

MASSACHUSETTS INSTITUTE OF TECHNOLOGY.

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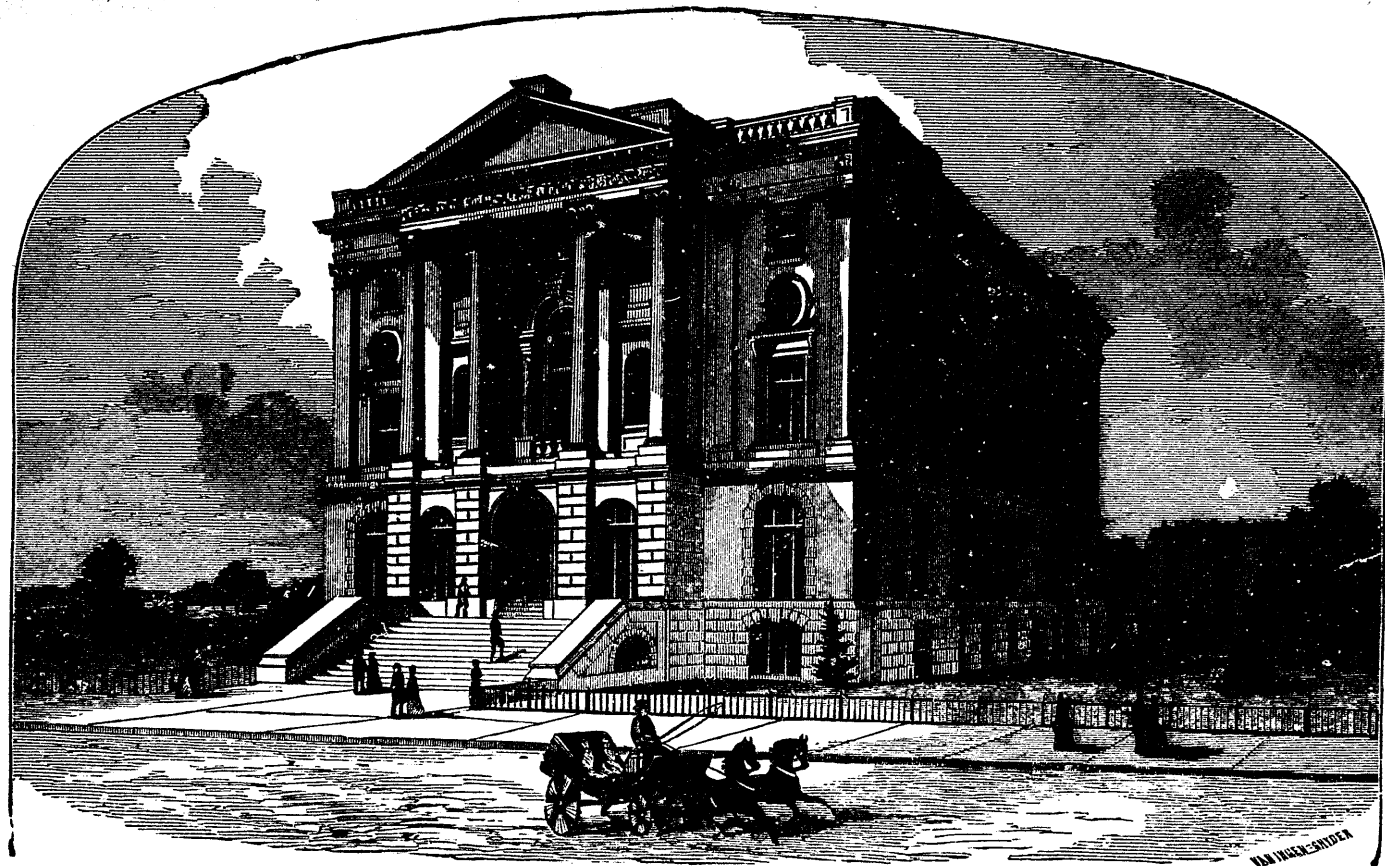
**PRESIDENT'S REPORT**

FOR THE

**Year ending Sept. 30, 1875.**

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**BOSTON:**  
**PRESS OF A. A. KINGMAN.**  
**1876.**



INSTITUTE BUILDING.

VAN NORDEN

MASSACHUSETTS INSTITUTE OF TECHNOLOGY.

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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.*



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## PRESIDENT'S REPORT.

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*To the Corporation of the Institute :—*

Your attention is respectfully invited to the following reports and matters relating to the various departments of the Institute for the current year, the tenth since the establishment of the School.

The only changes in the corps of Instruction during the year have been the resignations of S. Edward Warren, C. E., Professor of Descriptive Geometry, Stereotomy and Drawing, and Edward K. Clark, S. B., Instructor in Mechanical Drawing.

Instructor William E. Hoyt has been given charge of the Stereotomy, Instructor Wells of the Descriptive Geometry, and Assistants Francis T. Sargent and J. Austin Knapp, of the Mechanical Drawing in the department of Mechanical Engineering.

*Attendance.* The whole number of students in attendance for the year 1874-75, was 288 ; a decrease of 22 from the preceding year. Of the 73 applicants for admission to the first year, at both the June and September examinations, 29 passed without conditions at an average of 73 per cent.; 26 passed with conditions at an average of 51 per cent.; and 18 failed to pass. Based on the mathematics alone these averages were 81 and 60 per cent. Of those admitted 15 did not join the class.

These reductions left a class of 40 new men, and one repeating, 36 of whom were regular students, and 5 special. It will be noticed that 25 per cent. of the applicants failed to pass, and that over 25 per cent. of those who passed did not join the class, mainly on account of the continued hard times, as was afterwards ascertained. Sixteen new students entered the second year, 8 without, and 8 with conditions. The average age of the class entering the first year was 17 years and 10 months.

*Preparation for Admission.* The suggestions made on pp. 210-215 are respectfully submitted to teachers by the Faculty, in order to make the work of preparation as definite as possible. The poorest preparation has usually been upon what are properly the grammar school studies. It is not overlooked that public policy usually demands that the High School must accept such preparation as the Grammar Schools can furnish, and should not therefore be held wholly responsible for these studies. Still it is hoped that the High Schools may be able to remedy the defect, in part, by requiring a careful revision during the early part of their course of such portions of the subjects as have been pointed out. Moreover, it cannot be denied that a large proportion of the High Schools continue to maintain classical departments for the purpose of fitting students for admission to College at a cost altogether disproportionate to the end gained. It would be far more economical for each town to support the few students who enter College from its High School, at a good classical school, and thus save the time and energies of the best teachers for other subjects of growing importance, as the modern languages, mechanical and free-hand drawing, chemistry and physics with laboratory practice, and such elements of Natural History as the teachers of each school may be best fitted to give; and if, in addition to the above changes, Latin could be rationally studied for about two years as part of the required course for graduation, these schools would be vastly more useful to the large numbers whose education ends here, and would also be better able to prepare

students for admission to scientific and technical schools, and that without in the least departing from their legitimate work. Much of the work now done in our first year should be done in these schools, and could be, if the changes indicated were made, without much increasing the average age at which students now enter the Institute. The gain to the High Schools as well as to us can hardly be over-estimated.

*Degrees.* One hundred and twenty-six students have completed prescribed courses of study, and degrees have been given in years and departments as follows:—

	1868	1869	1870	1871	1872	1873	1874	1875	Total.
Civil Engineering . . . .	6	2	4	8	3	12	10	10	55
Mechanical Engineering . .	1	2	2	2	1	1	4	7	20
Mining Engineering . . . .	6		2	5	4	2	1	6	26
Architecture . . . . .						1	1	1	3
Chemistry . . . . .		1	1	2	3	6		1	14
Physics . . . . .								1	1
Science and Literature . .	1		1			1	2	2	7
Total . . . . .	14	5	10	17	11	23	18	28	126

For the names of the Alumni, with present residence and occupation, so far as known, see Appendix, pp. 200–205.

Your attention is particularly invited to this list, as furnishing the best evidence of the estimation in which the work of this School is held by the public. We have every reason to be gratified by the record of the graduates of our first ten years.

*Lowell Free Courses of Instruction.* In the establishment of the School of Industrial Science of the Institute, two distinct objects were contemplated:—

*First*, regular four years' courses of study having special ends in view, and leading to graduation; and

*Second*, courses of instruction for those who could not command all their time, to be given mainly in the evening, and under such conditions as would secure the attendance of those having the proper preparation to profit by them.

Thus far in the history of the school this second department has been supported by the Trustee of the Lowell Institute. Each year, in the month of October, the courses to be given are announced, with the conditions of attendance.

These courses, which have always been free, and open to both sexes, are given on pp. 216-218.

During the year instruction in Physics has also been given to the Sophomore Class of Boston University, partly by lectures, partly in the Rogers Laboratory. This instruction has been entirely separate from that given to our own students, and has not in the least degree interfered with either the work or discipline of the school, while the department has been very sensibly benefitted by the increased income; and we anticipate the same good results for the chemical department during the coming year, from the same source. Judging from past experience, we shall be justified in opening more generally the lecture-rooms and laboratories of the Institute for the instruction of outside classes, and advanced special students of either sex, in such departments as have the means and space to give it. The advanced instruction in many of the studies, particularly in the later years, is given to small classes, which would not be incommoded by the admission of such advanced students.

I respectfully ask that you will give this subject the attention which it appears to me to deserve.

*Lowell School of Industrial Design.* The number of students in this department was 25, the same as in the preceding year. Eleven of these students were young men, and fourteen young women. Three years have passed since the establishment of this department, and it can no longer be considered an experiment. It will be seen from Mr. Kastner's report that fifteen students have been granted "Certificates of Proficiency," and nearly all of them are employed by some of the leading Mills in New England. Many samples of goods from designs made by the pupils, or graduates of this school, are already in the market and have been received with favor.

During the past year a much larger variety of designs have been made. Students have been encouraged to work in special directions, and the results have been marked by greater breadth and character. The execution, almost without exception, even among the newest pupils, is remarkable, and is the best possible evidence of the value of the system pursued, and the skill of the teacher. While the designs may not in all cases exhibit the highest type of excellence or taste, it must not be overlooked that they are the work of beginners and must be judged as such.

In this respect also there will be great improvement when students fail to find desirable places before thoroughly completing the prescribed three years' course of study. Lately painting on tiles, porcelain and furniture has been introduced with every prospect of success. It is expected that gradually the range of the school will be widened, and thus give scope to a greater variety of taste and employment. The foundation is well laid for the building up of a great school of practical Industrial Art. It will aid in educating the public taste and increase the demand which it is intended to supply. I earnestly commend this department to your confidence and support.

*The Mining and Metallurgical Laboratories.* These laboratories have become so important an element in our courses of Mining and Metallurgy, and are besides so novel in such a connection, that it may not be uninteresting to briefly review them in their origin and progress thus far in the history of the department. From the beginning, vacation excursions to mining regions for the purpose of study by teachers and pupils have constituted an important element in the instruction; and in this systematic way many of the more important centres in the United States and Canadas have already been visited. Not only in each locality have the geology, the minerals, the mode of their deposition and extraction, and their metallurgy been studied, but the opportunities have been used to make collections of cabinet specimens, and particularly of the ores of each

locality sufficient for quantitative study in these laboratories. The most important of these excursions took place in the summer of 1871, when a party of professors and students, twenty-one in number, and nearly all belonging to the departments of Mining and Metallurgy, visited some of the most important points in Missouri, and afterwards spent some six weeks in studying all the more developed centres in Colorado and Utah. It was during this excursion, while observing the wrecks of fortunes strown all over the territories, that the thought occurred to us, that much of this waste was due to a want of practical skill joined with scientific knowledge, and that the opportunity for experimenting upon comparatively large quantities of ores must be furnished to our students during their course, as a part of their laboratory work. After disbanding the party I visited San Francisco, and had the good fortune to make the acquaintance of some skillful practical metallurgists, who were making the examination of ores a specialty, and had built up laboratories for ore-dressing, on about the scale we needed. But the processes were detached, and no attempt was made to represent the best forms and kinds of machinery in use at that time in California for the reduction of gold and silver ores.

I had the good fortune to meet Professor William P. Blake, who not only gave me the aid of his scientific and practical experience, but introduced me to the firm of H. J. Booth & Co., of the Union Iron Works, of San Francisco. Mr. I. M. Scott, of this firm, entered fully into the matter, designed the five-stamp battery now in our laboratory, made drawings for the placing of this and the connecting pieces of apparatus, and also furnished us full illustrative drawings of one of the largest and most complete mining mills in California. The sum charged was not much above the cost of the drawings; the firm making a generous contribution to our laboratory.

These steps would have been fruitless if I had not been so ably and enthusiastically supported by Professors Ordway and Richards. The furnaces in the Metallurgical laboratory were designed by Professor Ordway and built under his direction,



while the Mining laboratory has reached its present state of progress almost entirely through the ability, practical skill, and untiring energy of Professor Richards. Thus, what was a conviction has become a practical reality, and the entire credit for the existence of these novel laboratories is due to the professors whose unfaltering faith in success has made them possible.

It is not supposed that the student's experience, gained in these laboratories in handling comparatively large quantities of ores, will supersede the necessity of that wider and more definite experience which can only be gained at the works; but it is claimed that he is made aware by his failures, if not by his successes, of the difficulties he is sure to encounter in actual practice, and is taught not to despise mere practical skill, but to proceed with great caution, and to enter upon constructions involving large expense only after careful preliminary investigation, such as the experience gained in these laboratories especially qualify him to undertake. Full abstracts of two theses are given, to show more clearly than any statement can do the kind of problems assigned and the labor involved.

The pressing need of these laboratories is more space to properly arrange the apparatus and to accommodate the increasing numbers of students taking these courses.

*The Fourth Year Chemical Laboratory.* The contents of this laboratory were burned on the evening of November 11, 1875. It has been thoroughly refitted, and is now, owing to the skill of Professor Wing, a model of neatness and convenience. The opportunity has been improved to secure a more commodious balance room, and to make the space at the disposal of the department as available as possible. All the apparatus and materials destroyed have been renewed, except the large collection of analyzed substances, which it will take time to replace.

*The Mechanical Laboratory.* My last report contained a full account of this laboratory by Prof. Whitaker. Another year's experience has furnished additional proof of its value to students in steam engineering. Some of the evidence will be found in the abstracts of theses by students in this department. We still need a small shop fitted with the usual machine tools.

*Department of Architecture.* I need only to ask your attention to the report relating to this department, and particularly to the large and varied collections available to both teachers and students to illustrate the several courses of instruction. The instruction in this department did not begin till the fall of 1868, and it may be of interest to you to know how it is now considered by one of our best students, who, after completing the course here in 1874, went abroad to continue his studies. We are often asked whether the advantages for architectural study are not far greater abroad, and it is also to answer this question that I quote a few sentences from a letter of one well qualified to give an intelligent opinion : —

"One thing I am firmly convinced of, and that is that any one who thinks of leaving the Institute and coming abroad at the end of his first year, ought to be dissuaded from it — by main force. He is infinitely better off where he is if he did but know it. In one thing especially the Institute has a great advantage — the freedom and character of the library and collections are so much superior to the advantages we have here. Of course there is an admirable library and fine collections at the School of Fine Arts, but they are not at all times accessible in that they are so far distant from the several *ateliers*, and are protected by bands of red tape. So a student has to depend entirely on the library of his *atelier*, which is at best a small and often an ill-chosen one."

"Another great advantage one has at the Institute is that he has those framed drawings by Brune, Calinaud, Escalier, Tissandier, and Létang always at hand. Here at the *atelier* we have nothing whatever to refer to, and when a drawing has to be rendered it has to be done by guess-work and on general principles each time."

"At the *expositions* of the second class [comprising the students who have been only three or four years at the *École*], I think I am safe in saying that the average draughtsmanship is not so good as the average of

the second year at the Institute. Another advantage is the more practical light in which things are looked at."

It is also true that there has been during the past few years a marked improvement in architecture in this city, making it a more desirable place for the building up of such a school. The student will not fail to find in Boston and vicinity good examples of all kinds of such public and private buildings as he may hereafter be called upon to construct.

It gives me great pleasure to be able to present this satisfactory evidence of the character and success of the department.

*Department of Military Science and Tactics.* The drill hall and gymnasium, which the aid of friends<sup>1</sup> has enabled us to build, together with some changes in the details of the instruction, seem to have finally settled all difficulties. I am extremely happy to be able to report that the department is in an excellent condition, and that the best discipline is maintained without any more difficulty than any other department meets in securing the same efficiency. I think the present status is substantially supported and approved by all; and it is simple justice to Lieut. Zalinski to say that while enforcing the necessary regulations with strictness, he has retained the respect of his pupils, and won the esteem of all by his unselfish devotion to their interests.

<sup>1</sup> Subscriptions in aid of the Drill Hall and Gymnasium: —

George B. Emerson . . . . .	\$500	E. B. Robins . . . . .	\$25
Wm. B. Rogers . . . . .	400	Theodore Lyman . . . . .	25
Kidder, Peabody & Co., . . . . .	350	Charles H. Delton . . . . .	25
James L. Little . . . . .	200	R. C. Greenleaf . . . . .	25
Ernest W. Bowditch . . . . .	150	T. T. Bouvé . . . . .	25
Bent & Bush . . . . .	100	M. L. Bradford . . . . .	25
Wm. C. Peters . . . . .	100	Joseph P. Ellicott . . . . .	25
M. D. Ross . . . . .	100	Frost & Adams . . . . .	25
J. D. Runkle . . . . .	100	E. Collamore . . . . .	25
Henry L. Pierce . . . . .	75	Charles W. Galloupe . . . . .	25
John H. Reed . . . . .	50	Wm. B. Spooner . . . . .	25
Thomas F. Edmands . . . . .	50	George P. Denny . . . . .	20
Henry W. Williams . . . . .	50	Wm. V. Hutchings . . . . .	20
Mellen, Williams & Co. . . . .	50	Surg.-Gen. Dale . . . . .	20
J. Iasigi . . . . .	50	Mrs. Daniel Treadwell . . . . .	10
Wm. E. Baker . . . . .	50	J. H. Blake . . . . .	10
Rufus S. Frost . . . . .	50	From "Friends" . . . . .	360
John C. Ropes . . . . .	50		
George W. Simmons . . . . .	50	Total . . . . .	\$3,240

*The Restaurant.* In my last report you were informed that we were trying the experiment of establishing a restaurant, which, if reasonably successful, we should attempt to put on a more permanent basis. This has been done at an expense of about \$900.<sup>1</sup> We have now a dining room, a lunch room, a kitchen with store rooms, and caterer's rooms, all suitably furnished. Full dinners are served for thirty-five cents, and board by the week for \$3.50. I am fully satisfied that it is the duty of the Institute to maintain this restaurant as a means of promoting the health of students, and of reducing their necessary expenses.

*Conclusion.* Upon the whole, the year's work has been satisfactory. The gain has mainly been in the improvement of the laboratories, and making the experimental side of the instruction more systematic and thorough. All we need to make the progress in the future as marked as in the past ten years is more space. Some important work has never been properly done on this account. The department of Industrial Chemistry is almost entirely destitute of the proper room for large operations, and work in Organic Chemistry is only done at the expense of the comfort, if not the health, of all in the building. But I must refer you to reports of departments for a fuller statement of their several needs.

I close by thanking teachers and students for their hearty coöperation in the work of the year.

JOHN D. RUNKLE, *President.*

<sup>1</sup> Subscriptions in aid of the Restaurant:—

Joseph S. Fay . . . . .	\$150	James L. Little . . . . .	\$50
S. P. Ruggles . . . . .	100	Wm. Endicott, Jr. . . . .	50
J. M. Forbes . . . . .	100	E. R. Mudge . . . . .	50
John Cummings . . . . .	100	H. P. Kidder . . . . .	50
E. B. Bigelow . . . . .	50	From "Friends" . . . . .	100
H. B. Rogers . . . . .	50		
M. D. Ross . . . . .	50	Total . . . . .	\$900

## SECRETARY'S REPORT FOR 1874-75.

There have been held during the year twelve meetings of the Society of Arts, at which various subjects of practical importance were discussed.

At the meeting of *Nov. 12, 1874*, Mr. Robert B. Forbes read a paper on the "Tracks for Atlantic Steamers," as a report of his doings as representing the Institute in conference with the Committee of the Social Science Association in regard to the "Maury Lanes." He concludes by saying "Now that we have a steamer leaving Europe and North America on the Atlantic every five or six hours, no amount of argument should be necessary, and no pains omitted, to induce all to adopt the Maury Lanes. Unless steamers adopt some definite lines for going and returning, recent disasters show that size, speed, and elegance of ship may not save from collision accompanied by great loss of life."

Within a few months the loss of over four thousand human lives shows the necessity for more means to save life, and better arrangements to prevent accidents from fire, collision, etc. He advocated more and better boats, rafts, life-buoys, mattresses and belts, and various buoyant contrivances carried by the ship herself; all of these, however well-contrived, may yet be useless if the crew are not rendered familiar with their use by frequent drilling. Any properly constructed raft, well supplied with food and water, would be very likely to save its passengers if in the track of steamers crossing the Atlantic, as the lines, if

adopted, would be only a hundred miles or so wide ; a sailing vessel, too, disabled, would know where to send her boats to be sure of meeting a passing steamer. The ship herself should be made invulnerable to ordinary ocean casualties, by double bottom as far as the load line, iron decks, water-tight compartments, boiler spaces cut off from other compartments and from coal bunkers below the load line, donkey engine and boiler far away from ordinary casualties of the main machinery, and pumps so fitted that steerage passengers could be used for their working. In other words, make the ship a life-boat.

He advocated better means of detaching boats from their tackle, the Ammen wooden raft, or the Perry or Monitor raft of vulcanized rubber, the swinging davit, and the substitute of the centre-board for a keel in boats. Means for throwing a line two hundred or three hundred yards should be on all passenger ships and men-of-war.

At the same meeting, Mr. H. P. Langley read a paper on "Artificial stone, and its uses," illustrated by specimens. He confined his remarks to that made by the use of hydraulic cements, lime and magnesia, including the Ransome, Frear, Beton-Coignet, and Sorel processes. Stone made by any of these processes has not come into general use in this country as building material ; a few buildings, in Boston and vicinity, have been erected wholly or in part of the Frear stone, and the Beton-Coignet has been used to some extent in foundations, piers, etc. ; a stone embodying strength, durability and elegance can be made from Portland or the best American cements and pure silicious sand. Many useful and ornamental articles for domestic use are made by the Sorel process. He also exhibited and explained several grinding machines.

*Dec. 10.* Mr. John C. Hoadley, of Lawrence, read a paper, illustrated by numerous carefully made drawings, on the "Indicator Diagram and its Interpretation."

The indicator, an instrument invented by James Watt, to show the operation of steam in his engines, was the forerunner of a large class of philosophical instruments for noting and

recording vibrations, from the pulsations of an infant's heart to the throes of an earthquake, and velocities, from that of a gentle breeze to that of a rifle projectile or a ray of light.

The diagram, credited to the same inventor, in which forces are exhibited to the eye under the form of curves, by abscissæ proportional to times, spaces, or volumes, and ordinates proportional to pressures, stresses, strains, or any other similarly related magnitudes, is applied to almost all subjects to which the human mind directs its attention.

The indicator is a small, subsidiary, reciprocating engine, attached to the cylinder of a steam engine, or other similar machine, sharing the pressures, expansions, and forces of the chamber with which it communicates; and expending the work developed in its own cylinder in compressing a spring, and in giving motion to a pencil or marking point, which traces on a slip of paper, moving under it with a known velocity, a curved line which, properly interpreted, discloses much concerning the action of the steam or other fluid in the engine, the adjustment of valves, the adequacy of ports and passages, the tightness of packing, the dryness of the steam, the quantity expended per unit of force, and other important points bearing on the question of economy.

After describing the best indicators in use, he showed how the diagrams were made, and how interpreted; he took up the subject mathematically, analyzing observations of his own made during several years, and drew from them practical lessons of great value.

*Dec. 24.* Mr. George Woods, of Cambridge, made a communication, illustrated by a model worked by steam and water, on his new process for drying lumber and other materials in a natural and rapid manner. The old process of drying lumber in the open air requires from six to ten years, and the consequent loss of time and capital stimulated inventors to devise quicker processes, and various drying rooms have accordingly been in use, with more or less success. In the usual method of forcing a current of air through a room heated to about 150°

Fahr., from partial ventilation the drying was found to be imperfect, causing irregular shrinkage and consequent inequalities in the wood; the steam pipes were carried under the lumber, and the air forced to pass over it, drying the outside first, the interior remaining damp from the air being saturated with moisture. He uses steam pipes under the lumber, but the moisture which is driven by the heat into the containing chamber, instead of being carried off with great loss of heat by the ventilating current, is condensed by cold water constantly running in pipes through the chamber into a grooved channel below, by which it escapes. The moisture is thus gradually, uniformly, and constantly withdrawn from the wood, which dries regularly, without strain on the outside or cracking on the inside. He claims that he can accomplish in six days what the ordinary drying room requires three weeks for, and with much better results; he saves three quarters of the time and utilizes all his heat, and the moisture once out of the wood can not get back.

Mr. N. M. Lowe made some remarks, illustrated by photographs, on the "Leaning Tower of Pisa," adding his testimony in support of the general belief that the tower was not built so, but has sunk from imperfection in the foundation, aided by the yielding character of the soil. Its height is nearly two hundred feet, and its diameter thirty feet; it leans from the perpendicular about thirteen feet, but, as the centre of gravity falls within the base, the structure will not fall unless there be further sinking of the foundations.

Mr. H. P. Langley made some remarks on various mechanical devices, which have of late years made their appearance in this community, achieving for their inventors a short-lived success, and for their users and purchasers vexation and pecuniary loss, with especial reference to steam boilers.

*Jan. 14 and 28, 1875.* Mr. H. McMurtrie presented portions of a wooden casing which had surrounded a steam pipe at a hotel in this city, showing how wood may be charred by steam used for heating purposes at a distance of an inch from the iron



pipe. Many mysterious fires may owe their origin to this cause.

Mr. Thomas S. Hall, of West Meriden, Conn., made a communication, illustrated by an extensive series of working apparatus, on his system of automatic electric railway signals, for the prevention of accidents from head and rear collisions, misplaced switches, open drawbridges, and railroad and highway crossings, dispensing with the steam whistle, and lessening the number of workmen required, an automatic electric power taking the place of careless and forgetful human agents. The usual way has been to allow a certain interval of *time* to elapse before one train is permitted to succeed another. This system is exceedingly defective, as, if an accident or detention occur, the engineer behind has no reliable means of knowing where the preceding train is; even the electric telegraph, from the carelessness or inexperience of operators, may, as in a recent case, fail to give warning in time to prevent collision.

