts on our time, strength, and money, it seemed advisable that the mining students, before our return to Boston, should take advantage of our nearness to the anthracite region and spend another week in seeing something of the great mineral resources of Pennsylvania *in situ.* Accordingly we made up a party of thirteen, of the classes of 1876 and 1877. Arranging for some to join us on the way, ten of us started early Monday morning, June 26th, by the North Pennsylvania Railway, and arrived betimes at the busy town of Bethlehem. Here a walk of some four miles, under a blazing mid-day sun, brought us to the Bethlehem zinc mine, noted for being drained by one of the most powerful pumping engines in the world. The mine itself is of a remarkable character and its irregular veins were yielding a good supply of very compact blende. But the huge engine had to be kept in unceasing motion to render the deposits accessible, and the cost of working had become too great as compared with the contract price of New Jersey zinc ore, and not long after our visit the mine was closed not to be reopened probably for a generation to come. So it seems we had improved almost the last opportunity to go through the intricate, dripping passages of the Bethlehem zinc mine. Returning to a very late dinner in town we afterwards spent some time in the extensive zinc smelting works and took up the rest of the long day in watching two "blows" of Bessemer iron in the immense and well appointed works of the Bethlehem Iron Company.

A night ride brought us to the closely hemmed in town of Mauch Chunk, with its never ending rumble of coal trains. Tuesday morning we found our way to the romantic Glen Onoko all aglow with its lavish profusion of wild rhododendron flowers. Here was scenery that might well stir the hearts of even such delvers in the earth as ourselves, and when we had scaled the heights above and were enjoying the broad view from Lookout Point it was resolved, in our by no means temporary enthusiasm, that a visit to Glen Onoko may make an entirely proper and legitimate part of a mining excursion. The returning train brought us back to Mauch Chunk in time for a forenoon trip up the famous Switch Back railway to Summit station. We took a half mile walk along the surface debris of the burning coal mine and crawled down into one opening far enough to find an ice pavement. Little indication was there of the combustion which has been going on for years, except one or two very faint vents of vapor through cracks at the surface of the ground. When dinner was over we had to hurry a mile down hill, baggage in hand, to catch the train for Tamaqua. At dusk we found good quarters in Pottsville, and while waiting for the arrival of the rest of our party from Philadelphia some of us visited the only blast furnace then at work in town.

The next day we joined the excursion party of the American Institute of Mining Engineers, and enjoyed a rare opportunity of seeing the best parts of the anthracite region. Leaving the excursionists at Reading we waited some time for the westward train, and reached Harrisburg soon enough to have some four hours' sleep before a very early start for Johnstown. So the ascent of the Alleghanies and the ride around Horse Shoe Bend was made by daylight after a breakfast at Altoona, and our westward destination was reached before noon. Johnstown proved a much more comfortable place than the dingy aspect of things there would lead one to expect. We were very courteously received at the extensive works of the Cambria Iron Company, which were in full operation, turning out two thousand tons of rails per week, notwithstanding the great depression in the iron business. But with coal and iron ore on the spot and each costing, ready for use, considerably less than a dollar a ton, this Company may well defy competition. Here was a fine chance to study in one compact area several three foot semi-bituminous coal seams, a thirty inch deposit of iron carbonate, the wholesale roasting of the ore, the manufacture of fire bricks, coal washing, the skilfully planned coke kilns with steam discharging-ram, blast furnaces, puddling furnaces, rail mills, and Bessemer converters, running day and night. Mr. Fulton, the engineer of the Company, devoted his whole time to us for a day, and having studied his work as an investigator was able to give us much new information at first hand. Crouched down in mine cars we had a lively two mile ride underground through the horizontal upper coal seam, and another through the ore bed. We are much indebted to the Superintendent and his several assistants for their kind attention and hearty aid during our very instructive and pleasant two days' stay.

More time might have been well spent, but it was possible, by starting homeward Friday night, to reach Boston before the national holiday and avoid the extraordinary rush of travel to the grand centennial celebration in Philadelphia. As it was, we could not all secure seats in the cars till some of our fellow passengers got out at Cresson Springs. We reached the old camping ground, where a few tents were still standing, in season for breakfast Saturday morning. Here the party was resolved into individuals, some staying longer in Philadelphia, some going on at once to New York, some taking another look at the Exhibition before embarking in the noon train for home. The approaching fourth of July had caused us to crowd a proper fortnight's work into six days, but after a few days' rest I believe no one felt the worse for our flying trip.

I must not close without grateful mention of assistance rendered by Mr. Felton and Mr. Gowen, whereby transportation on the Pennsylvania Central and Reading railroads was secured on the most favorable terms.

Respectfully yours,
JOHN M ORDWAY.

APPENDIX.

CENTENNIAL CATALOGUE.

THE MASSACHUSETTS INSTITUTE OF TECHNOLOGY exhibits:—

1. Two Photographs of its Buildings, in Boylston Street, Boston, and twenty Photographs of the principal lecture-rooms and laboratories.
2. A complete set of printed documents describing its work.
3. A set of elementary Drawings made by students of the First Year in portfolios.
4. Drawings of students in the Department of Civil Engineering, framed and in portfolios.
5. Drawings of students in the Department of Mechanical Engineering, framed and in portfolios.
6. Drawings and Designs of students in the Department of Architecture, framed.
7. Drawings, Models and Samples, illustrating the professional work in the Department of Mining and Metallurgy.
8. Models, Instruments and Papers, illustrating the professional work in the Department of Physics.
9. Drawings and Designs made by pupils in the Lowell Free School of Industrial Design.
10. Graduating Theses in the Departments of Civil, Mechanical and Mining Engineering, Architecture, Physics, Chemistry, Natural History, Science and Literature, and Philosophy.

The exhibition consists entirely of work done in the school, and the apparatus of instruction is not exhibited except so far as it has been devised or made by professors or students.

THE DEPARTMENT OF CIVIL ENGINEERING exhibits:—

I. Sixteen framed drawings.
II. Ninety drawings in portfolios.

The subjects of these Drawings embrace Railroad Surveys, Topography, Stone Cutting, Bridge and Roof Construction, and Original Designs for Structures.

III. Thirteen theses by members of the class graduating this year, as follows: —

1. The Providence, R. I., Water Works, by Thomas Aspinwall, Jr., Brookline, Mass.
2. The Merrimac River Bridge, at Nashua, N. H., by Thomas W. Baldwin, Bangor, Me.
3. The West Chester Park Bridge in Boston, by Joshua B. F. Breed, Louisville, Ky.
4. A Review of the Buffalo Water Supply, by Harry T. Buttolph, Buffalo, N. Y.
5. The Front Street Bridge in Worcester, Mass., by Frederick K. Copeland, Fairhaven, Vt.
6. The Broadway Bridge in Boston, by John R. Freeman, W. Bridgton, Me.
7. The Superstructure of the East River Suspension Bridge in New York, by Martin Gay, Staten Island, N. Y.
8. The Albany Street Bridge in Boston, by Frederick W. Hodgdon, Arlington, Mass.
9. The Iron Bridge over the Merrimac River at Tyngsboro', Mass., by Arthur L. Mills, Everett, Mass.
10. Design for a Wrought Iron Post Truss, by Henry Raeder, Hyde Park, Mass.
11. Draw in the West Boston Bridge, by C. Leon Rich, Morristown, Vt.
12. The Eastern Avenue Swing Bridge in Boston, by Henry M. Waitt, Nantucket, Mass.
13. A Highway Bridge at Haverhill, Mass., by Henry B. Wood, Woburn, Mass.

THE DEPARTMENT OF MECHANICAL ENGINEERING exhibits: —

I. Four hundred and thirteen drawings and tracings framed and in portfolios, as follows: —

Boilers.

1–21	A Martin Boiler.	4 Drawings, 17 Tracings.
22–25	Boiler of Providence Pumping Engine.	4 Tracings.
26–28	Boiler of Monitor Nahant.	3 Tracings.
29–30	High Pressure Marine Boiler.	2 Tracings.
31–45	Cunningham Stationary Boiler.	15 Drawings.

Stationary Engines.

46–82	Harris Corliss Engine, Elevation.	2 Drawings.
	" " " Details.	12 Drawings, 5 Tracings.

83–85	13 HP. High Pressure Engine.	1 Drawing, 2 Tracings.
86	Beam Engine.	1 Drawing.
87–90	Steam Cylinder and Valve.	2 Drawings, 2 Tracings.

Marine Engines.

91–94	Beam Engine.	4 Tracings.
95–100	Engine of Steamer Humboldt.	6 Tracings.
101–109	Launch Engine.	6 Drawings, 1 Tracing.
110	Marine Engine.	1 Drawing.

Locomotive Engines.

111–160	Elevation and Details.	9 Drawings, 41 Tracings

Steam Pumps and Pumping Engines.

161–169	Blake, Lawrence and other Pumps and Pumping Engines.	9 Tracings.

Hydraulic Machinery.

170–175	Cranes and Presses.	5 Drawings, 1 Tracing.

Water Motors.

176–186	Turbines and Breast Wheels.	2 Drawings, 9 Tracings.

Screw Propellers.

187–193	Various examples.	17 Tracings.

Machine Tools, etc.

194–197	Upright Drill.	4 Drawings.
198	Boring Machine.	1 Drawing.
199–206	Car-axle Turning Lathe.	8 Drawings.
207, 208	Steam Hammer.	2 Tracings.
209	Steam Derrick.	1 Drawing.
211, 212	Section of Mill.	2 Drawings.
213–219	Stub End.	7 Drawings.
220–222	Cross Head.	3 Drawings.
223–226	Eccentric.	2 Drawings, 1 Tracing.
227–251	Screws, Cams, Cranks, etc.	24 Drawings.
252–265	Driving Pulley. Boott Mills.	14 Drawings.

Toothed Wheels and their Construction.

266–280	Sector Gears.	15 Drawings.
281–294	Bevels.	14 Drawings.
295–337	Gear Templets.	43 Drawings.
338–341	Sector Gears.	4 Drawings.
342–359	Bevel Gears.	18 Drawings.
360, 361	Gear Teeth.	2 Drawings.
362–370	Rolled Curves.	9 Drawings.
371–382	Course in Gear Construction.	12 Drawings.
383–389	Gear Templets.	7 Drawings.
390–413	Spur Gears.	23 Drawings, of which seven are designs.

These Drawings are not exhibited as evidences of skill in Draughtsmanship, but as graphical reports of some of the information which the Students acquire during their professional course. They are the work of Students, and are about half the drawings made by them during the year.

II. Seven Theses by the Graduating Class.

1. Locomotive Engineering, by Francis E. Galloupe, Lynn, Mass.
2. Steam Boilers, by Clarence L. Dennett, Beverly, Mass.
3. Screw Propellers, by Charles F. Prichard, Marblehead, Mass.
4. The Efficiency of Marine Engines, by Charles T. Main, Marblehead, Mass.
5. Design for a Mechanical Laboratory, by Aaron D. Blodgett, Boston, Mass.
6. Shafting and its Fittings, by Theodore J. Lewis, Philadelphia, Pa.
7. Paper Mills and Machinery, by Sumner Hollingsworth, South Braintree, Mass.

The Department of Architecture exhibits 77 drawings in 60 frames, illustrating the instruction in Architectural Drawing and Design. These drawings are the work of the regular and special students during the last year and a half, and comprise about a tenth part of similar drawings made during that time by about fifty different students.

1. The Drawings numbered 1 to 5 show the Elementary Work taken up at the beginning of the Course. Every student does similar work to this, or its equivalent.

2. The Drawings numbered 6 to 11 are exercises in Architectural Drawing, being fac-simile copies of original drawings, made in the *Ecole des Beaux-Arts*, in Paris, now in possession of the Department.

3. The Drawings "from prints" numbered 12 to 19, involve more independent work than the foregoing, the originals being in most cases small line drawings, without shading or color.

4. The Drawings numbered 20 to 24, are made from free-hand sketches of buildings in Boston, generally without exact measurements. This work is done by the more advanced class.

The work already mentioned is mostly done during the months of October and November, at the beginning of the school year.

The six remaining months, from December to May inclusive, are mostly occupied with a series of architectural problems, made in accordance with written programmes, specimens of which are given.

The subjects of these drawings are:—

1, A Porch; 2, A Campanile; 3, A Summer House; 4, A Pavilion between two Bridges; 5, A Billiard Room and Boat House; 6, The Employment of Six Columns; 7, A Temple Tomb; 8, A Staircase under a Vault or Dome; 9, The Restoration of a Pompeiian House; 10, A Lamp Post; 11, A Fountain; 12, A Memorial Library; 13, A Memorial School House; 14, A Railroad Station; 15, An Artist's House; 16, A Catholic Church; 17, Water-Works in a Park; 18, A Dwelling House; 19, A Farm Barn; 20, A School of Architecture.

5. The rest of the drawings, numbered 25 to 60, illustrate this work.

This Department exhibits two Graduating Theses, illustrated by drawings.

1. A Railroad Station upon a Bridge, by William B. Dowse, of Boston, Mass.
2. Reservoir and Water Works in a Park, by Amos J. Boyden, of Foxboro', Mass.

THE DEPARTMENT OF MINING AND METALLURGY exhibits:

1. Two Sketches of the Mining Laboratory.
2. Two Sketches of the Metallurgical Laboratory.
3. A Novel Assay Ore Dresser.
4. A set of Samples of work done by this Ore Dresser.
5. A Tabular Statement of the System of Ore Dressing used at the Institute.
6. A set of Samples taken from the working of a ton of Ore with the Mining Machinery in the Laboratory.
7. Specimen of Lead from the Practical Treatment of an Argentiferous Lead Ore from Burleigh Tunnel, Colorado, extracted by S. James, Jr., in the Metallurgical Laboratory, from 1100 lbs. of ore.
8. Specimens of Lead from the Practical Treatment of an Argentiferous Lead Ore from the Merrimac Mine, Newburyport, Mass., extracted by W. D. Townsend and Julius H. Susmann, in the Metallurgical Laboratory, from 784 lbs. of the ore.

Six Graduating Theses.

1. The Newburyport Silver Lead Mine, by J. H. Susmann and W. D. Townsend, Boston.
2. The Richmond Blast Furnace, by Thomas W. Robinson, Chicago, Ill.
3. A Report on the Vershire, Vt., Copper Mine and Ore, by R. H. Gould, East Cambridge.
4. The Port Henry Iron Foundry, by C. F. Allen, Cincinnati, O.
5. The Metallurgical Treatment of an Argentiferous Galena from Burleigh Tunnel, Colorado, by S. James, Jr., Cambridgeport, Mass.
6. An Investigation and Report on the Pomeroy Iron Works at West Stockbridge, Mass., by Theo. E. Schwarz, Boston.

THE DEPARTMENT OF CHEMISTRY exhibits:

Five Theses of the Graduating Class.

1. Anthracene, a Coal-Tar Product, by Charles R. Fletcher, Chelsea, Mass.
2. The Action of Chloride of Sulphur upon Spirits of Turpentine, by Albert H. Low, of Chelsea, Mass., and Charles N. Waite, of Medford, Mass.
3. The Action of Tungstic Acid upon Gelatin, by W. P. Atwood, Lowell, Mass.
4. A Practical estimation of the Value of Tanning Materials, together with Points on Tanning, by Wm. E. Nickerson, Somerville, Mass.
5. The Determination of Oxygen in Organic Bodies, by Charles C. R. Fish, Cambridgeport, Mass.

THE DEPARTMENT OF PHYSICS exhibits:

I. *Experiments.*

1. Estimating Tenths.

14. Spherometer.

72. Polarized Light.

These experiments are selected from a list of two hundred, and are performed by students in classes of twenty or thirty.

The apparatus is simple, inexpensive, and not easily injured.

II. *Work done by students.*

1. Curves showing the results of the above experiments.

When two nearly coinciding are given, one is obtained by calculation, the other by actual measurement.

2. Photographs taken by students.

3. Simple Truss Bridge, built by students.

4. Arch Bridge, planned, built, tested and reported upon by E. Holbrook, student.

5. Draw-bridge, planned, built, tested and reported by C. D. Austin and W. T. Blunt, students.

III. *Novelties and Inventions.*

1. Polarimeter, to measure the amount of polarization in a beam of light. Invented by E. C. Pickering.

2. Simple apparatus for drawing Lissajous' curves. Invented by E. C. Pickering.

3. Wind Vane. Invented by W. H. Pickering, student.

4. Micrometer Level, and Mountain Stadia, to determine the height and distance of a distant mountain. Invented by E. C. Pickering.
5. Balance, in which the object to be weighed and the weights are successively placed in the same scale. Invented by E. C. Pickering.
6. Dividing Engine. A cheap and accurate instrument for constructing scales of equal parts. Invented by E. C. Pickering.
7. Plane Table. Invented by E. C. Pickering.
8. Cosine Galvanometer.
9. Simple Galvanometer.
10. Phonautograph Curves, drawn by C. F. Morey, student.
11. Daylight Photometer, made by Charles H. Williams, student.
12. Results of experiments made by students on saving heat by different ways of covering steam pipes.
13. Resistance Coils, made and adjusted by students.
14. Published Memoirs, by students.
15. Text Books.
16. Examination Papers on Lectures.

IV. *Three Theses by the Graduating Class.*

1. The Atomic Theory as applied to Gases, with some Experiments on the Viscosity of Air, by Silas W. Holman, Framingham, Mass.
2. New Experiments in Sound, by William W. Jaques, of Newburyport, Mass.
3. On the Mean Specific Gravity of the Earth, by J. B. Henck, Jr., of Brookline, Mass.

THE DEPARTMENT OF NATURAL HISTORY exhibits:

Two Theses by the Graduating Class.

1. Geology of Eastern Massachusetts, with a Map, by W. O. Crosby, Georgetown, Col.
2. Catalogue of the Alcidæ contained in the Museum of the Boston Society of Natural History, with a Review and proposed Classification of the Family, by W. B. Barrows, of Reading, Mass.

THE DEPARTMENT OF SCIENCE AND LITERATURE exhibits:

Three Theses by the Graduating Class.

1. The Kingdom of Italy, by W. E. Davis, of San Francisco, Cal.
2. The Times of Edward the Third, by Charles H. Heustis of Hyde Park, Mass.
3. The British Provinces of Australia, by Charles A. Sawyer, of Chicago, Ill.

The Department of Philosophy exhibits:

Two Theses by the Graduating Class.

1. Kant's Æsthetic: A Re-statement of it, with some Critical Queries, by David W. Phipps, Boston, Mass.
2. Historical and Logical Relations between Fichte and Kant, by R. C. Ware, Marblehead, Mass.

The Lowell School of Practical Design exhibits seventy-seven designs in thirty-seven frames, the work of its male pupils. The work of the female pupils is exhibited in the Women's Pavilion.

CATALOGUE OF MATERIAL

COLLECTED AT

THE CENTENNIAL EXHIBITION OF 1876.

CONTENTS.

DEPARTMENT I.—EDUCATION AND SCIENCE.

Class.
1. Books and Pamphlets for the General Library.
2. " " " " Department of Civil Engineering.
3. " " " " " Mechanical Engineering
4. " " " " " Mining Engineering.
5. " " " " " Architecture.
5½. " " " " " Physics.
6. Articles constructed from Wood and Iron for purposes of Instruction.

DEPARTMENT II.—AGRICULTURE.

FOREST PRODUCTS.

7. Timber and useful Woods.

TEXTILE SUBSTANCES OF ANIMAL OR VEGETABLE ORIGIN.

8. Wool, washed and unwashed.
9. Hair, Bristles, &c.
10. Silk in the cocoon and reeled.
11. Cotton on the stem, in the ball, and ginned; also Cotton and Fibre Seeds.

AGRICULTURAL PRODUCTS.

12. Cereals, (Wheat, Rye, Oats, &c.,) with their products.
13. Plants used for Food other than Cereals, (Peas, Beans, &c.)
14. Nuts.
15. Fleshy Fruits, (Dates, Apricots, &c.)
16. Thein Plants, (Tea, Coffee, Cocoa, &c.)
17. Sacharine Seeds and substances.
18. Aromatics, (Anise, Dill, &c.)

19. Olengineous Seeds, (Flax, Rape, Dill, &c.)
20. Forage Plants, (Clover, Hay, &c.)
21. Gums and Resins.
22. Medicinal Plants.
23. Miscellaneous Seeds and Plants.

DEPARTMENT III.—MINING AND METALLURGY.

MINERALS, ORES, BUILDING STONES AND MINING PRODUCTS.

24. Mineral Combustibles, (Coals, &c.)
25. Clays, Kaolin, Silex, &c., Earths, and Refractory Stones for Furnace Linings.
26. Limes, Cements, both raw and burned, accompanied by specimens of the crude rock or material used. Also Artificial Stone, Concrete, &c.
27. Iron Specimens in the Pig and Rolled Bar.
28. Collection of Ores and Associated Minerals.