Mr. Hall's system substitutes for this an interval of *space*, trains being kept a mile apart as indicated by his automatic signals, rendering collision impossible, avoiding the multiplication of tracks, and allowing the much more frequent despatching of trains. The block system, used in England, requires a great number of men day and night, and many accidents have happened under it.

In Mr. Hall's system the road is divided into sections of about a mile in length, at the ends of which are placed two signals, one red, to denote danger; the other blue, signifying caution. When all is right, the red signal should be out of sight, and the blue signal exhibited. As the train passes the first, it raises it, at the same time removing the blue signal, which is about 1000 feet ahead. The red signal then prevents the next train from approaching too near, while the blue signal shows the engineer that the red signal has been displayed. About 600 feet beyond the blue signal, the train reverses the signals of the previous section, or those of a mile and a third back, thus allowing the next train to approach.

Only two instruments are employed, one to enable the train to close an electric circuit, and the other to display a signal to show when this circuit has been closed. He showed his system in operation, of full size, explaining the electrical mechanism; it was seen that a red signal always remains up after a train until it is a mile and a third distant, and that, if all is right, the engineer should see neither the red nor the blue signal, but only the empty windows of the signal frames. The battery, which should consist of about twenty cups to the mile, is kept on an open circuit, except when a train is passing, and the consumption is thus comparatively small.

Should a wire break, or any accident happen, the only result will be that the caution signal will remain visible, and the engineer be thus notified to take care.

The system has been introduced on many of the principal railroads of the country, and on several in this vicinity.

*February 11.* Mr. A. W. Sprague, of Quincy, read a paper on "Automatic Regulation of Heat and Ventilation," exhibiting operative models of a draft-damper for furnaces and stoves, and also of a ventilator, both working automatically from the heat of the room.

The present devices for controlling drafts of heaters by what are known as "*back checks*" are known to be a prolific source of disease; by them the free exit of the poisonous anthracite gases is prevented, and these are forced out, and pass along with the heated air up into the apartments warmed. He thinks that the combustion should be controlled by *front* drafts, and that the opening and closing of dampers should be automatic, operated by the heat of the rooms warmed. Several devices have been in use for this purpose, worked by the direct heat of the furnace, but such a variable element could not be depended on. In this device the power which works the damper is controlled by a small cylinder of confined air placed in the apartments warmed, which, like an engineer, shuts or opens the damper when the heat of the room goes above or below the point at which the instrument is set. His ventilator operates

upon the same principle, ensuring a pure air, relieving from all watching of drafts, and preventing waste of fuel. They were exhibited in successful operation at the meeting, worked by the heat of the room.

Several members of the senior class of the school, in the department of Mechanical Engineering, then read papers describing their experiments with various pieces of apparatus, to determine some of the properties of steam on a practical scale. The subjects illustrated were superheaters, the Corliss engine, calorimeter and surface condenser, steam gauges, thermometers and pyrometers, and indicators, bearing upon various mechanical, physical, and chemical problems of practical importance.

*Feb. 25.* Mr. Alfred R. Payne, of Lynn, read a paper, illustrated by a large number of models and diagrams, on "Boiler Explosions," showing the causes of the disasters, and the position assumed by the fragments.

1. Among faults in *original construction*, he drew attention to bad welds, to collapsed flues from insufficient supports, to large boilers improperly stayed, to bad shaped boilers, and such as had no compensation for a large man-hole in the shell. 2. From *frequent and ill judged repairs*. 3. From *weakness, in ordinary working*, principally from external and internal corrosion, especially due to leakage. 4. From *shortness of water*. 5. From *over pressure*, from inoperative or absent safety valves.

For the four years ending June 1870, there were in Great Britain 219 boiler explosions, by which 315 persons were killed and 450 wounded; the greater part of these would have been prevented by proper inspection; very few were caused by shortness of water. He mentioned also many American explosions, including that of the ferry boat Westfield, in 1871. In 1870, there were in this country 118 explosions, by which 326 men were killed and 227 injured; in 1871, there were 93, with 313 killed and 281 injured; in 1874, there were 105 explosions, with 183 killed and 199 injured.

*March 11.* Mr. Charles W. Spurr read a paper, illustrated by an extensive series of specimens, on patent papered wood-hangings, to the improvement of which he had devoted several years.

About forty years ago the invention of veneering led to the use of thin layers of the valuable woods as a substitute for the solid wood. Attempts to apply veneers to house walls, on cotton or canvas supports, did not prove successful. Then the sheets were laid directly upon plastered walls; they were cut from a log revolving against a horizontal knife in continuous sheets; it was necessary to put them on green, and the ends consequently cracked on drying, while the centre moulded; they were so tender that it was very difficult to handle them, and the process fell into disrepute.

His improvement consists in covering the back of each sheet, as it comes from the cutting machine, with fine, strong Manila paper; this gives a surface to which the wood firmly adheres, and which clings everywhere to the plastered wall in all its irregularities. The paper is applied to alternate sides of the wood, so that corresponding edges come together, forming a regular pattern, without waste of material or useless expense. The wood and paper are united with pure flour paste, and are applied to the wall with the same. Steam and furnace heat have no effect upon them; frost and dampness will not injure them; they will neither shrink nor swell, and can be washed; and they strengthen the plastered wall, and prevent its cracking.

The rolls are cut by a rotary veneer-cutting machine, revolving on two different centres, cutting in the form of an ellipse; it makes from six to fourteen revolutions per minute, gaining in power what is lost in speed; it cuts sheets twelve feet long, the width varying with the size of the log. Walnut and other open-grained woods are cut one hundred and twenty-five sheets to the inch, while maple is cut to two hundred. They have been tried in this vicinity sufficiently to test their durability.

*March 25.* Mr. Horace McMurtrie read a paper, illustrated by diagrams and models, on the "Governing Principles of the Screw Propeller, practically considered."

If we imagine the shaft of the propeller, with a screw on its extremity, to be a bolt with a thread on its end, and the surrounding water to be a solid immovable nut, it will be understood, in a general way, how by the revolution of the shaft and screw, the vessel is propelled forward or backward.

In the application of power to the propulsion of vessels, part of the effect is lost by the instrument of transmission. In the common paddle wheel this loss is made up of *slip* plus *oblique action*—in the feathering wheel, of *slip* plus *drag*—and in the screw, of *slip* plus *friction* of the surface on the water. The surface of a screw blade may be supposed to be generated by a line revolving around a cylinder at right angles to the axis, at the same time moving along it. The "pitch" of a screw is the advance made by it in a complete revolution in the direction of the axis; in actual practice the full convolution is never used, but only a fraction, say one tenth of the entire pitch for each blade, the number of which varies from two to four. By changing the angle of the blade to its axis, the pitch can be increased or diminished.

The main loss of effect is due to *slip*. Water being movable, a portion of the power of the screw is lost in imparting motion to this water in an opposite direction to the advance of the vessel. The recession of this watery fulcrum is called the *slip*, which is measured in per centums of the speed of the screw. He illustrated the nature of slip, by the action of a man pushing a cart in loose sand. As the man pushes the cart forward, the sand, which is the fulcrum of the power, yields backward to the pressure of the feet, and the cart, instead of advancing the length of a step for each step, which it would do were the man pushing on rock, would advance only the complement of the length of the step, after deducting the distance receded by the sand. Each step, whether on sand or on rock, causes the man an equal expenditure of labor; in the latter

case, the labor being all utilized in giving motion to the cart, while in the former a portion is uselessly expended in giving motion to the sand.

The resistance of the screw may be increased, and the slip thereby diminished, other things being equal: 1, by increasing the diameter of the screw; 2, by diminishing the pitch; 3, by giving the screw an expanding pitch from the anterior to the posterior edge of the blade; 4, by increasing the fraction of the pitch used; 5, by employing two equal and similar screws, one under each quarter; 6, by increasing the depth of immersion.

*April 15.* Mr. A. D. Blodgett, a student of the Institute in the department of Mechanical Engineering, read a communication on an "Automatic Electric Burglar Alarm," of his own invention.

This he explained, and exhibited in operation attached to doors and windows, so arranged that the opening of one or the raising of the other, would not only ring an alarm, but, in connection with an electric annunciator, indicate the room in which the burglarious attempt was made.

His device combined both the open and closed circuits. It is very simple, there being no clock work to be wound up, as is sometimes the case with closed-circuit alarms, and there is no machinery to increase expense or to render repairs necessary. As there are three wires running to each door and window, a burglar would not know which to cut and which to connect, which he might in a closed or open circuit; as all the wires come through the same aperture in the casing, it would be almost impossible to tamper with them successfully. If all three wires are cut the alarm is sounded.

Mr. Martin then exhibited in operation, and described a "type writer," a machine to supersede the pen in manuscript writing.

In size and appearance it resembles a sewing-machine; writing is performed by touching small round keys, like those of a piano, arranged in four rows of eleven each, and may be done by one or both hands; each key, on the top of which the letter

or sign is indicated, by depression with the finger causes its letter to be printed on the paper by means of a lever. Any one who can spell can write with it, and any quality or length of paper can be used, from three to eight inches wide. The type receives ink from a moving ribbon, which can be used for months without being re-inked, and with proper usage will last a year. Its work is as legible and as uniform as print; its average speed is twice that of the pen, and one good operator is as good as two expert penmen for all purposes except book-keeping and writing in books. For lawyers, reporters, copyists, clergymen, the blind, and for those whose hand writing is illegible from age or any other cause, such a machine is of great value. Any one with two weeks' practice can write with it faster than with a pen. By using copying ink and the manifold process, with thin papers, twenty copies can be written at a time. For teaching spelling and punctuation in schools it is of advantage, and its use would be like play to a child.

*April 29, and May 13.* Mr. George B. Dixwell read a paper, illustrated by diagrams and tables, on "Cylinder Condensation," and the means of suppressing it, in steam and vapor engines. The conclusions he arrived at after a large number of experiments, extending over several years, and verified in the Mechanical Laboratory of the Institute.

His first object was to show that this condensation was of great importance as a difficulty to be overcome, and to do this he examined the published experiments of Chief Engineer Isherwood, about one hundred in number, made on fifty different engines.

Since the time of Watt, engineers have been trying in vain to realize all the theoretical advantages of working steam expansively, and it was supposed that cylinder condensation was the cause of their failure; the loss from this cause was shown, at about a half cut off, to be about forty per cent. of the steam utilized, thus disappearing more than one half of the gain expected from expansion; clearance, back pressure, and friction would take off more, so that the gain would be very little; with

a shorter cut-off it is worse, and there may be absolute loss instead of gain.

Being satisfied of the importance of cylinder condensation, the next question was how to suppress it, and to ascertain what had been or could be done by steam jackets, and the system of compounding. He showed that the saving by jackets was really very small.

He explained how he thinks it comes to pass that cylinder condensation is different at each cut-off, that the actual amount should be many times the equivalent of that directly due to the conversion of heat into work and radiation, and that the condensation in the higher pressure cylinder of a compound engine should be much less at the same cut-off than that in the low pressure cylinder.

He then explained how he had come to the conclusion, which he thought entirely new, that the action of the metallic surface is *cumulative*, causing the total condensation to be several times that caused at each stroke by the conversion of heat into power, and by radiation. Even in the best compound engines there is a loss by condensation of 20 per cent. of the steam utilized; he showed how their performance may be increased some 35 per cent. by an expenditure of 10 per cent. of heat, and this by superheating. He explained how the vapor of water is, unlike air, one of the best radiators and absorbers of heat, and how a film of steam converted the polished metallic surfaces into an energetic radiator. Steam may be superheated sufficiently to balance the radiation and the heat converted into work, without fear of its carrying into the cylinder a temperature injurious to the working parts. The expense of such superheating is trifling, cylinder condensation is suppressed, and the gain is about 25 per cent. in compound engines.

There have been no elections during the year. Five members have died during the year. Messrs. Hammatt Billings, Samuel Hooper, James Lawrence, Charles G. Putnam, and N. B. Shurtleff; twenty-three have resigned, and six have been



dropped for non-payment of fees. The list now comprises 63 life, and 200 associate members.

The attendance at the School of Industrial Science for the year has been 288, as follows: Resident Graduates, 21; Regular Students of 4th year, 35; of 3d, 45; of 2d, 55; of 1st, 36; — Students not candidates for a Degree; 4th year, 15; 3d, 13; 2d, 24; 1st, 5; Architectural Students, 26; Students in Practical Design, 25, of whom 14 were females. Total 288, of whom 12 were graduates of other Institutions. Of these, about five-sixths were from Massachusetts, principally from Boston and its vicinity; — from other New England States, 17; viz.: from Maine, 7; New Hampshire, 3; Vermont, 2; Rhode Island, 2; Connecticut, 3. From other States, there were from New York, 9; Ohio, 7; Illinois, 6; Pennsylvania, 5; Indiana, 4; New Jersey, Minnesota, and California, 2 each; Tennessee, Kentucky, Michigan, Iowa, Nebraska, Colorado, British Provinces, Japan, Canary Islands, 1 each; Hawaiian Islands, 5.

Thirty-four professors and teachers have been connected with the school, and, as usual, several advanced students have rendered assistance in the laboratories and in surveying. The fees from students have amounted to about \$47,000, a decrease of \$3000 from the previous year.

The class in the School of Design has been full, and eminently successful. For details, see the Report of Mr. Kastner, on page 34.

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 Saturday, Nov. 21.

II. *Qualitative Analysis*. Twenty-four laboratory exercises of two hours each, on Wednesday and Saturday afternoons at 2½ o'clock, by Professor Nichols, beginning Saturday, Nov. 21.

III. *Practical Geology of the United States*. Eighteen lectures, on Tuesday and Friday evenings at 7½ o'clock, by Dr. T. Sterry Hunt, beginning Tuesday, Nov. 17.

IV. *Lantern Projections*. Eighteen lectures on the use of the Lantern as a means of illustration in teaching, on Wednesday and

Saturday afternoons at 3½ o'clock, by Professor Pickering, beginning Wednesday, Nov. 18.

V. *Elementary French*. Eighteen lessons, on Monday and Wednesday evenings at 7½ o'clock, by Instructor Jules Luquiens, beginning Monday, Nov. 16.

VI. *Modern Philosophy from Descartes to Hegel*. Eighteen elementary lectures, on Monday and Wednesday evenings at 7½ o'clock, by Professor Howison, beginning Monday, Nov. 23.

VII. *Elementary Principles of Mechanism*. Eighteen lectures for machinists, on Tuesday and Thursday evenings at 7½ o'clock, by Professor Lanza, beginning Tuesday Dec. 7.

Open to both sexes over eighteen years of age; applicants to apply in their own handwriting, stating age, occupation and previous preparation.

The Corporation has held six meetings during the year.

At the meeting of April 14, 1875, it was voted that the students of the Boston University may receive instruction in Chemistry at the Institute on payment of a certain sum to the Department.

At the same meeting it was voted that the Professorship of Geometry, Stereotomy, and Drawing be vacated at the end of the school year.

At the meeting of June 9, 1875, it was voted to confer the Degree of Bachelor of Science on the following students, who had complied with all the conditions :

Allen, Samuel E. . . .	Fall River . . .	Dept. of Civil Engineering.
Burrison, H. K. . . .	Boston . . .	" " "
Church, Christopher A. .	New Bedford . .	" " "
Dodge, Frank S. . . .	Beverly . . .	" " "
Dorr, Edgar S. . . .	Mt. Auburn . .	" " "
Edes, William C. . . .	Bolton . . .	" " "
Hammatt, E. A. W. . .	Newton Centre .	" " "
Handy, Edward A. . .	Barnstable . .	" " "
Howes, Clar. L. (1873)	Hanover . . .	" " "
Huntington, Wm. F. .	Springfield . .	" " "
Sargent, Welland F. .	Sedgwick, Me. .	" " "

Head, James H. . . .	Brookline . . .	Dept. of Mechanical Engin'ing.		
Hibbard, Thomas . . .	W. Roxbury . . .	"	"	"
Knapp, J. Austin . . .	Hanover . . .	"	"	"
Lewis, Wilfred . . .	Philadelphia, Pa. . .	"	"	"
Plimpton, Thomas D. . .	Walpole . . .	"	"	"
Sargent, Francis T. . .	Malden . . .	"	"	"
Stanwood, James B. . .	Cincinnati, O. . .	"	"	"
Burnett, Moses D. . . .	Syracuse, N. Y. . .	Dept. of Mining Engineering.		
Goodale, Chas W. . . .	Hudson . . .	"	"	"
Oxnard, Benj. A. . . .	Jamaica Plain . . .	"	"	"
Shockley, Wm. H. . . .	New Bedford . . .	"	"	"
Warren, H. L. J. . . .	Boston . . .	"	"	"
Webster, Wm. R. . . .	Philadelphia, Pa. . .	"	"	"
Wrinkle, L. F. J. (1870)	Lee . . .	"	"	"
Boyden, Amos J. . . .	Foxboro' . . .	Architecture.		
Kinnicutt, Leonard P. . .	Worcester . . .	Chemistry.		
Mixer, Samuel J. . . .	Boston . . .	Physics.		
Arnott, James L. . . .	Thompsonv'e, Ct. . .	Science and Literature.		
Prentiss, Wm. A. . . .	Holyoke . . .	"	"	"

The subjects of the Theses, and abstracts of the same, will be found on p. 105.

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

SAMUEL KNEELAND, *Secretary.*

*Boston, Oct. 9, 1875.*



## DEPARTMENT OF PHILOSOPHY.

*To the President:—*

During the year just closed, the changes in the course of study proposed at the end of the preceding one have been matured and put in operation. By alterations in the course for the school at large, my work with the regular students of *all* departments has been limited to two lectures a week during the whole of the First Year, and three a week during the first half of the Fourth Year. The changes in the Department of Philosophy itself, have amounted to carrying its leading subject a half-year backward, so that it now begins at the opening of the Second Year. In this way, the time allotted to the study of the Modern Systems has been extended, so that it now covers the Third and Fourth Years entire. The particulars of the Course as it now stands may be gathered from the last catalogue. Details of the work done in the two sections of my department are herewith submitted.

### I. THE WORK WITH ALL REGULARS.

*First Year's Class.* During the first half-year, there were lectures and exercises twice a week on the Classification and Analysis of Terms, and the Structure and Analysis of Sentences. During the second half-year, the same number of lectures was given upon the Rudiments of Logic, including the Classification of Propositions—their Notation, Reduction, Opposition, Conversion, and Permutation—and the Elementary

**Principles of Inference.** As this was our first attempt at teaching Deductive Logic to First Year men, it is worth while to state that the experiment has been quite successful. At the annual examination in May, the class proved themselves to be well acquainted with all the general forms and principles of deductive inference, and showed a creditable skill in detecting the ordinary fallacies. But to secure the best results from the work now assigned to the First Year, it is desirable that we shall have a better preparation. For this reason, I would call the attention of the Faculty to the recommendation made in this connection last year, and would ask that it be adopted and put in operation when the next class is admitted; namely, that all candidates for the First Year's class be required to pass an examination in the Analysis of Sentences and the Classification of Terms.

*Fourth Year's Class.* During the first half-year, a course of three lectures a week was given to this class upon the following topics: the Elementary Principles of Inference; the Idea and General Divisions of a Philosophy of Science; and the Nature of Induction, with an account of its Recognized Methods. The lectures were accompanied by a study of Mr. Fowler's textbook on Inductive Logic. The interruption of our work at the middle of the preceding year, made it necessary to take part of this year's time to bring up the lost topics; consequently, the subjects proper to the Fourth Year had to be presented more briefly than our regular plans contemplate. With the next class, I shall be able to carry out the course in the Philosophy of Science as laid down in the catalogue.

## II. THE WORK WITH STUDENTS OF PHILOSOPHY.

In the department proper of Philosophy, there have been this year nine students—three regular and six special—an increase of four over the year preceding. The changes involved in bringing the course of study for this department into the form now given in the catalogue, have ranked all the regulars as

students of the Third Year. Of the specials, three took the philosophical studies of the Third Year, and the remaining three the course in Psychology belonging to the Second Year. These last read with me the more important parts of Mr. Jardine's recent treatise on the *Psychology of Cognition*, which, including as it does a very good sketch of the various theories of Perception from Descartes to Kant, gave them a valuable introduction to the whole field of philosophy.

The regulars and specials of the Third Year have covered the ground assigned in the catalogue. They have thoroughly read the following matter: —

- Descartes' *Method*, and his six *Meditations*, entire;
- Spinoza's *Ethics*, in outline;
- Leibnitz's *Monadology*, *New System of Nature*, *Nature of the Soul*, and *Doctrine of a Universal Spirit*, entire;
- Locke's *Essay*, in its most important parts, with Cousin's *Critique* of the same;
- Berkeley's *Principles of Human Knowledge*, entire;
- Hume's *Inquiry Concerning Human Understanding*, — the first eight sections.

In addition to making and studying notes of my explanations and criticisms, the class have read from Schwegler's *History of Philosophy* the accounts of the systems of Descartes, Geulinx, Malebranche, Spinoza, Leibnitz, Locke, Berkeley, and Hume, together with Stirling's notes on the same, and Ueberweg's accounts of most of these systems. On Berkeley, they have read, besides, Fraser's *Introduction*, and the *Prolegomena* and *Notes* (by Ueberweg and others) contained in Krauth's edition of the *Principles*. The results of their examinations have been very gratifying. Specimens of the papers used during the year are subjoined.

## EXAMINATION ON LEIBNITZ.

1. Brief narrative of Leibnitz's career. His principal works, etc.
2. Items of agreement between Leibnitz and the Cartesians, and between Leibnitz and Spinoza.
3. Points of vital difference between Leibnitz and both of these.
4. What specific difficulties felt in both of the previous systems was the Theory of Monads intended to overcome? In how far does it succeed? What difficulties does it leave still unsettled?
5. Sketch the Theory of Monads. [Definitions — Exposition of their Nature, Relations, and Gradations — the "City of God."]
6. State Leibnitz's peculiar argument for God's existence.
7. Name and state the Three Working Principles of Leibnitz's System.

## EXAMINATION ON BERKELEY.

1. Titles of Berkeley's principal works, with the date and burden of each.
2. Clear and full outline of his *Principles*, including its parts, and the contents of each part.
3. What, according to Berkeley, constituted the currently received principles? What, exactly, does he mean by the expression, "principles of knowledge"?
4. What are the principles that he proposes to substitute? With what general school does his fundamental principle connect him?
5. In what sense, and in what sense only, does Berkeley deny the existence of Matter? Rebut the common objection of "plain absurdity," charged upon his view.
6. What, exactly, is Berkeley's doctrine a theory concerning? What point against the common theory does he unquestionably establish? What depth hid in the common view does Berkeley's fail to appreciate?
7. How, precisely, does Berkeley's theory differ from Malebranche's "Vision in God"?
8. Sketch Berkeley's several arguments for the insubstantiality of Matter? What does he mean by his perpetual reiteration that matter is merely "phenomenal," or that its "*esse* is simply *percipi*"? Into what contradiction, or at any rate obscurity, does he fall, when pressed with the apparent *discontinuity* which his doctrine introduces into na-



ture? What ambiguity here comes to light in Berkeley's use of the term *idea*?

9. State Berkeley's argument for the existence of God.

10. What does Berkeley think he has *demonstrated* concerning Matter and concerning God?

11. Criticise each of his arguments for the insubstantiality of Matter. Show that, in two of them, he practically begs the question, and how; and that, in the other two, he strikes wide of the mark, or, as the logicians say, commits *ignoratio elenchi*.

12. Reflect on Berkeley's argument for God's existence, and then endeavor to state *completely*, all the principles it implies. Give an estimate of it in the light of your results.

13. What, in the second grand division of his treatise, does Berkeley unquestionably succeed in showing?

14. What does he attempt to show in the Third Part? What estimate would you put upon his success here, and why?

15. What permanent contribution may Berkeley be said to have made to Modern Philosophy? In whom, however, did a conscious insight into this view first arise?

16. Compare Berkeley's doctrine with the Cartesian; show their difference upon formal points, but their essential identity in failing to solve the problem of intercommunion between Subject and Object.

17. Compare Berkeley's view with Spinoza's; show from what standpoint it has the apparent advantage over the latter of preserving the identity of the Individual Soul and its distinctness from God; but show, also, from what standpoint it loses this advantage entirely. Point out the contradiction in Berkeley's thinking, which is here implied.

18. What remarkable passages in the *Principles* seem to penetrate to a philosophy which, while thoroughgoing idealism, would fathom the insight, deeper than Berkeley's, contained in the common view? Why cannot this deep view be credited to the *Principles* as a system?

#### ANNUAL EXAMINATION, MAY 29, 1875.

Write a connected sketch of the history of Philosophy, from Descartes to Hume inclusive, giving the systems of Descartes, Spinoza, Leibnitz, Locke, Berkeley and Hume. Be especially clear upon the following matters:—

1. The essential and distinguishing principle of the whole modern philosophic method.

2. The relations of the several systems to each other, and to the modern philosophic movement as a whole.

3. The exact statement of those points in the several systems which the ordinary reader is pretty sure to misapprehend, but an error about which will prevent any real insight into the systems.

4. The characterization of each system as a whole; the statement of the points upon which it has attained to permanent views; and the criticism of its errors and failures.

5. The tracing of Cartesianism through its various attempts to solve the Problem of Certitude consistently with its preconceived principles; including, particularly, the extensions of Descartes' doctrine made by Geulinx and Malebranche.

6. In the case of Leibnitz, the conception of the Monads, the Gradations of Existence, and the Three Principles of Thought.

7. In Locke's case, the exact point rendering him of lasting significance in the history of philosophy.

8. In Berkeley's, to show just how he differs from the ordinary view, just what he means by his "Idealism"; and to refute the vulgar objections to his theory, though criticising it.

9. In Hume's, to be full upon his critique of Causality, and his application of its results to the doctrines of Providence and Moral Obligation.

Respectfully submitted,

GEO. H. HOWISON.

## DEPARTMENT OF ENGLISH AND HISTORY.

*President Runkle :—*

I hereby transmit through you to the Government of the Institute the following account of my classes and lessons during the past school year.

To the second class, I gave a course of lectures on the history and literature of the latter half of the Eighteenth Century. Attendance on these lectures was compulsory, but early in the term, owing to the pressure of their scientific studies the time assigned for writing up notes was taken away. A good deal of voluntary writing was, however, done by various members of the class, and a considerable number gave a voluntary attendance on a continuation of the course through the second term.

To the third class, I gave a course of lessons on the history and text of the U. S. Constitution, with such references to English constitutional history as time allowed. Attendance on these lectures was compulsory and at the close of the term the class was examined on the text of the Constitution, but time enough was not allowed for more extended study of the subject out of the class-room.

During the second term nearly the whole of the class gave a very regular and constant voluntary attendance on a course of lectures on the Elementary principles of Political Economy and its connections with History.

At the request of a majority of the members of the fourth class, I read with the whole class some of the more important chapters in Prof. Parsons' work "The Laws of Business for Business Men," especially those on the law of contracts, a subject which was assigned to the students in "Science and Literature" only. Study was not compulsory, but the students generally bought the book and a considerable number passed a good examination in the parts gone over. The subject is out of my province and should be in the hands of a legally educated instructor.

With a small number of students in the department of "Science and Literature" who have attended my lectures I have done a good deal of collateral reading in History and Political Economy, accompanied on their part by a considerable amount of writing. The theses of two graduates in this department, that of Mr. Prentiss, on the condition and resources of the Empire of Austria, and that of Mr. Arnott on Switzerland are herewith presented.

The Elementary exercises in Rhetoric and Composition which I have heretofore given to the first year's class, were this year omitted to make room for exercises in the department of Logic and Philosophy. I cannot but express my regret that more time cannot be found for all the classes for study and writing in connection with the exercises in my department, and that efficient assistance cannot be afforded me in the laborious work of examining written work.

Respectfully presented,

W. P. ATKINSON,  
*Professor of English and History.*

## DEPARTMENT OF MODERN LANGUAGES.

*President Runkle:—*

DEAR SIR, Permit me to submit to you the following report of the department of Modern Languages, with especial reference to its operation during the past year.

### I. FRENCH REQUIREMENT FOR ADMISSION.

This is one of the most important matters relating to the department, and has occupied much of the attention and time of the same. It is now three years that French has been among the requirements for admission. During the past two years the amount required has been the same, viz., "French Grammar through Regular and Irregular verbs, and twenty-five pages of easy reading," *i. e.*, the more prominent forms and laws of the language with some practice in reading. The first year (1873) French was required for admission the amount was less, viz., "The first nineteen lessons of Otto's grammar," *i. e.*, the elements of the language as far as regular verbs. The following table gives the results of these three examinations.

1873.	1874.	1875.	
70	41	71	No. taking French in First Year.
53	49	53	Average per ct. at Entrance Examination.
15	5	3	No. admitted without French.
49	26	51	No. admitted without conditions.
81	66	61	Average per ct.
21	15	20	No. admitted with conditions.
10	19	32	Average per ct.

From this it appears, 1st, that the number of those without French has decreased each year; 2d, that notwithstanding the increase in the amount required, the average of the whole class at the examination in 1875 was not lower than in 1873; 3d, that the average of the lowest portion of the class, who had to be conditioned, has been increasing each year; 4th, that the number of those admitted without conditions has slightly increased, while that of those admitted with conditions has slightly decreased.

The experiment therefore of requiring a certain amount of French for admission, that is of having so much of what was previously done in the school made a part of the preparatory work, seems to have been thus far reasonably successful. Still there is very great room for improvement in the quality of the work. There are too many cases now where cramming is evident, and too few where the ground has been well and systematically gone over and thoroughly digested. With the view of facilitating the preparation in French and improving the character of the same, we would offer a few suggestions to be printed in the Annual Catalogue in respect to the manner of treating the French at this stage of its study, thinking that they may be of assistance to instructors and private students.

The amount of French at present required for admission, if well done, would be equal to at least two thirds of a year's work at the Institute, so that certainly there is a prospect of the time when French may be discontinued at the end of the first year, and a full two years' course in the language be regarded as completed. After such a course of practice and training it is probable that students would be able to read easy French at sight and have sufficient strength to solve with accuracy such difficulties as might arise. For the sake of giving a better idea of how a class now stands at the end of the first year, we subjoin the French examination paper at the Annual of the last First Year, the average of the class of thirty-nine students on the same being 56 per cent.

In regard to the *French requirement for the future*, it seems to us desirable to increase somewhat the amount of reading matter, so as to afford a larger field for the observation and study of the grammatical principles. We would therefore, leaving the amount of Grammar as it is, propose sixty pages of easy French instead of twenty-five as at present, and indicate this by "the first two books of Voltaire's 'Charles XII.' (*i. e.*, about sixty pages) or the equivalent of the same."

In the report of this department for last year it was stated that much inconvenience and loss attended the union in one class of students so unequally advanced as were those in the First Year's class of the year before in French. It was suggested also that an *Elementary Class* consisting of those behind-hand be formed, to recite by themselves and oftener than the rest. This plan has been carried out the past year and has worked to the great advantage of both parts of the class. This class (consisting of twelve students) had four exercises a week, three being outside of school hours, it being impossible to find time otherwise that would not conflict with regular school duties. At the Semi-Annual this class was merged with the regular one. A like class (consisting of thirteen students) has been formed for the present year. Poor preparation, which makes such a class necessary, is perhaps at first a necessary consequence of a new requirement for admission. But it should be dispensed with as soon as possible by requiring the full amount of candidates before they are allowed to enter. It would certainly seem that after this students who have no French, though prepared in other subjects, should be required to make up by means of private instruction before being admitted.

It is too late now to go back and inquire whether it would not have been more advisable to require *Latin instead of French for admission*. Out of sixty-five students in the class just entered, forty-five report that they have studied Latin and twenty-two that they have not; fifty-one were from schools where Latin was a branch of study and sixty-three from schools where French was. It seems hardly consistent with this to suppose

that a Latin requirement would have been more easily obtained than a French one. Moreover, although it cannot be doubted that the student having a knowledge of Latin to start with would advance much more rapidly on that account in his French, still it is hardly probable that he would get so far at the end of a year as if he had started with a corresponding amount of French. It seems therefore fair to conclude that the requirement of French for admission saves time for other work in the school without being one harder to fulfil than Latin would be.

Of course we do not mean to imply by this that Latin would be of no value to the student at the Institute. On the contrary, it would be of very great value to him, in view of the general culture afforded by its study on the one hand, and its practical bearing upon the various departments of science on the other. It becomes therefore an important subject for consideration whether, in addition to the French, a certain amount of Latin may not sooner or later be required for admission.

## II. WORK OF THE PAST YEAR.

This has been conducted nearly in accordance with the revised scheme of studies arranged year before last, that is a two years' course in each of the studies, French and German. The following indicates the disposition of this time:—

<i>French.</i>	{ Before entrance.		<i>German.</i>	{ II Year (2d half).	
	{ I Year.			{ III "	
	{ II " (1st half)			{ IV " (1st half).	

The number of hours in each of these courses is one hundred and eighty, which however includes the time occupied by Intermediate, Semi-Annual and Annual examinations. Three hours a week have been used for both courses, this number, it is believed, producing the best results. This amount of time is certainly not large for the French. For the German it is decidedly small, when the difficulties of the language are considered, and the amount of practice necessary to obtain any readiness in reading. If the French requires two years, two and a



half years are certainly not too much for the German, if the student is to advance as far in the same.

During the past year the First Year's class has had French; Second and Third Years' classes German. The Fourth Year's class had German the first half of the year. The Second Year commenced German, contrary to the above scheme, at the beginning of the year as heretofore, instead of waiting until the French was finished, it being the intention to have the French finished the first half of the fourth year in the time assigned to the German. It was felt that, if the German were commenced later, students would not be able to use it in their professional work in the school. It seems to be however undesirable to intermit the French for two years and then resume it for half a year, and better to finish it at once, even if the time for commencing the German should have to be postponed.

Regular dictation exercises have accompanied the recitations, so also regular exercises on the forms and principles of the language. The First Year had read at the Annual two hundred and twenty-five pages, from Otto's French Reader, *Mérimée* ("Colomba"), and Lacombe ("Petite histoire du peuple français"). The Second year read during the year extracts from Whitney's German Reader, and from Andersen's "Märchen." The Third Year had read at the Annual (*i. e.*, during two years) two hundred and four pages, from Whitney's Reader, Putlitz ("Badekuren"), Zschokke ("Wirtshaus zu Cransac"), and Heyse ("La Rabbia"). The Fourth Year read during the first term portions of the "Goetz von Berlichingen" of Goethe, and of the "Lügen" of Benedix. The average of the Third Year class, of forty-four students, at the Annual on the annexed paper in German was 66 per ct.

The above are the regular courses in French and German for all the students. The "Science and Literature" students of the Third Year had an advanced course in French, in which the "Atala" of Chateaubriand and two plays of Molière were read.

The "Science and Literature" students of the Fourth Year read during the second half from Goethe's "Goetz von Ber-

lichingen," and had also a course in the Science of Language, Whitney's "Language and the Study of Language" being used as a text book.

In the Second year there has been an optional class in French reading, numbering twenty-eight students the first term and twenty-one the second, there being two exercises a week with no time for preparation. Most of About's "*L'homme à l'oreille cassée*" was read the first term, and portions of "*Visites au Jardin d'Acclimatation*" by Barr, the second term. The object of these optional readings in French was to remove the objections attending the intermission of the French for two years.

There has been also during the year an optional elementary class in Spanish, composed of students of the Third and Fourth Years, with two exercises a week, no outside work being required. This class numbered ten the first term, and seven the second. For the present year an opportunity will be given to students of the same years to take Italian. In future we would suggest that this class be confined to half of the year, and an hour's preparation be required for each one of the two weekly exercises.

The number of exercises a week in all the studies of this department has been thirty-one the first term, and thirty-two the second.

### III. TECHNICAL READING.

Strictly technical reading is quite out of the question in a class composed of students from several departments, for the practical reason that a student in one department does not need the technical words of another. Moreover, the instructor could not be expected to have the proper knowledge of the technicalities in various departments in French and German, any more than in English. On the other hand a student has a special advantage in beginning such reading under the guidance of a Professor in his own department, and with the illustrations at hand which a laboratory affords. This is more especially the

case with the German, where a brief introductory course, for learning technical words and the general style of technical reading is quite necessary, even though a student be well advanced in general reading. Such strictly technical reading has not been attempted in the regular classes. It has however to some extent been carried on by some of the students under the direction of the Professors in the departments concerned.

But if strictly technical reading is not practicable in the regular courses, it is proper to inquire whether scientific reading of a general nature would not be more profitable than something in general literature, as having more or less bearing upon the professional work of the students. This kind of reading has been tried to a limited extent the past year in both French and German, and with such success apparently as to warrant replacing the general reading in a great measure by the same. Perhaps, aside from the practical difficulty of obtaining the proper material for such reading, the only objection to having the entire reading of the student of this nature, is the danger that there would not be variety enough for him to observe the uses and styles of the language as they appear in the various kinds of literature.

#### IV. MODE OF STUDYING THE MODERN LANGUAGES.

The views of the department on this point remain the same as stated in the last report, only strengthened and confirmed by experience. A thorough grammatical training seems to us essential, if one would understand a language. Without such training and study he cannot expect accuracy and strength in the interpretation of the same. Studying a language indeed, and studying its grammar, must go hand in hand, if the term grammar be taken in its proper sense. The study of Grammar, it is true, has from abuse come to convey to the mind of the student the idea of cramming the memory with certain dogmatic and technical statements not connected with a living organism ; while he is further discouraged by having put before

him at the same time what, though of the highest value in its place, belongs to the department of logic not language. But let him consider that grammar is the methodical embodiment of the facts and laws of a language and that, when by actual observation of, and practice on the language itself he is getting possession of its laws and facts, he is studying its grammar. He will then find that he is growing in knowledge of the language in proportion as he is mastering these facts and laws, and that his study has the attraction of the study of any science. The material of a language, consisting in its words, is also essential, but no more so than the principles which teach one how these are used. Our aim has accordingly been to accompany the exercises with methodical statements of the principles as they are indicated by the text. Of course there is danger of going too far in this direction, to the sacrifice of the material and the practice. But if a mistake were made in either direction, it seems to us that it would be safer to make it in the direction of little practice and the acquisition of few words, than in that of an inadequate knowledge of the structure and laws of the language.

Very Respectfully,  
 CHARLES P. OTIS.

Dec. 17, 1875.

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

*Translate.* — I. On appelle *colons* à cette époque, des hommes qui cultivent la terre d'un propriétaire moyennant une redevance fixe qui s'élève au quart ou à la moitié des fruits. Les colons sont, comme on voit, des espèces de métayers, mais des métayers perpétuels. Le maître ne peut pas les chasser, et eux, en retour, ne peuvent pas quitter le domaine. On les tient pour personnes libres, mais il faut entendre libre au regard du maître et en ce sens qu'ils ne lui doivent que des redevances fixées ; d'ailleurs, ils sont esclaves de la terre à laquelle ils sont attachés, serfs de la glèbe, comme on dira plus tard. S'ils s'enfuient, le maître pourra les faire reprendre.

LACOMBE.

II. Dès qu'il eut quitté le tillac, la femme de chambre remonta, et, après avoir fait subir un interrogatoire au matelot, rapporta les renseignements suivants à sa maîtresse : la ballata interrompue par la présence d'Orso

avait été composée à l'occasion de la mort du colonel della Rebbia, père du susdit, assassiné il y avait deux ans. Le matelot ne doutait pas qu'Orso ne revînt en Corse pour *faire la vengeance*, c'était son expression, et affirmait qu'avant peu on verrait de la viande fraîche dans le village de Pietrannerà. Traduction faite de ce terme national, il résultait que le seigneur Orso se proposait d'assassiner deux ou trois personnes soupçonnées d'avoir assassiné son père, lesquelles, à la vérité, avaient été recherchées en justice pour ce fait, mais s'étaient trouvées blanches comme neige. "Il n'y a pas de justice en Corse, ajoutait le matelot, et je fais plus de cas d'un bon fusil que d'un conseiller à la cour royale."

MÉRIMÉE.

III. Orso, répondit Colomba, chacun honore ses morts à sa manière. La *ballata* nous vient de nos aïeux et nous devons la respecter comme un usage antique. Madeleine n'a pas le *don*, et la vieille Fiordispina qui est la meilleure voceratrice du pays, est malade. Il faut bien quelqu'un pour la *ballata*.

Crois-tu que Charles-Baptiste ne trouvera pas son chemin dans l'autre monde si l'on ne chante de mauvais vers sur sa bière ? Va à la veillée, si tu veux ; j'irai avec toi, si tu crois que je le doive, mais n'improvise pas, cela est inconvenant à ton âge, et . . . je t'en prie, ma soeur. MÉRIMÉE.

IV. Il va poser une première pierre à Corte ; je m'imagine que ce doit être une cérémonie bien imposante, et je regrette fort de n'y pas assister. Un monsieur en habit brodé, bas de soie, écharpe blanche, tenant une truelle . . . et un discours ; la cérémonie se terminera par les cris mille fois répétés de *vive le roi* ! — Vous allez être bien fat de m'avoir fait remplir les quatre pages, mais je m'ennuie, Monsieur, je vous le répète, et par cette raison je vous permets de m'écrire très-longuement. MÉRIMÉE.

V. (*Passage not translated in class.*) — Pendant le repas, le chef de la loi m'avait fait faire plusieurs questions par Joseph : il voulut savoir pourquoi je voyageais, puisque je n'étais ni marchand, ni médecin. Je répondis que je voyageais pour voir les peuples, et surtout les Grecs qui étaient morts. Cela le fit rire ; il répliqua que, puisque j'étais venu en Turquie,<sup>1</sup> j'aurais dû apprendre le turc. Je trouvai pour lui une meilleure raison à mes voyages, en disant que j'étais un pèlerin<sup>2</sup> de Jérusalem. Il fut pleinement satisfait. La religion est une espèce de langue universelle, entendue de tous les hommes. Ce Turc ne pouvait comprendre que je quittasse ma patrie par un simple motif de curiosité, mais il trouva tout naturel que j'entrepris un long voyage pour aller prier à un tombeau.<sup>3</sup>

CHATEAUBRIAND.

1. Explain the pronouns *eux*, *laquelle* (V) ; *m'(ennuie)*, *m'(écrire)* (II).
2. What is the tense in "dès qu'il m'eut quitté" ? Is there any rule as to the use of this tense ?

<sup>1</sup> Turkey.

<sup>2</sup> Pilgrim.

<sup>3</sup> Grave.

3. Explain the form of the past participle in "*ils sont attachés*," "*s'étaient trouvées*," "*m'avoir fait remplir*," giving the rule of agreement in each case.

4. What mode and why in *Orso ne revint* (II), *que je le doive* (III), *que j'entreprisse* (V) ?

5. Give the principal parts of *doivent* (I) ; *subir* (II) ; *faut* (III) ; *écrire* (IV) ; *entreprisse* (V).

6. State when the past participle remains invariable.

7. What verbs can be followed by an infinitive without any preposition ?

8. When is the compound of present chiefly used ? Of what other tense may it at times take the place ?

9. What is the difference of meaning between *aussi* at the head of a sentence and after a verb ; between *puis*, *puisque* and *depuis* ; between *ailleurs* and *d'ailleurs* ?

10. What would be the construction in French of these two sentences : *I believe I am right* and *I believe he is right* ?

*Translate.*—1. The danger in which he finds himself is great. 2. Your tale<sup>1</sup> amused me ; tell it to him also. 3. The letter which I have begun to read is badly written. 4. We obtained peace<sup>2</sup> by making sacrifices. 5. The qualities of Alexander were those of a king, his faults those of a soldier. 6. I lent him all the aid<sup>3</sup> I could. 7. It does not seem that you love him. 8. I do not doubt that your Majesty will learn with pleasure that I have discovered a world. 9. I could not prevent him from falling. 10. He was ready to go up to his room when some one knocked at the door.

<sup>1</sup> conte (m) ; <sup>2</sup> paix (f.) ; <sup>3</sup> assistance (f.).

FIRST YEAR. MAY, 1875.

[EXAMINATION PAPER IN GERMAN OF THE THIRD YEAR AT THE ANNUAL]

I. Vielleicht wären alle diese aufgezählten Ursachen der Dürre und Wärme nicht hinlänglich, so beträchtliche Theile der afrikanischen Ebenen in ein furchtbares Landmeer zu verwandeln, hätte nicht irgend eine Naturrevolution, z. B. der eintretende Ocean, einst diese flache Gegend ihrer Pflanzendecke und der nährenden Dämmerde beraubt. Wann diese Erscheinung sich zutrug, welche Kraft den Eindruck bestimmte, ist tief in das Dunkel der Vorzeit gehüllt Humboldt.

II. Folgt auf die brennende Hitze des Tages die Kühlung der, hier immer gleich langen Nacht, so können Rinder und Pferde selbst dann nicht sich der Ruhe erfreuen. Ungeheure Fledermäuse saugen ihnen, während des Schlafes, vampyrartig das Blut aus; oder hängen sich an dem Rücken fest wo sie eiternde Wunden erregen, in welche Moskitoes, Hippoboscen und eine Schaar stechender Insecten sich anhebeln. So führen die Thiere ein schmerzvolles Leben, wenn von der Gluth der Sonne das Wasser auf dem Erdboden verschwindet. Humboldt.

III. Mit dem Eintritt in die Südbonauländer erfolgten Angriffe der hier wohnenden Bulgaren; sie tödteten manchen Pilger mit ihren Pfeilen, spießten einzelne Gefangene und

wurden erst geschreckt, als Kaiser Friedrich streng das Wiedervergeltungsrecht androhen, und eine ihrer Städte Brundisium zerstören ließ. Auf die Griechen fiel wegen dieser Feindseligkeiten zunächst kein Verdacht, weil man sehr gut wußte, daß die eingewanderten Stämme ihnen nicht gehorchten; als aber Gefangene bekamen, daß man die Bulgaren allerdings von Konstantinople aus angereizt habe, entstand Argwohn, welcher noch höher stieg, da die Fürsten von Serbien und Racyna dem Kaiser bei Nizza persönlich aufwarteten, für Lebensmittel forsten und zugleich ihre treuen Dienste gegen die stets räuberischen Griechen anbotent raumer.

#### IV. (Passage not read before.)

Noch ungefähr eine halbe Stunde fuhren die Reisenden die glatte, ebene Schaulsee entlang, dann bogen sie seitwärts ab in den dunkeln Wald, durch den ein gutgehaltener Fußweg lief. Die Sonne zeigte sich bereits in voller Pracht am Himmel und blickte verwunderlächelnd auf die Erde, die ohne Vorwissen ihrer hohen, leuchtenden Protectorin sich über Nacht einen prächtigen Brillantschmuck angeschafft hatte. Nach Mitternacht war ein starkes Gewitter über die Gegend gezogen; es hatte viel geregnet, noch hingen schwere Tropfen an Bäumen und Gesträuchern und fielen rauschend auf das Wagenverdeck, wenn der Postillon mit der Peitsche einen niederhängenden Ast berührte.

Marlitt.

#### <sup>1</sup> Highway.

1. Prin. Pts. of *zutrug*; (I); saugen, verschwindet; (II); ließ, fiel, anboten (III).
2. Give in full the Fut. Act. and Pass. of *verwandeln* (I). How would *wird gefüllt* differ from *ist gefüllt* (I).
3. As what part of speech may the infinitive be used, and how is it then treated. What is put before it, when it is used to express a purpose. After what verbs is *zu* not used with the infinitive.
4. Explain the subjunctives *hätte* (I), *angereizt habe* (III); explain the tense of the latter. State the main divisions of the subjunctive.
5. Construction of *theile*, *Gegend*, *Pflanzenbede* (I); *gleich*, *Nacht*, *Ruhe* (II); *Wiedervergeltungsrecht*, *ihnen*, (von Konstantinopel) *aus* (III).
6. Analyze the following words, *hinlänglich*, *afrikanisch*, *furchtbar*, *Vorzeit* (I); *schmerzvoll* (II); *Südbanauländer*, *Wiedervergeltungsrecht*, *Feindseligkeiten* (III); stating which are compound and which derived, and the force of the suffixes.
7. What *endings* of nouns denote the feminine gender. Nouns of what *signification* are feminine. Illustrate from the texts.
8. Give the corresponding English for *zählen*, *fragen*, *Kraft*, *Zeit*, *füllen* (I); *Rücken*, *Thier* (II); *treten*, *stören*, *ließ*, *wissen*, *hören* (III).
6. Distinguish between *wann*, *wenn*; *welcher*, *der*; *aber*, *sondern*; *erst*, *zuerst*; *Staat*, *Stadt*; *kopf*, *Haupt*.

V. 1. John's books are still lying on the sofa in the drawing-room, and he has gone out riding. 2. I am afraid that our expected guests will stay away to-day, because it is bad weather. 3. I think that I have read too long, for my eyes pain me very much. 4. Come to our house to-morrow, if

you wish to see my father ; but you must be there punctually, for he goes out at eight o'clock. 5. My friend dines with me on Sunday, which habit he has had for years. 6. He said that they were in the same town the whole summer through, without seeing each other a single time. 7. I have had to act thus, because my brother wished it; in this matter I am determined not to act against his wishes. 8. Our whole family was yesterday evening at a concert at Mrs. S.'s, where there was much dancing. 9. Can you remember how his summer house by the river side looked? 10. Without heeding<sup>1</sup> my express<sup>2</sup> commands, he has run away, in order to amuse himself somewhere,<sup>3</sup> or to attend to<sup>4</sup> his own affairs.

<sup>1</sup> achten auf.    <sup>2</sup> ausdrücklich.    <sup>3</sup> irgendwo.    <sup>4</sup> besorgen.

*Third Year. May, 1875.*



## DEPARTMENT OF MILITARY SCIENCE AND TACTICS.

*President J. D. Runkle : —*

SIR, In this my report for 1875, the centennial year of the first battles of the Revolution, I may be pardoned for adverting to the importance of causing a certain degree of military instruction to be given, side by side with instruction in the arts of peace. The fruits of the latter can only be fully assured to us, by ability to defend them against aggression. I can not do better than quote the words of Washington : —

(From Inaugural Speech, April 30th, 1789.)

“ Among the many interesting objects which will engage your attention, that of providing for the common defense will merit particular regard. To be prepared for war is one of the most effectual means of preserving peace.

“ A free people ought not only to be aroused, but disciplined ; to which end a uniform and well digested plan is requisite ;” \* \* \*

(From Speech to both Houses of Congress, Dec. 3d, 1793.)

\* \* \* \* \*

“ I cannot recommend to your notice measures for the fulfilment of *our* duties to the rest of the world, without again pressing upon you the necessity of placing ourselves in a condition of complete defense and of exacting from *them* the fulfilment of *their* duties towards *us*. The United States ought not to indulge a persuasion that, contrary to the order of human events, they will forever keep at a distance

those painful appeals to arms, with which the history of every other nation abounds. There is a rank due to the United States among nations, which will be withheld, if not absolutely lost, by the reputation of weakness. If we desire to avoid insult, we must be able to repel it. If we desire to secure peace, one of the most powerful instruments of our rising prosperity, it must be known that we are at all times ready for war." \* \* \* \* \*

Until the entire nature of the human race has become changed, it will be necessary to provide for defence against armed aggression by foreign nations, and also against internal attempts to subvert our liberties. On political and economical grounds it is undesirable to maintain a large standing army. It is then to the people, *en-masse*, that we must trust for defence. To do this effectively, experience has shown that they must be provided with capable instructors and leaders, officers.

These would naturally be selected from the most intelligent and educated citizens, from the graduates of our institutions of higher learning. The wisdom of legislation which requires military instruction to be given in institutions receiving a certain public bounty is obvious.

Permit me to quote from a letter written by President Andrew D. White of Cornell University.

"The law, as it now stands, enables at least one collegiate institution in each State to send out every year, a body of men with a good substantial knowledge of military matters, to aid in keeping up citizen soldiery, and to be of use in various communities, in case of emergency. Of course, the highest military education in the country must be given at West Point. But the instruction given to the country under the slight expense caused by the existing law, is, it seems to me, a matter which any statesman should take care of.

"It has always seemed to me that the control of citizen military organizations should be kept, as far as possible, in the hands of the more thoughtful and better educated classes. I dread to see the day arrive when, with the civil commotions sure to arise in a Republic as wide in extent, and as thickly settled as ours is to be, the thoughtful men and the educated men will be shrinking in corners for want of

the simple elements of military knowledge, and military organizations for emergencies will be entrusted to men of little or no character and standing. Take the Rebellion — we had, then, an opportunity to note the advantage gained for the Confederacy by the fact that so many of their better educated men had some military training at their schools and colleges.

“As a Professor at the University of Michigan, I saw the other thing. I saw at that institution our very best young men — and the best were the very first to enlist — go forth under the charge of a drunken blackguard, taken out of a lager beer saloon, his only title to command being that, in all that community, he was the only one who had any military knowledge, he having been a non-commissioned officer during the Mexican war. The result, I need hardly tell you, was disastrous. This company of noble young men melted away, and the captain was one of the few who came back.