METALLURGICAL PRODUCTS.

29. Lead and Silver, (the result of extractive processes).

DEPARTMENT IV.—MANUFACTURES.

YARNS AND WOVEN GOODS.

30. Cotton Sheeting and Shirting, plain and twilled.
31. Coarse Fabrics of Bark, Grass, &c.
32. Woolen and Mixed Fabrics, Yarns, &c.

METALLIC PRODUCTS.

33. Telegraphic Wires and Specimens of the Insulating Materials in both the Crude and Manufactured states.
34. Specimens of Nails, Tacks, &c.
35. Files and Hardware.

CHEMICAL PRODUCTS, CERAMICS, POTTERY, ETC.

36. Bricks, Drain Tiles, &c.
37. Fire Clay Goods, (Crucibles, Pots, &c.)
38. Tiles, plain, enamelled and encaustic; also for pavements, roofing, &c.
39. Porcelain and Pottery.

DEPARTMENT I.

CLASS 1. BOOKS AND PAMPHLETS FOR THE GENERAL LIBRARY.

169. Abernethy, Alonzo. School Laws of Iowa.
72. American Museum, N. Y. 1st Annual Report, 1870.
73. " " " 2d " " 1871.
74. " " " 3d and 4th " 1872.
75. " " " 5th and 6th " 1874.
76. " " " 7th " 1875.
71. American Museum, N. Y., ceremonies at laying of corner stone, 1874.
5. Argentine Republic. Centennial Catalogue of the Argentine Section.
14. Austria. Katalog. der Osterreichischen Abtheilung.
135. Bankers Building (Centennial Grounds). Report of Opening of Building.
136. Barcena, Mariano. Certain Mexican Meteors.
24. " " The Rocks known as Mexican Onyx, (2 copies.)
11. Belgique. Catalogue des produits industriels et des Œuvres D'Art, (4 copies).
7. Belgium. Catalogue des Œuvres D'Art, (3 copies).
118. Belgium. Construction et Ameublement de Batiments D'Ecole.
94. Bitterlin, Paul et Fils. Catalogue of Publications.
204. Boston College Catalogue, 1874–75.
155. School of Modern Languages, Boston. Report.
107. Brazil. Agricultural Industries for Emigrants.
35. " Archivos do Museu Nacional.
101. " Catalogo da Exposiçao Nacional em 1875.
36. " Descripçao topographica do Mappa da provincia de Santa Catharina.
19. " Estudos sobre A Quarta Exposiçao Nacional de 1875.
102. " Relatorio sobre a pretendida enxertia da canna de assucar, 1876.
34. " Revista de Horticultura.
33. " Subsidies to the formation of the physical map of Brazil.
21. " Supplement No. 1 to Brazilian Catalogue.
27. " Special Catalogue of the Brazilian Section.
98. " The Empire at the Universal Exhibition, 1876.
99. " " " (German)
100. " " " (French)
13. " The Maté of Parana.
20. " Trabalhos Historicos Geographicos. E. Hydrographicos.
198. Brewers' Industrial Exhibition 1876. Essays on the Malt Liquor Question.
53. Buist & Co., Phila. Catalogue and Garden Manual.
124. Canada. Catalogue of Educational Exhibit.
87. " Catalogue of Exhibitors.
134. " Council of Arts and Manufactures.
79. " Descriptive catalogue of Economic minerals.
59. " Educational Institutions of the Province of Ontario.
57. " Information for intending emigrants.
64. " Province of Ontario, Annual Report of Commissioners on Agriculture and Arts.
208. " Rapport sur le service de l'Asile d'Alienes de Quebec.
125. " Report of Fruit Grower's Association of Ontario.

91. Canada. Report of the Select Committee on Immigration and Colonization.
92. " Report of the Surveyor General of Dominion Lands.
209. Carlisle, Henry C. Sixth annual report of the Trade, Commerce, Railroads of Indianapolis.
2. Catalogue du cercle de la librarie de l'imprimerie.
137. Charlestown. Report of the Sect. of Infant-schools.
226. Charpentier, —. Catalogue de la Bibleothèque-Charpentier.
152. Chauncy Hall School. Catalogue.
31. Chicago. Course of study for Public Schools.
97. " Twenty-first Annual Report of Board of Education.
170. Chili. Catalogue of Centennial Exhibit.
171. " " " " in Portuguese.
17. China. Catalogue of the Chinese Section.
189. Christern, F. W. Catalogue of Standard French Books.
220. Clarke Institution. Teaching the Deaf by Articulation.
150. " J. L. History of the Massachusetts Insurance Department.
126. Coldwater. Address to the State Public School.
115. College of Holy Cross. Historical Sketch.
232. Cone, Wm. R. (et. als.). Anniversary of the Retreat for the Insane at Hartford, Connecticut.
143. Connecticut. Hospital for the Insane. Report of the Board of Trustees.
233. " " " Tenth Annual Report.
231. " State Reform School. Twenty-Fourth Annual Report, 1876.
23. Creswell, F. Australia. List of Seeds.
200. Crosby, W. O. Report on the Geological Map of Massachusetts.
139. Deer Island, (Boston Harbor). Pauper Boys School.
190. Delagrave, Ch. Extrait du Catalogue Général de la Librairie.
186. Delahaye, V. Adrien et Cie. Catalogue des Livres de Fonds.
9. Denmark. Catalogue of Danish Section.
144. Doulton Stone-ware and Lambeth Faience.
225. Ducroro, —. Catalogue of the Ducroro Library.
210. Dufferin, Lord. "Canada the place for the Emigrant."
80. Dumaine, J. Catalogue de la Librarie Militaire.
179. Empire Transportation Co. Statements, etc.
236. Fialho, Aufriso. "Dom Pedro II, Emperor of Brazil."
84. Foote, A. E. Catalogue of Minerals.
39. France. Catalogue des ouvrages de Géographie et de Topographie de Institut Géographique de Paris.
85. Germany. Catalogue of Exhibit of Chemical Industry.
4. " Catalogue ot German Section.
123. " Der Buchhandel und Die Graphischen künste Deutschlands.
175. Giovanni Boucenelli e Figli. The Manufacture of Mosaics.
203. Grafton High School. Catalogue, 1875-6.
Great Britain. Catalogue of British Section.
86. Guillaumin et Cie. Catalogue.
172. Hawaii. Statistics and Information.
47. " Hawaiian Guide Book.
153. Heard, J. C. Report of the Russian Ministry of War.
221. Henderson, Howard, A. M. Exhibit of Kentucky's Educational System and Institutions.

222. Henry, James P. Resources of the State of Arkansas.
191. Hetzel, J. & Co. Catalogue of Publications.
141. Highland Military Academy. Report.
118. Holidaysburg Seminary. Catalogue of Officers and Students.
215. Holland. The Artisan's School in Rotterdam.
164. Howard, B. Frank Annual Report of the Pork Packing of the West.
206. Illinois Industrial University. Catalogue, 1875–6.
51. " Report of the Railroad and Warehouse Commission, 1875.
63. " School Report, 1873–4.
37. India. Descriptive Catalogue of Indian Section.
111. Indiana. Agricultural Report, 1875.
112. " Geological Survey, 1875. Cox, E. T.
107. " Institute for the Blind. Twentieth Annual Report.
108. " New school law, and report of the Supt. of Public Instruction, 1872–3–4.
109. " Twentieth report of the Supt. of Public Instruction.
110. " Twenty-second " " " "
89. " Twenty-third " " " " 1875.
45. Iowa. State Facts.
18. Italy. Catalogo degli Expositori Italiani.
48. Japan. Catalogue of Imperial University of Tokio.
30. " Catalogue of Japanese Section.
49. " Report of the Minister of Education, 1873.
65. Kansas. Agricultural Report, 1875. (2 copies.)
82. Kuhn, B. The Farmers Friend.
228. Laboulaye, M. Ch. Dictionnaire des Arts et Manufactures et de l'Agriculture.
120. Lafayette College. Catalogue of Officers and Students.
140. Lasell Seminary. History and Description.
117. Lehigh University. Catalogue of Officers and Students.
223. Lévy Nuchel. Catalogue of Publications.
229. Lovues, Henri. Catalogue de la Librairie Renouard.
184. Lowell, Mass. Fiftieth Annual Report of School Committee, 1875.
106. Maryland. Report of the Commissioners of Fisheries.
159. Massachusetts. Catalogue of Educational Exhibit.
219. " Catalogue of Exhibit of Industrial Drawing and Modelling.
158. " Educational Institutions, 1876.
147. " Report of the Supt. of the School for Feeble Minded Youth.
148. " State Board of Health. First Annual Report.
149. " State Library. Report of the Librarian.
160. " Tenth Annual Report on Inland Fisheries.
227. Massen, G. Catalogue général de l'Académie de Médecine.
56. Maury, M. F. Resources of West Virginia.
127. Mayhew, Ira. Statement and Exhibit of Business College work.
52. Meme, Alfred & Sons. Catalogue of Publications.
67. Meteorological Observatory, N. Y. Report of the Director, 1871.
69. " " " " " " 1872.
68. " " " " " " 1873.
70. " " " " " " 1874–5.
213. Meyer, Heiur - Ad. - " Ivory."
32. Mexico. Catalogue de la colleccion de Productos Naturales Indigenas.
10. " " of Mexican Section. (3 copies.)

128. Michigan. Chart and Key of the Educational System.
129. “ Sketches of its Resources and Industries.
130. “ Historical Sketch of the University of Michigan.
131. “ Calendar “ “ “ “
132. “ Second Annual Report of the Board of Control of the State Public Schools.
133. “ Catalogue of Centennial Exhibit.
42. State Catalogue.
156. Montreal. Report of Fruit Committee of Agricultural and Horticultural Society, 1876.
217. Moore, J. G. & Co. Creosoting by the Bethel Process.
193. Moreira, Nicolau, J., M. D. Brazilian Coffee.
192. “ “ “ “ Note on Brazilian Vegetable Fibres.
188. Morel et Cie. Catalogue de la Librairie Morel.
58. Mount Holyoke Seminary. Historical Sketch.
181. Munday, E. H. The Proof Sheet.
29. Netherlands. Catalogue of Booksellers Association.
1. “ Collection of the Treasury Department.
78. “ “ “ “ “
66. “ Elementary and Middle Class Instruction.
55. New Brunswick. Catalogue and Report on the Woods and Minerals.
196. New Jersey. Catalogue of the Centennial Exhibit of the Geological Survey.
6. New South Wales. Catalogue of Centennial Exhibit.
211. “ “ “ Its Progress and Resources.
212. “ “ “ Mineral map and general statistics.
161. “ “ “ “ “ “ “ “
40. Newspapers. Catalogue of American Newspapers, 1876.
151. Newton. Report of Public Schools.
28. Norway. Norwegian Special Catalogue.
201. Nowell, Edwin C. Paper on the Local Industries of Tasmania.
12. Pennsylvania. Catalogue of Educational Exhibit.
122. “ Common School Laws.
50. “ School Report, 1875.
104. “ “ “ “
8. Perthes, Justus. Verlags Catalog.
214. Peter, Robert, M. D. Hemp Culture in Kentucky.
121. Philadelphia Institution for the Feeble Minded. Catalogue of Exhibit.
26. Philippine Islands. Catálogo General. (3 copies.)
180. “ “ Catalogue of Forestal products exhibited at the Centennial Exhibition, 1876.
230. Pickering, T. R. Connecticut at the International Exhibition.
138. Pittsfield High School. Statistics, etc.
224. Plou, E. & Cie. Catalogue of Publications.
168. Polytechnic Review. May 10th, 1876.
178. Proctor, J. R. General account of the Commonwealth of Kentucky.
216. Quebec Lunatic Asylum. Report of the Superintendent, 1875.
81. Randolph, Chas. Eighteenth report of the Trade and Commerce of Chicago.
163. Rensselaer. Polytechnic Institute. Annual Register, 1876.
62. “ “ “ Publications. Troy, N. Y.
218. Russell, E. Harlow. State Normal School at Worcester, Mass.

154. Russia. Catalogue of Exhibit of Fossils.
16. " Catalogue of Mining Department of the Ministry of Crown Domains.
3. " Catalogue of Russian Section. (2 copies.)
46. " Catalogue of School Apparatus, etc. Pedagogic Museum.
194. Saldanah da Gama, José, Ph.D. Notes on Textile Plants of Brazil.
195. " " " Products of the Brazilian Forests. Catalogue.
15. Schröder, J. Catalogue and price list of Schröder's Models.
96. Scribner, Armstrong & Co. Catalogue of Educational Publications.
105. Sève, Edaourd. Le Chili tel qu'il est.
197. Shaler, N. S. General Account of the Commonwealth of Kentucky.
68. Shantz, J. Y. Relation d'un voyage a Manitoba.
54. Smart, James H. Indiana Schools and the men who have worked in them.
205. " " Public Instruction in Indiana. Twenty-third Annual Report.
157. Smith College. Report.
199. " Walter. Circular of the Massachusetts Normal Art School.
119. Soldiers Orphans. Annual Report of Pennsylvania Superintendent.
77. South Australia. Its history, resources, etc. Wm. Harcens.
90. Spence, Thomas. Manitoba and the North-west of the Dominion.
162. Sullivan, Sir Ed. Bart. Protection to Native Industry.
83. Sweden. Catalogue of Exhibit by Motala Iron and Steel Works.
88. " Exhibition of Geological Survey.
145. " Hammers Museum. Synopsis.
60. " Swedish Catalogue. Part 1st.
185. Switzerland. Bericht der Erdgenössischen Polytechnischen Schule in Zürich.
41. " Catalogue of Swiss Section.
177. " Report of Artisan's School in St. Gall.
183. " Report of Swiss Unions of Young Merchants, 1876.
142. Tennessee. Its Agricultural and Mineral Wealth.
167. Thompson, Chas. O. Report of the Worcester Free Institution.
182. Trow, Jas. A Trip to Manitoba.
146. Tunis. Règlement des études à la grande Mosquée de Tunis.
234. University of Michigan. Calendar, 1876-6.
165. University of Pennsylvania. Catalogue and Announcement. 1874-5.
166. " " " " 1875-6.
174. " " " " 1876-77.
114. " " Publications by the Medical Department.
61. U. S. Naval Observatory. Reports of Foreign Societies on awarding medals to American Arctic Explorers.
103. Vausant, I. L. The Royal Road to Wealth.
43. Victoria, Australia. Catalogue of Exhibit.
187. Villars, Gauthier. Catalogue des Livres de Fonds, 1876.
116. Warren Street Chapel. Thirty-Eighth Annual Report.
173 Wharton, Joseph. National Self Protection.
235. Wickersham, J. P. The Pennsylvania School Journal. Aug. 1876.
93. Willmett, T. Northern Queensland Directory.
95. Wisconsin. Catalogue and Sketches.
44. " State Report and Catalogue.
202. Wootten, J. E. The Philadelphia and Reading Rail Road.
22. W. Virginia. Catalogue of State Exhibit.

CLASS 2. CIVIL ENGINEERING.

67. American Bridge Co. Album of Designs.
43. Boston. Seventh Annual Report of the Railroad Commissioners.
22. Brazil. Map of the General Railroads and Telegraph lines in Brazil.
23. “ “ “ Provincial Railroads.
24. “ “ “ “ “ Province of St. Pauls.
26. “ Topographical Map of the Province of St. Pauls.
25. “ General Map of the Empire.
42. “ Railroads of the Province of St. Pauls.
64. Clarke Reeves & Co. Centennial Catalogue and Publications.
2. “ “ “ Photograph of Chain Bridge over Potomac River.
3. “ “ “ “ Biddeford Bridge over Saco River. Eastern Railroad.
4. “ “ “ “ Trumansburgh Viaduct, Geneva & Ithica Railroad.
38. Davis, Rear Admiral Chas. H. Interoceanic Communication between Atlantic and Pacific Oceans.
39. “ “ “ “ Same as preceding, with Maps.
44. Deutschlands. Der Buchhandel und die graphischen küuste, auf der wellansselung zu Philadelphia, 1876.
47. France. Description of the Models, Charts and Drawings relating to the works of the “ Ponts et Chaussèes ” and the Mines.
48. “ Same as preceding. (In French.)
49. “ Historical and Statistical Studies upon the means of communication in France.
45. Heller & Brightly, Philadelphia. Remarks on Engineer's Surveying Instruments.
62. Holyoke, Mass. City Water Power and Industries.
34. Keystone Bridge Co. Description of Raritan Swing Bridge.
35. “ “ “ Illustrated Circular of Long Span Bridges.
36. “ “ “ Illustrated Albums.
5. Keystone Bridge Co. Photographs. Three views (side, end, and top) of Collowhill Street Bridge over Schuylkill River at Philadelphia.
6. “ “ “ Collowhill Street Bridge (side view).
7. “ “ “ Terre Haute & Indianapolis Railroad Bridge over Wabash River at Terre Haute, Ind.
8. “ “ “ Ohio River Bridge, Parkersburg, West Virginia, Baltimore and Ohio R.R. (end view).
9. “ “ “ “ “ (side view).
10. “ “ “ Illinois and St. Louis Bridge (finished structure).
11. “ “ “ “ “ end span (in process of erection).
12. “ “ Illinois & St. Louis Bridge; all spans (in process of erection).
13. “ “ “ “ “ Two spans “ “
14. “ “ “ “ “ All spans “ “
15. “ “ Blanks for specifications of Bridge.

16. Keystone Bridge Co. Photographs Ohio River Bridge, Cincinnati Southern Railway. Five sheets of designs.
17. " " " J. L. Piper's Improved Centre for Wrought-iron Turntables.
18. " " " J. L. Piper's Patent Hollow Wrought-iron Columns.
19. " " " Wrought-iron Highway Bridge.
20. " " " " Railway Bridge.
21. " " " Details for wrought-iron Bridge over Mississippi River at Rock Island.
68. Kneffel & Esser. Catalogue of Draughting Instruments.
46. Lyman ———. Description of Lyman's Trigonometer and Universal Draughting Instrument.
66. Mexico. History of the Railway wealth of Mexico.
61. Netherlands. Eckstein, Charles. New method for reproducing Maps and Drawings.
50. Netherlands. Photo-Lithographs. Bridge over the Hollandsch Diep.
51. " " Reclamation of Haarlemmermeer.
52. " " Pneumatic Foundation of the Railway Bridge before the Madse at Rotterdam.
53. " " Bridge at Bommel.
54. " " New Channel from Rotterdam to the North Sea.
55. " " Steel Swing Bridge at Dordrecht.
56. " " { A. Lifting-bridge over the Linge.
B. Swing-bridge over the North Holland Canal.
57. " " Canal from Amsterdam to the North Sea.
58. " " Bridge at Hurlenburg.
59. " " { A. Dam across the Sloe.
B. " " Schelde.
60. " Sketch of the Public Works.
33. " View of the Harbor of Flushing.
41. Norman, V. Report on the Design and Construction of a Military Bridge Equipage, 1876.
37. Phoenixville Bridge Co. Clarke, Reeves & Co. Supplement to Album of Designs.
37a. " " Illustrated Album of Designs.
65. Roebling, John A. & Sons. Catalogue and Price-list of Wire Rope.
63. Switzerland. Atlas uber die entwicklung von Industrie und Handel, der Schweiz.
29. " R. Lurzinger, Topographer at Berne. One Map Section Grono.
30. " Wurster, Randegger, & Co. School Atlas.
31. " " " " "
32. " North-East Railroad Co. Album of Road and Stations ——Designs.
1. U. S. Navy. Catalogue of Centennial Exhibit.
40. U. S. Naval Observatory. Instruments and Publications, 1845—1876.

CLASS 3. MECHANICAL ENGINEERING.

19. Arbey, Fd. Illustrated Catalogue of Wood-working Machinery.
49. Aveling & Porter. Road Locomotives, &c. Illustrated pamphlet.
17. Avery, John G., Worcester, Mass. Catalogue of Thread and Twine Machinery.
45. Bough & Sons. Bough's Sectional Mills. Illustrated pamphlet.

31. Botelho de Mayalhaes, Benjamin Constant. Theora das Quantidades Negativas.
41. Buckeye Engine Co. Illustrated circular.
11. Butterworth, H. W. & Sons. Photographs of Drying Machines and Improved Stuffing-boxes.
23. Douglass Manufacturing Co. Descriptive Price-list of Mechanics' Tools.
8 & 36. Eaton, Cole & Burnham. Illustrated catalogue of Steam and Gas-fitters' Supplies.
21. Empire Threshing Machine Co. Descriptive circular.
34. Ferris & Miles. Steam Hammers and Machine Tools.
12. Fitchburg Machine Co. Twelve photographs of Improved Machinery.
47. Ganguillet & Kutter. Hydraulics. Motion of Water in Canals and Rivers.
33. Greenlee Brothers & Co. Descriptive catalogue of Wood-working Machinery.
30. Hampson, Whitehill & Co. "Engines and Boilers."
32. Harrison, Edward. Standard Flouring Mills. Illustrated pamphlet.
37. Hoops & Townsend. Bolts and Screws. Descriptive catalogue and price-list.
9. " " Photographs of Bolts, Screws, &c.
39. Hotchkiss, A. S. The Tower Clocks made by Seth Thomas & Co.
35. Howe & Co. Howe's Improved Scales. Illustrated pamphlet.
6. Kirkaldy. Experimental inquiry into the properties of Fayersta Steel.
51. Krupp, Fried., Essen, Germany. Cast-steel and Iron. Descriptive publications.
38. Leffell, James. Improved double Turbine Water-wheel.
43. Lyall, J. & W. Lyall's Positive Motioned Loom.
42. Mast, P. P. & Co. Agricultural Machinery.
13. Mirrbes, Tait & Watson. Photograph of Sugar Mill.
18. Mitchell, J. E. Catalogue of Grindstones and Fixtures.
22. National Fire Alarm Co. Description of Apparatus.
15. Northampton Emery Wheel Co., Leeds, Mass. Catalogue and price-list.
44. Noye, John T. & Sons. Portable Flouring and Grist Mills.
3. Nystrom. New treatise on Steam Engineering.
2. " Elements of Mechanics.
27. Otis Brothers, Yonkers, N. Y. Descriptive pamphlets of Otis Elevators and Hoisting Machinery.
16. Peace, Cox & Co. Steam and Gas Fitters Tools. Catalogue and price-list.
25. Perkins, A. M. & Son. London Heating Apparatus. Descriptive pamphlet.
26. Philadelphia Burring Machine Works. Descriptive pamphlet.
28. Porter, Bell & Co. Light Locomotives. Illustrated description.
24. Pratt & Whitney Co. Descriptive catalogue.
48. Rodney, Hunt & Co. Hunt's Double-acting Turbine Water-wheel. Descriptive circular.
1. Russia. Description of the Scientific Appliances in the Imperial Technical School at Moscow.
50. Shapley & Wells. "The Shapley Engine."
20. Siemen & Co. Description of Regenerative Gas Furnace.
29. Smith, James & Co. Manufacturers Supplies. Illustrated catalogue.
40. South Bend Iron Works. Description of the Works at South Bend, Indiana.
5. Sweden. The state of the Iron Manufacture.
4. Switzerland. Illustrated description of the large Water-works at Bellegrade.
46. Utica Steam Gauge Co. Descriptive circular.
14. Wetherell, Robert & Co. Photograph of Engine Regulator.
7. Yale Lock Manufacturing Co. Illustrated catalogue.

CLASS 4. MINING ENGINEERING.

6. Actien-Gesellschaft fur Anolin-Fabrikation; coal tar products and analine colors.
4. Akerman, Rich. State of the Iron Manufacture in Sweden at the beginning of 1876.
1. Analysen von Durchschnittsproben des Zur Hemrichshütte bei Au an der sieg producirteu Prima spiegeleisens Morke.
5. Boyer, Fredr. & Co. Department of Analine Colors.
2. Krupp, Fried. The Cast-steel and Iron Works at Essen, Germany.
7. Moore, J. G. & Co. "Creosoting by Bethell Process."
8. New South Wales. "Mines and Mineral Statistics."
10. Pennsylvania Steel Co. Catalogue and Album.
9. Sawyer, Fredr. E. "The Coal Trade."
3. Whitewell, —. Illustrated Paper on Whitewell's Patent Fire Brick Stoves.

CLASS 5. ARCHITECTURE.

1. Mott, J. L. & Co. Catalogue of Ornamental Designs.
4. Spain. Conservatory of Arts at Madrid. Perspective Drawings by Evening Classes.
5. " " " " Geometric Drawings.
6. " " " " Human Figure and Ornamental Drawing.
7. " " " " Young Ladies Class.
8. " " " " Water Color Drawing.
3. Switzerland. Kantonsrathhaus herausgegeben durch die Bandirection des Kantons. Bern, 1876.
2. Switzerland. Neue Entbindnuysanstalt herausgegeben durch die Banderection des Kantons. Bern, 1876.

CLASS 5⅓. PHYSICS.

4. Coston, J. Description of Coston's Telegraphic Night Signals.
3. Juvet, L. P. Glen Falls, N. Y. Photograph of New Time Globe.
2. Western Electric Manufacturing Co., Chicago. Catalogue and price-list.
1. " " " Samples of Insulated Telegraphic Wire.

CLASS 6. ARTICLES CONSTRUCTED FROM WOOD AND IRON FOR PURPOSES OF INSTRUCTION.

From the Imperial Technical School at St. Petersburg, Russia. Department of Industrial Art.

Course No. I. Six pieces of cast iron finished with the file by students, showing the course of instruction in the art of filing.

Course No. II. Nineteen pieces of wrought iron forgings showing the course of instruction in the art of forging.

Course No. III. Seventeen pieces of wrought iron showing the course of instruction in the art of turning.

From the Artisans' School at Rotterdam, Holland.

Complete drawings of the workshops for boys from twelve to fifteen years of age.

The crosshead, governor, connecting rod and valve rod for an upright engine.

Two locks, showing instruction given in filing and fitting. Fourteen forgings showing instruction given in the smith's shop.

Two specimens of copper work, including brazing.

One pulley block and one post showing work done in the turning shop.

Fifteen specimens of carpenters' work, including stair building. Three specimens of carving and inlaid work.

Six specimens of painting upon cloth.

DEPARTMENT II. — AGRICULTURE.

CLASS 7. TIMBER AND USEFUL WOODS.

AUSTRALIA.

From the Colony of Queensland.