“I have thought much upon this, and it seems to me that the clause in the Bill of 1862, providing for military instruction in the various State colleges, and the supplementary legislation since, allowing the detail of the army officers to conduct this education, showed real statesmanship.

“In view of emergencies which are sure to arise, sooner or later, in a Government like ours, may I not ask you to give this matter your careful consideration, and to see, if possible, that a provision in all respects so beneficent, be not destroyed.”

Unfortunately, there is a tendency to construe this law and to meet its requirements in a manner so antagonistic to its spirit, that the amount of good derived therefrom is reduced, most frequently, to a minimum.

In all wars, the loss of life by disease far exceeds that resulting from actual combat. It is therefore essential that, first of all, instruction be given how properly to care for the health of troops when subjected to abnormal fatigues and exposure. *This should commend itself simply on the ground of humanity, as it is for the purpose of preventing suffering and loss of life.* War, at best, is horrible. It is inevitable in the affairs of all nations. Let us deprive it of its stings and horrors as far as human foresight, based upon experience, will admit. In our

eagerness to acquire material prosperity, let us not close our eyes to the dangers and contingencies of the future, however far removed they may seem at present.

Besides the instruction as to the care of the health of troops, it is necessary to instruct in the mode of organizing, disciplining and drilling troops, not alone in the actual details, which may be changed from time to time, but also in the general principles involved and their *rationale*.

#### THE MILITARY INSTRUCTION DURING 1874-5.

The instruction during the year ending May, 1875, was satisfactory, when one considers the many drawbacks arising from limited time and a lack of hearty support to the work of the department. This was made apparent by the written examinations and closing drill. The students were, apparently, very much interested. The officers performed their duties in an efficient manner. Commissions were given, at the closing exercise to the following :

##### *Staff Officers ranking as First Lieutenants.*

*Adjutant* : G. F. Swain.

*Quartermaster* : E. H. Gowing.

*Signal and Ordnance Officer* : J. Kirk.

*Captains* : F. E. Peabody, C. H. Morton, W. Jenney, A. G. Everett.

*First Lieutenants* : H. J. Monroe, W. M. Peters, C. H. Fisher, I. M. Story, F. P. Spalding.

*Second Lieutenants* : W. A. Frost, C. F. Lawton, E. G. Faber.

The warrants of the non-commissioned officers were presented at the same time. No commission or warrant will hereafter be given to any student who has not shown a capacity for performing efficiently the duties of the office conferred, or one of higher grade, in actual service.

#### VOLUNTARY ENCAMPMENT.

On May 31st, 1875, twenty (20) students accompanied me for a week, in a voluntary encampment near Lexington, Mass.,

on grounds belonging to the Hon. John Cummings. The tents and camp equipage were loaned to us by the courtesy of the Adjutant General of the State. The camp was laid out and the tents were pitched by the students. They here put into practice some of the makeshifts of camp life, which enable soldiers to make themselves comfortable under unfavorable circumstances. The regular duties of the camp were performed by the students early in the forenoon and late in the afternoon, thus giving them the greater portion of the available day for their own recreations. Voluntary exercises of day and night signalling, and target shooting, were given. Parties of two or three were detailed to cook certain articles of food in the same manner and with the same facilities that soldiers in the field would be apt to have. All these experiments were successful. The relaxation afforded by this encampment, after the severe mental tax imposed by the annual examination, greatly benefited all. This was evidenced, if in no other way, by the excellent appetites and increased weight of every student who participated in the encampment. Our thanks are due for many courtesies extended by inhabitants of Lexington. The conduct of our students was, throughout, unexceptionable. The fears that were expressed, that discredit might be brought upon the Institute by the reckless conduct which but too frequently characterizes encampments, were without foundation. On Sunday, all attended Divine Service except those who were required to take charge of the camp. It is my desire to repeat this at the close of the next year. May not this be advantageously extended to all classes, accompanied by some of the Instructors, and be, in so far, an extension of the general system of the school in giving technical instruction? Much useful instruction might thus be given in the laboratories of nature. The civil engineering students might have exercises in various kinds of surveying. A week might be advantageously spent in geological work. For this purpose the locality of the encampment might be changed from year to year. Botanical instruction

might be imparted in the woods and fields. With all this, opportunities would be secured for out of door sports ; relaxation, so necessary after the severe strain imposed by the annual examinations, would be given. Useful instruction and experience would be gained in the makeshifts of camp life and in the preparation of food in the field.

#### THE MILITARY INSTRUCTION DURING 1875-6.

As so much of the school year of 1875-6 has elapsed at the time of making this report I will extend it sufficiently to cover the time up to date of writing.

The principal objections which presented themselves to the Faculty and some of the students against the military instruction as it was, were, that after entering the second year, it interfered with the strictly professional work of the students ; on my own part, that I could not give a sufficient amount of the theoretical instruction in the duties of officers and yet have the *battalion* as well drilled as it should be. With all this in view, desirous alike of seeing the military instruction established on a basis which would be unobjectionable, of receiving the support of the Faculty, and of being able to attain better results, I proposed the following plan, at the opening of the school year, based upon the understanding that the Corporation and Faculty had, *conjointly*, allotted the *time* of two hours per week for two years, to military instruction : —

1st. (a.) That the drill should be obligatory only during the first year, but for *three* hours, instead of *two*, per week.

(b.) Permit such second year students, as volunteer, to drill. I should be likely to get only such men as would be competent and desirous of performing the duties of officers.

(c.) Have the *battalion* organized as two companies instead of four. Allow the officers (second-year students) a small deduction of tuition fee for performing their duties. Have these appointments subject to the control of the Faculty, in order that no student be permitted to occupy an office, the duties of which

would prevent his attending properly to his studies. By this system I felt confident that the drill and discipline of the battalion, at the end of the year, would be better than in previous years.

2d. Require second-year students to attend exercises of one hour per week, either lecture or recitation, in subjects pertaining to the duties of officers; about one-third of these exercises would be lectures, two-thirds recitations. The lectures would require, on an average, one-half hour of not very hard reading in preparation. Objections having been made that by this plan, more time would be given than before, on account of time required for preparation, allowance was made for this, and the number of exercises for the second year was reduced to twenty-four (24). The results have been eminently satisfactory, both Faculty and Students apparently acquiescing in this arrangement, as being the best solution which could be arrived at, based upon the premise that military instruction shall be given and received in good faith. It is desirable that this shall be recognized as its permanent *minimum* status.

The following is the roster of acting commissioned officers at the present date.

*Staff Officers ranking as First Lieutenants.*

*First Lieutenant and Adjutant:* E. F. Williams.

*First Lieutenant and Quartermaster:* J. Kirk.

*First Lieutenant, Signal and Ordnance Officer.*

*Captains:* I. Rich, D. Pierce.

*First Lieutenants:* L. O. Towne, E. S. Draper.

*Second Lieutenants:* E. C. Miller, A. T. Lincoln.

THE GYMNASIUM AND PHYSICAL CULTURE.

The outfit of the Gymnasium of the Institute is tolerably complete, and requires but a few pieces of apparatus to make it as complete as any in this vicinity. A large proportion of the students have availed themselves of it. But now that we have the Gymnasium, one step further seems desirable, *i. e.*, the adoption of a system of *obligatory* gymnastic exercises. The

students who most need physical exercise are the very ones who least take it, either in the gymnasium or elsewhere. The mind cannot be used advantageously unless the body is in good condition. The Faculty of the Institute prescribe certain studies and methods of study, which, in their judgment, will ensure the greatest mental vigor and greatest amount of mental acquirements. It, therefore, seems a vital omission not to also prescribe such physical exercise as will place the body, and consequently the mind, in the best possible condition to sustain the burden which is put upon it. As the mental instruction given at the Institute is but the foundation upon which its students are to build after graduation, it would seem but a natural and necessary complement of the work of the school, so to exercise and develop their bodies, as to send them forth physically, as well as mentally, strong. The mental strength which may be acquired at the cost of the physical can avail but little, wasting itself prematurely in its feverish efforts to realize itself. Engineers, as a rule, do not have the opportunities to distinguish themselves by great works until after they have practised their professions for years, and shown their capacity by successfully performing many works of minor importance and magnitude. Their calling demands an incessant exercise both of body and mind. How important, therefore, that they should be duly strengthened for their work, by such preparation of the body as the experience of years has shown to be feasible and profitable. It may be said that the time of the students is so much taken up as to make it impossible to assign any time for a regular physical exercise. It will be found more profitable to *make* this time. Require every student to participate daily in an exercise of from fifteen to twenty minutes, and I have but little doubt that fewer complaints will be made of excessive burdens being imposed in their studies. These exercises should be of such a nature as to improve the respiration and to impart a general tone of health in the entire body, developing in harmony all parts and functions of the body. They may be comparatively light in their nature,



and should be given under the direction and supervision of a physician, in order that no student, however weak, may be injured by any inordinate or misdirected exercises. The introduction of obligatory physical culture into the curriculum of the Institute can hardly be considered in the light of an uncertain experiment. A system of such culture has been in active operation at Amherst College for nearly fifteen years. In this connection I would quote the following extracts from a report on that subject, by Dr. Nathan Allen: —

“In President Stearns’ Report to the Trustees for 1859, the health of the students again constituted a prominent topic. He says, ‘time and experience have convinced me of an imperious demand, in the circumstances of an academic life, for immediate and efficient action on this subject: many of our students come from farms, mechanic shops, and other active occupations, to the hard study and sedentary habits of college. Physical exercise is neglected, the laws of health are violated, the protests and exhortations of instructors and other friends are unheeded. The once active student soon becomes physically indolent, his mental powers become dulled, his movements and appearance indicate physical deterioration; he makes occasionally spasmodic efforts to regain his former elasticity by exercise, but by finding discomfort more than advantage from it, he eschews exertion and becomes more inert than ever.

“‘By the time the Junior year is reached, many students have broken down their health, and every year some lives are sacrificed. Physical training is not the only means of preventing this result, but it is among the most prominent of them. If it could be regularly conducted,—if a moderate amount of physical exercise could be secured as a general thing to every student daily, I have a deep conviction, founded on close observation and experience, that not only would lives and health be preserved, but animation and cheerfulness, and a higher order of efficient study and intellectual life would be secured. It will be for the consideration of this Board, whether, for the encouragement of this sort of exercise, the time has not come, when efficient measures should be taken for the erection of a Gymnasium, and the procuring of its proper appointments. It is a settled conviction in my own mind, that only by a certain amount of regular exercise

together with attention to other laws of health, can that listlessness and dullness and inefficiency which is so hostile to good scholarship and so common among students, be overcome." \* \* \*

The following are mentioned as some of the results of the system of required physical exercise which was adopted a short time after the publication of the above mentioned report.

"1st. There has been a decided improvement in the very countenances and general physique of the students. Instead of the pale, sickly and sallow complexion once very commonly seen, with an occasional lean, care-worn and haggard look, we now witness very generally, fresh, ruddy and healthy countenances, indicative of a higher degree of vitality, and thus the vital currents, enriched by nutrition and oxygen, have a free and equal circulation throughout the whole system. \* \* \*

"2d. In the use of the limbs and the body,—in the physical movements and conduct of students generally, there has been, we think, decided improvement. \* \* \*

"5th. A comparison of the present health of students with what it was ten or fifteen years ago, shows a surprising improvement. It is rare now for any student to break down suddenly in his health, or to be compelled to leave college on this account. In 1855-6-7 and 8 such cases were common, as may be seen by referring to the statements of President Stearns in the opening of this paper; and the truth of the statements is moreover confirmed by others personally conversant here for twenty or thirty years. As no record was formerly kept of the amount of sickness from year to year, or of the number of students leaving college on account of illness, no exact comparison on these points in figures can be instituted. But the experience and observation of those who have been on the ground a long time must bear decided testimony to a greatly improved state of health among the students over that of former times; and as for those who once were members of the Institution, and return here on public occasions, they cannot fail to see a great improvement in this respect. \* \* \*

"7th. But the most marked evidence of improved health is found in the diminished sickness of every class each year after entering college.

In a table giving the amount of sickness arranged by classes, it seems there has been for these eight years on an average *more than three times* as much sickness in the *Freshman* Class as in the *Senior* Class. It may be said that the students upon first entering college do not know so well how to take care of themselves as they do in the third and fourth years; or that some students who come here feeble and sickly, leave the Institution early, so that the vigorous and more healthy alone remain. This may account in part for the change, but only for a small part of it. For some students who now enter college with slender constitutions encounter considerable sickness the first year, but afterwards improve in health, and in the third and fourth years are comparatively well. And the number now leaving college during the first and second years, on account of ill-health, is very small. Then again, if we compare the sickness or health of a class all the way through college now, with that of one ten or fifteen years ago, a surprising difference will be found; if the sickness did not then increase or keep up through the whole course, it certainly did not diminish so much in the second and third years and almost entirely cease in the fourth, as is the case now. \* \* \*

"There is still another very important consideration, viz.: has the standard of scholarship in college been raised by means of gymnastics? As the system of marking, or mode of exhibiting this standard was changed a few years since, an exact comparison in figures cannot here be instituted; but it is the decided opinion of the Registrar, (the College Officer who has charge of these statistics,) that there 'has been an elevation of rank within the past few years.' It may be that some individuals in a class formerly reached as high scholarship as any now do; but the *aggregate* scholarship of a whole class, we are confident, is higher now than it once was, and, to say the least, is much easier obtained, with fewer hours of study, and less loss of health and life. \* \* \*

"Said President Felton to the writer, shortly before his decease, referring to the gymnastics at Amherst which he had just witnessed: 'Such a system of physical exercises thoroughly understood and applied by the members of Harvard University, would aid me in the matter of discipline in that Institution more than anything else.' We are here authorized to state, that the faculty of Amherst College have found great assistance in government from this source; — that since

the introduction of this department, the cases requiring discipline have been far less numerous, and more easily managed, than formerly."

Having quoted some of the most essential portions of this admirably written report, wherein the opinions of the *governing authorities* of the college have been cited, I submit, likewise, a letter written by the *students*, viz; —

"TESTIMONY IN FAVOR OF THE GYMNASIUM.

"AMHERST COLLEGE, June 14th, 1865.

"The class of 1865, having completed its studies in Amherst College, desires to express its high appreciation of the physical culture which it has received under the direction of Prof. Hitchcock. As this class is the first one in College which has enjoyed through its whole course this physical training, some expression of opinion seems quite proper. There have been ninety-two different students connected with the class, fifty-five of which now graduate; eight have died,—two with consumption, and six in the army from wounds or disease. There is no one of the graduating class but could pass a complete examination for life insurance or admission into the United States Army. From a thorough trial of four years' course of training, we can fairly judge of the system here adopted. Our exercises have been conducted in a well-furnished gymnasium, and always under the direction of the Professor in this department. We have found the required attendance—a part of the system—not at all objectionable, and, what at first in the exercise was a little embarrassing or unpleasant, soon became a positive pleasure. The simultaneous participation of many persons in the same exercises has contributed a lively zest to them, when otherwise they would have proved dull and uninteresting. These exercises have been so varied in character as to be adapted both to the strongest and the weakest student, conducing alike to health, strength and grace of action. The half-hour required for exercise has proved the golden mean between length and brevity of time for this purpose, and has never been considered lost by us, as our health at the close of our college course testifies to the inestimable value of this training. We are confident, if this matter of exercise had been left a voluntary thing, many of our class, who are now strong and healthy, would have yielded to the diseases incident to student life.

while others, who were weak and slender boys on entering college, are now strong and vigorous men. Cases of protracted illness have been almost unknown among us, and large numbers in the class have not been detained by illness from a single college duty. Believing that a strong body is the best bulwark to a sound mind — that strong muscles and well-developed limbs are powerful aids to the brain, — and being indebted very much for these results in our case to the physical training we have received in Amherst College, — we give this voluntary testimony to the value of the system of gymnastics here adopted."

"E. P. FROST,  
M. K. PASCO,  
A. H. HOWLAND, } Committee."

Consideration of these statements and facts, as also that of others which the already too great length of this report prevents me from mentioning, have convinced me of the great importance of adopting similar measures at the Institute of Technology. Whilst the suggestions herein embodied are foreign to my province as military instructor, I felt impelled to make them from my interest in the welfare of the Institute and a deep seated conviction that the adoption of a system of obligatory physical exercises would eventually enhance its efficiency and reputation, inasmuch as its graduates would leave it with unimpaired, nay *improved* health, instead of being physically weakened by their labors. They would be more certain to live long enough to reflect credit upon their Alma-Mater.

Respectfully submitted,

E. L. ZALINSKI,  
*1st Lieut., 5th U. S. Art'y.*

## REPORT UPON THE LOWELL COURSE OF PRACTICAL DESIGN, FOR 1874-75.

*President J. D. Runkle:—*

SIR:—The success of this Department (Practical Design for textile fabrics) has been most flattering during the three years of its existence, terminating in May 1875.

It is provided with all the requisite facilities and novelties necessary for the study of Practical Design. Samples of carpets, oil cloths, silks, laces, cachemeres, shawls, paper hangings, percales, muslins, prints, cretonnes, etc., are received every year, anticipating current styles. Under these favorable auspices, fifteen students have now graduated, eleven of whom have secured situations in different manufactories in the New England States. We have had during the year two public exhibitions of pupils' work, one at Horticultural Hall, Boston, and the other at Lowell, which proved highly gratifying to visitors, and the manufacturers especially.

The advanced pupils have the privilege during each season of showing their designs to manufacturers and frequently succeed in disposing of their patterns. The amount received by students for their designs, in oil cloth and prints, has reached about three hundred dollars. The following is a list of the graduates from this Department, who have received the certificate of proficiency.

James L. Folsom	.	.	Hartford Carpet Mill., Thomsonville, Ct.
Henry Morse	.	.	Carpet Mill, Maine.

Alex. Johnston . . .	Pacific Mills.
Ernest Pierce . . .	" "
Everett Anthes . . .	Manchester Print Works.
Miss Mary Jefferson . . .	" " "
Miss Elizabeth Mendum . . .	" " "
Carroll Faunce . . .	Hamilton Woolen Co.
Charles Cowdery . . .	Oriental Print Works.
Howard Hinckley . . .	Merrimac Co.
Miss Mary Ricker . . .	Hamilton Manufacturing Co.
Miss Annie Barnard . . .	No situation.
Miss Kate Simonds . . .	" "
Henry Mabile . . .	" "
Edward Williams . . .	Lithographer.

Respectfully submitted,

**CHARLES KASTNER,**

*Director.*

## REPORT ON THE FIRST YEAR'S COURSE IN FREE HAND DRAWING.

*President Runkle: —*

DEAR SIR: — In the courses of Civil, Mechanical, and Mining Engineering, and Architecture, as given at the Institute, one of the most important branches and one which requires a large proportion of time for its thorough acquisition, is Mechanical Drawing; and a proficiency in this branch is one of the most useful and necessary things in after professional life. But in order to become an expert or even a fair draughtsman, a firmness of hand and knowledge of form are necessary, that cannot be obtained by mere mechanical work and can only be acquired by a course of practice in free-hand drawing.

The value of free-hand drawing is very apt to be underrated in a scientific school, but it is absolutely the making of good draughtsmen. And those who are the most proficient in it will always succeed well in their mechanical work. Its value is seen in the execution of all shaded drawings, in good lettering, in the neatness and taste shown in the work, and indeed in every line that depends upon anything beyond a straight edge and pair of dividers.

The subject as given at the Institute is not laid out with any artistic end in view, but it is merely intended to give in the time allotted to it, that portion of elementary free-hand drawing which will be of the greatest use in mechanical work. The first lessons consist in exercises on straight lines, circles, and



simple curves; after which Schubert's plates are taken up, and the remainder of the time spent in drawing from them. These plates consist of lithographic copies of simple machine details. They are all details of frequent use and are taken from the best designs; are correctly and nicely shaded, part by line shading and the rest by simple cross-hatching, and introduce a number of simple forms, so that the student learns from them the application of light and shade to a large variety of surfaces.

The drawings are made upon brown paper, and the crayon point is used in preference to the pencil, as it requires a greater delicacy in the handling and gives a much better effect in a much shorter space of time.

The first term is thus spent in learning the mere execution of outline and shading; but during the second term, some attention is also paid to making drawings of objects so as to show their three dimensions. The first part of the term is then spent in isometric drawing, that being one of the simplest methods of showing bodies in this manner; and the remainder of the term is devoted to free-hand perspective. In both of these subjects, large plates are made of various geometrical solids and hung up at the end of the drawing-room to be used as copies. The drawings then made by the students are shaded by line-shading, the shadows also being carefully put in. Such parts of the theory as are necessary are given from time to time in short lectures preceding the regular exercises.

It would be of great advantage to many students to have some knowledge of sketching, but with the present limited time devoted to drawing, it is impracticable to take up this branch at all, so that the course, as at present arranged, ends with the subject of perspective. The number of plates drawn by each student varies greatly owing to the difference in the rapidity with which they work. A certain number of plates, however, are required, and the students finish as many more as they can. The total number required amounts, in the year's course, to twenty, and the average of the students complete three or four

more, while a few will do eight or ten more ; but these latter usually include the best and poorest workmen in the class, so that the number of plates completed is no criterion as to their excellence.

Examinations are held twice a year. At the Semi-Annual, the projections of some solid are put upon the black-board together with its proportions, and the students are required to make a correct drawing from them, both in outline and in shade. A fixed time is allowed them, so that the rapidity with which they work is thus taken into account in determining their mark. At the Annual examination, similar projections are given them to draw from, but this time they are required to make a correct shaded drawing of the object in perspective. And in addition to this a few questions on the theory of the subject are given.

Free-hand drawing requires patience and perseverance more than anything else for its successful accomplishment. A hard working and not particularly talented student usually excels a more gifted but less patient one. But when a student has a peculiar talent for the subject and unites patience and perseverance with it — and there are usually several such in every class — excellent work is the result. So the standard of any class in Free-hand drawing is very apt to be the same as its standard in other studies. But there are always a few in every class who appear to be entirely without any ability to draw, though many of them try their best and are faithful in their work ; but in all such cases due credit is given for their perseverance. As was said before, the regular course does not aim at teaching anything more than the elements of drawing. But there is a good collection of casts at the disposal of the department, and special students and such regular students as are interested in their drawing, and desire to continue it, have special instruction.

Respectfully yours,

FRANK B. MORSE.

## REPORT OF THE FIRST YEAR MECHANICAL DRAWING.

*President Runkle : —*

In compliance with your request I herewith submit the following report of the manner of instruction and the work accomplished in Mechanical Drawing in the First Year's class of 1874-5.

During the first year the students are taught the use of the drafting instruments and such general principles of Mechanical Drawing as are applicable to all the various divisions of the subject created by the different professional courses. To this end therefore, the work of the year has been conducted. Professor Warren's three elementary works, "Drafting Instruments," "Elementary Projection Drawing" and "Elementary Perspective" were used as text books, and from them the system and examples were chiefly taken. "Drafting Instruments" was the first book taken up, from which various examples having the following ends in view, were selected and drawn. Proficiency in the use of the drawing instruments, familiarity with a few important geometrical problems, the manner of laying on ink and color washes with the brush, the conventional representations of wood, iron, stone, and earth, water sections, and a limited amount of lettering. The latter consisted of three title pages, one for each principal division of the year's work. Seven weeks were given to this subject. Projections were next taken up, under the head of which was included the principles of

shades and shadows, isometric drawing, shading and construction drawing from models and copies. In projections proper were given the mode of representing the plan, and end and front elevations of rectilinear and cylindrical figures, when seen both in parallel and oblique projection; also problems covering the most general cases of the intersection of solids, both by planes and by other solids, together with their developments. The subject of shades and shadows was pursued by first finding the shades of objects and then their shadows when the latter fall on the vertical or horizontal planes of projection, or on both; and secondly, by finding the shadows on oblique abutments and the like, by means of auxiliary planes. Examples were drawn in isometric projection which included the manner of representing isometric and non-isometric lines, circles, and curved lines, together with isometric shadows. At this stage, practice was had in shading with India ink, some of the isometric constructions being made with special reference to this. As this was for pictorial effect only, but little time was devoted to it owing to the amount of work to be done on more important subjects. It is very desirable, however, that the students should have more practice in making highly finished drawings of structure designs and inventions. Much more time than is in my power to allow for the purpose could be profitably employed in this manner. The year's work gone over thus far, was next practically applied by making one or two construction drawings, the examples being taken from the book, from notes, and from the model. This completed the course in projections after thirteen weeks had been spent on the subject. During the remaining ten weeks of the term Elementary Perspective was taken up. Between two and three weeks were devoted to the natural method of perspective drawing as founded on projections. This consists of finding by projections where a visual ray from a given point to the eye pierces the perspective plane. It satisfies in the most natural manner the simplest geometrical definition of the perspective of a given point; viz., that it is where a visual ray from that point pierces a picture plane. This method however, when

applied to any but the most simple objects, complicates the drawing to such an extent that it is not a desirable one to use for practical work. Nevertheless it has a certain value, for it gives to the student a knowledge of the principles upon which the artificial or derivative methods are based. The remaining weeks were given to drawing in perspective both simple and complicated examples, by the methods of diagonals and perpendiculars and of vanishing points.

All the work thus described was drawn on uniform sheets of twelve and one half, by eight and one half inches in size, and at the end of the year were bound in neat paste board covers. Besides this course from the text books, at the end of each of the following subjects, additional drawings from notes and models were made on sheets eighteen, by twelve and one half inches in size. Immediately following the elements of drawing as taken from "Drafting Instruments," drawings were made on one of these sheets which served both as a review and as an application of all previously gone over. Following projections proper, a sheet was filled with a few simple applications of the subject to the drawing of patterns for constructions in sheet metal, and the like. A large and complicated line drawing, with its shadow falling on both planes of projection, was constructed from the model as a review of shades and shadows. Two large shaded drawings in perspective completed the year's work in Mechanical Drawing. These review plates, as they were called, were required of all the students as a part of the regular course.

Regular drawing exercises of five hours per week were held in the drawing room, during which time each student received personal instruction whenever it was required. In addition to this, recitations were held once a week in the class room and lectures given on the Theory of Drawing. As far as possible these exercises in theory were kept in advance of the work in the drawing room, in order that the students might progress with their drawing as rapidly as possible.

Seven examinations were held in Theory of Drawing during the year, including those of the Semi-Annual and Annual. At the former, three students were conditioned, and one failing to make up his condition was obliged to drop the subject at the middle of the second term. At the annual examinations none were conditioned, no one obtaining a lower mark than fifty per cent. The drawings of the students were also examined and marked at the Semi-Annual and Annual examinations. The following is the paper given at the Annual examination : —

#### ANNUAL EXAMINATION.

##### *Theory of Drawing.*

May, 1875.