1. Araucaria Bidwillii, Hook. Bunya Bunya. Diameter, 30 to 48 in.; height, 100 to 250 ft.

2. Araucaria Cunninghamii, Ait. Moreton Bay Pine. Diameter, 36 to 66 in.; height, 150 to 200 ft.

3. Dammara robusta, Moore. Kawrie or Dundathu Pine. Diameter, 36 to 72 in.; height, 80 to 130 ft.

4. Callitris columellaris, F. Muell. Cypress Pine. Diameter, 20 to 30 in.; height, 40 to 60 ft.

5. Callitris verrucosa, R. Br. The Desert Cypress Pine. Diameter, 12 to 24 in.; height, 50 to 70 ft.

6. Callitris Endlicheri, Parl. The Mountain Cypress Pine. Diameter, 9 to 18 in.; height, 40 to 50 ft.

7. Podocarpus elatus, R. Br. She Pine. Diameter, 20 to 36 in.; height, 50 to 80 ft.

8. Casuarina tenuissima, Sieb. River Oak. Diameter, 18 to 22 in.; height, 40 to 70 ft.

9. Casuarina leptoclada, Miq. The Erect She Oak. Diameter, 9 to 15 in.; height, 20 to 30 ft.

10. Casuarina equisetifolia, Forst. Swamp Oak. Diameter, 12 to 20 in.; height, 50 to 70 ft.

11. Casuarina torulosa, Ait. Forest Oak, Beef wood. Diameter, 9 to 15 in.; height, 30 to 35 ft.

12. Casuarina Cunninghamiana, Miq. Fire Oak. Diameter, 6 to 10 in.; height, 20 to 30 ft.

13. Cedrela Toona, Roxb. Red Cedar. Diameter, 24 to 76 in.; height, 100 to 150 ft.

14. Flindersia Australis, R. Br. Flindosa. Diameter, 36 to 48 in.; height, 80 to 100 ft.

15. Flindersia Oxleyana, F. Muell. Light-Yellow Wood. Diameter, 24 to 42 in.; height, 80 to 100 ft.

16. Flindersia Bennettiana, F. Muell. Bogum Bogum. Diameter, 18 to 26 in.; height, 70 to 90 ft.

17. Flindersia maculosa, F. Muell. Spotted Tree of the Colonists. Diameter, 12 to 18 in.; height, 30 to 40 ft.

18. Owenia venosa, F. Muell. Sour Plum. Diameter, 12 to 24 in.; height, 40 to 75

19. Owenia cerasifera, F. Muell. Sweet Plum. Diameter, 9 to 18 in.; height, 25 to 35 ft.

20. Amoora nitidula, Benth. Diameter, 18 to 30 in.; height, 70 to 90 ft.

21. Synoum glandulosum, A. Juss. Diameter, 15 to 24 in.; height, 35 to 60 ft.

22. Dysoxylon Muelleri, Benth. Pencil Cedar. Diameter, 20 to 35 in.; height, 70 to 90 ft.

23. Melia composita, Willd. Diameter, 15 to 20 in.; height, 50 to 60 ft.

24. Ailanthus imberbiflora, F. Muell. Diameter, 20 to 28 in.; height, 50 to 70 ft.

25. Bosistoa sapindiformis, F. Muell. Diameter, 6 to 12 in.; height, 15 to 20 ft.

26. Citrus australis, Planch. Native Orange. Diameter, 6 to 14 in.

27. Citrus australasica, F. Muell. Native Lime. Diameter, 6 to 10 in.: height, 15 to 20 ft.

28. Atalantia glauca, Hook. The Native Cumquat. Diameter, 2 to 6 in.; height, 8 to 15 ft.

29. Acronychia Baueri, Schott. Diameter, 6 to 12 in.; height, 16 to 24 ft.

30. Acronychia lævis, Forst. Diameter, 15 to 20 in.; height, 30 to 50 ft.

31. Zanthoxylon brachyacanthum, F. Muell. Satin Wood. Diameter, 6 to 9 in.; height, 20 to 30 ft.

32. Geijera parviflora, Lindl. Diameter, 6 to 12 in.; height, 20 to 30 ft.

33. Geijera Muelleri, Benth. Balsam Capivi Tree. Diameter, 12 to 18 in.; height, 40 to 60 ft.

34. Evodia micrococca, F. Muell. Diameter, 6 to 10 in.; height, 20 to 30 ft.

35. Celastrus dispermus, F. Muell. Diameter, 3 to 5 in.; height, 12 to 16 ft.

36. Denhamia pittosporoides, F. Muell. Diameter, 6 to 8 in.; height, 20 to 30 ft.

37. Denhamia obscura, Meisn. Diameter, 3 to 5 in.; height, 12 to 20 ft.

38. Alphitonia excelsa, Reissek. Mountain or Red Ash. Diameter, 18 to 24 in.; height, 45 to 60 ft.

39. Pittosporum rhombifolium, A. Cunn. Diameter, 6 to 12 in.; height, 40 to 55 ft.

40. Pittosporum bicolor, Hook. Diameter, 6 to 21 in.; height, 20 to 40 ft.

41. Pittosporum phillyræoides, D. C. Diameter, 4 to 6 in.; height, 20 to 35 ft.

42. Tarrietia argyrodendron, Benth. Silver Tree. Diameter, 24 to 34 in.; height, 70 to 90 ft.

43. Tarrietia actinodendron, F. Muell. Diameter, 18 to 30 in.; height, 60 to 70 ft.

44. Commersonia echinata, Forst. Diameter, 6 to 12 in.; height, 20 to 30 ft.

45. Cupania xylocarpa, A. Cunn. Diameter, 12 to 24 in.; height, 40 to 60 ft.

46. Cupania serrata, F. Muell. Diameter, 8 to 14 in.; height, 20 to 30 ft.

47. Diploglottis Cunninghamii, Hook. Native Tamarind. Diameter, 12 to 20 in.; height, 40 to 55 ft.

48. Cupania semiglauca, F. Muell. Diameter, 10 to 20 in.; height, 30 to 60 ft.

49. Ratonia pyriformis. Benth. Diameter, 10 to 18 in.; height, 30 to 45 ft.

50. Nephelium tomentosum, F. Muell. Diameter, 10 to 15 in.; height, 30 to 40 ft.

51. Heterodendron oleæfolium, Desf. Diameter, 4 to 10 in.; height, 20 to 30 ft.

52. Heterodendron diversifolium, F. Muell. Diameter, 4 to 6 in.; height, 10 to 15 ft.

53. Harpullia pendula, Planch. Tulip Wood. Diameter, 14 to 24 in.; height, 50 to 60 ft.

54. Dodonæa triquetra, Andr. Hop Bush. Diameter, 3 to 4 in.; height, 10 to 12 ft.

55. Rhus rhodanthema, F. Muell. Dark Yellow Wood, K. Diameter, 18 to 24 in.; height, 50 to 70 ft.

56. Sarcocephalus cordatus, Miq. Leichhardt's Tree. Diameter, 24 to 30 in.; height, 40 to 60 ft.

57. Ixora Pavetta Roxb. Diameter, 2 to 4 in.; height, 8 to 10 ft.

58. Hodgkinsonia ovatiflora, F. Muell. Diameter, 6 to 10 in.; height, 12 to 20 ft.

59. Canthium lucidum, Hook, and Arn. Diameter, 6 to 12 in.; height, 20 to 30 ft.

60. Canthium oleifolium, Hook. Diameter, 4 to 10 in.; height, 25 to 30 ft.

61. Canthium latifolium, F. Muell. Diameter, 8 to 12 in.; height, 25 to 30 ft.

62. Canthium vacciniifolium, F. Muell. Diameter, 2 to 4 in.; height, 6 to 10 ft.

63. Cœlospermum paniculatum, F. Muell. Diameter, 3 to 5 in.; height, 100 to 150 ft.

64. Callistemon lanceolatus, D. C. Bottle-brush Tree. Diameter, 12 to 18 in.; height, 30 to 40 ft.

65. Callistemon salignus, D. C. Broad-leaved Tea Tree. Diameter, 18 to 24 in.; height, 40 to 60 ft.

66. Melaleuca linariifolia, Sm. Diameter, 20 to 24 in.; height, 30 to 40 ft.

67. Melaleuca nodosa, Sm. Tea Tree. Diameter, 10 to 20 in.; height, 30 to 40 ft.

68. Angophora subvelutina, F. Muell. Apple Tree. Diameter, 20 to 26 in.; height, 40 to 60 ft.

69. Eucalyptus pilularis, Sm. Black-butt. Diameter, 24 to 40 in.; height, 60 to 80 ft.

70. Eucalyptus Microcorys, F. Muell. Diameter, 18 to 30 in.; height, 60 to 80 ft.

71. Eucalyptus hemiphloia, F. Muell. Yellow Box. Diameter, 20 to 30 in.; height, 40 to 60 ft.

72. Eucalyptus siderophloia, Benth. Ironbark. Diameter, 20 to 30 in.; height, 60 to 80 ft.

73. Eucalyptus meleanophloia, F. Muell. Silver-leaved Ironbark. Diameter, 18 to 20 in.; height, 30 to 60 ft.

74. Eucalyptus maculata, Hook. Spotted Gum. Diameter, 20 to 30 in.; height, 60 to 80 ft.

75. Eucalyptus saligna, Sm. Grey Gum. Diameter, 24 to 34 in.; height, 60 to 80 ft.

76. Eucalyptus Resinifera, Sm. Red Mahogany. Diameter, 20 to 30 in.; height, 30 to 70 ft.

77. Eucalyptus corymbosa, Sm. Bloodwood. Diameter, 24 to 30 in.; height, 50 to 60 ft.

78. Eucalyptus globulus, Sm. Blue Gum. Diameter, 30 to 48 in.; height, 70 to 90 ft.

79. Eucalyptus tereticornis, Sm. Red Gum. Diameter, 18 to 30 in.; height, 60 to 80 ft.

80. Eucalyptus Stuartiana, F. Muell. Turpentine Tree. Diameter 24 to 36 in.; height, 60 to 80 ft.

81. Eucalyptus fibrosa, F. Muell. Stringy Bark. Diameter, 18 to 24 in.; height, 40 to 60 ft.

82. Eucalyptus tesselaris, F. Muell. Moreton Bay Ash. Diameter, 14 to 24 in.; height, 30 to 60 ft.

83. Myrtus acmenioides, F. Muell. Diameter, 12 to 18 in.; height, 30 to 40 ft.

84. Eugenia Smithii, Poir. Lilly Pillies. Diameter, 12 to 18 in.; height, 30 to 40 ft.

85. Myrtus Hillii, Benth. Scrub Ironwood. Diameter, 6 to 12 in.; height, 20 to 40 ft.

86. Rhodamnia trinervia, Blum. Diameter, 10 to 18 in.; height, 20 to 30 ft.

87. Rhodomyrtus psidioides, Benth. Diameter, 12 to 20 in.; height, 30 to 40 ft.

88. Rhodamnia argentea, Benth. Diameter, 15 to 22 in.; height, 40 to 60 ft.

89. Tristania conferta, R. Br. Box. Diameter, 36 to 50 in.; height, 80 to 100 ft.

90. Grevillea robusta, Cunn. Silky Oak. Diameter, 30 to 40 in.; height, 80 to 100 ft.

91. Macadamia ternifolia, F. Muell, Queensland Nut. Diameter, 30 to 40 in.; height, 30 to 50 ft.

92. Orites excelsa, R. Br. Diameter, 6 to 14 in.; height, 30 to 60 ft.

93. Banksia integrifolia, Linn. Beef Wood. Diameter, 8 to 12 in.; height, 20 to 30 ft.

94. Persoonia lucida, R. Br.; var. latifolia, A. Cunn. Diameter, 3 to 7 in.; height, 10 to 20 ft.

95. Grevillea Hilliana, F. Muell. Diameter, 10 to 18 in.; height, 40 to 60 ft.

96. Exocarpus latifolia, R. Br. Broad-leaved Cherry Tree. Diameter, 6 to 9 in.; height, 12 to 25 ft.

97. Exocarpus cupressiformis, R. Br. Cherry Tree. Diameter, 4 to 8 in.; height, 10 to 16 ft.

98. Santalum lanceolatum, R. Br. Sandal Wood. Diameter, 3 to 6 in.; height, 15 to 25 ft.

99. Eremophila Mitchelli, Benth. Bastard Sandal Wood. Diameter, 6 to 12 in.; height, 20 to 30 ft.

100. Myoporum acuminatum, R. Br.; var. parviflorum, Benth. Diameter, 4 to 6 in.; height, 12 to 15 ft.

101. Avicennia officinalis, Linn. Mangrove. Diameter, 19 to 20 in.; height, 20 to 30 ft.

102. Gmelina Leichhardtii, F. Muell. Beech. Diameter, 24 to 36 in.; height, 80 to 100 ft.

103. Vitex lignum-vitæ, A. Cunn. Shrub Lignum Vitæ. Diameter, 20 to 24 in.; height, 50 to 70 ft.

104. Elæocarpus obovatus, G. Don. Diameter, 12 to 20 in.; height, 30 to 40 ft.

105. Acacia falcata, Willd. Diameter, 6 to 12 in.; height, 20 to 30 ft.

106. Acacia glaucescens, Willd. Diameter, 12 to 18 in.; height, 30 to 35 ft.

107. Same as 8 in a younger stage.

108. Acacia fasciculifera, F. Muell. Diameter, 10 to 16 in.; height, 30 to 40 ft.

109. Acacia salicina, Lindl. Diameter, 6 to 12 in.; height, 30 to 40 ft.

110. Acacia harpophylla, F. Muell. Diameter, 12 to 20 in.; height, 40 to 70 ft.

111. Same as 110 in a younger stage.

112. Acacia excelsa, Benth. Brigalow. Diameter, 20 to 30 in.; height, 50 to 80 ft.

113. Acacia neriifolia, A. Cunn. Diameter, 6 to 12 in.; height, 20 to 30 ft.

114. Acacia doratoxylon, A. Cunn. Diameter, 6 to 12 in.; height, 25 to 35 ft.

115. Acacia pendula, A. Cunn. Weeping Myall. Diameter, 6 to 12 in.; height 20 to 35 ft.

116. Acacia stenophylla, A. Cunn. Ironwood. Diameter, 15 to 24 in.; height, 40 to 60 ft.

117. Acacia leptostachya, Benth. Diameter, 4 to 10 in.; height, 20 to 25 ft.

118. Acacia uncifera, Benth. Diameter, 3 to 5 in.; height, 6 to 10 ft.

119. Acacia decurrens, Willd; Green Wattle. Diameter, 3 to 8 in.; height, 30 to 40 ft.

120. Acacia amblygona, A. Cunn. Diameter, 6 to 10 in.; height, 20 to 25 ft.

121. Acacia decurrens, Willd. var. mollis, Lindl. Silver Wattle. Diameter, 6 to 10 in.; height, 30 to 40 ft.

122. Albizzia thozetiana, F. Muell. Diameter, 12 to 30 in.; height, 40 to 60 ft.
123. Acacia linifolia, Willd. Diameter, 3 to 4 in.; height, 10 to 15 ft.
124. Acacia penninervis, Sieb. Diameter, 2 to 4 in.; height, 6 to 12 ft.
125. Pithecolobium pruinosum, Benth. Diameter, 5 to 12 in.; height, 40 to 50 ft.
126. Hovea acutifolia, A. Cunn. Diameter, 2 to 4 in.; height, 6 to 10 ft.
127. Barklya syringifolia, F. Muell. Diameter, 12 to 18 in.; height, 40 to 60 ft.
128. Cassia Brewsteri, F. Muell. Diameter, 3 to 6 in.; height, 30 to 50 ft.
129. Jacksonia scoparia, R. Br. Dogwood. Diameter, 3 to 8 in.; height, 10 to 15 ft.
130. Marlea vitiensis, Benth. Musk Tree. Diameter, 6 to 12 in.; height, 20 to 30 ft.
131. Olea paniculata, R. Br. Native Olive. Diameter, 18 to 24 in.; height, 50 to 70 ft.
132. Notelæa ovata, R. Br. Dunga Vunga. Diameter, 6 to 12 in.; height, 20 to 30 ft.
133. Notelæa microcarpa, R. Br. Diameter, 9 to 12 in.; height, 30 to 45 ft.
134. Endiandra pubens, Meissn. Diameter, 18 to 24 in.; height, 40 to 70 ft.
135. Tetranthera ferruginea, R. Br. Diameter, 14 to 20 in.; height, 30 to 40 ft.
136. Litsæa dealbata, Nees. Diameter, 18 to 24 in.; height, 40 to 60 ft.
137. Cryptocarya patentinervis, F. Muell. Diameter, 12 to 20 in.; height, 30 to 40 ft.
138. Cargillia australis, R. Br. Diameter, 6 to 12 in.; height, 30 to 40 ft.
139. Mallotus philippinensis, F. Muell. Diameter, 6 to 14 in.; height, 30 to 45 ft.
140. Mallotus nesophilus, F. Muell. Diameter, 12 to 18 in.; height, 35 to 45 ft.
141. Croton insularis, Baill. Cascarilla. Diameter, 8 to 12 in.; height, 30 to 40 ft.
142. Croton Verreauxii, Baill. Diameter, 3 to 5 in.; height, 15 to 20 ft.
143. Petalostigma quadriloculare, F. Muell. Crab Tree. Diameter, 12 to 18 in.; height, 40 to 50 ft.
144. Excæcaria Agallocha, Linn. River Poisonous Tree. Diameter, 6 to 18 in.; height, 20 to 30 ft.
145. Bridelia exaltata, F. Muell. Diameter, 12 to 18 in.; height, 30 to 45 ft.
146. Bradleia australis, R. Br. Diameter, 12 to 18 in.; height, 13 to 50 ft.
147. Daphnandra Micrantha, Benth. Diameter, 18 to 30 in.; height, 60 to 80 ft.
148. Hormogyne cotinifolia, A. DC. Diameter, 6 to 9 in.; height, 20 to 35 ft.
149. Chrysophyllum pruniferum, F. Muell. Diameter, 12 to 20 in.; height, 30 to 70 ft.
150. Celtis phillippinensis, Blanco. Diameter, 4 to 12 in.; height, 20 to 40 ft.
151. Morus calcar-galli, Cunn. Cockspur Thorn.
152. Ceratopetalum apetalum, Don. Coachwood. Diameter, 24 to 36 in.: height, 70 to 90 ft.

CLASS 8. WOOL, WASHED AND UNWASHED.

Nos. 1 to 89 inclusive are specimens of cloths manufactured in the Netherlands and Brazil, and will be found under the head of Manufactures, Department IV, Class 30.

TASMANIA.

90. Work done by Parkhurst's Patent Burring Picker.
91. Merino, weight 11 lbs. before being skirted.
92. Unwashed fleece.
93. " " No. 1, Extra.
94. Medium qual., washed.
95. Unwashed fleece from the Ram "Duke."
96. Commercial fleece, washed.
97. Unwashed fibre, nine inches long.
98. Exhibition by F. Shaw.
99. Fleece, washed.

100. Merino from unwashed fleece.
101. Washed on the sheep.
102. Extra quality washed.
103. Unwashed.
104. Washed by hand. Extra long and fine.
105. Washed. Extra quality.
106. Merino fleece, 1st quality, unwashed.
107. Commercial, washed.
108. Medium quality — washed and unwashed.
109. Merino, extra quality, unwashed.
110. Fleece, unwashed.
111. Merino, as shorn from sheep.
112. Lamb's, extra quality.
113. Fine fleece, washed.
114. Leicester.
115. Medium quality.
116. Fleece, Merino, medium quality, unwashed.
117. Commercial.
118. Merino, medium quality, unwashed.
119. 1st quality, washed in the fleece.
120. Extra quality lamb's wool, washed.
121. Good quality, long fibre.
122. Medium quality, washed.
123. Merino, 1st quality, washed.
124. Merino, unwashed.
125. Medium quality.
126. Extra quality lamb's wool.
127. Fleece, unwashed.
128. Coarse wool, 13 inches long.

AUSTRALIA.

129. Merino, 1st quality, unwashed.

New South Wales.

130. Merino, extra No. 1.
131. Merino, unwashed.
132. No. 1, unwashed.
133. Merino fleece, washed.
134. Merino, 1st quality, unwashed.
135. Merino, washed.
136. Merino, unwashed, extra No. 1.
137. Merino fleece, unwashed.
138. 1st quality.
139. Merino, 2d quality.
140. 1st quality.
141. Merino, unwashed.
142. 1st quallty, washed.
143. Merino, washed.
144. Fair Merino.
145. Cotswold.
146. Washed in the fleece.
147. 3d quality, unwashed.
147. Merino fleece, extra quality.
149. Merino, 2d quality.
150. Merino fleece, No. 1.
151. Prime quality, unwashed.
152. Medium, washed.
153. Fine Merino, washed.
154. No. 3, unwashed.
155. Merino, 2d quality.
156. Merino, No. 3, fleece.
157. Merino, good quality, unwashed.
158. Lamb's, washed.
159. Medium, unwashed.
160. Merino, extra fine and long.
161. No. 1, washed.
162. Merino, unwashed.
163. Extra quality, washed.
164. Merino, washed.
165. Fair quality.
166. Medium quality.
167. Merino, No. 3, washed.
168. No. 1, unwashed.
169. Merino, unwashed.
170. Medium fleece, washed.
171. No. 1, unwashed.
172. Extra fine fleece, washed.
173. Fleece, washed.
174. " "
175. Merino, No. 2, unwashed.
176. Merino fleece, washed.
177. " " "
178. Merino fleece, extra quality, unwashed.
179. Medium quality, unwashed.
180. Merino, No. 2, unwashed.
181. Medium quality, unwashed.
182. Fleece No. 1, washed.
183. Medium, washed by hand.
184. Extra Merino, washed by hand.
185. 1st quality, washed by hand.
186. Merino, No. 1, washed.
187. No. 1, Merino, washed.
188. 1st quality Merino, washed.
189. Merino, No. 1, washed.
190. Medium, unwashed.
190*a*. " washed.
190*b*. No. 1, washed.

Victoria.

191. Greasy fleece wool.
192. Hot water worked fleece.
193. Washed on the animal; age when shorn 6 months.
194. From Melbourne.
195. Ewes, washed.
196. Greasy fleece.
197. Merino ewe's fleece.
198. Greasy Lincoln.
199. Merino ewe's, fed on natural pasturage only.
200. Greasy Merino.
201. Wethers, greasy Merino; 12 months' growth.
202. Washed ewe's fleece.
203. Greasy Merino ewe's fleece.
204. Greasy crossbred.
205. “
206. “ Merino.
207. Hot water washed.
208. Greasy Leicester.
209. Merino ewe's.
210. Greasy crossbred.
211. “ Merino.
212. Washed Merino.
213. Fleece, hot water washed.
214. Merino, wether.
215. Washed fleece.
216. Young ewes, hot water washed.
217. Washed fleece.
218. From Geelong.
219. Greasy Merino.
220. Washed Merino.
221. Greasy Merino.
222. “ “
223. Washed Merino ewe's fleece.
224. Greasy fleece.
225. Washed Merino.
226. Greasy fleece.
227. “ Merino lamb's.
228. “ crossbred.
229. Wool.
230. Greasy Lincoln.
231. “ “
232. From Thos. F. Cumming.
233. “ “
234. “ “
235. “ “
236. Washed Merino,
237. Merino lamb's, hot water washed.
238. Greasy Merino.
239. Cheviot ewes.
240. Greasy Merino ewe's.
241. Washed ewe's.
242. “ crossbred.
243. Merino.
244. Scoured fleece.
245. Washed Merino lamb's.
246. “ “
247. Greasy.
248. “ crossbred.
249. Cheviot lamb's.
250. “ “
251. “ “
251*a*. “ “
251*b*. Merino ewe, 12 month's growth.
251*c*. Ewe lamb, 12 month's growth.

Queensland.

252. Merino.
253. “
254. “
255. “
256. “
257. “
258. “
259. “ 2d quality unwashed.
260. “ “ “ washed by hand.
261. “ “ “ unwashed.

TASMANIA.

262. Merino, 1st quality.
263. Known as No. 74.
264. Merino, unwashed.
265. Fleece from Merino ram.
266. Merino, unwashed.
267. “ “
268. “ “
269. from the ram " Melhimus."
270. from ewe.
271.

AFRICA.

Cape of Good Hope.

272. Wool known as Tides.
273. Merino unwashed.
274. “ fleece.
275. “
276. Known as No. 95.
277. “ fleece.
278. “ unwashed.
279. “ in the natural grease.
280. Wool.

281. Angora hair.
282.
283. Wool, scoured.
284. “ 95.
285. “ Merino.

RUSSIA.

286. Merino, washed.
287. “ “
288. “ “
289. “ “
290. “ unwashed.
291.
292.
293. Merino, unwashed.
294. “ washed.
295. “ “
296. “ unwashed.
297. Goat's hair.

TURKEY.

298. Angora hair.
299. Goat's hair.
300. Camel's hair from Bagdad.
301. “ “ “ Aleppo.
302. “ “ “ Dardanelles.
303. Goat's “ “ Sivas.

CANADA.

304. Hamilton wool, 27 cts. per lb.
305. Cotswold fleece.
306. Wool.
307. “
308. “
308*a*. “
309. “
310. “ John Harvey & Co.
310*a*. “ “ “ 30 cts. per lb.

BRAZIL.

311. Wool.
312. “

CLASS 9. HAIR, BRISTLES, ETC.

BRAZIL.

313. Hair.
314. Hair.

TURKEY.

315. Camel's hair.
316. “ “ Esine.
317. “ “ Bagdad.
318. Bagdad, coarse wool, washed.
319. Konieh, Hair or coarse wool.
320. Erzeroum, Camel's hair.
321. Castamanni, Hair.
322. “Duvet de chien.”
323. Adana, Camel's hair, very long.
324. Smyrna, Wool.
325. “ “
326. Konieh, “
327. Wool.
328. Coarse wool.
329. Castamanni wool.
330. Bagdad, “
331. Prérézé, “ unwashed.
332. Tripoli, woolen yarn.
333. Broussl, thread, black silk.

CLASS 10. SILK IN THE COCOON AND REELED.

TURKEY.

334. Samos, Silk, raw.
335. “ “ “
336. “ “ “
337. “ “ “
339. Silk, cocoons, Antakir.
340. “
341. “ La Canée.
342. “ Yanina.
343. “ “
344. “ Monastir.
345. Silk, Monastir.
346. “ Salonique.
347. “ Government.
348. “ Smyrna.
349. “ Konieh.
350. “ “
351. “ Salonique.
352. “ “
353. “ “
354. “ La Canée.
355. “ Yanina.

356. Silk, Yanina.
357. " "
358. " "
359. " Bigha.
360. " "
361. " Yanina.
362. " Diarbekir.
363. " Yskeep.
364. " Valoma.
365. " "
366. " Konieh.
367. " Yanina.
368. " Samos.

AUSTRALIA, QUEENSLAND.

369. Silk. Cocoons, Japanese worm.
370. " European "

SPAIN.

371. Silk.
372. "
373*a*. "

BRAZIL.

374. Silk.
375. " Raw.

EGYPT.

375*a*. Vegetable fibres, Silk of the Gamphocarples fruit.

CLASS 11. COTTON ON THE STEM, IN THE BALL, AND GINNED; ALSO COTTON AND FIBRE SEEDS.

EGYPT.

376. Cotton.
377. "
378. "
379. "
380. "
381. "
382. "
383. " Aschmuni.
384. " "
385. " "
386. " "
387. " "
388. " "
389. " "
390. " "
391. " "
392. " "
393. " "
394. " "
395. " "
396. " "
397. " "
398. " "
399. " "
400. " Mako.
401. " "
402. " "
403. " Hindi.
404. " Sciubra.
405. Cotton and cotton seed, Monteray.
06. " " " " Indian.
407. Cotton seed, Indian.
408. Cotton seed. Ash Muni.
409. " " America.
410. " "
411. " "
412. " "

SOUTH AMERICA, BRAZIL.

413. Paina of Chorisa speciosa.
414. " " "
414*a*. " " "
415. Cotton.
416. " S. Paulo.
417. " Pernambuco.
418. " "
419. " Matto Grosso.
420. " Porahyba.
421. " Bemposta.
422. " "
423. " "
424. " Moranhuo.
425. " Ceara.
426. " Rocha Leao.
427. " Rio Grandi del Nort.
428. "
429. " Cotton seed, S. Paulo.
430. " " " Bemposta.

MEXICO.

431. Cotton, Algodon, Pachuea.
432. " " Cuantha.
433. " " Morelia.
433*a*. " " "

434. Cotton, Algodon, Guerrero Rio Coahuila.
435. " " San Luis Potosi.
436. " " Saltillo.
437. " " Oaxaca.
437*a*. " " "
438. " " Pachuca.
438*a*. " " "
439. " " Campech.
440. " " Merida.
441. " " Ceiba.
441*a*. " " "
441*b*. " " "

RUSSIA.

442. Cotton seed, Ag. Museum Univ. of Domains.
443. " " " " "
444. " " " " "
445. " " " " "
446. " " " " "
447. " " Sea Islands.
448. " Buttons, Ag. Museum Univ. of Domains.
449. " Samarkand.
450. " Kokan.
451. "
452. " Ag. Museum Univ. of Domains.
453. " Kokan.
454. " Katta Uranchy.
455. " Buchana.
456. " Sea Island, Samarkand.
457. " 1st qual. "
458. "

TURKEY.

459. Cotton.
460. "
461. " Bagdad.
462. " Kennyek.
463. " Monastir.
464. " Bagdad.
465. " Yanina.
466. " Dalatmas.
467. Maidos cotton.
468. Polatanas cotton in bolls.
469. Aleppo " "
470. Yanina "
471. Diarbekir cotton.
472. Cotton.

INDIA. NETHERLANDS COLONIES.

473. Cotton with seed.
474. Vegetable fibres.
475. " "
476. " "

FIJI ISLANDS.

477. South Sea Island Cotton.
478. " " " "

AUSTRALIA, QUEENSLAND.

479. Cotton.
480. "
481. " No. 2.
482. "
483. " No. 1.
484. " "
485. " No. 2.

KANSAS.

486. Cotton.

CHINA.

487. Cotton seed, Hupeh Prov.
488. " " Shantung Prov. value at Chefoo $0.08 pe sample.
489. " " Chehkiang Prov. for making oil. Valued at Ningpo $3.00 per pecul.
490. " White.
491. " Yellow.

EGYPT.

492. Jute fibre seed.
493. Aralia papyrifera.
494. Broussouetia.
494*a*. Ramieh Fibre.

CLASS 12. CEREALS (WHEAT, RYE, OATS, ETC.), WITH THEIR PRODUCTS.

CHINA.

495. Wheat, Shantung Prov.
496. Wheat, Tamsui Dist.
497. " Kiangse.

498. Wheat, Newchwang.
499. “ Shantung Prov.

CAPE OF GOOD HOPE.

500. Wheat, 1st qual.
501. “

CANADA.

502. Wheat, Highgates.
503. “ Manitoba.
504. “ Pr. Ed. Island.
505. “ Manitoba.
506. “ Ontario.
507. “ Spring.
508. “ Nova Scotia, Lost Nation.
509. “ Nova Scotia Spring.

CHICAGO BOARD OF TRADE.

510. Wheat, white winter.
511. “ Spring.
512. “ N. W. Spring.
513. “ Red winter.
514. “ N. W. Spring.
515. “ “ “
516. “ Spring.
517. “ Rejected spring.

DENMARK.

518. Wheat, Champion.
519. “ Hallet's white.
520. “ Hickling's prolific.
521. “ Kolbcheode.
522. “ Spalting's prolific.
523. “ Manchester.
524. “ Falveria.
525. “ Kentish red.
526. “ Full measure.

EGYPT.

527. Wheat, 1st qual.
528. “ Gharbijeh.
529. “

FRANCE.

530. Wheat, Golden drop.
531. “ Algeria.
532. “ Clear.
533. “ Brown.
534. “ Algeria.
535. “
536. “ de Hernon.
537. “
538. “
539. Wheat, Kissengland.
540. “
541. “

542 to 570*e*. A collection of samples of Wheat from Victoria.

NETHERLANDS COLONIES. GUELDERLAND.

571. Wheat, red bunch.
572. “ smooth eared.
573. “ red.
574. “ smooth eared.
575. “ red Swedish.
576. “ rugged eared.
577. “ “ “
578. “ tough.
579. “
580. “ white.
581. “ “ Polish.
582. “ “ Bunch.

MEXICO.

583. Wheat, Frigo de Guanajuato.

NORWAY.

584. Wheat, Spring heavy.
585. “ Winter, 1875, “
586. “ “ “

RUSSIA.

587. Wheat, Kazan, Model farm.
588. “ “ “ “
589. “ Pleghin.
590. “ “
591. “ “
592. “ “ 1st qual.
593. “ “ extra.
594. “ “
595. “ Bell.
596. “ Nostilz.
597. “ “
598. “ Maltzoff extra.
599. “ Tablotzky Dessetovsky.
600. “ Tablotzky “
601. “ Dookhinoff.
602. “ Petrovsky.
603. “ Obralnoff.
604. “ Odessa Exchange Com.
605. “ “ “ “
606. “ “ “ “
607. “ “ “ “
608. “ “ “ “

609. Wheat, Dyokhinoff.
610. “ Ermoloff.
611. “ Kobzareff.
612. “ Levchin.
613. “ Plechanoff, extra qual.
614. “ Firsoff, “ “
615. “ “
616. “ Ookhin.
617. “ Shotiloff.
618. “ Stichensky.
619. “ Vassiltchikoff.
620. “ “
621. “ Vickberg.
622. “ “

SPAIN.

623. Wheat, Frigo.
624. “ “
625. “ “
626. “ “ Alaza.
627. “ “ Alonso.
628. “ “ “
629. “ “ “
630. “ “ “
631. “ “ Caudeal.
632. “ “ “
633. “ “ Esquivel, No. 1.
634. “ “ “
635. “ “ Macolo.
636. “ “ Var Neyro.
637. “ “ Kylebery.
638. “ “ Pichi.
639. “ “ Raspeblanco.
640. “ “ “ 2d qual.
641. Black Wheat, Sarria (Provencia de Lugo).
642. Wheat, Frigo, Ucgrillo im Varipa.
643. “ Frigo, Ucgrillo im Varipa.
644. “ Frigo, Verdial.

SWEDEN.

645. Wheat, Kolbchoede.
646. “ Clear.
647. “ 2d qual.

TASMANIA.

648. Wheat, Archer, W. D. Longford.
648*a*. “ “ “ “
649. “ Red Tuscan, Creswell, C. F.
650. “ Golden Crop, Creswell, C. F.
651. “ Purple straw, Creswell, C. F.
652. Wheat, Red Lamas, Creswell, C. F.
653. “ Farmer's Friend, Cresswell, C. F.
654. “ Goldsmith.
655. “ —— Gibson, W.
656. “ Winter Braemar Velvet, Hogarth, D., Launcestown.
657. “ Lamont's Prolific, Kemp, G. A., Upper Bagdad, 1875.
658. “ Armstrug's Prolific, Kemp, G. A., Upper Bagdad, 1875.

TUNIS.

659. Wheat, medium quality.

TURKEY.