1. Construct a diagonal scale of three inches to the foot, from which sixteenths of an inch can be taken.
2. On a given line construct a semi-oval, which shall pass through a given point on the bisecting perpendicular of the given line.
3. Construct the projections of a line two inches long, when it is oblique to both planes of projection.
4. Construct the projections of a vertical circle seen obliquely.
5. Find the intersection of a vertical cylinder with a horizontal one, whose axis is parallel to the ground line. Develop one of the cylinders showing the curve of intersection.
6. Find the shadow of a vertical cylinder resting on the horizontal plane, when it falls on both the horizontal and vertical planes of projections.
7. Find the shadow of the floor of a bridge upon the concave surface of a vertical abutment whose plan is shown on the blackboard.
8. Draw the isometric of a cross and pedestal. Also the isometric of a circle on the face of a cube.
9. Draw the isometric of a rectangular pyramid, and find its shadow. Show all construction lines used.
10. Construct by means of three planes, the perspective of a triangular pyramid and its shadow.
11. Construct by the method of diagonals and perpendiculars the perspective of a cross.

12. Find the perspective of a cube by the method of lines in parallel sets, or by vanishing points, and find the perspective of its shadow by the method of vanishing points.

Respectfully submitted,

H. N. MUDGE,

*Instructor in Mechanical Drawing.*

DEPARTMENT OF DESCRIPTIVE GEOMETRY,  
STEREOTOMY AND DRAWING.

*To the President : —*

The preparation of this third annual report has been a pleasure, as well as a duty, owing to the marked gain over previous years, particularly in the firmer establishment of wholesome traditions and usages. These traditions and usages, and the spirit of mutual ambition and co-operation in which work may be done, form, as hardly need be said, an unwritten law, more influential upon the quality and amount of work done, than formal rules and prescriptions can be, and one which has found a happy illustration in my work, generally, of the past year.

Being otherwise fully occupied, my personal attention to the *first year class*, during the first half year, was limited to a careful laying out of their work with the instructor, frequent conferences on its progress, and visits to their drawing room to aid and encourage their labors. During the second half, as in the previous year, I shared in the regular class and drawing room instruction, hearing each half of the class one half of the term.

The results of the year's work are on record, and well reward the labor spent by the faithful instructor in securing them. The subjects pursued were, as before, Elementary Drawing Operations, including Free-hand ; Elementary Projections, and Perspective, with weekly lecture and interrogative exercises, and frequent drawing exercises.



The conducting of the *Second Year Class* through their Descriptive Geometry, during the first half year, was marked by the first use of my new text book on that subject, and by the lively zeal and diligence exhibited by the class in working out as full a programme as the time allowed.

The class had three exercises per week, each, in recitation and drawing, for five weeks, and then two per week for about ten weeks, giving, after loss by holidays and in the opening week, thirty actual class room exercises.

After long experience in teaching the subject, I am perfectly satisfied that at least thirty-six exercises, with ample time for study, are necessary for giving a fairly comprehensive course as a foundation for subsequent applications. And as this raises the question, What is a fairly complete standard course in Descriptive Geometry for our more advanced Technical Schools? I will add the following summary contribution towards a discussion of it.

For ten consecutive years, I had given a course whose composition and results were as follows, the number of problems varying from 100 to 109 for the ablest classes.

I. The Point Line and Plane ; 21 problems.

II. Developable surfaces (including the developable helicoid) their tangent planes ; intersections with planes, and with each other ; and developments ; 26 problems.

Auxiliary plane constructions upon conic sections, conveniently associated with the preceding ; 8 problems.

III. Warped surfaces, representing seven of them, as illustrative of general properties, and for subsequent wants in Machine Drawing and Stone Cutting ; 20 problems.

IV. Double curved surfaces, singly, and as usefully combined with each other, or with any of the preceding, either in intersections or tangencies ; 19 problems.

Special curves ; spiral, cycloidal, helical, for after use in Machine Construction and Drawing ; 15 problems ; 109 in all.

The aggregate results, taken from the original records, were as follows : Number of examinations in ten years, 20. Number

of students appeared, 565. Total number passed on first examinations, 460. Average per cent. of ditto., 81; varying from 50 to 100 per cent., according to the quality of the class. And here it is well worthy of note, that in the last six of the twenty examinations, an average of 92 per cent., varying from 87 to 100 per cent. of all who appeared, passed. This was doubtless due, partly to higher standards of admission, strictly enforced, partly to improved details and means of instruction, and partly to generous class ambitions not to be outdone.

At our semi-annual examination, now, very properly, as I think, made final, in view of the strict intermediate examinations and other reviews, 42 men appeared, of whom 32, or 76 per cent. passed, on marks of 60 or above. Of 13, conditioned by failure or absence, four have since made up their conditions, four left, and the remaining five, partly on account of numerous other conditions, preferred to make a thorough review during the summer. The work required in the class room was seventy-one problems, in the thirty exercises.

Each student was *required* to draw at least *fourteen inked figures*, in behalf of fully finished practice. Forty-seven men, being all who presented drawings, submitted *twenty-two inked figures* each, on an average, besides an average of twenty-three pencilled figures each; the requirement being that each student should make as many of the latter as possible besides the inked ones.

It is important to add that all of the figures were required to be taken from the "examples" in the book, where the given parts were differently placed from those of the engraved plates, and that most of the inked figures were the larger ones, subsequent to those of the Point, Line, and Plane, and equivalent to from two to four times their number of the pencilled figures.

Turning over the "fifteen" problems, more or less, of "mechanical curves" to the department of Mechanical Engineering, the experience of the past year would doubtless enable a fair representative course of eighty problems to be given, with a high average percentage of success, provided that Descriptive

Geometry could be alternated with other subjects so as to give it three days per week, with the consequent continuity of study so peculiarly desirable when beginning it, during the first five weeks of the term.

*Third Year's Class ; Stone Cutting.* The advance made in this subject towards a desirable standard has been nearly as great as that secured for the descriptive geometry. Occupying four hours per week of the first half year, I was personally present with the class in the drawing room through the whole of that time, and also at some extra hours.

I divided the term into three portions, to give pleasing and useful variety to the exercises. In the first five weeks, each student was required to work from the plaster models, making full working drawings of at least three of them. To provide agreeably for the voluntary element, each man was further, under due limitations, allowed to choose his own models. Some chose winding stairs, or others of like difficulty.

In the next seven weeks an elaborate form of wing-wall was given, embracing a front, partly plane, and partly conical, bed surfaces the same, and the top, with the coping, formed of a combination of mutually tangent warped surfaces, the whole designed as both a tolerably comprehensive review of Descriptive Geometry, and a practicable and handsome masonry structure. This, being a long continuous problem, suffered from the want of continuity in the study of it, coming as it did but twice a week, so that I had to supplement the printed notes of it which I had always found ample, when giving the work in eight consecutive days, by numerous written ones, posted from time to time, and amounting to a full text of the problem. In this way, all thoroughly worked up a task as extended and difficult as has often been spread over a whole term.

The remainder of the term was devoted to the groined arch, drawn twice, and on two different systems, by several. In the system drawn by all, the inner groins alone were straight as seen in plan. In the others, both the outer and inner groins were thus straight. Of the two methods by which the latter

unusual result can be brought about, the one chosen was the simpler, though practicable only within certain limits. In all cases full details were made.

Besides the work done with the First Year Class, and already mentioned, I gave a very satisfactory course in Shades and Shadows to the architectural students and to three others, volunteers, during the second half. An interesting special work in the same period was that with the "special architects," in elementary Masonry and Stone Cutting. Five inked working drawings being required, from five to eight were made, some of them elegantly, and including winding stairs, and other equivalent problems.

All of which is respectfully submitted,

S. EDWARD WARREN.

*July 5th, 1875.*

## REPORT ON THE INSTRUCTION IN PHYSIOLOGY AND HYGIENE, AND ZOÖLOGY.

*To the President : —*

The lectures on Physiology and Hygiene, thirty in number, are given in the second half of the first year, when the students have acquired such a knowledge of chemistry as is necessary for the comprehension of the most important functions of life, such as digestion, respiration, secretion, and the processes of growth and decay. They are given thus early in the course, because the foundations of health or disease are very liable to be laid when young persons, freed more or less from the restraints and the care of home, associate together for purposes of intellectual and physical training; ignorance of the laws of life in youth may result in premature death or confirmed invalidism in the adult.

The course pursued is as follows: the organs of support, as the bones, ligaments, joints, muscles, and skin; the functions of nutrition, including digestion, absorption, circulation, respiration, and secretion: the function of the brain and nervous system; the laws of growth. Each of these departments has its dangers, and the student is instructed in the warnings given by the various organs that he may in time take measures of precaution. The dangers arising from the skin, the lungs, the muscles, the digestive apparatus; the use and abuse of physical exercise, the necessity of rest for muscles and brain, the importance of nourishing food and pure air, are specially dwelt upon.

The instruction is given by lectures, fully illustrated, and the students are advised to pursue the subjects in standard works suited for general instruction. It is believed that by the attention given to these important laws of life and health, the student may save himself from many painful and dangerous diseases, or, in case of sickness in himself or others, may assist nature in her attempts for his recovery.

The lectures on Zoölogy, also thirty in number, are given in the first half of the third year, based on the previous knowledge of human physiology, and are intended to present such a view of the principles of animal life as every educated person should have, and to serve as a basis for the subsequent lectures on Palæontology which is of such importance to the geologist and mining engineer and the student of natural science. Of course, in thirty lectures such a vast field can be only partially covered, and no attempt therefore is made to do more than to give the elements of the science, such as will display the distinguishing characters of the great classes and their principal sub-divisions, — show the gradual progress in time and development from the simplest protozoön to the highest mammal — and to indicate, as far as may be, the plan of creation, which is equally significant whether we regard it from the Darwinian or the Cuvierian point of view. The lectures are fully illustrated by diagrams belonging to the Rogers collection, and by specimens from the Boston Society of Natural History.

SAMUEL KNEELAND,

*Professor of Zoölogy and Physiology.*

## REPORT UPON THE INSTRUCTION IN PHYSICAL GEOLOGY AND GEOGRAPHY.

*President Runkle:—*

DEAR SIR:— As no report upon the instruction in this department has been presented before, it may be well, at this time, to briefly notice it from its beginning.

The work began four years ago, with a single course of instruction in Physical Geography and Physical Geology, given to the students of the second year. The plan adopted of teaching in the same course those portions of geographical and geological knowledge, which by nature are inseparably associated, has been the foundation of all the good results thus far obtained. Each examination of the class has furnished additional proof that the students acquire greater accuracy and more completeness in geographical knowledge, by considering the surface features of the earth as the outward expressions which the geological structures beneath them have received through the agencies of geological change. This association of these subjects is one which advancing science is daily rendering more indispensable in any well organized course of instruction in this department, and it is, therefore, one which the Institute should carefully perpetuate.

Although the first results of the instructions given were better than I had anticipated, yet the rearrangement of the different courses of study at the Institute and the introduction of

Political and Industrial Geography as a fourth year study, have made the present results far more satisfactory.

The classes in Physical Geography are so large, that it becomes almost necessary to give a large portion of the instruction by lectures. The students are required to take brief notes in the class and to carefully write them out in full at their rooms. Most of their note books have shown a logical arrangement of topics, a correctness in definition, a clearness in description and explanation, and a fullness of statement, which have been creditable to the students. The course has been so arranged as to give a general knowledge of the subject, rather than a minute one of its details, that it may be adapted to the students of the different courses, and that it may serve as a general introduction to the more specific branches of science.

The class in Political and Industrial Geography, being much smaller and composed of students of the fourth year, a somewhat different method in the instruction can be pursued to advantage. While lectures are given upon such topics as can be better presented by them than by other means now at our service, topics are also assigned, either to the class or to individual members, upon which they recite, giving such information as they may have obtained from authorized sources; and personal observations are sought as much as possible.

This course is designed to teach the association of the earth's productions with certain geographical features, geological structures and climatic conditions. The influences which these productions, together with the physical forces acting in the inhabited portions of the earth, exert in determining or modifying the characteristics of races, nations, habitations, modes of life, industries and civilizations of men, are made subjects of special consideration in this course.

The progress attained in each of these courses has been limited to the more careful arrangement and better presentation of the topics, and to the increasing interest which the students have shown in the work.



To make this department what it should be, room and apparatus are indispensable. The subjects taught are of such a nature that good representations are required for the proper presentation of them. Thus far, however, the illustrations have been those furnished by the instructor, there being no available room for the keeping of such materials. I hope the day may be hastened, when a proper room can be appropriated by this department, where the best maps of various kinds, charts, models and other illustrations, may be safely kept and used for this instruction. Until that time, the progress, if there be any, must be very slow, for the difficulties which now arise are more than the instructor can overcome. May we not even anticipate the day, when we shall have a geographical room so well appointed that it shall be to the geographer, what a museum of natural history is to the naturalist, a repository of such valuable materials and a centre of such instructions, as shall lead the more advanced student and the specialist to seek the opportunities offered.

Respectfully submitted,

W. H. NILES,

*Professor of Physical Geology and Geography.*

## THE COURSE IN PALÆONTOLOGY.

*To the President: —*

The section of Palæontology and special Zoölogy has now a Laboratory which has been fitted up in the basement of the Museum of the Boston Society of Natural History. This room is commodious and is comfortably furnished with cases for the storage of an educational collection. The present collections of Palæontology available for class purposes are considerable and quite efficient, though by no means complete. Considerable additions however, are made every year by the Assistant, Mr. Crosby, as he works over and picks out the duplicates of the collections, which are being prepared for exhibition in the Museum of the Society. There are many forms absolutely indispensable to the system of instruction, which can only be attained by direct purchase and these should be obtained without too great delay. The system of instruction consists in completely illustrating all the more important points of any one lecture, either with specimens or with diagrams, or with both, if essential. Specimens are placed in the hands of the students during the lecture, and they are obliged to make sketches which shall show that they have seen the characteristics described from the rostrum. One would suppose that a very small amount of ground would be gone over in each lecture, and that the compensation for this would be found in the thoroughness with which the main points of the lecture could be comprehended. Such was my own impression until I found to my great surprise,

that the amount of ground covered in any one lesson, was almost equal to that which is usually condensed into an extemporaneous lecture, occupying the same length of time in its delivery. It is evident also, that constant effort for improvement will reduce this difference, and I hope to show that proper manipulation of specimens by the students themselves, not only materially assists them to understand the teacher, but is of great assistance to him in the abbreviation of his oral instructions or descriptions. Of course it will be understood that the system has been principally applied to those who have learned the elements of drawing, but I have had instances of men who knew almost nothing in this direction. Though these could not in any given time usually equal those who had had previous instruction, it was very astonishing to see how quickly they supplied the deficiencies of training, and learned to sketch more or less creditably. A knowledge of the art of delineation is therefore of great assistance in the practical application of this system, but the absence of this knowledge is not an insuperable obstacle, or at least has not yet been found to be so by the writer.

Though the lectures only occupy two hours per week for one term, and the Institute schedule does not allow any time for laboratory work in this department, that is, only about thirty hours in all, the students do get a certain reliable grounding in Structural Palaeontology, certainly far more than could be obtained in the same time by the ordinary process.

The examinations are conducted upon a similar principle. There are about twenty questions intended to be answered in writing and covering the whole ground practically and theoretically, and a box containing about ten specimens which must be named, described and correctly referred to their separate divisions. The greater or less success of individuals proves how completely such a system is a thorough test of proficiency. I have known several inattentive and undeserving young men to pass the questions very creditably, but never yet has one been able to get through his allowance of specimens, where no special gifts of memory or intellect could supply the place of previ-

ous application. Again I have had one very curious case of a student, who had been very attentive and constantly in his place, but who entirely failed to pass the written part, though the first in his class in the determination of the specimens. Usually the best class of students stand high in both parts, but not infrequently, as in this case, high powers of observation may be possessed by a person with little or no verbal memory, and perhaps only a moderate share of reasoning power. I would most earnestly recommend that some steps be taken by which students may be obliged to spend a part of their time each week in laboratory work as supplementary to the lectures. This is absolutely necessary in order to fix in their minds the principal points treated of in the lectures. There is a certain rawness about the information obtained in the lectures and a certain amount of error which can only be overcome by greater familiarity with the specimens. The least time which ought to be given, would be an hour a week, and with this something might be done to cure this defect. Quite complete collections of the typical forms of animals are in course of preparation, and will be completed in the course of another year as far as it will be possible in the present laboratory. The collections belonging to the Institute, though stored in the building of the Society, are labelled so as to be readily identified, and so also are those belonging to the Society, the duplicates of whose collections are used to a limited extent for the benefit of students.

Of course it will be understood that in such a course as is here described no text books are used. There are most excellent books in existence, but all are either too extensive or simply stratigraphical in their arrangement.

The difficulties in the path of farther progress in this, lie in two directions. The students are at first but very slightly prepared in Zoology, so that they enter upon the course without a sufficient general knowledge of Natural History. This obliges the instructor in Structural Paleontology to make the course much more general than it should be, and forces him to dwell upon the general characteristics of the classes and orders of the

animal kingdom, when he should be dealing more particularly with smaller divisions. Then again, all the instruction in Zoölogy and Palæontology should be preparatory to a course of lectures and laboratory study in Stratigraphical Palæontology. This course is at present entirely deficient, and the student therefore to a great extent loses that which is most important to him, either as a mining engineer or geologist. Both of these courses should be made as long as possible, and should be accompanied by a proportionate amount of laboratory work. At present the amount of time given is wholly inadequate, and the students are necessarily left in ignorance of one of the most essential parts of his preparatory training as a mining engineer or practical geologist.

A. HYATT,

*Professor of Palæontology.*

## REPORT OF THE DEPARTMENT OF GEOLOGY.

*President Runkle:—*

DEAR SIR:—The courses of instruction in Geology in the Institute of Technology are, as you are aware, in part general and in part special in their character. The relations of Geology to every-day life are such that a certain knowledge of it must now be considered as an indispensable part of higher education. The student of physics, of chemistry and of mineralogy finds in geology the application and the practical significance of these studies, while the student of physical and even of political geography learns how intimately these subjects are connected with the geological character of various regions. Hence it is wisely ordered that in the course of study at the Institute, a certain amount of instruction in geology shall be obligatory for all the students. This is given by a course of thirty lectures in the second half of the third year on Elementary Geology, embracing *first*, a discussion of the objects and the scope of geology and its relations to physical geography, chemistry, mineralogy, botany and zoölogy; *second*, the nature, origin, structure and arrangement of stratified rocks; *third*, the history of the successive rock-formations, their geographical distribution, their lithographical character and their organic remains; *fourth*, the theory of eruptive rocks and volcanoes, and the general principles of geological dynamics.

Of the students of the fourth year, those whose studies are such as to bring them more directly into relation with matters pertaining to geology, have a special course of forty lectures in the first half of the year. These lectures, which are obligatory for Mining Engineers, Metallurgists, Chemists and students in Science and Literature, are also followed by a good number of optional students, including physicists and specials. The subject of these lectures is nominally American Geology, but in its treatment occasion is taken to discuss many matters of general interest much more fully than in the elementary course. The crystalline rocks, both stratified and unstratified, are first considered, and in this connection particular attention is given to their mineralogy and to lithology. In tracing the history and the distribution of the various stratified rocks the principles of geological classification are considered with reference to the developments of geological science both in Europe and America, and the bearings of palæontology are illustrated. The relations between the various geological formations and the great physical features of the continent are discussed at length, and a general view is given of the mineral wealth of the country and of its distribution considered both geologically and mineralogically. These lectures are illustrated by maps, plans and blackboard sketches, and also by a large collection of rock-specimens, with which the students are made familiar. It is to be regretted that there cannot more time be given to the systematic study of these labelled and classified collections, but they are so arranged that students can at all times have access to them, a privilege of which many avail themselves.

In the second half of the fourth year the subject of American geology is farther considered in a course of twenty lectures on Economic Geology, designed especially for the students of Mining Engineering. In this course the ores of the principal metals, coal, petroleum, salt and all other useful minerals are made the subjects of discussion with relation to their geological and geographical distribution in the United States, the modes of their occurrence and their economic importance, the whole, as

before, being illustrated by large collections. The object of this course is to give the student a concise view of the mineral resources of the country.

This is followed by a course of ten lectures on Rocks and Minerals employed as Building Materials, designed for students in Architecture and in Civil Engineering, but attended also by the students in Mining Engineering, it being made to include a farther portion of economic geology. In these lectures the elements of mineralogy and lithology are discussed with especial reference to materials used in construction. Granites, limestones, marbles, sandstones, slates, mortars and cements, and clays for bricks and terra-cotta are here considered both with reference to their nature and mode of occurrence, the manner of working them and their distribution in the United States.

In addition to all these there is given to the students in the latter part of the fourth year, a course of ten lectures on Chemical Geology, in which are discussed the origin of the various rocks of the earth's crust, the formation of mineral veins, ore-deposits and mineral springs, and the nature and source of volcanic phenomena.

The number of students following the course of Elementary Geology last year was forty-five, of which forty-three passed the examination. Of the students of the fourth year, fourteen attended the course on American Geology, and eight the courses on Economic Geology and Chemical Geology, all of whom passed. Eighteen followed the lectures relating to Building Materials and of this number fourteen passed.

No special text-book is made use of in these courses of instruction, but the students are recommended to read Gickie's edition of Jukes's *Manual of Geology*, Dana's *Manual*, and Lyell's *Student's Manual of Geology*.

The general plan and scope of the studies in this department may be seen by the examination-papers for the past year, which are subjoined.



## EXAMINATIONS IN GEOLOGY.

*Elementary Geology. Third Year.*

May, 1875.

- I. State the differences between crystalline and uncrystalline stratified rocks, with illustrative examples.
- II. Describe the nature, mode of occurrence and principal varieties of eruptive rocks.
- III. Define bedding, lamination and slaty cleavage in rocks, and explain the origin of the latter.
- IV. Give the great divisions of rocks with regard to life, and illustrate the law of progress in animal forms.
- V. Give the history of coal, its origin and mode of occurrence.
- VI. Explain the nature of anticlinals and synclinals, and their relations to erosion.
- VII. Give the theory and mode of formation of salt-deposits.
- VIII. Give the limits of the American paleozoic basin, and its history.
- IX. Explain the origin of limestones, of sandstones and of clays.
- X. Describe the three great classes of superficial or quarternary deposits.

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*American Geology. Fourth Year.*

January, 1875.

- I. What are the great divisions of the Eozoic rocks, and their characteristics?
- II. Give an account of the mineralogy of the Laurentian limestones.
- III. Give a list of the divisions of the New York system of rocks, and the lithological characters of each.
- IV. Give an account of the paleozoic Carboniferous system of Pennsylvania, and of that west of the Mississippi.
- V. State what mesozoic rocks are found in eastern North America, and what we know of their fauna and flora.
- VI. What do you understand by palæontological, and what by stratigraphical breaks? Give examples of each from the American paleozoic.

VII. Give the history of the granites and of the mesozoic dolerites of New England.

VIII. Give the geological history of the North Mountain of Pennsylvania.

IX. Give an account of the coal-deposits of the Rocky Mountain region.

X. Explain the nature and origin of the drift-phenomena of New England.

*Economic Geology. Fourth Year.*

May, 1875.

I. Describe the iron ores of the eozoic rocks of the United States; their nature, composition, mode of occurrence and principal localities.

II. Give the history of the various paleozoic iron ores of the United States, with details as above.

III. Give the geological and mineralogical history of the native copper of Lake Superior.

IV. Describe the petroleum wells of Pennsylvania and of Canada, and their geological history.

V. Describe the anthracitic and semi-bituminous coals of the United States, and their geological relations.

VI. Describe the gold-deposits of eastern North America, their mode of occurrence and geological history.

*Chemical Geology. Fourth Year.*

May, 1875.

I. Give the classification of mineral springs, and the origin of the various classes of waters.

II. Explain the origin of limestones, of dolomites and of gypsum.

III. What is the theory of the formation of iron-ore deposits.

IV. Explain the theory of the origin of beds and of veins of metallic sulphurets.

V. State the three principal theories as to the origin of crystalline stratified rocks.

VI. Give the various theories of volcanic rocks, and the arguments for and against each.

*Geology of Building Materials. Fourth Year.*

May, 1875.

I. Explain the differences in texture and structure between crystalline and uncrystalline rocks.

II. Illustrate the porosity of rocks, its importance, and the mode of its determination.

III. Describe the bedding of rocks, its meaning and its importance to the builder.

IV. Explain the effect of heat on granites and on sandstones.

V. Describe the nature, character and varieties of marbles.

VI. Explain the structure, and give the characters of roofing-slate.

VII. Describe the differences between pure magnesian and hydraulic limes.

IX. Give an account of cements and asphaltic concretes.

X. Give a description of the clays used for bricks and for terra-cottas.

I may here be permitted to call attention to the straitened condition in which this, like so many other departments of the Institute, is now placed, and which greatly detracts from its efficiency. The single and indifferently lighted room, which now serves alike for lectures and for collections is not adequate for either of these purposes, and is moreover subject to be taken complete possession of, on occasions, for the purposes of the Society of Arts. From the limited accommodations of this room, it is found necessary to assemble the students of the third year in a larger lecture-room, the occupation of which at hours immediately preceding and following that assigned for Elementary Geology, does not permit either of the preparations or of the subsequent conferences, questionings and examinations of specimens which are found so advantageous in the other courses in Geology given to smaller classes in the room reserved for that purpose. A lecture-room sufficient for the larger classes, fitted not with chairs, but with desks at which notes can be conveniently taken, is greatly needed for the department. In addition to this there should be a reading-room with tables where

the students in geology might at all times find for consultation the various text-books, special treatises and state geological reports, the study of which should form a part of the work of the advanced students.

Moreover there is greatly needed for the Institute a proper Geological Museum in which collections should be suitably arranged for study, in glazed cases. The collections belonging to the department and my own large accumulations are, for the greater part, necessarily hidden away in boxes, and require for their utilization a large and well lighted room with table-cases, wall-cases and drawers, in which these precious materials for study can be properly displayed. Finally it is greatly to be desired that there should be some facilities for the study of the applications of the microscope and of chemistry to geology. Proper microscopes, collections of rock-sections and means of preparing sections of American rocks, are required, and with these a special laboratory for their farther chemical study. Outside of the Institute building Professor Hyatt has already been enabled to lay the foundations of a working laboratory for palæontology in the rooms of the Society of Natural History, and this in connection with the scheme I have above indicated would enable us, with adequate pecuniary means, to build up in Boston such a school for geological study as has hitherto been wanting in the country.