661. Wheat, from Adana (fair).
662. “ “ Andunoples.
663. “ “ An Gora.
664. “ “ Candie (crile).
665. “ “ “ (criss).
666. “ “ La Canée.
667. “ “ “ “
668. “ “ Cahil.
669. “ “ Diarbekir, extra long and heavy.
670. “ “ Diarbekir, extra long and heavy.
671. “ “ Dardanelles, 1st quality.
672. “ “ Dardanelles, 2d quality.
673. “ “ Erzeroum, 2d quality,
674. “ “ Kouoo.
675. “ “ Monastir.
676. “ “ “
677. “ “ “
678. “ “ Sivas, extra quality.
679. “ “ Smyrna.
680. “ “ Yanina.
681. “ “ “ 1st qual.
682. “ “ “ 2d qual.

MEXICO.

684. Wheat, Frigo.
685. “ “ de Puebla.
686. “ “ “

NETHERLANDS COLONIES. ZEELAND.

687. Wheat, Canada.
688. “ Chiddaw.
689. “ Hallett's white Pedigree.

690. Wheat, Hunter's white.
691. “ Macklenburgh.
692. “ Rough chaffed, Essex.
693. “ Rivet's Bearded.
694. “ Summer.
695. “ Taunton Dean.
696. “ Walchurern.
697. “ White square-headed.
698. “ Zeeland.
699. “ Brazil.
700. “ “
700*a*. “ “

CANADA.

701. Rye, Nova Scotia.
702. “ Barley oats.
703. “ Fall rye.

CHICAGO.

704. Rye, Chicago Board of Trade, No. 1.
705. “ “ “ “ No. 2.
706. “ “ “ “Rejected.

DENMARK.

707. Rye, Campen.
708. “ Eldenaur Bastard.
709. “ Graf Valdersdorff.
710. “ Jerusalenes.
711. “ Swedish Land.
712. “ Vaja Land.

FRANCE.

713. Rye, Single, 36 Hectolitres de Sigle.

GUELDERLAND.

714. Rye, Great Rije.
715. “ Zeeland Rije.

NORWAY.

716. Rye, Summer.
717. “ Winter.
718. “ “
719. “ “ 1875.

RUSSIA.

720. Rye.
721. “ Bell.
722. “ Dookhinoff.
723. “ Kazan Model Farm.
724. “ “ “ “
725. “ Novossiltseff.
726. “ “
727. “ “
728. Rye, Odessa Exchange Committee.
729. “ Vassiltchikoff.
730. “ Vickburg.
731. “ “
732. “

SWEDEN.

733. Rye, Extra quality.
734. “ “ Host Rag.
735. “ 1st quality.
736. “ 2d “
737. “ 3d “
738. “ early common, No. 11.
739. “ early.
740. “ hardy.
741. “ hulled.
742. “ long eared.

TURKEY.

743. Rye, Cus Kun.
744. “ Monastir.

ZEALAND.

745. Rye.
746. “
747. “ New Giant.
748. “ Probster.

CHINA.

749. Millet, Newchwang.
750. “ Shantung Prov., value at Chefoo 7 cts. per sample 6338.
751. “ Manchooria, fr'm Newchwang 6333.
752. “ Shantung Prov., value at Chefoo, 4 to 7 cts. per sample 6336.
753. “ Shantung Prov., value at Chefoo, 4 to 7 cts. per sample 6338.
754. “ Shantung Prov., value at Chefoo, 4 to 7 cts. per sample 6339.
755. “ Shantung Prov., red six cts. per sample 6335.
756. “ Kiangsi Prov., value at Ku Kiang $1.16 to $1.54 per pecul 6345.
757. “ Kiangsi Prov., value at Chefoo, 3 cts. per sample 6354.

758. Millet, Prov. of Hupeh, used for food and sowing. Value at Hankow $6.00 per pecul 6511.

UNITED STATES.

759. Millet, Delaware.

FRANCE.

760. Millet, Crefle Rouge.

RUSSIA.

761. Millet, Manyuska Model Farm.
762. " Odessa Exch'nge Committee.

TURKEY.

763. Millet, Diarbekir, large.
764. " Cahif.
765. " Yanina.

ZEELAND.

766. Millet, in the ear.

NETHERLANDS COLONIES.

767*a*. Variety of Bird seed.

CHINA.

767. Basil seed, Shantung Province.

AUSTRALIA.

768. Millet, Victoria.
769. Barley, "
770. " English, from Mayston, Vic., 56⅛ lbs. per bushel.
771. " Malt from Melbourne.
772. " " 59¼ lbs. per bushel.
773. " " from Richmond, 58½ per bushel.
774. " " St. Armand, 56 lbs. per bushel.
775. " Campbell's creek, 58½ lbs. lbs. per bushel.
776. " " from Melbourne.

UNITED STATES.

777. Barley. California malt fr'm Bergner and Eugel, Philadelphia.

CANADA.

778. Barley from Canada.

PHILADELPHIA.

779. Barley. Refuse from Bergner & Eugel, used for feed.

BRAZIL.

780. Barley.
781. "

CANADA.

782. Barley, Nova Scotia, four rowed.
783. " Nova Scotia.
784. " Manitoba.
785. " Ontario two rowed.
786. " " six "
787. " Toronto.

CHICAGO.

788. Barley, Board of Trade No. 1.
789. " Board of Trade No. 2.
790. " Board of Trade No. 3.
791. " Board of Trade Rejected.

CHINA.

792. Barley, Pearl, Prov. of Hupeh, 6329. Value at Hankow, $3.00 per pecul.
793. " Prov. of Hupeh. Value at Hankow, $1.00 per pecul, 6325.
794. " Kiangsi Prov. Value at Kinkiang 50 cts. per bushel, 6313.
795. " Kiangsi Prov. Value at Chinkiang $2.50 per pecul. 6315.
796. " Manchuria from Newchwang 6363.
797. " Manchuria from Newchwang 6323.
798. " Pearl, Manchuria, from Newchwang, 6327.
799. " Shantung Prov. Value at Ningpo $18.00 per pecul. 4243.
800. " Pearl, Shantung Prov., value at Chefoo 12 cts. per sample 6328.
801. " Suburbs of Ningpo. Value at Ningpo $1.00 per pecul, 6326.

DELAWARE.

802. Barley, Chevaloir.
803. " Potter's.
804. " Carter's prolific.

DENMARK.

805. Barley, Riis.
806. “ Great Bluih.
807. “ Long specked six rows.
808. “ Kalina.
809. “ Yorkshire.

EGYPT.

810. Barley, Upper Egypt.

FRANCE.

810*a*. Barley.
811. “
812. “ No. 1.
813. “ Malt.
814. “ “
815 “ “

NETHERLANDS COLONIES.

816. Barley, Guelderland.
817. “ Guelderland, summer.
818. “ Guelderland, winter.
818*a*. “ Guelderland.
819. “ Guelderland.

NORWAY.

820. Barley, Six rows.
821. “ Supposed four rows,

RUSSIA.

822. Barley, Bell.
823. “ Deughink,
824. “ Korf,
825. “ Nostitz,
826. “ Novassiltseff.
827. “ Black, Novassiltseff.
828. “ Odessa Exchange Com.
829. “ Petrovska Model farm.
830. “ Black, Shatiloff.
831. “ Vickburg.
832. “ “

NORWAY.

833. Barley, Two Rows.
834. “ Hulled Hordeum friforcatum.

SPAIN.

835. Barley, Cebanda Negra.
836. “ “ Caballar.
837. “ “
838. “ malt, Cebanda.

SWEDEN.

839. Barley, marked No. 15.
840. “ “ No. 7.
841. Barley, large grained.
842. “ Early.
843. “ and oats for feed.
844. Malt, No. 1, marked No. 5.
845. “ No. 2, “ No. 20.

TASMANIA.

845*a*. Barley Malt, Wm. Gracie, Hobart Town.
846. “ “ John Degraves.

AFRICA.

847. Barley, Tunis.

TURKEY.

848. Barley, 2d quality.
849. “ Aleppo.
850. “ Anonnoples, 1st qual.
851. “ Cahif, “
852. “ Konia,
853. “ “
854. “ La Canée,
855. “ Salonique,
856. “ Volonia,
857. “ Yanina, 1st quality,
858. “ “ “

EGYPT.

859. Barley, Upper Egypt.

NETHERLANDS COLONIES.

860. Barley. Zeeland Chavalier.
861. “ “ Gumagen Spring.
862. “ “ Six Rows First.
863. “ “ Summer.
864. “ “ Thump Winter.
865. “ “ Winter.
866. “ “ Winter.

CANADA.

867. Buckwheat,
868. “ Manitoba,
869. “ Nova Scotia,
870. “ Silver Hulled.

CHINA.

871. Buckwheat, Kiangsi Prov. Value at Hinkiang $2.10 per pecul, 6320.
872. “ Value at Hinkiang $2.10 per pecul, 6320.
873. “ Value at Hinkiang $2.10 per pecul, 6320

874. Buckwheat, Kiangsi Prov. Value at Chinkiang $2.67 per pecul 6321.
875. " Manchuria from Newchwang, 6318.

DELAWARE.

876. Buckwheat.

EGYPT.

877. Buckwheat.
878. " Spinach.
879. " Hemp Ketmil.

NETHERLANDS COLONIES.

880. Buckwheat, Guelderland, Gray Bunch.
881. " Guelderland.

RUSSIA.

882. Buckwheat, Grotenfeld.

SPAIN.

883. Buckwheat, Brioa.
884. " Fajol.
885. " "

AUSTRALIA.

886. Oats, Victoria.
887. " " from Buangor, 52½ lbs. per bushel.
888. " " Grown at Hopton, soil heavy clay. Yield, 40 bushels per acre. Wt. 48 lbs. per bushel.
889. " " Short oats, 52½ lbs. per bushel.
890. " " 50½ lbs. per bushel.
891. " " Tartarian oats from Buangor, 47 lbs. per bushel.
892. " " Tartarian oats from Colomski 45 lbs. per bushel.
893. "

BRAZIL.

894. Oats.

CANADA.

895. Oats, Black.
896. " Pr. Ed. Island Bulman Black.
897. " " " Black.

CHICAGO BOARD OF TRADE.

899. Oats, No. 1.
900. " " 2.
901. " Rejected.

DENMARK.

902. Oats, Algier.
903. " Odenbrucher.
904. " Siberian.

DELAWARE.

905. Oats, black Scotch.
906. " Sandy.
907. " Providence.
908. " Scotch potatos.
909. " Beuvisk.

FRANCE.

910. Oats, black.
911. " black, large yield.
912. "
913. " black.
914. " Avoine rouge.
915. " " black.
916. "

GUELDERLAND, NETHERLANDS COLONIES.

917. Oats, Procstein.
918. " big.
919. "
920. " bunch.
921. "

NORWAY.

922. Oats, black.
923. " No. 2.
924. " Potato.
925. " No. 3.
926. "
927. " Kinn Bush.
928. " Mixed barley and oats, 102 Holland lbs.
929.

RUSSIA.

930. Oats, Ermoloff.
931. " Shatiloff.
932. " Odessa Exchange Committee.
933. " Shatiloff.
934. " Vassellchikoff, R. W.
935. " Dookhinoff.
936. " Bell.
937. " Fereoff.
938. " Kazan Model farm.

939. Oats, Novossiltseff.
940. “ Dookhinoff.
941. “ Kazan Model farm.
942. “ Leochin.
943. “ Stichinsky.
944. “ “

SPAIN.

945. Oats, Avena.
946. “ “
947. “ “

SWEDEN.

948. Oats, No. 3.
949. “ Hulls.
950. “ Mixed grain.
951. “
952. “

TASMANIA.

953. Oats, Poland.
954. “ Tartarian.
955. “ “

TURKEY.

956. Oats, Canée.
957. “ Yanina, 1st qual.
958. “ “
959. “ Kus Kuri.
960. “ Bevat.
961. “

ZEELAND, NETHERLANDS COLONIES.

962. Oats, Heavy Groningen.
963. “ Frisian.
964. “ Winter.
965. “ Black Tartarian.
966. “ Danish.
967. “ Probster.

BRAZIL.

970. Rice, unhulled white.
971. “ “ yellow marked 1040.
972. “ Hulled, extra, marked Maranhou.
973. “ Marked Moranhou, 1043.

CHINA.

974. Rice, Black roasted and taken as coffee, South Formosa.
975. “ 2d qual., “ “
976. “ 3d crop.
977. “ Tamsui district.
978. “
979. Rice, 2d crop, suburbs of Ningpo.
980. 3d “ “ “
981. “ Tamsui district.
982. “ “ “
983. “ Shangtung Prov.
984. “ Unshelled, 2d crop, suburbs of Ningpo.
985. “ 1st qual., South Formosa.
986. “ Paddy, Kiangsi Prov.
987. “ “ Tamsui district.
988. “ 1st crop unshelled, suburbs of Ningpo.
989. “ 3d qual., South Formosa.
990. “ “ “ “
991. “ Paddy, Tamsui district.
992. “ 2d qual., Kiangsi Prov.
993. “ Paddy, Tamsui district
994. “ 2d qual., Fukien Prov.
995. “ Red, South Formosa.
996. “ Tamsui district.
997. “ 2d crop unshelled. Suburbs of Ningpo.
998. “ 1st qual., Kiangsi Prov.
999. “ Paddy, Tamsui district.
1000. “ “ “ “
1001. “ Kiangsi Prov.
1002. “ “ “
1003. “ 3d crop unshelled. Suburbs of Ningpo.
1004. “ Tamsui.
1005. “ unshelled, Prov. of Foochow
1006. “ Suburbs of Ningpo.
1007. “

EGYPT.

1008. Rice barley.
1009. “ cleaned.
1010. “ barley.

MEXICO.

1011. Arroy de Yucatan, unhulled rice.

TURKEY.

1012. Variety of rice.

HAWAIIAN ISLANDS.

1013. Rice, unhulled.
1014. “ hulled, No. 1.
1015. “ “ “ Chaleur Plantation.
1016. “ “ No. 2. “ “
1017. “ “ No. 1. Wiahole Plantation.

INDIA, NETHERLANDS COLONIES.

1018. Rice, on the stalk.
1019. “ “ “ marked 119.
1020. “ “ “ marked 120.
1021. “ “ “ marked 121.
1022. “ “ “ marked 122.
1023. “ “ “ marked 123.
1024. “ Shelled, marked 124.
1025. “ Red, shelled, marked 125.
1026. “ Black, “ “ 126.
1027. “ White, “ “ 127.
1028. “ “ “ “ 128.
1029. “ “ “ “ 129.
1030. “ “ “ “ 130.
1031. “ Unshelled “ 131.
1032. “ Shelled “ 132.

SPAIN.

1037. Rice, Arroz Cilindrad.
1038. “ “ “
1039. “ “ “
1040. “ “ “

MEXICO.

1041. Rice, Arroz de Puebla.

CHINA.

1042. Rice, Shantung Prov. Basil seed.
1043. Maize, Kiangsi Prov.
1044. Corn, Prov. of Hupeh. Value at Hankow $3.00 per pecul. 6330.
1045. “ Manchuria from Newchwang, Maize, 6347.
1046. “ Manchuria from Newchwang, Maize, 6346.
1047. “ Suburbs of Ningpo. Value at Ningpo $1.50 per pecul.
1048. “ Shangtung Prov. Value at Chefoo 4 cts. per sample. 6348.
1049. “ Shantung Prov. Value at Chefoo 4 cts. per sample. 6349.
1050. “ Small yellow.

CHICAGO BOARD OF TRADE.

1051. Corn, No. 1.
1052. “ “ yellow.
1053. “ “ white.
1054. “ No. 2.
1055. “ New high mixed.
1056. Corn, new mixed.
1057. “ Rejected.

DELAWARE.

1058. Corn, Adams extra.
1059. “ Yellow, known as Canada.
1060. “ Extra early.
1061. “ Tuscarora.
1062. “ Early sugar.
1063. “ Ground seed.
1064. “ White Flint.

EGYPT.

1065. Corn, Naire Maize.
1066. “ Pearl “

MEXICO.

1067. Corn, Maize de Yucatan.

SPAIN.

1068. Corn.
1069. “ Encarnado de Francia.
1070. “ Maiz perla blanco.
1071. “ Maiz perla inferior.
1072. “ Maiz amorillo de la perla.

RUSSIA.

1073. Corn, Maize Denyhink red.
1074. “ “ “ yellow.
1075. “ Odessa Exchange Com.

TURKEY.

1076. Corn, Andrínoples, 1st qual.
1077. “ Canée.
1078. “ Catril.
1079. “ Dardanelles.
1080. “ Hidgar.
1081. “ Volonia Maize.
1082. “ Yanina.

BRAZIL.

1083. Flour of Mandioca.
1084. “ “ “
1085. Farinha de “
1086. Scraping of “ powdered.
1087. Starch of “
1088. Fecula.
1089. Corn meal.
1090. From corn.
1091. Prepared corn.
1092. Starch.
1093. Tapioca, Escaldad.
1094. Arrow root.
1095. marked 818.

1096. marked 817.
1097.
1098. " 179.
1099. " 816.
1100. " 792.

CHINA.

1101. Wheat flour, Shantung Prov.
1102. Macaroni, " "
1103. Vermicelli, Newchwang.

CANADA.

1104. Oatmeal, Mount Forest.
1105.

GLEN COVE, N. Y.

1106. Duryea's Satin Gloss Starch.
1107. " " " "
1108. " Improved Corn Starch.
1109. " Maizena.

HAWAIIAN ISLANDS.

1110. Tapioca.
1111. Farina.
1112. Arrow root.
1113. " "

OSWEGO, N. Y

1114. Corn-Starch for culinary use.
1115. Blue Starch.
1116. Silver Gloss Starch.
1117. Refined Corn-Starch.
1118–1120. Varieties of starch.

NETHERLANDS.

1121. Flour, Meal, &c.
1122. " " "
1123. " " "
1124. " " "
1125. " " "
1126. " " "
1127. " " "
1128. " " "
1129.

SPAIN.

1130. Afreitas.

SWEDEN.

1131. Nafn-gryn. 2 gauger krossode.
1132. Rag-mjol.
1133. Wheat Bran.
1134. Rag-mjol.
1135. Nafu-gryn.
1136. Hafregryns mjol (affan).
1137.

TURKEY.

1138. Bulbed Selep (a starchy food).

TASMANIA.

1139. Flour from Tasmania.

CLASS 13. PLANTS USED FOR FOOD OTHER THAN CEREALS, (PEAS, BEANS, ETC.).

AUSTRALIA.—VICTORIA.

1140. Beans, long pod; the best yielding variety known; from Geelong.

BRAZIL.

1141. Beans.
1142. " speckled.
1143. " Castor Oil.
1144. " red mixed.
1145. " "
1146. " white flat.
1147. " " common.
1148. " " sweet early.
1149. " light silver "Carana," 1020.
1150. " dark silver, small.
1151. " light gray, 1017.
1152. " " very small.
1153. Beans, yellow.
1154. " yellow, small.
1155. " reddish yellow.
1156. " red, 1004.
1157. " long mixed, 1005.
1158. " brown.
1159. " " small.
1160. " " Parana, 1014.
1161. " brown.
1162. " dark mixed.
1163. " yellowish, 1018.
1164. " reddish, 1007.
1165. " large yellow, 1018.
1166. " reddish medium.
1167. " horse.
1168. " "
1169. " spider, 1048.
1170. " black, 1009.

1171. Beans, black, medium, 1015.
1172. " " "
1173. " black, small, 1019.
1174. "

CANADA.

1175. Beans, Montreal White Pea.
1176. " Nova Scotia Purple speckled Bush.
1177. " " " Dunclourd Bush.
1178. " " " Yellow-eyed Bush.
1179. " " " Dwarf China Bush.
1180. " " " Pole.
1181. " " " Royal pale.
1182. " " " Fawn.
1183. " " " Robin's egg Bush
1184. " " " Provincial.
1185. " St. Janvier Early Brown.
1186. " Petite Cote H.
1187. " Province Quebec Dwarf Butter.
1188. "
1189. "

CHINA.

1190. Black beans from Formosa.
1191. Large flat green Peas, Kiangsi Province.
1192. Large black Beans, Shantung Province.
1193. Beans, white, suburbs of Ningpo.
1194. " small green, Kiangsi Prov.
1195. " " Shantuug "
1196. " " " Kiangsi "
1197. " " Hupeh "
1198. " " Shantung "
1199. " black, Hupeh Prov.
1200. " small green, Newchwang.
1201. " black, Formosa.
1202. " " for rheumatism, Kiangsu.
1203. " white, Shantung Prov.
1204. " yellow, Kiangsi "
1205. " rice, Formosa.
1206. " small black, Shantung Prov.
1207. " white, " "
1208. " black, " "
1209. " yellow, " "
1210. " large black, " "
1211. " " red, " "
1212. Beans, large red, Shantung Prov.
1213. " yellow, Hupeh Prov.
1214. " red, Shantung "
1215. " large, suburbs of Ningpo.
1216. " flat, Kiangsi Prov.
1217. " " " "
1218. " small mixed, Shantung Rrv.
1219. " from Newchwang.
1220. " " Kiangsi Prov.
1221. " " Formosa.
1222. " " Kiangsi Prov.
1223. " name unknown, Kiangsi Prov.
1224. " from Newchwang.
1225. " Kiangsi Prov.
1226. " medicine, Newchwang.
1227. " Chefoo.
1228. " Newchwang.
1229. "
1230. "

DELAWARE.

1231. Beans, Mohawk.

EGYPT.

1232. Beans, large white.
1233. " " round.
1234. " speckled butter.
1235. " red kidney.
1236. " Lubia Doliohos.
1237. "
1238. " from lower Egypt.
1239. " (Castor oil) Ricurus plant.
1240. " from Fayoma.
1241.
1242. " Dolichos Lablab.

FRANCE.

1243. Beans, large white.

NETHERLANDS COLONIES, GUELDERLAND.

1244. Beans, Arab short.
1245. " white short.
1246. " " "
1247. " " French.
1248. " "
1249. " yellow.
1250. " brown.
1251. " yellow, short.
1252. " horse.
1253. " " mixed.
1254. " Pigeon.
1255. " spotted short.
1256. " Fretillery.

1257. Beans, salad short.
1258. “ white.
1259. “ Mottha.
1260. “ spotted French.
1261. “ Laden big beans.
1262. “
1263. “ Frijol de Puebla.
1264. “ “ “ Yucatan red.
1265. “ “ “ “ black.

RUSSIA.

1266. Beans, French, Odessa Exchange Committee.
1267. “ French, Odessa Exchange Committee.
1268. “ French, Manyska model farm.
1269. “ French, Manyska model farm common.
1270. “ large flat common.
1271. “ sweet French.

SPAIN.

1273. Beans, Judias de Garrofa.
1274. “ Habas de Manteca.
1275. “ Habas Mumda.
1276. “ Judias.
1277. “ Jabachas blancas.
1278. “ Fosols.
1279. “ “ Jabes.
1280. “ “ Renegas.
1281. “ Judias Rénegas senoritas.
1282. “ Judias pintadas.
1283. “ Chinas.
1284. “ Fasols Gabachas.
1285. “ Jabas.
1286. “ Fasols Reneyas dark.
1287. “ Frijoles Americanos.
1288. “ Habas negras panesquetas.

SWEDEN.

1290. Beans, yellow.
1291. “ brown.
1292. “ green, large.

TASMANIA.

1293. Beans, horse. C. F. Creswell.

TUNIS.

1294. Beans, white.
1295. “ small black spots.
1296. “ large, flat.

TURKEY.

1297. Beans, Adana, Castor Oil.
1298. “ Aleppo, small.
1299. “ Canée, small.
1300. “ Konia, white.
1301. “ Palamar.

NETHERLANDS COLONIES.

1302. Beans, Zeeland.
1303. “ large white.
1304. “ giant runners.
1305. “ white globe.
1306. “
1307. “ small white.
1308. “ “ “
1309. “ white dwarf.
1310. “ black Pewet.
1311. “ brown “
1312. “ large speckled.
1313. “ brown “
1314. “ large brown.
1315. “ Pigeon.

GUELDERLAND.

1316. Beans, great.
1317. “ “ flat.
1318. “ Gronnigen.
1319. “ Ruiselaer.
1320. “ large, mixed.
1321. “ sheep.
1322. “ Besilian sheep.
1323. “ Thump.
1324. “ sugar.
1325. “
1326. “
1327. “

AUSTRALIA, VICTORIA.

1328. Peas, Bellevine new fodder.
1329. “ Geelong new fodder.
1330. “ Bellevine Prussian Blue, crop of 1876.
1331. “ Geelong, 1876, Yorkshire head, delicious.

BRAZIL.

1332. Peas, marked 1080.
1333. “ Chicaro Parana.
1334. “ white.
1335. “ small green.

CANADA.

1336. Peas, white.

1337. Peas, young.
1338. " Beauharions gray.
1339. " Manitoba Field.
1340. "
1341. " " Crown.
1342. " Vandeuil Bean.
1343. " Nova Scotia marrow fat.

CANADA.

1344. Peas, Yeudon split.

CHINA.

1345. Peas, Hupeh. Value at Hankow $2.50 per pecul.
1346. " Wuton. Value at Kiukiang $1.46 per bushel.
1347. " large yellow. Value at Chinkiang $2.67 per pecul.
1348. " Kiangsi, small dried. Value at Chinkiang $2.60 per pecul.
1349. " Pharbitis convolvulus. Value at Ningpo $7.00 per pecul.
1350. " Pharbitis seed. Value at Ningpo $7.00 per pecul.
1351. " Kiangsi, Vitexirisea. Value at Ningpo, $8.00 per pecul.

EGYPT.

1352. Peas, chick.
1353. " sugar. Pisum Sativium.
1354. " green crushed.
1355. " from Middle Egypt.
1356. " roasted chick.
1357. " Lupine.
1358. " Vitia Stativa.
1359. " Cyperus Esculentus.

BRAZIL.

1360. Peas.

FRANCE.

1361. Peas, mixed.

NETHERLANDS COLONIES. GUELDERLAND.

1362. Peas, green crown.
1363. " green field.
1364. " " "
1365. " yellow "
1366. " Capucin yellow.
1367. " " brown.
1368. " gray.

NORWAY.

1369.
1370. Peas, gray, early ripe.
1371. Peas, black, for fodder.

RUSSIA.

1372. Peas, Ermoloff.
1373. " Levchin.
1374. " Odessa Exchange Com.
1375. "

SPAIN.

1376. Peas, Melas.
1377. " Attramuces.
1378. " "
1379. " Guijas.
1380. " Titos ó muclas.
1381. " Garbanzoi.
1382. " " not cultivated in U. S.
1383. " quisantes verdes.
1384. " Zeros, (Coresha de 1875.)
1385. " Areponces.
1386. " "
1387. " Galgana.

SWEDEN.

1389. Peas, small white, early.
1390. " white, grown by F. Jacobson.
1391. " green.
1392. " white hvita.
1393. " early green.
1394. " small early green.
1395. " Aker arter (gra).
1396. " black.

TASMANIA.

1397. Peas.
1398. " Field green, Hoodford's, from C. F. Creswell.
1399. " grey, C. F. Creswell.

TUNIS.

1400. Peas, yellow.
1401.

TURKEY.

1402. Peas, Bagdad, early table.
1403. " La Canée, small.
1404. " " "
1405. " Dardanelles, small.
1406. " Konia.
1407. " Smyrna, small.
1408. " Yanina, mixed.
1409. " " "
1410. " " small dark.

NETHERLANDS COLONIES, ZEELAND.

1411. Peas.
1412. “ white.
1413. “ large blue.
1414. “ small blue.
1415. “ wrinkled.
1416. “ brown.
1417. “

NORWAY.

1418. Tares, Futter Viciar.

RUSSIA.

1419. Tares, Mookhin white.
1420. “ “ black.
1421. “ Kazan Model farm.

SPAIN.

1422. Tares, Leegum.

SWEDEN.

1423. Tares and oats used for feed.

TASMANIA.

1424. Tares, Golden, C. F. Creswell.
1425. “

EGYPT.

1426. Lentils, Gleditshia friatanthos.
1427. “ Upper Egypt.
1428. “ Bean, upper Egypt.
1429. “ Lower “
1430. “ Crushed, lower Egypt.
1431. “ “ “ “

RUSSIA.

1432. Lentils, Pearl Deughink.

SPAIN.

1433. Lentils, algarrola.
1434. “ Lentejas.
1435. “ “

TUNIS.

1436. Lentils.

TURKEY.

1438. Lentils, Adana.
1439. “ Kara Hissar.
1440. “ Yanina.

RUSSIA.

1441. Carrot, Zapevaloff.
1442. “

FRANCE.

1443. Beet, Betteraves.

RUSSIA.

1444. Beet, Vassiltchikoff.
1445. “ Zablotzky Dessetovsky.

SPAIN.

1446. Beet.

NETHERLANDS COLONIES, ZEELAND.

1447. Beet, mangold wurzel.

CHINA.

1448. Onion, Kiangsu Prov. Leek, value at Chinkiang, $25 per pecul.

RUSSIA.

1449. Onion, Zapevaloff.

TUNIS.

1450. Onion.

TURKEY.

1451. Onion, Smyrna.

RUSSIA.

1452. Radish.
1453. “ Zapevaloff.

EGYPT.

1454. Turnip, etc., Brassica Aveka.
1455. “ Maysus alba.
1456. “ “ Ravs.

DELAWARE.

1457. Turnip, white flat.

TURKEY.

1458. Turnip, Saxonkhan.

SWEDEN.

1459. Cabbage, etc.

RUSSIA.

1460. Cress, Zapevaloff.
1461. Spinach.
1462. Lettuce, Zapevaloff.

EGYPT.

1463. Lettuce.
1464. Parsley, Apsium petroselimun.
1465. Spinach.

RUSSIA.

1466. French grass, Ermoloff.
1467. “ “ Kharkoo Model farm.

EGYPT.

1468. Endive.

1469. Hibiscus Esculentus as used for soup.
1470. Hibiscus Esculentus as used for pickles.

CHINA.

1471. Seeds, commercial, in paper.
1472. “ Gourd. Kiangsi Prov. Value at Amoy $22 per pecul.

EGYPT.

1473. Seeds, Gourd. Rouora Tavuile.
1474. “ “ Pava “

CHINA.

1475. Seeds, Pumpkin. Shantung. Value at Chefoo 8 cts. per sample, 3846.
1476. “ Pumpkin. Kiangsi. Value at Chinkiang $15.50 per pecul.

EGYPT.

1477. Seeds, Pumpkin. Quara Houpi.
1478. “ “ “ Asfar.

RUSSIA.

1479. Seeds, Pumpkin. Zapevaloff.
1480. “ Cucumber. “

EGYPT.

1481. Seeds, Melon. Shammam.

SPAIN.

1482. Seeds, Melon. Penitas de Melon de todo clano.
1483. “ “ Penitas.

EGYPT.

1484. Seeds, Melon, Water.

CHINA.

1485. Seeds, Melon, Water. Newchwang.
1486. “ “ “ Kiangsi Prov. An aperient. Value at Chinkiang $19.44 per pecul.

TURKEY.

1487. Seeds, Melon, Winter. Aleppo.

CLASS 14. NUTS.

CHINA.

1488. Brown Lotus Nuts.
1489.
1490. “ “ “ Hupeh Prov. Value at Hankow $6.00 per pecul.
1491. White Lotus Nuts.
1492. Salisbercan Seed. Value at Chefoo 11 cts. pecul. Hupeh.
1493. White Nuts for food. Value at Hankow $1.50 per pecul.
1494. Hazel Nuts from Newchwang.

RUSSIA.

1495. Chestnuts from Crimea, Swokhin.
1496. “ Povudooks, Swokhin.

CHINA.

1497. Chestnuts. Shantung. Value at Chefoo 12 cts. per sample.
1498. Peanuts. Shantung. Value at Chefoo 17 cts. per sample.

EGYPT.

1499 Peanuts.

SPAIN.

1500. Peanuts. Cacahuet, Mani.
1502. Pinones in shell.
1503. “ shelled.

BRAZIL.

1504. Sapucaia Nuts.
1505. Almendras Blamadas del Vale, seed imported from Spain.
1506. Almendra Fina.
1507. Walnuts.

SPAIN.

1508. Walnuts.

CHINA.

1509. Nuts. Chêhkiang.
1510. Apricot kernels. Hupeh. Value at Hankow $7.00 per pecul.

RUSSIA.

1511. Succory. Swokhin, to adulterate coffee.

EGYPT.

1512. Hibiscus Esculentus. Chufas.

SPAIN.

1513. Chufas.
1514. “

CLASS 15. FLESHY FRUITS (DATES, APRICOTS, ETC.).

EGYPT.

1515. Ferones Elephantum.

CHINA.

1516. Jujubes, red. Shantung Prov. Value at Chefoo 3 cts. per sample.
1517. " black. Value at Chefoo 4 cts. per sample.

SPAIN.

1518. Walnuts.

EGYPT.

1519. Melia Azedarach.
1520. " "

SPAIN.

1521. Higos blancos o' de cofin.

EGYPT.

1522. Apricot paste.
1523. Preserved dates from the Oasis.
1524. " "
1525. Phoenis Dactylifera Volma.
1526 " " "
1527. " " da guana.
1528. " " gondala.
1529. " " ibriny.
1530. " " shâmi.
1531. " " "
1532. " " yarroutis.
1533. Ceratnia siliqua.

SPAIN.

1534–1537. Castanas.

CLASS 16. THEIN PLANTS, (TEA, COFFEE, COCOA, ETC.).

BRAZIL.

1538–1547. Coffee.
1548. Cofiee, Bahia.
1549. " " mixed.
1550. " Bemposta.
1551. " "
1552. " "
1553. " " Augusto Sovres.
1554. " " " "
1555. " " choice.
1556. " with and without husk.
1557. " Augusto, Sovres.
1558. " Unhulled.
1559. " "
1560. " Brunido Cantagallo.
1561. " Cantagallo.
1562. " "
1563. " Brunido Cantagallo.
1564. " Crogueira da gama.
1565. " Corovellas.
1566. " Cantagallo, Rio de Janerio.
1567. " Dospolpado.
1568. " Dommgos, Rio de Janerio.
1569. " Exhibition Committee, Vienna.
1570. " Exhibition Committee, Rio de Janerio.
1571. " Eucreo.
1572. Cofiee, Fezueda de Triumpho.
1573. " Lavoda.
1574. " Rio de Janerio.
1575. "
1576–1579. Rocha Leao.
1580. " Rodrigeus Jordao.
1581. " Supelped.
1582–1585. San Paulo.
1586. " Vergueiro.
1587. "

HAWAIIAN ISLANDS.

1588. Coffea, Kona.
1589. " "

MEXICO.

1590. Coffee. Café de Colima.
1591. " " de Cordoba.
1592–1595. Coffee. Café de Uruapan.

INDIA, NETHERLANDS COLONIES.

1596–1654. Coffee, Netherlands Catalogue, Nos. 59–116.

RUSSIA.

1655. Coffee. Barley, Sivokhin.
1656. " Acorn, "
1657. " " "

BRAZIL.

1658–1661. Cocoa.
1662. Cocoa. Dipterius odorator.
1663. “
1664. “

EGYPT.

1665. Tamarind husks.
1666. “ “
1667. Pongamia glabra.
1668. “ “
1669. Acacia niloiica.
1670. Ceratonia Siliqua.

CLASS 17. SACHARINE SEEDS AND SUBSTANCES.

CHINA.

1672. Sorghum, Kiangsi Prov. Value at Chefoo 2 cts. per sample.
1673. “ Kiangsi Prov. Value at Kiukiang $1.50 per pecul.
1674. “ Heupeh. Value at Hankow $1.50 per pecul.

TUNIS.

1675. A seed resembling sorghum.

AUSTRALIA, QUEENSLAND.

1677–1682. Sugar.

BRAZIL.

1683. Sugar, Ceara.
1684. “ “
1685–1697. Sugar, manufactured at Campas Rio de Janerio.
1698–1709. Sugar, manuf., Pernambuco.

CHICAGO BOARD OF TRADE.

1711. Sugar, Beet, 1st product.
1713. “ “ 3d “

HAWAIIAN ISLANDS.

1714–1727. Sugar.

INDIA. NETHERLANDS COLONIES.

1728–1735. Sugar.

CLASS 18. AROMATICS, (ANISE, DILL, ETC.).

ALGERIA. FRENCH COLONIES.

1737. Hops.

AUSTRALIA, VICTORIA.

1738. Hops, from the aboriginal station Corrandeuk.
1739. “ California, from Bergner & Engel, Brewers, Phila.
1740. “ best Bavarian, from Bergner & Engel, Brewers, Phila.
1741. “ New York, from Bergner & Engel, Brewers, Phila.

FRANCE.

1742. Hops. Burgundy.
1743. “ Lorraine.
1744. “

RUSSIA.

1746. Hops. Bohemia.
1747. “ “

TASMANIA.

1748. Hops, Golden.
1749. “ known as No. 49.

SPAIN.

1750. Cauamones.
1751. “

TURKEY.

1752. Anise seed, from Mardis.
1753. “ “ “ Aleppo.
1754. “ “ “ Dardanelles.

SPAIN.

1755. Anise seed.

TUNIS.

1756–1759. Anise seed.

UPPER EGYPT.

1760–1762. Anise seed.

NETHERLANDS COLONIES. ZEELAND.

1763. Caraway.

RUSSIA.

1764. Dill. Zapevaloff.

TUNIS.

1765. Coreanda.

EGYPT.

1766–1768. Coriandrum Sativum.

SPAIN.

1769. Pimente de Naboo.

CHINA.

1770. Clove Tree seed.
1771–1772. Cloves.

INDIA, NETHERLANDS COLONIES.

1773–1775. Pepper, white.
1776–1779. " black.

EGYPT.

1781–1782. Pepper, red, Capsicum annuum.

INDIA. NETHERLANDS COLONIES.

1783. Chile Mulato.
1784–1789. Mace.

CLASS 19. OLEAGINOUS SEEDS, (FLAX, RAPE, DILL, ETC.).

CHINA.

1790. Seed of a plant, Syschuen Prov.

CANADA, NOVA SCOTIA.

1791. Flaxseed.
1792. " Varrennov.

FRANCE.

1793–1794. Flaxseed.

GUELDERLAND.

1795. Flaxseed.
1796. " Crop of 1875. Direct importation from Riga at Rotterdam.
1797. " Crop of 1875. White blossom, Dutch.
1798. Flaxseed.

RUSSIA.

1799. Flaxseed.
1800. " Bessarabian Horticultural School.
1801. " Pskor Statistical Com.
1802. " Haramycheff.
1803. " Kazan Model Farm.
1804. " Obralnoff.
1805. " Odessa Exchange Com.
1806. " Dootehmoff.
1807. " Repuin Princek.
1808. " Oil Press Pskor Statistical Com.
1809. " Pleshanoff.

SPAIN.

1810. Linaza.
1811. Flaxseed.
1812. "

SWEDEN.

1813. Flaxseed.

TASMANIA.

1814. Flaxseed, from C. F. Creswell.

TUNIS.

1815. Flaxseed.

TURKEY.

1816. Flaxseed from Tutours.

ZEELAND.

1817. Flaxseed.

GUELDERLAND.

1818. Lin Meal.

RUSSIA.

1819. Linseed Oil Cake.

CHINA.

1820–1822. Sesamum seed.
1823. Small Pine "
1824. Mustard "
1825. Sin "
1826. Cabbage "
1827. Castor oil beans.
1828. " " "
1829. Large pine seed.
1830–1833. Sesamum seed.

RUSSIA.

1834. Canary seed.

FRANCE.

1835. Canary seed, from Algeria.

ZEELAND.

1836. Canary seed.

BRAZIL.

1837. Mustard.

ZEELAND.

1838. Yellow mustard.

RUSSIA.

1839. Sunflower seed. Bessarabian Horticultural School.

TURKEY.

1840. Sunflower seed, white, fr'm Aleppo.

SPAIN.

1841. Sunflower seed. Alazor.

EGYPT.

1842. Sunflower seed. Carthamus.
1843. “ “ “
1844. Pistacia therebintus.
1845. Poppy.
1846. Lactuca Oleifera.
1847. Rape seed.
1848. “ “
1849. White Rape.
1850. Sesame.
1852. Mustard.

FRANCE.

1853. Cameline.
1854. Colza seed.

GUELDERLAND.

1855. Rape seed.

RUSSIA.

1856. Rape seed.
1857. “ “
1858. Camline seed.
1859. Rape “
1860. “ “ wild.

SPAIN.

1861. Semilla de madia sativa.

TURKEY.

1862. Oilseed.

TASMANIA.

1863. Rape seed.

ZEELAND.

1864. Winter rape.
1865–1868. Oilseed.

CLASS 20. FORAGE PLANTS, (CLOVER, HAY, ETC.).

DELAWARE.

1869. Red Clover.

NORWAY.

1870. Red Clover.

RUSSIA.

1871. Clover seed.
1872. “ “
1873. “ “ Kazan Model farm.

SWEDEN.

1874. Clover seed.

TASMANIA.

1875. Perennial Red Clover.
1876. White Clover.

RUSSIA.

1877–1880. Timothy seed.
1881. Kazan Model farm.

SWEDEN.

1882. Timothy seed.
1883. “ “
1884. Grass seed.

NORWAY.

1885. Mixed grass seed.
1886. Timothy seed.

DELAWARE.

1877. Timothy seed.

TASMANIA.

1888. Italian Rye-grass seed.
1889. Rape grass seed.

EGYPT.

1890. Cress seed.

AUSTRALIA.