Respectfully submitted,

T. STERRY HUNT.

*Boston, December, 1875.*

## BRIDGE AND ROOF CONSTRUCTION.

*President Runkle : —*

DEAR SIR : — In accordance with your suggestion, we have endeavored to supplement the established course in the department of Civil Engineering with a parallel course of lectures and exercises on Construction.

The experiment has proved entirely successful, and we are able already to see the favorable results of an immediate application to practice of principles derived from theoretical investigation.

In previous years, the time of the students has been so fully occupied with other studies that there was no opportunity to introduce a course of this kind ; but with the gain recently made in the time of completing various subjects of study, we are able now to begin with the second half of the third year, the lectures, experiments and excursions which I am about to describe.

After careful consideration and experiment, it has seemed best to adopt an analytic, rather than the usual synthetic method of instruction. First of all, the students are to get a general idea of the structures that they are afterwards to study carefully in detail, and finally to design for themselves. For this purpose, we have made class-excursions, and have examined bridges in this vicinity, noting the prominent features in each form of construction. Then in subsequent lectures, I have shown them the principles that led to the adoption of these

forms in each case ;— in short, the students have been shown *why* the bridges were constructed in the manner we found them. Structures similar to those examined are also described, and modifications and improvements suggested.

In this way, the interest of the student is awakened and constantly maintained. He has always a clear idea of the subject under discussion, and is better able to undertake, later in the course, the investigation of the magnitude of stresses in structures with which he has, in this way, been made already familiar.

For example, taking the form of bridge known as the Howe-truss, we observe the manner in which the bridge is built, noting the form and material and method of combining and securing the various parts. In the lecture-room, the first point to bring out is, that in certain localities where wood is cheaper than iron, this form of construction is preferable on the score of economy. Then we demonstrate that the braces must be mainly struts, since wood is better able to resist compression than tension. Flexible models of trusses are also exhibited, showing how the effect of a weight in the centre is transmitted to the abutments through the braces ; and we have then three important principles of construction demonstrated and illustrated in this one form of truss, — first, the reason for using wood instead of iron in any particular case ; second, the importance of employing it, so far as possible, in the form of compression members ; and, third, the purpose of inclining the main braces upwards towards the center of the bridge.

This explains the distinctive features of the Howe-truss, and, since we are not to investigate the actual magnitude of the stresses, it remains only to discover from what simple or elementary form of truss this was derived. Working backwards, we reduce the number of main braces to two, finding the ordinary trapezoidal or queen-post truss, and simplifying still farther, we come at last to a plain beam extending over an opening, with bracket braces running up to it from the abutment below,— a bridge with no lower chord.

This example serves to illustrate sufficiently the general method adopted in explaining the principles of bridge construction, and the designing and building of roofs. In every case where it was possible we have employed models illustrating the form of structure under discussion, and by means of flexible members in miniature, have been able to observe the effect of loads variously applied and distributed. In cases where the structures were too complex to be readily copied in models, we have had recourse to diagrams, photographs and drawings, illustrating some of the best engineering works in this country and in Europe. Many of these works I have visited myself, both at home and abroad, for the purpose of careful inspection and study; and the sketches and measurements obtained in this way have been of great service in illustrating the lectures on Construction.

In no case has it been considered enough to give a mere description of a structure without reference to general and particular principles involved in its design and execution. Each example has been studied and fully discussed in plan and detail, the object being to ascertain the considerations that led to the adoption of particular forms and combinations by the builder, and from these are derived precepts and principles to be applied by the student in other cases.

Reference to the accompanying *resumé* will show that the examples given and discussed have been comprehensive and numerous, so that the student, by this means, must become familiar with existing structures, representing the best designs of eminent engineers, and, in consequence, he has at his command a variety of forms and combination of parts, from which he can choose later in the course, when he is required to design bridges and roofs for himself.

I will add a synopsis of the subjects treated in the lectures given to the third year class.

*First Lecture.* Various forms of bridges shown by diagrams, briefly explained and the names learned.

The Howe-truss, Pratt-truss, Jones-truss, Whipple-truss, Post-truss, Fink-truss, Bollman-truss, Warren-girder, Lattice and Trellis-girders, Long's-truss, Burr's-truss, Bowstring-girders, Double Parabolic trusses, Hogbacked girders, Pauli-truss, Sedley's cantilever bridge, Continuous girders, Arches, Suspension bridges, Von Ruppert's bridge. — Main characteristics of each form.

*Second Lecture.* The same forms reviewed and more fully explained. References given of particular examples to be seen of each type. The Howe-truss analyzed and discussed. The elementary forms of trusses from which this originated.

*Third Lecture.* The Pratt-truss compared with the Howe-truss and similarly treated. Relative merits of each, and prominent defects of both. Elementary forms found as before. From what has been already learned, we deduce the rule for the position of struts and ties as inclined braces, and show by models how each part acts when the model-truss is weighted.

*Fourth Lecture.* Incomplete structures. How missing members are to be supplied. Abstract of portions of Bow's Lectures on Bracing. Subject of counterbraces investigated.

*Fifth Lecture.* General and particular defects pertaining to wooden bridges. Iron introduced in combination with wood to remedy these defects. Relative economy of the two methods of construction. Examples of each.

*Sixth Lecture.* Iron-bridges. Reasons for not employing iron in construction more generally. Recent increase in the number of iron-bridges. Durability and elegance of these structures. Coincidence of theory and practice in designing and building. Results to be derived from the forthcoming report of U. S. Commissioners appointed to test iron and steel.

*Seventh Lecture.* Iron-bridges continued. Saving in wages of watchmen compared with the interest on cost of rebuilding wooden bridges with iron. Ordinary forms, — I. Cast-iron alone. II. Cast and Wrought-iron combined. III. Wrought-iron alone. IV. Wire-bridges; — general features and characteristics of each.

*Eighth Lecture.* Cast-iron bridges. Cases in which this material may be profitably employed. Its inferiority to wrought-iron in certain respects and its superiority in others. From this, the arch is found to be a suitable form of construction. Advantages and disadvantages of arches.



*Ninth Lecture.* Other properties valuable in cast-iron. Durability and facility of taking certain shapes. Figures given in regard to cost of working. Recorded failures of cast-iron bridges. Government prohibition against their erection.

*Tenth Lecture.* Highway bridges. Most simple form. Result of Hodgkinson's experiments. Opinions of other eminent engineers in regard to ultimate strength. Most economical shape of girder. Girders with parallel flanges—how tested for safety.

*Eleventh Lecture.* Cast-iron continued. Examples of short-span bridges. I. Simple cattle-pass. II. Nottingham Bridge,—five spans of thirty-five feet each. III. Bridge over the Midland Railway,—one span of thirty-five and one half feet.

*Twelfth Lecture.* Standish Bridge,—eighty-three and one third feet span. Ten cast-iron half arches forming the roadway—how cast and why. Peculiarities of connections. Full details of construction, with an account of the unusual manner in which the bridge was designed by Barlow.

*Thirteenth Lecture.* Long spans. Rochester Bridge, by Sir William Cubitt,—one hundred and seventy-eight feet span. How constructed as to casting and connections. Deflection. Quantity of cast and wrought-iron in the whole bridge. Southwark Bridge over the Thames. Report on its resistance to decay since 1819. Nature and amount of the traffic over this bridge.

*Fourteenth Lecture.* Wrought-iron Bridges. Extraordinary length of spans which have been made of this material. Ratio of depth of girder to length in single and continuous girders. How this ratio is determined. Local conditions affecting the design in certain cases.

*Fifteenth Lecture.* Usual forms of chord-sections. Objections raised by Calcott Reilly to these forms. His proposed section for chords. Struts and ties,—ordinary forms of each, and manner of connecting with the chords.

At this point, the lectures were interrupted by the annual examinations. It was my intention to have proceeded farther with a detailed description of the bridges in and about London, together with an historical account of these structures, beginning with the building of the Old London Bridge in 994, by the Brothers of St. Mary's Monastery. During the coming

year, the course will be so laid out as to cover a wider range of subjects.

It will be observed that no mathematical investigations are undertaken in this scheme. The nature of the stresses is determined in the structures under consideration entirely by observation of flexible models, so arranged as to show thrusts and pulls in the different parts. This method gives the student a much clearer idea of the subject than can be obtained from mathematical study alone, and places him on a broad and sure foundation for the pursuit of advanced theoretical investigation during the last year of his professional course of study at the Institute.

If the objection be brought that a portion of the instruction is quite elementary in its character, my reply is, that in no other part of our course is provision made for instruction on the subjects I have taken up and presented in this way. Professor Rankine's work, the only text-book at present used on the subject of civil engineering, with the exception of the Field Book, fails to give information on most of the topics treated in this course; and, if left to himself, the student is not likely to acquire a substantial and thorough knowledge on these points by independent reading.

#### FOURTH YEAR COURSE IN DESIGNING.

Want of time and a lack of preparation were serious obstacles in the way of the graduating class of 1875, during the three months in which they attempted the work of designing structures. It was then that the want of previous preparation by means of a course on Construction during the third year was most keenly felt and regretted, and the labor of students and teacher was greatly increased thereby. In spite of all difficulties, however, some very creditable designs of bridges and roofs, carefully worked out and intelligently planned, were presented at the close of the term.

The present graduating class, at the commencement of their fourth year, have already begun the subject of Designing, and

are, in this respect, nearly four months in advance of other classes.

It is my intention to make this course, during the coming year, much more thorough and comprehensive than before, by giving a greater number and variety of problems to be worked out in the form of designs for bridges, roofs, foundations, etc., such as engineers in the practice of their profession are continually called upon to plan and build.

Thanking you for the personal support and encouragement given me in this work, I am

Very Respectfully Yours,

WILLIAM E. HOYT.

## THEORETICAL AND APPLIED MECHANICS.

*President J. D. Runkle :—*

DEAR SIR :—Until this last school year the Department of Mechanics was unable to derive material benefit from the change made in the courses of instruction a year and a half ago.

The opportunity having presented itself, however, was at once seized to extend the course and to adapt it more fully to the needs of the purely professional departments. The subjects treated were not only those formerly pursued, viz., the Composition and Resolution of Forces, the Conditions of Equilibrium, the subject of Distributed Forces as applied to determinations of centres of gravity and the laws governing the internal stress of bodies; and the main laws of Dynamics, viz., those governing motion, momentum, force, energy and allied subjects as Moments of Inertia, Radii of Gyration, etc., etc., but the course was made to include the ordinary theories of the Strength of Materials as applied to tensile, compressive, transverse, and torsional tenacity; the laws of Deflection of beams and columns, determinations of the stress in granular masses, the method of ascertaining the stresses in Frames, etc., etc.; the formulæ applicable to each of the above cases were deduced and studied, and an attempt was made to devote (as far as possible) special attention, in the case of each student, to the different subjects, according to their relative importance in his professional course. The text books used were the same as hereto-

fore, viz., "Rankine's Applied Mechanics" and my "Notes on Mechanics."

The progress of the class was quite satisfactory, those who were conditioned having subsequently made up their conditions at a re-examination.

The extension of the course above alluded to, without any increase of the time allotted to the subject, has been rendered possible by the fact, that the Calculus is now completed before the Mechanics begins, instead of their being studied contemporaneously as formerly.

It follows that the attention of the student is more fully concentrated on his Mechanics, and also that he is not hindered in his progress through ignorance of the methods of the Calculus which he needs to use.

The changes made in the courses of instruction, together with the subsequent amendments and developments have exerted a very beneficial influence in all the departments, and, among other things, have rendered it essential that the students should acquire in their Mechanics a knowledge of all the theories which depend upon Mechanical laws, that find application in their professional work; and be thus enabled to apply that knowledge readily to the practical cases that may there arise. It is important also that the above should be completed by the end of the third year, so that in the fourth year when the student ought to be wholly devoted to his professional work, he may not be hindered by being obliged first to learn something that he should have had in his Applied Mechanics.

To accomplish this most desirable result, and to adapt its instruction to the special needs of the student in the course he has selected, the Department of Mechanics is doing and will continue to do its utmost; but it is evident that in order to obtain a satisfactory result the time now allotted to this subject, viz., three times per week for three-fourths of the third year, is not at all sufficient, this being no more than the time allowed when the instruction was confined to the main principles of Analytic Mechanics.

A number of subjects that should be studied in the Mechanics must now be omitted for want of time. Nevertheless, far more has been done this last year than heretofore, and more yet will be done as soon as the time is allowed; and it is hoped that at no distant day the Professional Departments may find that their students do acquire in their Mechanics those principles, theories, and formulæ which they need to apply in their own work.

Whenever it is found possible to complete the Calculus in the second year and devote three exercises per week to the Mechanics for the whole third year, a step will be taken which will decidedly assist in carrying out the above scheme.

I would also take this opportunity to repeat the suggestion I made to you last year, that in all cases where it is possible for a Professional Department to give to its students the practical applications of the theory immediately after or contemporaneously with their work on the same subject in Mechanics, it is certain that the students' interest will be increased and their progress hastened, both in their theory and practice, as has been shown in a very marked manner in those cases where it has been done. The instruction, as heretofore, is given by lectures, recitations and blackboard exercises, and the computation of numerical and practical examples.

In regard to the special courses given in this department to the students of Mechanical Engineering during the last year, I will state that the subjects studied were as follows:

*Fourth year's class* — Water Power — Strength of Materials — Link and Valve motions and Thermodynamics.

*Third year's class* — Strength of Materials — Link and Valve motions and Mechanism.

*Second year's class* — Mechanism.

The text books used were Professor Rankine's treatises on "Machinery and Millwork" and on the "Steam Engine and other Prime Movers"; Weisbach's Mechanics of Engineering, Maxwell's Theory of Heat, Anderson's Strength of Materials,

Auchincloss' Link and Valve motions, Willis' Mechanism, Goodeve's Mechanism, and Shelley's Workshop Appliances.

The progress of all the classes was very satisfactory, and it is especially the good results derived from the fact that the same subjects are treated contemporaneously from different points of view in these courses, and in the Practical, the Graphical, the Experimental, and the Excursionial courses of the Mechanical Engineering Department, that causes me to urge the suggestion made above.

Very Respectfully,

GAETANO LANZA,

*Professor of Theoretical and Applied Mechanics.*

## DEPARTMENT OF MECHANICAL ENGINEERING.

*President Runkle:—*

DEAR SIR:— No important change has been made in the system of conducting the Mechanical Engineering Department during the past year. The system of study by subjects has increased the number of text-books used. Rankine's "Machinery and Mill Work," Willis's "Mechanism," Shelley's "Work Shop Appliances," Anderson's "Strength of Materials," Goodeve's "Mechanism," Weisbach's "Mechanics," Rankine's "Steam Engine," Wilson's "Treatise on Steam Boilers," Maxwell's "Theory of Heat," Porter's and Richard's "Steam Engine Indicator," Auchincloss's "Link and Valve Motion," Zeuner's "Treatise on Valve-Gear," Francis on Cast Iron Pillars, and Francis' "Lowell Hydraulic Experiments" are used, with other text-books.

Our library has proved to be of great service, and we have occasion to thank heartily many gentlemen for special reports upon special subjects, and for letters containing valuable advice and information. Numerous manufacturing companies and firms have admitted us to their manufactories from week to week, and explained to us with great courtesy and patience the interesting operations which they were conducting, allowing us to return again and again to complete our notes of those operations in minute detail. They have also loaned to us many valuable working drawings, which our students have reproduced and



returned. I am satisfied that some important improvements in our manner of sketching and drawing have been introduced during the year.

Our Mechanical Laboratory has more than justified the expectations had of it, and I do not hesitate to express my belief that the young men who graduated from the department last year have had more actual practice in the use of instruments for testing steam machinery than many experts have had in a term of years.

I take advantage of the late date at which this report is issued, to say, that at the recent test of the Providence Steam Engine Company's Pumping Engine at Hope Station, Providence, seventeen of the students were invited to assist in the test, on account of the experience which they had had in our laboratory. Their careful attention to minute matters of observation, their accuracy, and their endurance of the fatiguing duties of the extended trial, were alike noticeable and praiseworthy.

Respectfully yours,

CHANNING WHITAKER,  
*Professor of Mechanical Engineering.*

## DEPARTMENT OF CHEMISTRY.

*To the President : —*

In the Laboratories for Quantitative Analysis there has been, during the past year, a large and enthusiastic class. The quality of the work done has, as a rule, been good ; the amount large, the number of quantitative determinations that have been made averaging more than one hundred per week.

Considerable attention has been given to the analysis of ores and furnace products, and an important part of the work done by the students of Metallurgy, and of Mining-Engineering, during their senior year, consists of the analysis of ores employed in, and products resulting from, experiments performed in the metallurgical laboratory. Such analyses test the quality of the work performed, and will guide future experiments.

There has been a great lack of substances for analysis, the composition of which should be accurately known to those having charge of the instruction. A careful selection of substances, the analysis of which would give an appropriate analytical training for any branch of chemistry, has now been made ; several samples of each substance have been collected, and prepared for analysis ; a large number of these have been accurately analysed by the instructors in this department ; and at present we have a fine working collection, the value of which, perhaps, only a teacher of analytical chemistry can appreciate.

The laboratories, though crowded, and quite insufficient for the present wants of the department, have been put in thorough repair, and have been much improved in minor details. Additional balances have been provided; the jet-aspirators of Professor Richards (*Am. Journ.*, Dec., 1874) have been substituted for the "Bunsen" pumps hitherto employed for filtration and a modification of the same device is employed to furnish air for the blast lamps; increased facilities have been provided for volumetric, and for organic analysis, and for the analysis of copper ores and alloys by electro-deposition. To supply the want of a room for optical work connected with chemistry, a nook, in the metallurgical laboratory, kindly granted to the chemical department, has been furnished with a large reflecting goniometer, by "Meyerstein"; an optical circle, arranged for Landoldt's optical analysis, and also for use as a goniometer or as a spectrometer, by "Meyerstein"; a spectrometer, by "Browning"; a large direct-vision spectroscopy, by "Zeiss"; a large inverted microscope, by "Tolles"; a smaller microscope, by "Tolles"; three dissecting microscopes, by "Zeiss" and others; a saccharimeter, by "Soleil"; with the minor appliances for chemico-optical work. But as these fine instruments are crowded into a room less than ten feet square, in which not more than two students can work at a time, they are much less useful than they otherwise would be.

The instruction in chemistry is much hampered by the want of a laboratory for qualitative analysis, apart from the laboratory which is used for the instruction in general chemistry; of a laboratory for organic chemistry; of a laboratory for applied chemistry; of a suitable reading room, where the books of the chemical library may be consulted, and writing done; of a number of small rooms, for the use of special apparatus. There is no room in the present building to meet any of these wants, and till some provision be made, further growth and development seem impossible. Every inch of room at the disposal of the department has been fully utilized, and the writer is at present utterly at a loss to know where to find place for a piece of

apparatus requiring but about four square feet of floor room. Even the private laboratory of the professors has been given up for the use of the students.

In consideration of the above, and of the yearly increasing number of students, and referring to the reports of the preceding year, made by the several professors of chemistry, the department would pray that relief, in some form, be afforded.

In conclusion I wish to add, that much praise is due the students; for their zeal, their sympathy, and their hearty coöperation, have done much to aid in the development of the department.

Respectfully submitted,

CHARLES HALLET WING.

NOTE : — Since the above was written, the laboratory for fourth year students, and the balance room, have been destroyed by fire ; all the balances, and the collection of substances for analysis, above referred to, were destroyed, and the chemical library very seriously damaged. The books can, with a very few exceptions, be replaced, but it will require at least two years to restore the collection. We are indebted to Professor Cooke of Harvard University, and to Mr. Henry F. Durant of Wellesley College, for the loan of balances for immediate use ; and to Cornell University for a collection of analysed substances sufficient for use during the present year.

For the present the fourth year students occupy places in the third year laboratory and in the private room of the professors.

It is expected that the laboratory will be restored and equipped for work by the first of January next.

## THE COURSE IN MINING ENGINEERING.

*To the President: —*

It may be of interest at first to take a short but comprehensive view of the more strictly professional studies in this course, to ascertain the amount of symmetry in their arrangement, and also the advancement that a student is able to make in them.

The student begins his experimental work on entering the school with a course of general experimental chemistry, accompanied by a course of lectures. He then takes up qualitative analysis which is followed by a course in practical mineralogy.

At the opening of the third year he begins quantitative analysis, spending a large share of his time in the laboratory, receives instruction in palæontology, and attends lectures on mining throughout the year, and on geology the last half of the year. The summer vacation, at the close of this year, usually gives him an opportunity for an excursion to mining districts where he can have a chance not only to apply what he has learned, but to settle his mind on many vexed questions.

In his fourth year the student takes up assaying, continues quantitative analysis and geology; lectures on Metallurgy and ore-dressing taking the place of those on Mining of the third year. In the last half of the fourth year his time is mainly devoted to practical work on ore-dressing and smelting, which is at every step checked and controlled by chemical analysis and assaying. The subject for a thesis is taken from the work in the Mining or Metallurgical laboratory, or from works visited during the summer. Classes which have not had the privilege of making an excursion to mining regions during

the third year vacation, will have an opportunity to do so immediately after graduating.

Collateral subjects, and such studies as are calculated to give the student a liberal education, are carried on during the whole of the above course as far as is practicable. The subjects which come directly under the charge of the mining professor are given below in detail.

*Instruction in Mineralogy.* The subject is taught as far as possible in an experimental way.

Blowpipe analysis is dwelt upon sufficiently to enable the student to detect the common elements. A few specimens are then handled so as to gain a familiarity with, and quickness in recognizing, the physical features common to many minerals, viz., hardness, streak, lustre, diaphaneity, cleavage, etc.

Crystallography is taken up and studied until the class can recognize the crystalline form of the models and also of the minerals of the simpler forms.

Determinative mineralogy is begun at the same time with crystallography. Each student receives fragments of minerals, and determines the name of the species of each from its lustre, fusibility, and special features and reactions as put down in the excellent tables in Professor Brush's recent work on this subject.

The class is now well prepared to handle minerals with a view to become acquainted with the peculiar features of each by inspection with the eye alone. To this end four different reviews are made of the more important species.

A tabular statement showing the contemporaneous order of exercises is here given :

	1st hour of Exercise.	2d hour of Exercise.
5 Exercises	Blowpipe reactions.	Blowpipe reactions.
2 "	Physical features.	Physical features.
10 "	Crystallography.	Determinative Mineralogy from unknown fragments.
10 "	1st review of Minerals	"
6 "	2d " " "	"
4 "	3d " " "	"
4 "	4th " " "	"

*The Instruction in Mining Engineering* consists in a review of the machines, methods and processes, by which the various useful minerals are extracted from the ground and are made ready for the market or the smelter.

Veins, beds and superficial deposits are defined, and the methods of prospecting, boring and searching for them enumerated.

The various tools are mentioned; pick and shovel, schlegel and eisen, hammer and drill, drilling machines, powders, nitro-glycerine, fire-setting.

The methods of getting at and working out the mineral; shafts, levels, adits, stopes, wide veins, pillar and stall, longwall, square work, sumps, timbering, walling, dams.

Ore transportation on the level, on the shaft, engines, drums, ropes, cages, back balances, inclines.

Man transportation, ladders, rope hoisting, man engines.

Ventilation, bad airs and their causes, natural ventilation, furnace ventilation, machines, compression, distribution and regulation of currents, lighting, breathing apparatus, machines for testing badness of air, mine on fire.

Pumping, damming, checking, draining, Beam pump, Bull pump, steam pump, other devices.

Surveying a mine, transit, chain, tape, lights, targets, German gradbogen, clinometer, measuring by long wire.

Government of mines, financial, business consideration, causes of failure, mining law and the relations of Government to mines.

The students take notes of all the above subjects and illustrate them with careful pen sketches.

*Instruction in Assaying.* Each student has twelve or fifteen exercises at the assaying furnaces, learning to assay ores of silver, gold, lead, iron, tin and sometimes of copper and antimony. In these he has the opportunity of learning how to manage a simple fire, and the management of different fuels, coke, anthracite, Cumberland coal and charcoal.

*Instruction in Ore Dressing and Smelting.* The student is now fully prepared to begin practical work upon the extraction of metals from their ores. He receives an ore just as it comes from the mine and is expected to extract the metal from it in marketable form.

The experimental work of the laboratory is carried on by the students under the immediate supervision of an instructor, a sufficiently large quantity of ore being assigned to the student (from one hundred pounds to a ton) according to the quantity on hand and to the work proposed to be done. He first examines it for its component minerals, sorts and samples it, determines its character by analysis, from which he obtains the mineral percentage composition, and its value by assays. He also makes such other preliminary examinations as may serve to indicate the proper method of treatment. He then treats the given quantity, testing all his products at each step of the process.

These tests may be of two kinds :—(a) Commercial, in which case he assays all his rich and waste products alone for the metal under consideration, and thereby ascertains the percentage of metal saved in the rich products and that thrown away in the poor refuse products. He can tell at any time whether a rich product has been concentrated up to his smelting standard and whether a poor product has been sufficiently robbed of its metal to admit of its being thrown away. (b) He may make scientific tests of the machines and furnaces. Knowing the percentage of minerals in the ore started with, he may watch these minerals all through a complicated system of ore dressing by determining the principal mineral constituents of each product. After such a study he will have very good grounds for conjecture as to the efficiency of his machines for any other ore. In the case of a furnace his scientific tests will seek to find the chemical composition of all the ingredients that are put in the furnace and also of the slags, matts and metal which come out of the furnace. The tests will enable him to regulate the ingredients fed to the furnace so as to produce the slag which shall



have the least inclination to absorb and waste the metal, and which shall not badly attack the firebricks of which the furnace is made, and finally which shall run well or hold its liquidity for a sufficiently long time to effect good separations between metal and slag.

The mining machinery in this laboratory is supplied with power from an upright tubular boiler, which is fed with hot water by a force-pump and steam water-heater, by a ten horsepower engine. There are two suites of milling apparatus:—

I. A small five-stamp battery, capacity 100 lbs. of quartz per hour, of the form in use in Colorado and on the Pacific coast, an amalgamated plate, an amalgamating pan, a settler and concentrator of the kind used in the Washoe process in California and Nevada, for the treatment of silver and gold ores.

II. A Blake crusher with jaw opening  $2 \times 5$  inches, crushing rolls, capacity 400 lbs. per hour, with automatic screens, a series of sorting V-boxes (German spitzlutte), two automatic machine jiggers, a Rittinger shaking-table, a Freiberg shaking-table, and a set of little finishing V-boxes.

These machines are all arranged to give up their overflow sand into hand buckets, and the overflow water into a large tank. The water from this tank is forced back into the feed tank and used over again. This arrangement makes it possible to perform an experiment without the loss of slime due to an overflow of waste water. Steam drying tables are at hand to dry the wet sand for the furnace. The laboratory also contains the following auxiliary apparatus:—a Whelpley and Storer pulverizer, an edge-stone mill, a Sturtevant blower, and Batchelder's dynamometer. The metallurgical laboratory contains a blast furnace, a reverberatory smelting furnace, a roasting furnace, a furnace for cupellation, furnaces for fusion, crucible and muffle assay furnaces, a blacksmith's forge, and a melting kettle.

The Institute is from time to time receiving ores of gold, silver, lead, copper, antimony, zinc, iron, etc., from various lo-

*Instruction in Ore Dressing and Smelting.* The student is now fully prepared to begin practical work upon the extraction of metals from their ores. He receives an ore just as it comes from the mine and is expected to extract the metal from it in marketable form.

The experimental work of the laboratory is carried on by the students under the immediate supervision of an instructor, a sufficiently large quantity of ore being assigned to the student (from one hundred pounds to a ton) according to the quantity on hand and to the work proposed to be done. He first examines it for its component minerals, sorts and samples it, determines its character by analysis, from which he obtains the mineral percentage composition, and its value by assays. He also makes such other preliminary examinations as may serve to indicate the proper method of treatment. He then treats the given quantity, testing all his products at each step of the process.

These tests may be of two kinds :—(a) Commercial, in which case he assays all his rich and waste products alone for the metal under consideration, and thereby ascertains the percentage of metal saved in the rich products and that thrown away in the poor refuse products. He can tell at any time whether a rich product has been concentrated up to his smelting standard and whether a poor product has been sufficiently robbed of its metal to admit of its being thrown away. (b) He may make scientific tests of the machines and furnaces. Knowing the percentage of minerals in the ore started with, he may watch these minerals all through a complicated system of ore dressing by determining the principal mineral constituents of each product. After such a study he will have very good grounds for conjecture as to the efficiency of his machines for any other ore. In the case of a furnace his scientific tests will seek to find the chemical composition of all the ingredients that are put in the furnace and also of the slags, matts and metal which come out of the furnace. The tests will enable him to regulate the ingredients fed to the furnace so as to produce the slag which shall

have the least inclination to absorb and waste the metal, and which shall not badly attack the firebricks of which the furnace is made, and finally which shall run well or hold its liquidity for a sufficiently long time to effect good separations between metal and slag.

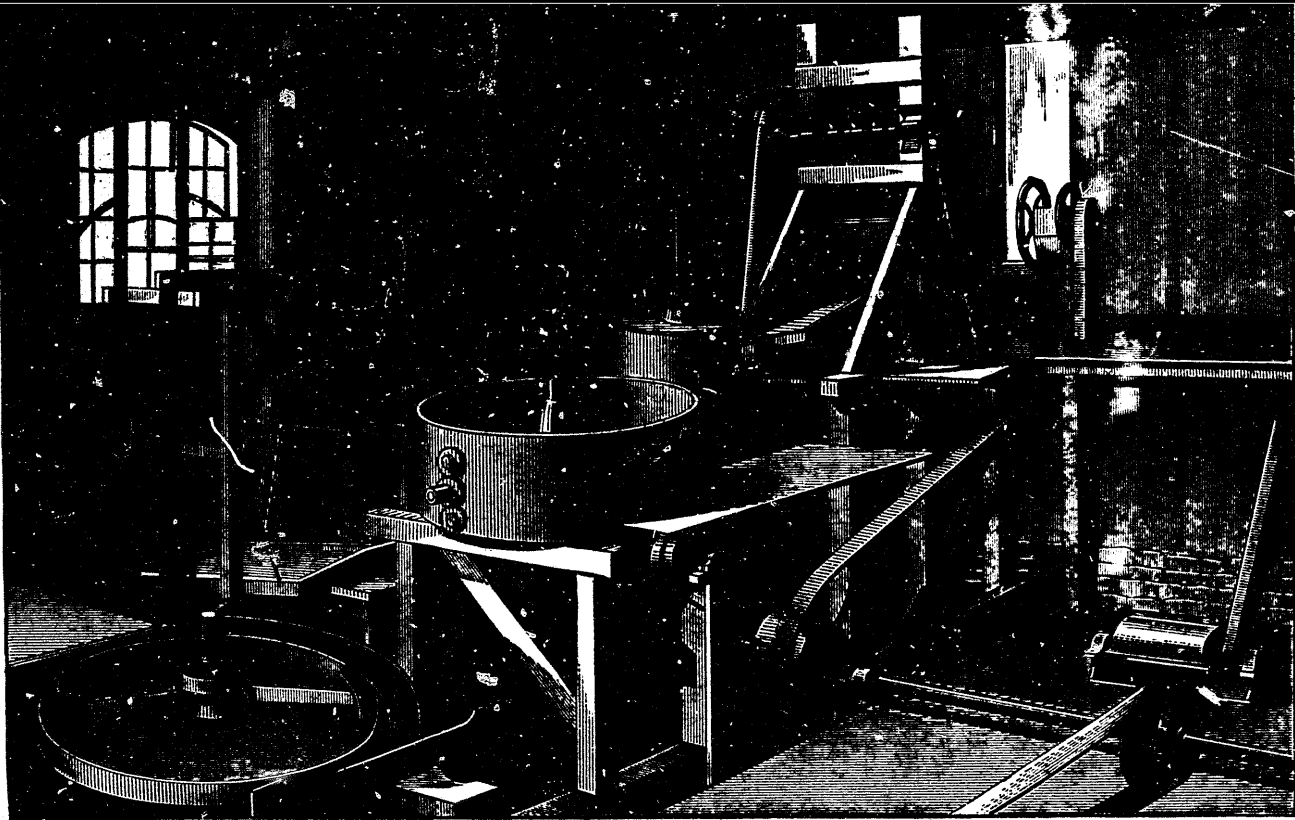
The mining machinery in this laboratory is supplied with power from an upright tubular boiler, which is fed with hot water by a force-pump and steam water-heater, by a ten horsepower engine. There are two suites of milling apparatus:—

I. A small five-stamp battery, capacity 100 lbs. of quartz per hour, of the form in use in Colorado and on the Pacific coast, an amalgamated plate, an amalgamating pan, a settler and concentrator of the kind used in the Washoe process in California and Nevada, for the treatment of silver and gold ores.

II. A Blake crusher with jaw opening  $2 \times 5$  inches, crushing rolls, capacity 400 lbs. per hour, with automatic screens, a series of sorting V-boxes (German spitzlutte), two automatic machine jiggers, a Rittinger shaking-table, a Freiberg shaking-table, and a set of little finishing V-boxes.

These machines are all arranged to give up their overflow sand into hand buckets, and the overflow water into a large tank. The water from this tank is forced back into the feed tank and used over again. This arrangement makes it possible to perform an experiment without the loss of slime due to an overflow of waste water. Steam drying tables are at hand to dry the wet sand for the furnace. The laboratory also contains the following auxiliary apparatus:—a Whelpley and Storer pulverizer, an edge-stone mill, a Sturtevant blower, and Batchelder's dynamometer. The metallurgical laboratory contains a blast furnace, a reverberatory smelting furnace, a roasting furnace, a furnace for cupellation, furnaces for fusion, crucible and muffle assay furnaces, a blacksmith's forge, and a melting kettle.

The Institute is from time to time receiving ores of gold, silver, lead, copper, antimony, zinc, iron, etc., from various lo-



MINING LABORATORY.



METALLURGICAL LABORATORY.

calities on this continent. These ores are worked, and reports sent to those who contributed them; and it is hoped that by such coöperation the laboratory will continue to receive the necessary amount and variety of ores.

*The Course in Metallurgy.* During the second year the studies of the courses in Mining Engineering and Metallurgy are the same, except that the mathematical studies in Mining Engineering are replaced by chemistry, in Metallurgy. In the third year the lectures on mining and applied mechanics given to students in Mining Engineering, are replaced in Metallurgy mainly by quantitative and industrial chemistry. With these exceptions the courses are the same during the four years, and although what precedes relates more particularly to the course in Mining Engineering, it will readily be understood to what extent it also includes the course in Metallurgy.

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#### MINING EXPEDITION TO NOVA SCOTIA.

A party of ten students with two of the professors left Boston, by the St. John steamer, on Monday, June 7th, and spent three weeks in visiting some of the mines and mineral localities of New Brunswick, Nova Scotia, and Maine.

Arriving on Wednesday, at Dorchester, N. B., we crossed the four mile ferry, at high tide, to Hopewell, and succeeded, at a late hour, in obtaining conveyance to the Hillsborough Albertite mine. Here occurs that peculiar bituminous mineral whose origin and classification has caused so much dispute among geologists. The highly inclined strata are mostly of a soft, shaly character, and the difficulty of locating the shaft of a mine in such yielding materials is well illustrated by the experience of the miners. The present working shaft, though at the distance of two hundred feet from the vein itself, is found to have been moved a little already by the comparatively quick filling in of the worked out parts, while three different shafts

have before been abandoned on account of this unavoidable creeping. As the Albertite is highly prized as a means of enriching coal gas, it is desirable to send it to market in a state of purity. It is therefore, carefully washed at the mine in long sluices to free it from a slight accidental contamination of pyrites and shale. The stoping of this very brittle mineral is effected with less labor than that of any other substance procured by mining. At times no tool is needed to dislodge it, but the fragile solid breaks up of itself when a barrier is removed, and flows out with an inconvenient rush. Mr. Wm. Blacker, the agent, and Mr. Byers, the mining engineer, were very kind in their attentions, giving us full opportunity to see all that our between tides visit would allow, and fully explaining the nature and working of the mine.

We left the railroad again at Maccan and went by stage to the Goggins. At the Goggins mine a seam of coal about five feet thick and inclined at an angle of about  $35^{\circ}$  is worked very systematically by "back balances." The pillar and stall method is carried out in such a way that the roof is allowed to fall in, after almost all the coal in each panel has been hoisted to the surface. The strata among which the coal occurs are wonderfully rich in large and well preserved fossils. The high, precipitious bluff, extending many miles along the shore of the Bay of Fundy, shows a complete section of the tilted coal measures several thousand feet thick. There is here a chance to study every leaf of a huge geological book. The special features of this region were carefully explained to us by Mr. B. B. Barnhill, a former student of our Institute.

Going on to Londonderry we spent a day at the Acadia Iron Works and the mine two miles distant. The whole property is now owned by the Canada Steel Co., Limited. The iron belt extends some thirty miles east and west in the Cobequid range. The ore is chiefly limonite, occurring promiscuously, mixed with ankerite and siderite, in irregular veins and pockets nearly vertical. The limonite, which is in various states of aggregation, is probably the result of the slow oxidation and hydration

of ankerite, a double carbonate of iron and magnesium. The Company has in operation a charcoal blast furnace, and is intending to build a high furnace for coke. Large preparations are also in progress for the manufacture of wrought iron and steel by the Siemen's direct process. The coarse ore from the mine is reserved for the blast furnace, while the fine, which has heretofore been rejected as useless, is sifted to free it from dirt and then forms an excellent material to supply the Siemen's furnace. In the new process, the rejected slack of the coal mines is mixed with this fine ore to effect the reduction. So from two refuse materials the Company expect to make iron and steel of good quality; and at the time of our visit, some excellent wrought iron had already been made in this way.

The Pictou coal region was next in order. The coals are mined near Stellarton and mostly taken by railway eight or ten miles to the port of Pictou for shipment.

The principal mines are the Albion, Acadia, Vale, Black Diamond, and Drummond; the latter noted for the fire which occurred in it in 1872.

The Albion mine is worked upon a vein 39 feet thick by the pillar and stall method, with back balances 150 yards apart. These workings, however, only remove the upper nine feet of coal, and they rest upon a two feet seam of slate. The remaining 28 feet of coal is left for future working.

The Ford shaft is 980 feet deep and has a hoisting engine of 75 horse power and two large cages, one of which goes up while the other goes down. The men are all lowered into and hoisted out of the mine by means of these cages. Each cage has two platforms and accommodates 20 men, and makes the descent in 70 seconds. The engine lifts 4,800 pounds of coal at once and makes the trip of 980 feet in 45 seconds. The water is pumped from the mine by an upright engine of 260 horse power, which raises 95 gallons at a stroke and makes seven strokes per minute. The mine is ventilated by a large suction rotary fan wheel 30 feet in diameter, 10 feet wide, run



at 45 revolutions per minute in dog-day weather when the mine is hard to ventilate. This rate is equivalent to 90,000 cubic feet of air drawn per minute, which is the amount required by 20 horses, 290 men, and for the removal of the fire damp. The Superintendent, Mr. Hudson, very kindly extended to the party the privileges of the mine, and his son devoted his time to us in the exploration of this mine and the Cage pit, which is worked by the same Company.

In the Ford pit we had the uncommon experience of walking about underground, several miles, through dry, spacious levels, by the dim light of safety lamps, each of the party carrying one.

At Gay's River, seven miles from Schubencadie, on the Intercolonial Railroad, is a very peculiar deposit, carrying gold. It is a conglomerate which has been pronounced by geologists to be as old as the carboniferous era, and as sedimentary deposits carrying gold are usually supposed to have derived that metal from the rocks from which their own pebbles came, this deposit gives a hint to the geologist that the veins originally carrying gold are pre-carboniferous. This ore yields from four to six dollars a ton, crushed by stamps and run over amalgamated copper plates.

The fourth of July was passed in Halifax, each one spending the day according to his own pleasure. A part of us went to several spots of much geological interest under the guidance of Dr. Honeyman, who assured us that the different rock beds of Nova Scotia are so well defined that an expert could locate almost any of the pebbles found in the gravel beds of Halifax. The doctor picked up pebbles which he identified as coming from the Cobequid hills, others from the amygdaloid beds of Blomidon, and still others from various places.

The Montague and Waverly gold mines were visited on the way to Windsor. But little work is now being done at either of these mines. At Montague a large number of specimens which showed visible specks of gold were found by the party. The impression gained from both these mines was that the

veins are narrow, six inches or less of quartz, but that they seem to make a good show of gold per ton of vein stone. Capital does not seem to have been much attracted here, whether from lack of confidence in the mines or in the men, or from want of proper representation, we did not ascertain.

The Windsor plaster quarries are well worth a visit from a mineralogist. Beautiful selenite crystals are found there beside ulexite, howlite and anhydrite. Cape Blomidon, celebrated for the beautiful trappean minerals which have come from it, could be reached from Windsor only by chartering a special steamboat for the trip. The mineral beach is thirteen miles long and it is said to be entirely a matter of luck whether or not a party may land at a spot which is abounding in good specimens. The minerals which are sought here, occur originally filling cavities in the trap. The trap crumbles and falls off the cliff in the spring as the frost melts, and the most perfect minerals are obtained then. Fine specimens of stilbite, hewlandite, scolecite, amethyst, and laumontite, were found by the party.

Returning by way of Annapolis to St. John, we made way with some little trouble to the Lake George antimony mines, which are not worked at present. There seems to be no lack of ore and the mine is well equipped with machinery and furnaces. The mine has been through various vicissitudes in having men who were skillful in some respects, but unable to adapt their knowledge to the needs of the country. Some of its superintendents were expensive in one thing, some in another. And so an apparently valuable property is lying unused awaiting a prudent, economical management.

Our work of observation was finished by an interesting trip from Bangor to the Katahdin iron works, situated 19 miles from Milo, a small town on the Bangor and Piscataquis Railroad. They have a charcoal furnace in successful operation and are turning out a good quality of iron. The ore deposit is one of peculiar interest to the geologist. It is apparently of recent age and is still in process of formation. The trees growing on

the deposit are mostly aspens and birches, which do not seem ever to have attained a diameter of over six or eight inches although undisturbed by man. When they have reached about this size they have fallen, and become changed by the chalybeate springs, into iron ore, to be followed in turn, by the succeeding crop. A large proportion of the ore which constitutes superficial beds from two to nine feet thick is composed of fossilized leaves and limbs of trees which are so well preserved that the species can be identified at a glance.

The thanks of the party are due to Mr. W. B. Hazeltine for his kindness in giving reduced fares on the Boston and Bangor boat, and to Mr. H. D. McLeod for reducing the fare from St. John to Bangor. These helps often times enable students to go on these expeditions who otherwise could not do so.

ROBERT H. RICHARDS.

## LOWELL FREE COURSES FOR 1874-75.

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*General Chemistry. Twenty-four laboratory exercises.*

*Qualitative Analysis. Twenty-four laboratory exercises.*

*President J. D. Runkle:—*

DEAR SIR:—For the last few years the Lowell Courses in Chemistry have consisted of Laboratory Exercises in General Chemistry and in Qualitative Analysis. One winter a course of lectures was given, but experience then and since has seemed to show that more good can, on the whole, be accomplished by laboratory exercises.

The number of tickets issued is, of course, limited by the size of the laboratory at my disposal. The number of applications is very greatly in excess of our accommodations, but many of the applicants have no appreciation of the nature of the course and if they receive tickets, either make no use of them or, after attending for a few exercises, appear no more. Others who would profit by the course are thus prevented from attending. As we have this same trouble year after year, I would respectfully suggest that applications for the courses in Chemistry be made in person.

The majority of the persons who avail themselves of the opportunities offered are school-teachers and practicing pharma-

cists, although these two classes are not the only ones represented: the two sexes are represented about equally.

In General Chemistry, those who are beginning the subject use Eliot and Storer's *Elementary Manual*, and perform, each for himself or herself, the experiments there described; those who have previously studied the subject experimentally proceed from the point already reached. In order to derive any profit from the course it is necessary that time be given to the study of the subject outside of the laboratory, and only those who take sufficient interest in the matter to be willing to devote the necessary time can expect to be benefited by the laboratory work. In *Qualitative Analysis* each person works independently of every other, and the progress made depends upon the individual. Except the beginners, who use a prescribed textbook (Eliot and Storer's *Manual*), the students use any book with which they are more or less familiar, and the selection of substances analyzed is made, as far as possible, with a view to the occupation of the student or to the use he or she is likely to make of their knowledge:

The class of 1874-75 numbered forty-five in all. No account was kept of the individual attendance, but the number present at each exercise was about thirty-five on the average. With some of the more advanced members of this class, I tried an experiment to see how much it might be possible to accomplish in *Quantitative Analysis* during such a course of twenty-four two-hour exercises. We labored under many disadvantages for lack of proper space and on account of the shortness of the exercises; but, in spite of this, the results were very satisfactory. Those who pursued this course (all ladies) acquired an idea of the general principles of gravimetric and volumetric analysis and of certain parts of stoichiometry, and had some practice (limited to be sure), in the application of the principles to special cases. It seemed, however, impracticable, with our present laboratory accommodations, to undertake regularly a "Lowell" course in *Quantitative Analysis*, but for the class

of persons from whom, at present, comes the greatest demand for such instruction, namely, the teachers, provision has this year, 1875-1876, been made by the Institute.

Yours Respectfully,

WM. RIPLEY NICHOLS.

*Practical Geology of the United States. Eighteen lectures.*

*President Runkle : —*

In the months of November, December and January, 1874—75, I gave an evening course of free lectures on the Economic Geology of the United States, of which the following is a synopsis : —

- I. Preliminary notions of geology and the classification of rocks and formations.
- II. History of granites and granite-like rocks.
- III. The crystalline stratified formations.
- IV. History of mineral veins and ore-deposits.
- V. The Paleozoic formations, their origin and history.
- VI. The Mesozoic and more recent formations.
- VII. Relations between the geology and the physical geography of the United States.
- VIII. Building-stones ; granites.
- IX. Marbles, sandstones and slates.
- X. The iron ores of the crystalline rocks.
- XI. The iron ores of the paleozoic rocks.
- XII. Copper ores and mines of native copper.
- XIII. Gold and silver mines.
- XIV. Salt, and gypsum ; mineral waters.
- XV. } Coal deposits, history, development, economic importance.
- XVI. }
- XVII. Petroleum and its geological relations.
- XVIII. The recent deposits ; soils and clays.

The object of these lectures was to give in the first place such notions as would serve to make intelligible the great fea-

tures of our geology and the relations of these to the physical geography of the country, and in the second place to describe our mineral resources, their geological history and their economic development.

T. STERRY HUNT.

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*Lantern Projections. Eighteen lectures on the use of the Lantern as a means of illustration in teaching.*

*President Runkle: —*

The course of lectures in Lantern Projections was designed especially for teachers who wished to use this valuable means of illustration in their daily work. The ground covered was substantially as follows: Sunlight, description of the *porte-lumière* and various forms of heliostats. The magnesium light, method of making and burning magnesium. The calcium light, methods of making oxygen and hydrogen, methods of storing by gas-holders, reservoirs and bags. Various forms of burners, substitutes for the lime cylinder, the Bude light. The electric light, regulators, forms of batteries, theory of their action, magneto-electric machines. Photometric measurements of the various lights. Experiments with the direct light, shadow and penumbra, phosphorescence and fluorescence. Theoretical considerations involved in the methods of projections, refraction, lenses, chromatic and spherical aberration. Construction of the lantern, various forms of condensers, their advantages and defects. Forms of projecting lenses, size of image, forms and dimensions of screens. Objects employed, drawing and painting on glass and gelatine, photographs. Projecting small objects, opaque objects, Chinese fireworks, chromatrope, dissolving views. Stroboscope, application to revolving wheel, tuning fork and electro-magnetic engine. Tanks, three methods of exhibiting chemical decompositions, convection, capillarity, electric decompositions, crystallizations. Vertical lantern, magnetic phenomena, waves, cohesion figures. Galvanometers, method of projecting objects in two planes at once, mirror galvanometers.

Lissajous' experiment, compound pendulum, Crova's apparatus. Lantern microscope, precautions and defects. Polarization of light, theory of apparatus employed, parallel beam, selenite plates, compressed, bent and unannealed glass, converging beam, crystals, mono-chromatic light. Spectra, method of projection by sunlight, calcium and electric light, spectra of metals, reversion of soda flame, monochromatic light, imitation of spectra with black lace curtains. The lectures were fully illustrated by various forms of lanterns, and the object aimed at was not merely to describe and exhibit the various phenomena, but to explain how the apparatus should be made and arranged and what precautions were essential to secure success.

E. C. PICKERING.

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*Elementary French. Eighteen lessons.*

*President Runkle:—*

I have the honor to submit to you the following report on the work assigned to me in the Lowell Evening courses for the winter of 1874-75.

Beginning on the 16th of November, 1874, our exercises took place, without interruption, on the Mondays and Wednesdays of every week, until brought to a close on the 13th of January, 1875. The class on the opening night numbered in the eighties; in the few succeeding nights, however, this number gradually fell off, until it reached a steady average of about fifty persons, who remained, to the end, assiduous attendants.

While adhering strictly to the letter of the programme, I availed myself of what freedom was left to me in the arrangement of details, selecting out of the topics included under the general head "elements" only such as appeared to me to be more important or more appropriate to my audience; thus, I left out many minor points, sketched others with a rapid outline and endeavored to set off among all others the characteristic parts of speech, the *pronoun* and the *verb*. There, in fact,



is found whatever originality or richness of forms the French has inherited from the Latin, and there also the student meets with most difficulties. Besides, the treatment of these two topics carries with it several questions of syntax, such as the construction or position of the different parts of the sentence, the arrangement of words in negative or interrogative clauses, etc., all of which points pressed themselves upon our attention and furnished us with an abundant material until the very last minute. Each exercise was divided into two parts: 1. A summary exposition of the topic on hand, with illustrations on the black-board. 2. An application of the principles and rules thus announced, by means of sentences given out to the students during the last twenty minutes of the lesson, to be translated into French and written down while the explanations still rang in their ears. These translations were handed in on leaving the class, carefully examined between the exercises, and the errors pointed out at the opening of the next lesson. In this way I was enabled to follow the progress of the class and to hasten or slacken speed as the case required. I may add that these papers, for the most part, did honor to the earnestness of purpose as well as to the understanding of the writers.

A course in "Elementary French" must needs include exercises in *pronunciation*. Here again we had to follow a short cut method; the study of pronunciation is a laborious process whereby the student's ear is inured to strange sounds and the clumsiness of his organs overcome; all this requires time and a constant, personal commerce between the teacher and the pupil; as we were limited in regard to both requisites, I restricted myself to exposing clearly the scheme of French sounds and the peculiar structure of the French syllable; then, I requested the class, as a unit, to scan aloud some of Lafontaine's fables, keeping time, giving out every sound distinctly and articulating each syllable as if it were a word in itself. The class brought to this very simple, almost childish, exercise, so much good will, that it was pursued, to the last, for a few minutes in each lesson, and we trust, not without profit, since

the students were thus taught a stringent observance of the syllabic division of words, a principle of utterance too often disregarded in our hasty methods.

A last remark, with quite a different bearing, I must also submit to you, Mr. President, as it goes far towards explaining what success the class may lay claim to, namely; although the French course is intended for persons desirous of beginning the study of that language, such real beginners form but an exceedingly small percentage of the entire attendance. In fact, without any previous training, a person is at a disadvantage in so large an assemblage. I hesitate to say that there were none of that class; yet, barring other proofs, a careful examination of the written translations bears witness to the fact that a very large majority of the students had studied French, whether at school or under private tuition, before joining our course. With such scholars alone could our hasty march find favor and for such ones, mainly, be fruit-bearing; it was for them not a new, hardship-like study, but a mere review of things and facts previously known. Whether this unrequired preparation of so great a majority of the attendants ought to be taken in consideration in the shaping of a subsequent course is a point which I must, Mr. President, leave to your consideration.

Yours, Very Respectfully,

JULES LUQUIENS, *Instructor.*

*December 20, 1875.*

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*Modern Philosophy, from Descartes to Hegel. Eighteen lectures.*

*President J. D. Runkle:—*

This series of eighteen Lectures was attended by some forty persons, about a third of whom were women. Fifty-four were present at the first lecture; at the last, there were thirty-five.

The following is a synopsis of the course:—

**Lect. I. Introductory:** The Definition of Philosophy, the Group-

ing of the Historic Systems, and the General Character of the Modern Movement.

Lect. II. *Descartes*: his Epoch, his Genius, and his Claims as Founder of Modern Philosophy.

Lect. III. *Descartes*—the Details of his System: an explicit Dualism, but at the same time an implicit Monism; its inconsistency as Dualism, its consistency as Monism.

Lect. IV. *Geulinx, Malebranche, Hobbes*: Attempt, by the two former, to save the Dualist view of *Descartes* by the added theories of *Occasionalism* and *Vision in God*; by the latter, to bring out the required consistent Monism by the theory of *Materialism*.