1891. Red grass seed.

FRANCE.

1892. Minette.

DELAWARE.

1893. Hungarian grass seed.

RUSSIA.

1894. Lucerne.

CHINA.

1895. Lucerne.

RUSSIA.

1896. German Mohair.
1897. Mohair.

TASMANIA.

1898. Lucerne.

EGYPT.

1899. Melilotus.
1900. "

SPAIN.

1901. Mijo.

SWEDEN.

1902. Klofver-fro.
1903. Mixed Clover.

RUSSIA.

1904. Spurry.
1905. " Kazan Model farm.

CHINA.

1906. Knot Grass.

CLASS 21. GUMS, RESINS, ETC.

BRAZIL.

1907. Acacia angico.

EGYPT.

1908. White gum.

INDIA.

1909–1911. Crude gums.
1912–1915. Refined wax.

MEXICO.

1916. Campeche wax.

NETHERLANDS COLONIES IN INDIA.

1917–1922. Rubber.

BRAZIL.

1923. Rubber.

QUEENSLAND, AUSTRALIA.

1924. Glue.
1925. Prepared strings for musical instruments.

BRAZIL.

1926. Glue.

CLASS 22. MEDICINAL PLANTS.

INDIA.

1927. Medicinal preparations.

CHINA.

1928. Opium, native. Value at Hankow, $340.00 per pecul.
1929. The fruit of a tree, a medicine. $11.50 per pecul.
1930. Rice roasted and prepared as coffee (not ground) to assist digestion.
1931. A tonic and cooling medicine. $11.00 per pecul.
1932. Cassiatora seed for Ophthalmia. $12.00 per pecul.
1933. A stomachic. $7.00 per pecul.
1934. A tonic and astringent. $13.00 per pecul.
1935. Leek seeds for neuralgia. $5.00 per pecul.
1936. Poison. $14.00 per pecul.
1937. A tonic and antirheumatic. $11.50 per pecul.
1938. Caterpillar for bronchial complaint. $11.00 per pecul.
1939. Cyperus esculentus, a stimulant. $9.00 per pecul.
1940. Cassia sophora bud, a tonic and astringent. $6.80 per pecul.
1941. Scrophularia seed, a stimulant. $5.00 per pecul.

EGYPT.

1942. Fraxinus ornus.
1943. Senna.

INDIA. NETHERLANDS COLONIES.

1944–1951. Medicinal.

MEXICO.

1952. Copal de pudra.
1953. Copalchi. Croton pseudo china.
1954. Lengua de Ciervo. Polypodium lanceolatum.
1955. Artèmina Mexicana Estafiata.
1956. Semillas de balsamo. Mysospermum.
1957. Yerba de la Puebla.
1958. Yerba dulce. Lippia dulcis.
1959. Zempoalxochitt. Zagetes Mexicana.
1960. Yerba del Negro. Malva angustifolia.
1961. Te de milpas. Bidens tetragona.
1962. Prodigiosa. Athanaria amara.

1963. Bonplandi.
1964. Yerba del Cañac. Gomphrena procumbens.
1965. Gayuba. Arctostaphylos pungens.
1966. Semillas de cominos nerticos. Thapsia asclepium.
1967. Nanchalahua. Erythrea Sticta.
1968. Palo del Muerto. Ipomæa Mumucoides.
1969. Raiz de Yesgos Urtica Mexicana.
1970. Calayuala. Polypodium aureum.
1971. Tripa de Judas. Cissus tiliacea.
1972. Contrayerba. Dorstenia contrayerva.
1973. Crytrina coralodendrum.
1974. Linaloe de Mexico.
1975. Cana festula. Cassia brasiliensis.
1976. Colancapatli. Solidago Montana.
1977. Salvia Beal. Buddleia globosa.
1978. Mispatle. Buddleia verticillata.
1979. Hachinol. Heimia salicifolia.
1980. Cebadilla. Veratrium cevadilla.
1981. Atlanchana. Cuphea lanceolata.
1982. Dictamo Real. Marrubium pseudo dictamus.
1983. Tacopatle. Aristolochia Mexicana.
1984. Peonia Mexicana. Cyperus rotundus.
1985. Ahuehueti. Taxodium distichum.
1986. Jamaica. Hibiscus sabdarifa.
1987. Yerba del Anel. Eupatorium sanctum.
1988. Gengibre Zingiber officinalis.
1989. Crameria pauciflora.
1990. Raiz del Yndio. Aristolochia fœtida.
1991. Fecula del Jatropha edulis.
1992. Acido Pipitzhoic estrado del fixis pipitzahoac.
1993. Tarilla. Senecio vernus.
1994. Gobunadora de Mexico. Zigophilum fabago.
1995. Tepozan. Buddleia Americana.
1996. Capulin. Cerasus capollin.
1997. Té limon. Andropogon citratus.
1998. Picosa. Croton ciliatum glandulosum.
1999. Cedron. Aloysia citriodora.
2000. Arrayan. Myrtus arrayan.
2001. Yerba del Zorrillo. Croton dioicus.
2002. Flor de Sauso. Sambucus Mexicanus.
2003. Contrayerba. Dorstenia Contrayerva.
2004. Codo de Fraile. Fevetia icotli.
2005. Gordolobo del Pais. Gnaphalium canescens.
2006. Cuapinole. Ambar Mexicana.
2007. Valeriana Folucana Collasatelus.
2008. Semillas de Curcas purgans.
2009. Sudda Consuelda. Potentilla multifida.
2010 Goma del mangle. Rizophora.
2011. Yncienso de Mexico.
2012. Goma de Sonora. Mimosa lacifocra.
2013. Recina del schinus molle mejico.
2014. Goma de Mesquita. Inga circinalis.
2015. Pimienta de Tabasco. Myrtus pimenta.
2016. Cortezia de Cuachalalate Rajania.
2017. Semilla de Ticama. Jolichos tuberosus.
2018. Cuayiote. Rhus perniciosa.
2019. Frittos dela Bixa Orellana.
2020. Toloxochitl. Magnolia Mexicana.
2021. Resina del Achras Zapota.
2022. Doradilla, Lycopodium nidiformis.

RUSSIA.

2023. Poppy seed, Manywska Model Farm.

CAPE OF GOOD HOPE.

2024. Prairie Damask leaves.

TASMANIA.

2025. Eucalyptus Globulus or blue gum. Prevents fever where sown.

EGYPT.

2026. Poppies cut for the opium.
2027. Tamarind cakes from Darfoor.
2028. " " " "

CHINA.

2029-2041. Tobacco.
2042. Large leaf tobacco. Port Foochow.
2043. " " " Newchwang.

GUELDERLAND.

2044-2047. Leaf tobacco for wrappers.
2048. Tobacco.
2049. " for snuff.
2050. " for cigar wrappers.

BRAZIL.

2051. Tobacco.

GUELDERLAND.

2052–2063. Tobacco.

BRAZIL.

2064. Tobacco from the Colony of St. Maria.

GUELDERLAND.

2065. Tobacco for wrappers.
2066. " " "

BRAZIL.

2067–2069. Stalks of rice and rye.

CLASS 23. MISCELLANEOUS SEEDS AND PLANTS.

A. *Fibrous Plants.*

RUSSIA.

2070. Fibrous barks.
2071. " "
2072. Bast string for making rope.

BRAZIL.

2073. Fibrous plants.
2074. " barks for making rope.
2075. " " as used for rope.
2076. Rope samples.
2077. Broom made from fibrous plants.
2078. Fibrous plants.
2079–2082. Barks from trees as used for paper stock.
2083–2084. Colored fibres as used for coarse cloth.
2084*a*–2084*h*. Certain Brazilian fibres.

TURKEY.

2085. Samos Soie.

CHINA.

2087. Coarse fibrous barks.
2088. Fibrous grass. Newchwang.
2089. " " Takow.
2090. " " ".
2091. " "
2092. " " Tamsui.
2093. Fibrous plants for making ropes.
2094. Coarse hemp. King Ma.
2095. Fibrous plants for making rope.
2096. " " " " Amoy.

MEXICO.

2097. Fibres of the Agave Sisalina.
2098. " " " "
2099. Sisal hemp, Agave Sisalina.
2100. Fibres of the Maguey Agave.
2101. " Lechuguella Agave.

CHINA.

2102–2103. Fibrous grass for making cloth. Canton.
2104. Majagua.

MEXICO.

2105. Pita fibres of a bromaceous plant.
2106. Fibres of the Maguey Agave Mexicana.
2107. Pita de Lechuguella.

QUEENSLAND.

2108. Sida Ratusa.
2109. Fibres.
2110. "

HAWAIIAN ISLANDS.

2111. Fibrous barks.

RUSSIA AND HOLLAND.

2114. Flax, blue Dutch, hand scutched.
2115. " " " " "
2116. Flax, 1st qual.
2117. " 5th "
2119. "
2120. Tow No. 2.
2121. Flax, blue blossom seed, mill scutched.
2122. " Blue Dutch, Guelderland.
2123. " " " "
2124. " " " Kin of Riga seed.
2125. " " " Grown in Groningen.
2126. " " " hand scutched.
2127. " " " Friesland Prov.
2128. " " " hand scutched.
2129. " " " mill "
2130. " " " white blossom seed Friesland.
2131. Flax, blue blossom seed, mill scutched.

2132–2145. Flax.
2146. Best Friesland flax. Blue Blossom-seed.
2147–2149. Flax.
2150. Best Groningen flax. Blue Blossom, Riga.
2151. 2d qual. flax.
2152. Prime Friesland flax.
2153–2155. 2d quality B flax.
2156. 2d quality flax.
2157. Tow flax.
2158–2161. Flax.
2162–2165. Half combed flax.
2166. A. H. Whishaw & Co. flax.
2167. “ “ “ “
2168. 1st qual. W. flax.
2169. “ “ flax.
2170. Best Friesland, hand scutched flax.
2171. “ “ “ “ “
2172. 1st qual. flax.
2173. 2d “ “
2174. White flax, growth of 1875.
2175. “ Zeeland flax.
2176. Groningen, mill scutched flax.
2177. 1st qual. flax.
2178. Best Groningen flax.
2179. “ “ “

TURKEY.

2180. Fibre resembling flax.
2181. “ uncombed.
2182. Italian flax, unscutched.
2183. “ “ scutched.
2184. Fibrous barks.
2185. “ “

RUSSIA.

2186. Flax unscutched.
2187. “ “
2188. “
2189. Tow.
2190. Flax, 2d qual.

MEXICO.

2191. Certain fibrous barks.
2192. “ “ “

HAWAIIAN ISLANDS.

2193. Cloak made from grass.
2194–2220. Various fibres.

NEW YORK.

Contributed by H. W. Jones.

2221. Asbestos from Cecil Co., Md.
2222. “ Mitchel Co., N. Carolina.
2223. “ Felting.
2224. “ paper.
2225. “ as used for steam packing.
2226. “ thread.
2227. “ as used for cement felting.
2328. “ as used for board, paper and thread.
2229. “ from Harford Co., Md.
2230. “ for paints, New York.
2231. “ from Harford Co., Md.
2232. “ used for lining felt, N. Y.
2233. “ Italian.
2234. “ from Richmond Co., N. Y.
2235. “ “ Oconee Co., S. C.

B. *Seeds and Barks.*

TURKEY.

2236. Black cherries.
2237. Hawthorn berries for hedge plants.
2238. “ “

RUSSIA.

2239. Cedar nuts.

EGYPT.

2240.
2241. Capia fistulata.
2242.
2243. Cassia faliata.
2244.
2245. Goat’s Thorn.
2246. red Coreopsis.
2247. yellow “
2248–2250. Dianthus sinensis.
2251. Gomphrena globosa.

BRAZIL.

2252. Marcella.
2253. “

EGYPT.

2254. Forest tree.

SWEDEN.

2255. Tall-fro, pine seed.
2256. Gran-fro.

EGYPT.

2257. Wigella.

CHINA.

2258. Buckthorn kernels.
2259. Sesamum seed.
2260. Thorn seeds, for hedge.
2261. Seeds.

EGYPT.

2262–2266. Gourds.

TURKEY.

2267–2269. Gall nuts.

CHINA.

2270. White nuts.

TURKEY.

2271. Gall nuts.
2272. Yellow berries, for a dye.
2273. Sumac berries.

ZEELAND.

2274. Two years' dried madder root.

GUELDERLAND.

2275. Oak tan. Peeled by steam engine.

CAPE OF GOOD HOPE.

2276. Damask tree.

SPAIN.

2277. Saffron. Pruin.
2278. Alazor.

ZEELAND.

2279. Dried madder.

CAPE OF GOOD HOPE.

2280. Waggon tree.
2281. Leucandendrum No. 2.
2282. Pro-tea Mellifera.
2283. Knotted tree.
2284. Rockwood.

GUELDERLAND.

2285. Oak tan.

NETHERLANDS.

2286. Indigo seed.

CHINA.

2287. Indigo seed.

EGYPT.

2288–2291. Various seeds.

TUNIS.

2292–2294. Various seeds.

EGYPT.

2295. Seeds.
2296. Forest tree seeds.

BRAZIL.

2297. Seeds.
2298. Seeds, marked 1038.

TASMANIA.

2299. Blackwood.

EGYPT.

2300. Seeds.

NETHERLANDS.

2301. Marked No. 265.
2302. " 266.

BRAZIL.

2303. Southern moss.

EGYPT.

2304. Gauve.

MEXICO.

2305. Dye stuff.

TURKEY.

2306. Various seeds.

EGYPT.

2307–2309. Various seeds.

BRAZIL.

2310. Nuts.

CHINA.

2311–2318. Various seeds.

GUELDERLAND.

2319. Oak tree. Peeled by hand.

DEPARTMENT III. — MINING AND METALLURGY.

CLASS 25. CLAYS, KAOLIN, SILEX, EARTHS AND REFRACTORY STONES FOR FURNACE LININGS.

KENTUCKY.

2321. Pea Ridge soil. Taken 18 in. below surface.
2322. J. W. Scott. Taken 1 foot below surface.
2323. Grayson County. Taken 2 feet below surface.
2324. Little Sandy River. Taken 6 in. below surface.
2325. Iron Hill. Taken 18 in. below surface.
2326. Woods in valley of L. S. River. Taken 6 in. below surface.
2327. Virgin soil in open woods.
2328. Old field subsoil.
2329. Old field soil.
2330. Tygert's Creek. Surface soil.
2331. W. Abbot farm. Old field soil.
2332. “ “ “ “ subsoil.
2333. V. Calvin farm. Virgin soil.
2334. Iron Hill. Top soil.
2335. Surface soil.
2336. Iron Hills. Top soil.
2337. “ “ Subsoil 18 in. below surface.
2338. Siliceous grit.
2339. Old field subsoil.
2340. Iron Hills. 18 in. from surface.
2341. W. Abbott farm. 1 foot from surface.
2342. Iron Hills. Top soil.
2343. Grayson County. Red marl.
2344. J. W. Scott. Subsoil.
2345. “ “ “
2346–2401. Soils from various counties in Kentucky.

QUEENSLAND, AUSTRALIA.

2402–2405. Soil.

AFRICA.

2406–2411. Sand from the Great Desert.
2412. Sable sand.

KENTUCKY.

2413. Various samples of clay.

NEW JERSEY.

2414. Fire bricks for furnace linings, manufactured by A. Hall & Sons, New Jersey.

ENGLAND.

2415. Fire bricks, manufactured by King Brothers, Stourbridge, England.

WISCONSIN.

2416. Fire bricks from B. W. Felthousen, Milwaukee, Wis.

CLASS 26. LIMES, CEMENTS, ETC.

FRANCE.

2417. Portland cement.

RUSSIA.

2418. Riga cement.
2419. Jabe cement.

HOWE'S CAVE, N. Y.

2420–2430. Jars of powdered cement.
2431–2437. Specimens prepared for the testing machine.
2438–2441. Specimens under water two years.
2442–2456. Specimens of the crude rock from various parts of the cave.
2457. Rough stalagmite.
2458. “ “ broken lengthwise.
2459. Rough stalagmite broken crosswise.
2460. Polished stalagmite.
2461. Rough stalactite from the cave.

FIRE PROOF BUILDING CO., N. Y.

2462–2470. Artificial stones, manufactured for building purposes.

JOSEPH HAMBLET, STAFFORDSHIRE, ENG.

2471–2475. Artificial stones for building purposes.

ROTTERDAM, HOLLAND.

2476. Various specimens of building stones and bricks.
2477. Collections of tiles and sidewalk paving bricks.
2478. Artificial street paving stones.

CLASSES 27, 28.

A. *Ores and Associated Minerals.*

CANADA.

2479–2530. Collections of ores and minerals from various parts of the Dominion.

NEVADA AND CALIFORNIA.

2531–2536. Rich gold and silver ores.

AUSTRALIA, QUEENSLAND.

2537–2545. Native copper, lead, and tin ores.

PENNSYLVANIA.

2546–2549. Rich iron ores.

OHIO.

2550–2555. Specimens of rich native ores.

WEST VIRGINIA.

2556–2606. Specimens of ores and minerals from various parts of the State.

KENTUCKY.

2607–2631. Selected specimens from several counties.

NEW YORK.

2632. Seven specimens of Ferromanganese containing various percents of Manganese collected and furnished by H. Chapman.

2633–2640. Specimens of coal, ore, and flux, used by the Union Iron Co., Buffalo.

B. *Iron Specimens in the Pig and Rolled Bar.*

UNION IRON CO., BUFFALO, N. Y.

2641. Specimens of pig iron.

2642–2698. Specimens of rolled bars, rails and iron for building purposes.

TRENTON CO., TRENTON, N. J.

2698–2734. Specimens of rolled beams and rails.

RUSSIA.

2735. Pig iron.

2736. Specimens of rolled bar.

CLASS 29. LEAD AND SILVER.

BELGIUM.

2737–2783. Specimens of lead and silver, the products obtained by work upon a silver lead ore.

DEPARTMENT IV. — MANUFACTURES.

CLASS 30. COTTON SHEETING AND SHIRTING, PLAIN AND TWILLED.

BRAZIL.

1–16. Plain and twilled heavy cotton cloths.

AMSTERDAM, NETHERLANDS.

Samples of the Reuendoom Steam Spinning and Weaving.

17. White heavy sheeting.

18. " " " with sample of filling.

19. Bleached.

20. Unbleached.

Samples of Theversmusche Steam Spinning and Weaving.

21. Unbleached plain 42 inches wide.

22. Twilled sheeting dressed.

23. Unbleached.

Komuklykeweefcoederen Fabrik, Van C. T. Stark & Co. te Hencelo.

24–28. Cottonnets, Java.

29–45. Prentanieres Sevant.

46–52. Ginghams.

53–88. Tringano sarongs (British India).

89. Coarse heavy sheetings.

CLASS 31. COARSE FABRICS OF BARK, GRASS, ETC.

CHINA.

2784-2927. Specimens of grass cloth of various varieties.

CLASS 32. WOOLEN AND MIXED FABRICS, YARNS, ETC.

TURKEY.

2927-2939. Linen yarns and threads.

2930. Cotton thread.

2931-2933. Woolen yarns.

2934. Specimen of silk.

CLASS 33. TELEGRAPHIC WIRES AND INSULATING MATERIALS.

SIEMENS BROS., LONDON.

2935. Mediterranean cable.

2936. Military cable, braided.

2937. Harvey's Torpedo cable.

2938. Black Sea cable.

2939. Hong Kong-Shanghai-Posiette. Gt. Northern Telegr. Co. Deep Sea cable.

2940. Shore end of 2939.

2941. Platino Brazilera Telegr. Co.'s cable. Shore end.

2942-2958. Sample coils of various insulated wires.

2959-2962. Specimens of crude gutta percha used for insulating wire.

2963-2970. Specimens of gutta percha in various stages of the process of manufacture.

2971-2975. Gutta percha in the finished products.

CLASS 34. SPECIMENS OF NAILS, TACKS, ETC.

BOSTON, MASS.

2976-2982. Samples of Horse shoe nails from Globe Nail Co.

2983. Sample card of nails and tacks from the manufactory of Dunbar, Hobart & Whidden.

CLASS 35. FILES AND HARDWARE.

FRANCE.

2984-3128. Files from the manufactory of Limet Lapareille & Cie.

3129-3148. Horse shoe magnets from the same firm.

PROVIDENCE, R. I.

3149-3207. Files from the Nicholson File Co.

FROM THE WASHINGTON MILLS, ASHLAND, MASS.

3208-3243. Collection of samples of Turkish emery in the rock as found, and in the manufactured state.

3244. Cascade evaporator. Presented by Wm. R. Lafourcade.

CLASS 36. BRICKS, DRAIN TILES, ETC.

NETHERLANDS ROYAL COMMISSION.

3245. Various specimens of building and drain bricks, also samples of drain pipes.

ENGLAND.

3246-3248. Ornamental bricks for building purposes, by Joseph Hamblet, Staffordshire.

NEW JERSEY.

3249. Varieties of bricks, by A. Hall & Sons, Perth, Amboy.

CLASS 37. FIRE CLAY GOODS (CRUCIBLES, POTS, ETC.).

TAUNTON, MASS.

3250–3305. Crucibles and pots from Phœnix M'fg. Co., as follows:

1 Spelter basin.
1 No. 40, the ordinary size, steel crucible.
1 No. 50 Brass crucible.
2 No. 25 “ “
2 No. 20 “ “
2 No. 18 “ “
2 No. 16 “ “
2 No. 14 “ “
2 No. 12 “ “
2 No. 10 “ “
2 No. 8 “ “
2 No. 7 “ “
2 No. 6 “ “
2 No. 5 Brass crucible.
2 No. 4 “ “
2 No. 3 “ “
2 No. 2 “ “
2 No. 1 “ “
3 Jeweller's, special.

All of the sizes from No. 1 to 14 are used by jewellers for melting silver, etc.

2 No. 1 Covers.
1 No. 40 Steel cover.
2 No. 4 Dips, used by Reed & Barton.
2 No. 3 “ “ “ U. S. Assay Office.
4 No. 2 “ “ “ “ “ “
2 No. 1 “ “ “ “ “ “.
2 Stirrers “ “ “ “ “
2 Muzzles used by Bessemer steel works.
2 Stoppers “ “ “ “ “

CLASS 38. TILES, PLAIN AND ENCAUSTIC, ETC.

LUXEMBOURG.

3306–3312. Specimens of plain floor tiles.

NETHERLANDS.

3313. Various specimens of plain and ornamental floor tiles.
3314. Specimens of roofing tiles.
3315. “ “ sidewalk paving tiles.

PHILADELPHIA.

3316–3322. Enamelled and encaustic tiles, presented by Sharpless & Watts.

NEW YORK.

3323–3334. Plain and ornamental floor tiles, presented by the Fire Proof Building Co.

CLASS 39. PORCELAIN AND POTTERY.

NEW JERSEY.

3335. Various samples of earthern ware, presented by A. Hall & Sons, Perth Amboy, N. J.
3336–3337. Danish Terra Cotta.

PHILADELPHIA.

3338. Ornamental vase from British Museum, London, presented by Galloway & Graff.
3339. Vase, imitation of Danish ware, from Galloway & Graff.

CLASS 24. MINERAL COMBUSTIBLES, (COALS, ETC.).

WEST VIRGINIA.

3340–3374. Coals from various parts of the State.

PENNSYLVANIA.

3375–3380. Coals from various coal fields.

MEXICO.

3381. Rich gas coal.

AFRICA.

3382–3383. Soft coal from Orange Free State.

AUSTRALIA.

3384–3385. Queensland coal.

BRAZIL.

3386–3398. Various coals.

CANADA.

3399–3400. Pictou coal, Nova Scotia.

KENTUCKY.

3401–3418. Coals from different parts of the State.

INDIANA.

3419. Samples of various coals collected and presented by the State Commission.

ENGLAND.

3420. Pressed coal dust from Birchgrove Colliery.

SWEDEN.

3421–3425. Samples of coke and peat.

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Lanza. Gaetano	“
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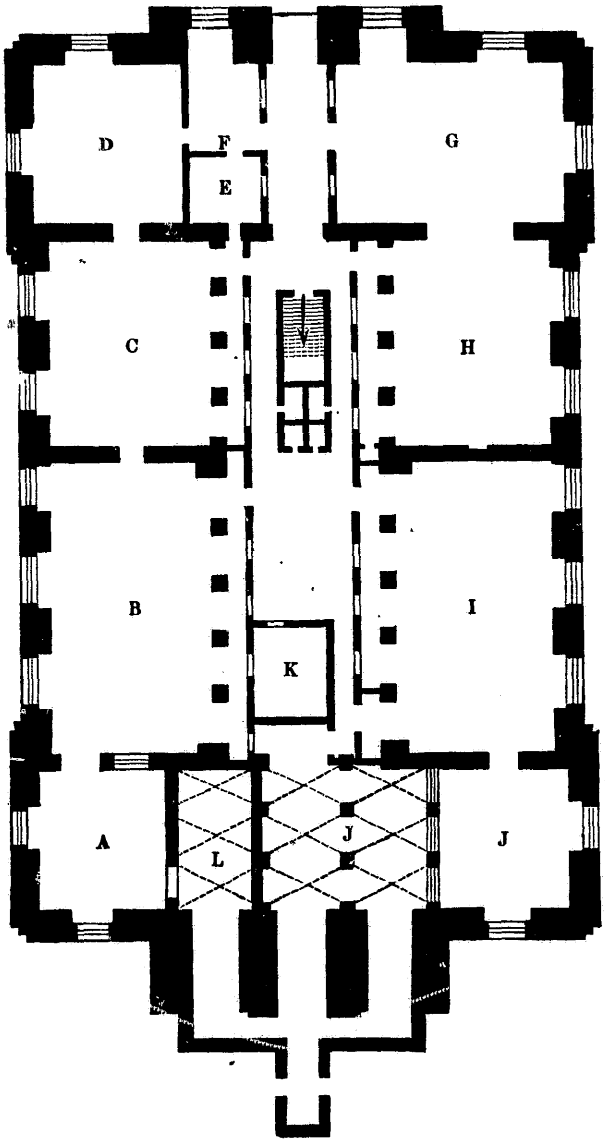
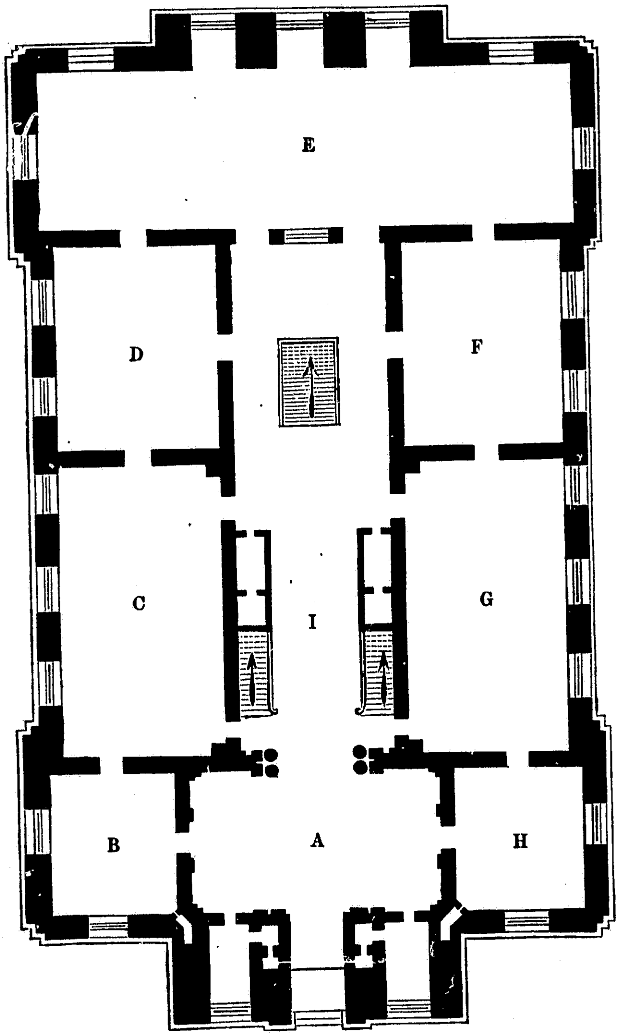
Sturgis, John H.	“
Sullivan, Richard	“
Thompson, Wm. H.	“
Tufts, John W.	“
Tuxbury, Geo. W.	“
Upham, J. B.	“
Urbino, S. R.	“
Ware, Chas. E.	“
Ware, Wm. R.	“
Warren, Cyrus M.	Brookline.
Warren, Geo. W.	Boston.
Warren, Joseph H.	“
Warren, Sam'l D.	“
Waters, C. H.	Clinton.
Watson, R. S.	Milton.
Watson, Wm.	Boston.
Weston, David M.	“
Whipple, Edwin P.	“
Whitman, Herbert T.	“
Whitmore, Wm. H.	“
Whiton, David	“
Wilder, Marshall P.	Dorchester.
Williams, H. W.	Boston.
Winthrop, Robert C.	“
Wright, John H.	“
Wyman, Morrill	Cambridge.

BASEMENT FLOOR.



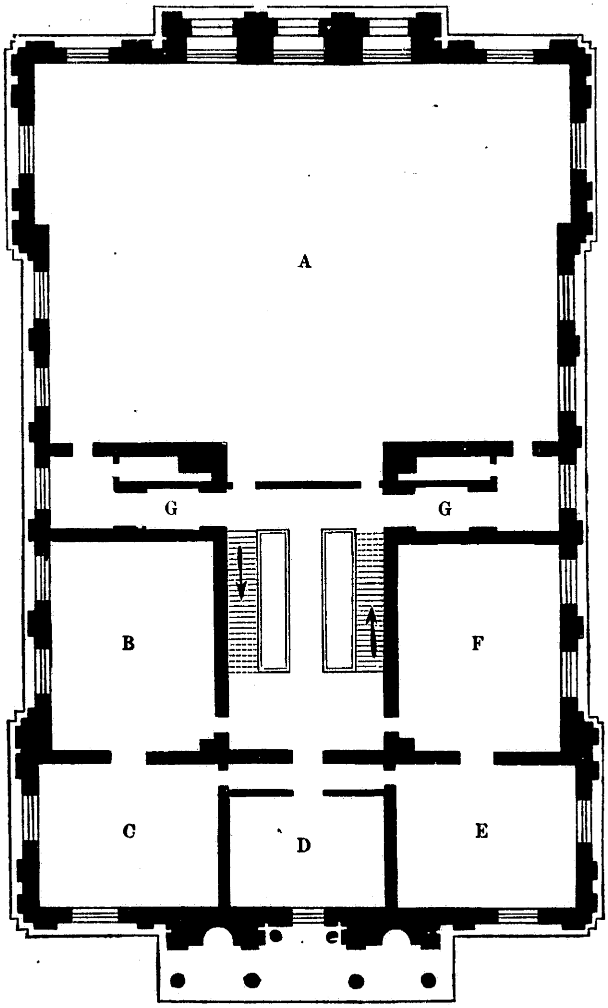
A. Professors' Chemical Laboratory, 25′ 0″ by 22′ 11″.
B. General and Qualitative Chemical Laboratory, 49′ 7″ by 34′ 0″.
C. Quantitative Chemical Laboratory, 35′ 8″ by 34′ 0″.
D. Quantitative Chemical Laboratory, 26′ 4″ by 24′ 0″.
E. Balance Room, 8′ by 13′.
F. Professor Wing's Private Laboratory, 16′ 0″ by 13′ 0″.
G. Mining Laboratory, 40′ 2″ by 27′ 10″.
H. Metallurgical Laboratory, 35′ 8″ by 34′ 0″.
I. Chemical Lecture Room, 49′ 7″ by 34′ 0″.
J. J. Mechanical Engineers' Laboratory, 25′ 0″ by 69′ 1″.
K. Daily Chemical Supply Room, 14′ 6″ by 12′ 0″.
L. Boiler Room, 15′ by 25′ 0″.

FIRST STORY FLOOR.



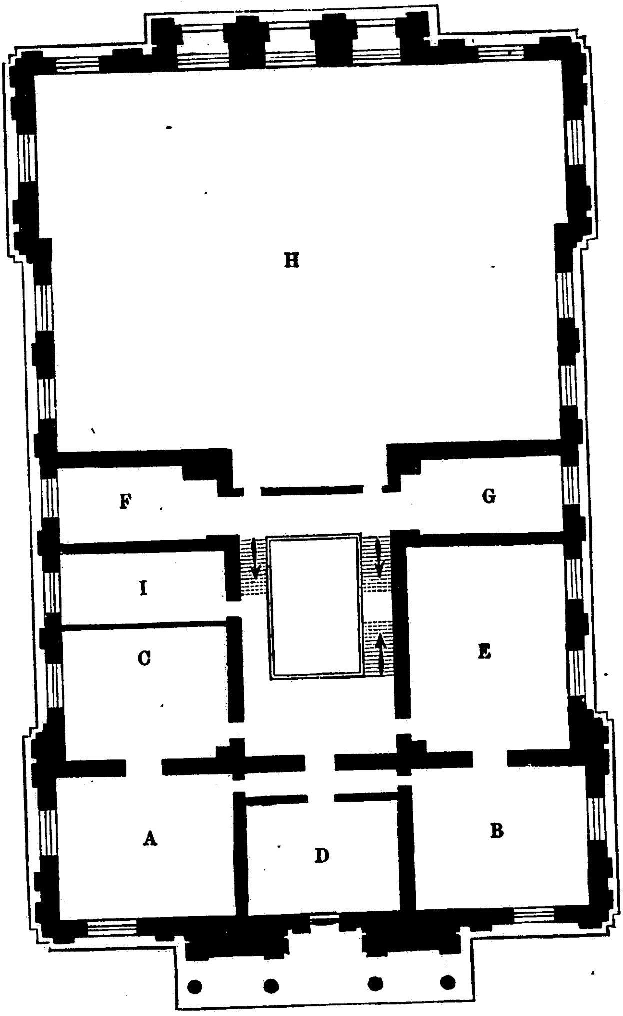
A. Entrance Hall, 42′ 2″ by 25′ 0″.
B. President's Office, 25′ 0″ by 22′ 11″.
C. Physical Lecture Room, 49′ 7″ by 28′ 3″.
D. Physical Laboratory and Apparatus Room, 35′ 8″ by 28′ 3″.
E. Physical Laboratory and Apparatus Room, 92′ 0″ by 27′ 10″.
F. Geological Lecture Room, 35′ 8″ by 28′ 3″.
G. Society of Arts Room, 49′ 7″ by 28′ 3″.
H. Secretary's Office, 25′ 0″ by 22′ 11″.
I. Stairway Hall, 87′ 3″ by 26′ 10″.

SECOND STORY FLOOR.



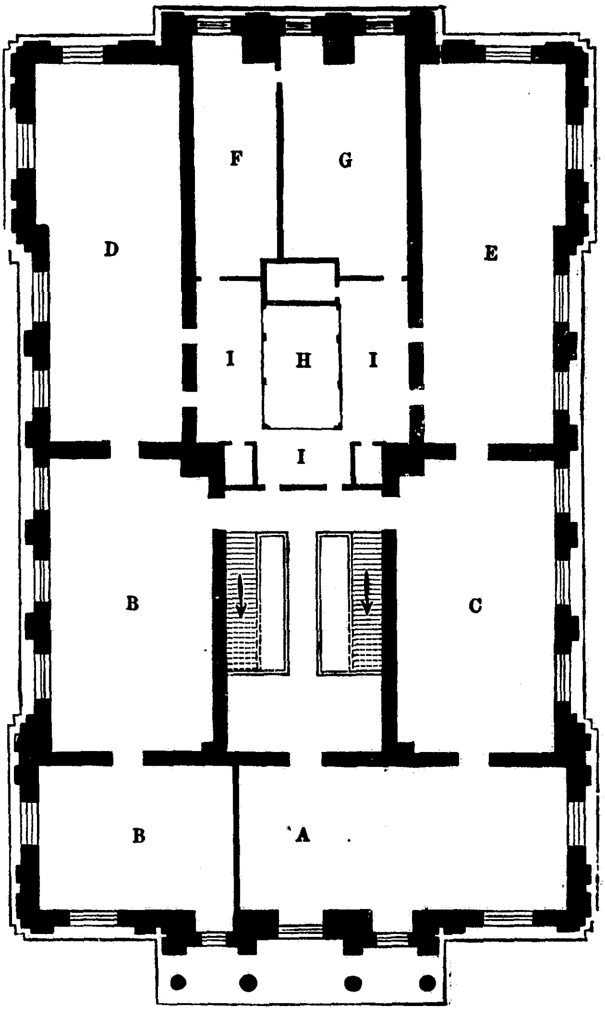
A. Huntington Hall, 92′ 0″ by 65′ 5″.
B. Mathematical Lecture Room, 34′ 9″ by 28′ 3″.
C. Civil Engineering Lecture Room, 32′ 2″ by 25′ 0″.
D. Modern Language Lecture Room, 26′ 2″ by 20′ 6″.
E. English Lecture Room, 32′ 2″ by 25′ 0″.
F. Mathematical and Astronomical Lecture Room, 34′ 9″ by 28′ 3″.
G. G. Passageways to Huntington Hall.

HALF STORY FLOOR.



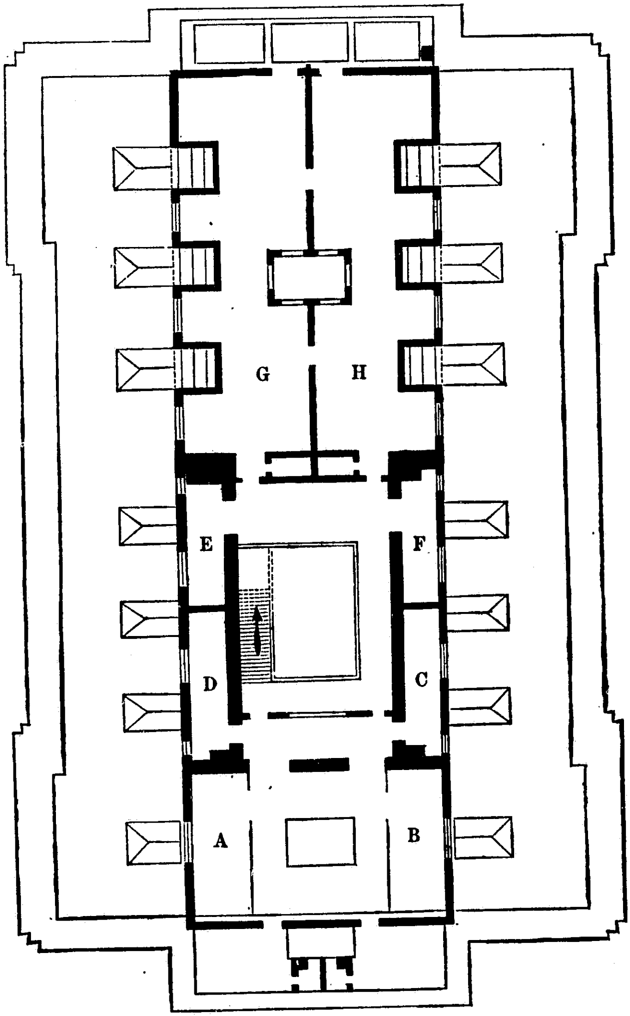
A. Architectural Museum, 32′ 2″ by 25′ 0″.
B. Architectural Library and Study Room, 32′ 2″ by 25′ 0″.
C. Architectural Museum, 28′ 3″ by 20′ 9″.
D. Natural History Lecture Room, 26′ 2″ by 20′ 6″.
E. Prof. Richards' Lecture Room, 34′ 9″ by 28′ 3″.
F. Prof. Atkinson's Study, 28′ 3″ by 14′ 2″.
G. Prof. Hunt's Study, 28′ 3″ by 14′ 2″.
H. Huntington Hall.
I. Prof. Howison's Study, 28′ 3″ by 14′.

THIRD STORY FLOOR.



A. Reading and Study Room, 62′ 0″ by 25′ 0″.
B. B. Civil Engineers' Drawing Rooms, 49′ 7″ by 28′ 3″.
C. First Year's Drawing Room, 49′ 7″ by 28′ 3″.
D. Mechanical Engineers' Drawing Room, 65′ 5″ by 26′ 0″.
E. First Year's Drawing Room, 65′ 5″ by 26′ 0″.
F. Mechanical Engineering Lecture Room, 37′ 0″ by 17′ 0″.
G. Mathematical and Descriptive Geometry Lecture Room, 37′ 0″ by 23′ 0″.
H. Model Room, 21′ 0″ by 13′ 0″.
I. I. I. Passageways.

FOURTH STORY FLOOR.



A. Prof. Lanza's and Prof. Whitaker's Study, 24′ 5″ by 11′ 6″.
B. Prof. Henck's Study, 24′ 5″ by 11′ 6″.
C. Prof. Osborne's Study, 24′ 9″ by 7′ 6″.
D. Prof. Richards's and Prof. Nichols's Study, 28′ 0″ by 7′ 6″.
E. Instructor Hoyt's Study, 21′ 6″ by 7′ 6″.
F. Prof. Ware's Study, 24′ 9″ by 7′ 6″.
G. Architects' Drawing Room, 65′ 5″ by 21′ 10″.
H. Lowell School of Design, 65′ 5″ by 21′ 10″.