Lect. V. *Spinoza*—General Estimate: Cartesian implicit Monism made explicit as Pantheism.

Lect. VI. *Spinoza*: Outline of his *Ethics*.

Lect. VII. *Locke*: Transfer of the Problem of Philosophy from the question of the Nature of Being to that of the Scope and Worth of Thought; Beginning of Empiricism, and preparation for Skepticism in the empirical Principle.

Lect. VIII. *Leibnitz*: The Revolt from Empiricism, and Return to the Question of Being; Preparation for Idealism in the *Monadology*, a system of an infinitude of *Substances* made one in *Essence* by the Pre-established Harmony.

Lect. IX. *Berkeley*: Idealism becomes explicit in the form of a Dualism of Spiritual Substance, Creator and Creature; the Insubstantiality of Matter as a corollary of Empiricism.

Lect. X. *Hume*: Return to the question of the Worth of Thought; thorough comprehension of Empiricism as in reality Skepticism.

Lect. XI. *Reid, and the Scottish School*: Revolt from Skepticism in the interest of Common Sense; Hypothesis of the Transcendental origin of the Principles of Common Sense.

Lect. XII. *Kant*: The Transcendental principle comprehended; the transcendentalism of Common Sense vanishes in Kant's Transcendental Skepticism, as Empiricism completed itself in Hume's Empirical Skepticism.

Lect. XIII. *Kant*: His Theoretical Philosophy; the *Critique of Pure Reason* in outline.

Lect. XIV. *Kant*: His Practical Philosophy; attempt to compensate for the skepticism of the *Critique* by the doctrine of *Ethics* and of

\* *Good Judgment; Sketch of the Critique of Practical Reason and of the Critique of Judgment.*

Lect. XV. *Fichte*: The removal of Kant's hypothetical "Thing in Itself" converts his Transcendental Skepticism into Subjective Idealism; the Human Ego the only Substance; all else, even God, only the Form and Mode of man's existence; Pananthropism, as inverted Spinozistic Pantheism.

Lect. XVI. *Schelling*: Reaction from Fichteanism, on viewing it as implicit Single-Individualism; Hypothetical identification of Being and Thought; the NEITHER, as abstract Common Essence of Spirit and Matter, proposed as the Sole Reality or Ground of All.

Lect. XVII. *Hegel*: Absolute Idealism; Reality as PERSON, *i. e.*, as the Living Unity in which the twofold of Subject and Object (Thought and Nature) given by Reflection, is taken up by means of the mutual neutralization of its two terms.

Lect. XVIII. *Hegel*: Sketch of the *Logik*, with especial reference to its doctrine of the *Begriff* as the real unit of thought.

GEORGE H. HOWISON,

*Professor of Logic and the Philosophy of Science.*

*Elementary Principles of Mechanism. Eighteen lectures.*

*President J. D. Runkle:—*

DEAR SIR:— The following is a synopsis of the work done in the Lowell free course of eighteen lectures on the Elementary Principles of Mechanism given by me last session. In these lectures, which were intended for persons actually engaged in work in machine shops and in similar occupations, an attempt was made to present, as far as time would allow, the mathematical principles which underlie a correct construction of the different mechanical combinations and their adjustment to the purposes they are intended to fulfill; and to give such explanations as would enable one to make correctly and understandingly computations and designs for practical cases.

The discussion of Belts and Pulleys and of Gearing occupied the greater part of the time, the remainder being devoted to the study of Cams, Linkwork and Universal joints.

Under the head of Belts and Pulleys, the following were the subjects discussed : —

Advantages and disadvantages of connections made by belts and cords, and cases when it is desirable to employ them. Open and crossed belts and cords. Lacing, splicing and rivetting. Limiting speed and length of wire ropes. Bearing pulleys for wire ropes. Construction of pulleys for belts, cords and wire ropes. Lateral stiffness of belts. Climbing of belt. Crowning of pulleys. Fast and loose pulleys. Quarter twist. Connection of non-parallel shafts by belts, by cords. Guide pulleys. Reversing gears where fast and loose pulley is used. Computations under given conditions of diameters of pulleys, velocity ratio of pulleys, speed of belt, length of belt, etc. Conical pulleys; 1st, Stepped cones, computation of the proper diameters; 2d, Speed cones, determination of swell. Non-circular pulleys. Velocity ratio. Straining pulleys. Fusee. Chain pulleys. Suspended pulleys, etc., etc. Tension on each side of the belt. Coefficient of friction of leather on iron. Strength of belting. Power transmitted by belts. The last four being discussed chiefly in the light of the experiments of Gen. Morin and Mr. H. R. Towne.

Under the head of Gearing the following subjects were studied : —

Computation under given conditions of diameters of pitch surfaces speed, etc., of spur and annular wheels and of rack and pinion. Determination of the pitch surfaces of bevel gears. Screw gearing. Frictional gearing. Non-circular gearing. Eccentric and elliptical gears and rolling cams. Rules governing the pitch and number of teeth. Crown wheels. Hooke's stepped teeth and Hooke's screw gearing. Trains of wheelwork. Computation under given conditions of velocity ratio of gears, numbers of teeth, diameters, etc. Hunting cog. Least number of teeth admissible in a pinion. Proper number of intermediate axes in a train. Idle wheel. Dr. Young's least number of teeth in a train, its advantages and disadvantages. Clock trains. Epicyclic trains. Copying lathe. Screw cutting lathe. Cal-

culatation of change wheels. Mangle wheel. Determination of the proper dimensions of the teeth of wheels, viz., Addendum, pitch, clearance, thickness of tooth, working depth, etc. Construction of rolled curves. Instantaneous axis. Mode of designing epicycloidal teeth and of constructing the template. Radial flanks. Curved flanks. Case when circumference of describing circle is six times the pitch. Mode of designing involute teeth, their advantages and disadvantages. Determination of the base circle. Cycloidal teeth for racks. The Odontograph and its use.

The time remaining from the above subjects was devoted to the following, viz, : —

Velocity ratio in Linkwork. Drag link. Link for contrary rotations. Link for reciprocating motions. Crank and connecting rod. determination of dead points, velocity, ratio, etc. Oldham's coupling Hooke's joint. Cams. Eccentrics. Construction of cams to actuate 1st, a rocker arm; 2d, a sliding bar. A *very* brief consideration of the slide valve was also made.

All of which is respectfully submitted.

GAETANO LANZA.

## ABSTRACTS OF THESES PRESENTED BY GRADUATES OF 1874-75.

### DEPARTMENT OF CIVIL ENGINEERING.

*Fall River Water Works. Abstract by the author, Samuel E. Allen.*

I. In the introductory portion of this review, I have considered the City of Fall River: — 1st, As regards its location; 2d, As regards its general character; 3d, As regards its available sources of water supply, since all these points have an important bearing on the character of the works to be constructed.

II. I have touched on some of the most important points to be considered in the construction of any work of a similar nature. 1st, Probably the point of most importance is that of adequacy; 2d, Perhaps next to the consideration of adequacy is that of economy; 3d, The third consideration is that of safety.

III. In the descriptive portion of the review, I have taken up the arrangements for obtaining the water supply from the lake, and described the most important of them more or less in detail. These arrangements are, the Gate House, Conduit, Engine House and Pumping Engine, the Force Mains to the Stand Pipes, the Stand Pipes, Supply Mains, Water Gates, Hydrants, etc.

The description is accompanied by three drawings. Drawing No. 1 shows a plan of the Pumping Station, No. 2, a plan and

elevation of the Weir and Stand Pipe, and No. 3 shows a plan, half side elevation, and two sections of a Man Hole and Blow-off.

*Lattice Girder Bridge. Abstract by the author, Henry K. Burrison.*

This particular design consists of an upper and lower boom to withstand the bending action, and a set of diagonals crossing each other at the middle of each panel, to withstand the shearing action of the load. The span of the bridge is one hundred and ninety-two feet, and consists of sixteen panels; the height is eighteen feet, and width fifteen feet clear; the length of each piece is dependent upon these given dimensions, while the *area* of any cross section depends on the stress at that cross section, and the *form* of cross section on the option of the designer, who is guided by the relative position of each piece and the forms which experience has shown to be best. The diagonals are simple bars of rectangular cross section, fastened to the lower part of the upper boom, which is a square cell set on edge, and the web of the lower boom which has an inverted T shaped cross section; the end posts are square cells.

The material used is wrought iron, except the supports for the I beams which are cast. The sustaining power of the bridge is calculated for a dead load of 800 lbs. and a live load of 1200 lbs. per ft. run. As the girder is composed of two simpler ones, the action of the load is considered on each, and the results combined. The diagonals acting as ties, are calculated for a working strength of 10,000 lbs. per sq. inch, while the struts are determined by Gordon's formula, the greatest action of the load alone being considered in every case.

The I beams which support the floor timbers, weigh 200 lbs. per yd. and are calculated to support, beside the floor timbers, a weight of 20 tons, being the greatest weight liable to come from a locomotive on them. The bolts which sustain them are calculated from the same data, and pass through the flange of the lower boom. The horizontal diagonals for wind bracing,



are calculated from a pressure of 25 lbs. to the sq. ft., acting on a surface 192 ft. by 18. The rivets are calculated from bearing area, the bearing of one square inch being considered as 8000 lbs.

*Lattice Girder Bridge. Abstract by the author, C. A. Church.*

The first part of the thesis is taken up by a description of the abutments and of their foundations. This is followed by a description of the details of the bridge.

Next is given a general description of the method of calculating the stresses of the diagonals and chords, followed by the calculations of these stresses, and the net area of cross-section required in the different pieces.

The calculations for the number of rivets required in the diagonals and joints of the chords are next taken up, after which the maximum stresses to which the floor is subjected, are calculated, and the sizes of the stringers and cross-girders fixed accordingly.

The last subject taken up is the determination of the weight of the bridge. The weights of the different parts of the bridge are first calculated in order, following which is a table giving a summary of the weights.

*Salem Water Works. Abstract by the author, Frank S. Dodge.*

I have divided my thesis into two parts, the first relating to the subject of water works in general, and the second to the works belonging to the city of Salem, Mass.

Part first embraces,

1. A few of the advantages of an abundant supply of pure water.
2. An account of some ancient and celebrated aqueducts.
3. The difficulties to be met in the construction of reservoir banks, and the various means of overcoming them.
4. A list of general principles to be followed, and which are essential to the durability of the structure ; also the means of preserving the purity of the water.

5. Methods and materials for rendering a reservoir water tight, especially at the joints between puddle and masonry or pipes.

Part second includes

1. A short account of the introduction of water into Salem, with a history of the old "Salem and Danvers Aqueduct Co."
2. A description of Wenham Lake, the source of supply, embracing its situation, capacity, quality of water, etc.
3. A detailed account of the works, beginning at the source, and extending through the whole in the order in which they occur, viz., the iron conduit pipe, gate chamber and screens, brick conduit, pump well (with the difficulties encountered in laying the foundations in quicksands), engine house, Worthington Pumping Engines, force main, check valve, branch main and stand pipe, reservoir, effluent pipes, supply main, and system of distribution.

The reservoir, being very important and difficult in construction, is treated in its minutest details. It is described in its situation, elevation, capacity and construction of its parts, including puddle floor and walls, paving of slopes, effluent pipes with their screens, and supports within the embankment, and the system of surface drainage.

The whole is illustrated by fifteen tinted drawings covering the most important points, and briefly explained in an appendix.

*The Iron Bowstring Girder Bridge over the Charles River at Waltham, Mass., by the author, Edgar S. Dorr.*

In this thesis I have first presented a description of the bridge and its details from measurements made by myself and others, and from information obtained from the builders, the King Bridge Company of Cleaveland, Ohio. From these data I have calculated the weight of the bridge, and thus obtained the fixed load. The live load for which the bridge was calculated, was given me by the engineers as seventy-five pounds per square foot, the bridge being a road bridge. With these

data I have calculated the greatest thrust at the crown of the bow, and the greatest tension in the main tie, by the formulæ of Rankine, p. 563, Art. 379. By the formulæ of the same article I have calculated the tension and the thrust, if any, in the verticals, and the tension in the diagonals produced by the rolling load. In each case I have computed the dimensions of the pieces necessary to resist these stresses, and compared them with the actual dimensions of the bridge. I have also calculated the strength necessary in the cross beams to support the platform and its load, and the strength of the various joints of the bridge.

I have also made two drawings, one representing the bridge in elevation, plan, and end view, and the other giving details of the bridge upon an enlarged scale.

*The Howe Truss Bridge at India Point, Providence, R. I.*

*By William C. Edes.*

(Abstract not received.)

*Tunnelling. An abstract by the author, Edward A. W. Hammatt.*

I have treated this subject under the following subdivisions: — 1st, Preliminary Work; 2d, Sinking Shafts; 3d, Transferring the Line and “dropping” the Levels down the shaft; 4th, Driving Headings; 5th, Excavation and Brickwork of Side Lengths; 6th, The same of Shaft Lengths; 7th, The same of Leading and Junction Lengths; 8th, Centre, and then a few statements in regard to Machine Drills.

I have illustrated my description by sketches in the body of the thesis, and by two plates of drawings, and as the operations of tunnelling in rock consist mostly of blasting and quarrying, I have confined my description to tunnelling through earth, and have had frequent recourse to Simms, “On Practical Tunnelling.” My illustrations refer mostly to the Blechingly Tunnel, Eng., although I have made some reference to the Mont Cenis,

Hoosac, and the Beacon Street Tunnels ; the latter of which is now in process of construction at Newton Centre, Mass., for the Boston Water Works. I regret to say that I was unable to obtain as much information in regard to Machine Drills as I could have wished.

*Brookline Water Works. Abstract by the author, Edward A. Handy.*

The subject of my thesis is the "Brookline Water Works." I first gave a short history of some of the methods which were proposed to supply Brookline with pure water, and stated as clearly as I could the reasons which led the Commissioners to adopt the present system, rather than any of the others. The works, as now built, consist essentially of a filtering-gallery on Cow Island, in the Charles River, a short distance below the town of Dedham, a pumping-station situated on the edge of the marsh about 3000 feet distant from the gallery, a stand-pipe 14' in depth on Walnut Hill in Brookline, and a reservoir, with a capacity of 6,500,000 gallons, situated on Fisher's Hill.

I gave a description of each of these essential features and spoke of the various difficulties that were met with in their construction. In speaking of the filtering-gallery, I entered upon the interesting questions which arose concerning the probable source from which the water is derived, and mentioned the various experiments by which it was proved almost conclusively that the water is supplied by springs and does not come from the river at all. The drawings which accompanied my thesis, were of details of such parts of the work as would serve to make my descriptions more easily understood. I did not touch at all upon the question of town distribution, as that in itself would have given material enough for an entire thesis.

*The Holly versus the Reservoir System of Water Works.  
By Clarence L. Howes.*

(Abstract not received.)

*The Holyoke Dam. Abstract by the author, William F. Huntington.*

The site chosen for the dam at Holyoke seems to possess all the advantages that could be desired. There is an available fall of upwards of sixty feet; the bed of the river at the place where the dam has been built is composed of Connecticut River sandstone, which furnishes an excellent foundation for the dam; and the lay of the land below the dam is peculiarly adapted for the construction of canals and mills.

The attention of capitalists was early turned towards the immense water power afforded by the Connecticut River at Hadley Falls. In 1847 a stock company was organized. The following year this company proceeded to build a dam across the river, a full description of which is given in the thesis. This dam was finished November 19, 1848, and was carried away the same day, before the water had risen as high as its crest. Some of the reasons that were given for the failure of the dam are stated in the thesis. In order to determine whether or not it was capable of resisting the pressure brought to bear upon it, the forces acting at a section six feet in width were calculated. From these calculations it appeared that the principal defect in the construction of the dam, was that the slope of the up stream side was too steep. It is said that the dam gave way by sliding upon its foundations. Had the slope just spoken of been less steep, the line of action of the resultant of the forces acting at a section of the dam would have been more nearly vertical, and it is probable that the dam would not have yielded to the pressure of the water, in the way that it did.

During the year 1849 another dam was erected by the Hadley Falls Company. A description of this dam and of the way in which it was built, is given in the thesis. The forces acting at a section of the dam were calculated, and from these calculations it was shown that the dam was sufficiently strong to resist the pressure of the water brought to bear upon it.

An examination of the dam spoken of last, was made in 1868, and it was found that the rocky bed of the river had been worn away by the continuous fall of the water. In order to protect the foundations from being undermined, an apron was built in front of the dam. This apron consists of a crib-work of logs loaded with stone.

The head gates at Holyoke are shown by drawings, which are fully described in the thesis.

The volume of water flowing in the Connecticut River at Holyoke at ordinary times, is estimated to be 5200 cubic feet per second. The available fall is sixty feet. From these data the water power was calculated to be equal to 35,400 horse power. This power is distributed by means of three canals at different levels, as described in the thesis.

*The Lawrence Dam. Abstract by the Author, W. F. Sargent.*

The Essex Company, the principal owners of the water power and canals, and the principal owners of the town, have erected the dam and canals. They dispose of the water power to other Companies on certain conditions, which are specified with great care and minuteness on the printed proposals for their sale. They define a "mill power" to be thirty cubic feet of water per second when the head and fall is twenty-five feet, which is to be graduated to a greater or less quantity as the head and fall shall be less or greater than twenty-five feet.

Charles S. Storow, Esq., was Principal Agent and Chief Engineer. Capt. Charles H. Bigelow was Assistant Engineer, and under the immediate direction of the latter the works of the dam and canal were carried forward to their completion, and in accordance with the original designs.

The excavation for the foundation of the dam was commenced August 1st, 1845. The first stone was laid Sept. 19th, of the same year, and the dam was completed in 1848. The whole structure is of solid masonry laid in cement. The foun-

dation is imbedded in the solid rock, and bolted to it with iron. The structure is 1,629 feet long, including the wing-walls; the overfall is 900 feet long. The north wing-wall is constructed to unite with guard locks at the head of the canal. The dam is 35 feet thick at the base and  $12\frac{1}{2}$  feet thick at the lower end of the coping crest stones. Its greatest height is  $40\frac{1}{2}$  feet, and its average height is 32 feet. The water falls from 25 to 27 feet, giving an effective fall of 28 feet for the whole of the river.

The lower front course of stone resting upon the rock is composed entirely of headers, which are let into the rock in such a manner that they cannot slip. All the front courses, and the coping crest stones are of hammered granite. The crest stones are all laid as headers, and each stone is bolted to the stone beneath it. The interior of the dam is composed of common rubble masonry laid in cement. The face has a batter 1 in 12, the crest stones a batter of 1 in 3, and the rear of the dam is laid in steps, having the general slope of  $45^{\circ}$ . The water is taken from the pond produced by the dam, by an artificial canal, which is about four hundred feet from, and nearly parallel to, the river, and in this space are the sites for the mills. The dam crosses the river obliquely, and is slightly arched up stream.

After giving a general and detailed description of the dam and canals, I calculated the stability of the dam, both with reference to overturning, and to sliding, and under two conditions, first, supposing the water to be just on a level with the top of the dam, second, supposing the water to be ten feet deep on top of the dam, and I found it stable in all cases.

## DEPARTMENT OF MECHANICAL ENGINEERING.

*On the Coefficient of Expansion of dry saturated Steam in an unjacketed cylinder. Abstract by the author, James H. Head.*

Professor Rankine states that the coefficient of expansion of dry saturated steam in an unjacketed cylinder is  $-\frac{1}{9}$ , and in a jacketed cylinder  $-\frac{1}{16}$ . That is  $p \propto b^{-\frac{1}{9}}$  and  $p \propto v^{-\frac{1}{16}}$  when  $p$  represents the absolute pressure and  $v$  the volume of the steam. These values of the coefficient were determined by calculations which were based on theoretical deductions from the known nature of steam and work. But they were not determined by direct experiment.

The purpose of this investigation was to ascertain whether the values calculated by Rankine, agreed with the results of direct experiment with ordinary steam in ordinary engines, for it was believed that the effect of an important influence was overlooked by Rankine in his calculations.

Twenty-five or thirty sets of indicator cards taken from different engines having unjacketed cylinders, were obtained for examination.

Generally saturated but sometimes superheated steam was used. No data was obtained from jacketed cylinders. The method which was used to obtain the coefficient from the indicator diagrams, was the general one devised by Professor E. C. Pickering, for the establishment of any physical law. A paper detailing the method was read by him at the meeting of the American Academy of Arts and Sciences, held May 12, 1874, and afterwards published by that Society.

As far as this investigation goes, it appears to be true that the coefficient of expansion given by Rankine for unjacketed cylinders is incorrect for practical usage. For,

*First,* The law expressing the relation of pressure to volume when either saturated or superheated steam is expanding in an ordinary unjacketed steam cylinder is not necessarily of the form  $p \propto v^x$ . Only in the case of one or two expansion curves



could the relation be expressed by that form, and approximate closely to the truth.

*Second*, On expressing the relation approximately by the form  $p \propto v^x$ ; I find that the coefficient  $x$  is not constant, but that it varies in different engines, and even in the same engine if the point of cut-off be changed.

In the cases which I examined I found it to vary from  $-.65625$  to  $-1.0200$ . These extreme coefficients were both derived from saturated steam diagrams taken from the front end of the Harris-Corliss Engine in the Mechanical Laboratory of the Massachusetts Institute of Technology. Its cylinder is  $8.01''$  in diameter and its stroke  $24''$ . The coefficient  $-.65625$ , was derived from diagrams taken with an apparent cut-off of  $\frac{1}{18}$ . The steam pressure was 71 pounds per sq. in. The speed of the engine was 57 revs. per minute. The coefficient  $-1.0200$  was derived from diagrams taken with a real cut-off of about  $\frac{3}{4}$ . The steam pressure was 70 pounds per sq. in. The speed of the engine was about 59 revs. per minute.

NOTE. — The author, in closing his thesis, expressed the hope that he should be able to carry this investigation further; but his sudden death on Aug. 18th, closed this and all his other earthly labors, and ended a life of great nobleness of character and bright promise.

*The Construction of Gear Teeth. Abstract by the author,  
Thomas Hibbard.*

I have not attempted to consider, in this thesis, all the bearings and details of the subject of designing teeth, but have called attention to some of the most important points, and have discussed a few of the principal methods by which teeth are constructed at the present day.

After a few introductory remarks, in regard to the construction of teeth in the past time, I have given some of the reasons for the selection of the proper curves for teeth, and have distinguished between the two great classes: — viz., involute teeth, and epicycloidal teeth. It is the latter class which is

principally discussed in this thesis. A few of the merits and demerits of involute teeth are spoken of.

Attention is then called to the fact that there are many ways of approximating to the true epicycloidal curve, some of which have very little effect on the true action of teeth, while others are exceedingly detrimental. The use of the describing circle in drawing flanks and faces to work together is explained. Then follows an explanation of the method of drawing rolled curves, and consequently curves for teeth, by means of normals, when no describing circle is used. In connection with this, I have added one or two problems which arise out of a consideration of this method, such as:—to find the path of contact; to find meeting points in the parts which work together; to draw clearing curves, etc. I illustrated this method with its problems with parallel flanked teeth on gears of 12 and 10 inches radii.

The importance of selecting the proper describing circle, if constructing teeth by the correct method, is next discussed. Among others, these four important elements depend on the size of the describing circle:—1st, The number of teeth in gear at any one time, and consequently the force that can be transmitted by them. 2d, The thickness of the teeth at the base, and, hence, their strength. 3d, The extent of wearing surface on the flanks and faces of the teeth, and, therefore, the durability of the teeth. 4th, The obliquity of action of the teeth, and the friction produced thereby on the bearings of shafts. The influence of the size of the describing circle upon each of these elements is discussed.

In order to clearly point out the peculiarities and differences of the various methods of designing teeth now in common use, I have drawn the outlines of two teeth of large dimensions by each method discussed. For convenience of comparison I have traced them on separate sheets, so that they can be superposed on each other, and most easily present to the eye the various points of difference.

I have discussed the : — (a.) Parallel flanked teeth ; (b.) Willis' Odontograph teeth ; (c.) Rankine's approximate method ; (d.) Haswell's approximate method ; (e.) Radial flanked teeth ; (f.) Molesworth's approximate method ; (g.) Hussey's method ; and (h.) the correct method of finding a series of circular arcs to which the true curve is tangent.

To compare with Willis' and Rankine's, I have drawn the same teeth by the correct method (h.), using the same describing circles which were used in those methods. The approximation of those methods is thus made clearly evident. With each plate I have endeavored to point out the chief peculiarities, and advantages and disadvantages as regards correctness of form, correctness of action, strength of teeth, obliquity of action, etc.

The length of addendum is then treated of, and its influence on the action of teeth. Rules for the selection of the proper addendum to give required results, are presented, together with a short discussion on the length of the arc of action most suitable for general cases. Willis' rules for addendum are given, and by them is calculated a short table for the length of addendum which would be given to certain gears, providing the arc of action was 1.4 times the pitch. The sizes of gears were selected from the pattern list of the Lowell Machine Shop. The variation in length of addendum with the number of teeth is proved by this table.

In closing, there are a few remarks about the selection of a proper method of designing teeth, which selection depends on the judgment of the designer and his knowledge of what has been done, whether that knowledge is derived from a study of good books, the opinions of practical men, or his own experience.

*The Crank as a means of converting Reciprocal into Circular Motion. Abstract by the author, J. Austin Knapp.*

This thesis begins with an historical account of the use of the crank as a means of converting reciprocating into circular mo-

tion, and of the erroneous opinions which mechanics have from time to time held regarding some of the more subtle forces developed during its action. The tendency to avoid the crank engine by the invention of rotary engines is referred to, and the theories of Mr. Charles I. Porter, of the Allen Engine Co., are then discussed.

Most of the mathematics of the thesis was given to Mechanical Engineering students of the Institute, by Professor Channing Whitaker, during the sessions of 1873-74 and 1874-75.

The principal points discussed in the thesis, show how to find the following things : —

- (a) The crank pin position from that of the piston.
- (b) The piston position from that of the crank pin.
- (c) The velocity ratio and the actual velocity of the piston and crank pin, at any point of the stroke.
- (d) The rate of acceleration or retardation of the piston at any point of the stroke.
- (e) The force producing acceleration or retardation at any point of the stroke.
- (f) The relative pressures acting on the piston along the connecting rod, perpendicular to the guides, perpendicular to the crank arm and along the crank arm.

The work is illustrated by numerous diagrams representing the positions, velocities, rates of acceleration, forces and pressures before referred to, and also showing the effect of short cut-off and of heavy reciprocating parts as modifiers of these pressures.

Several of the formulæ are applied to the case of an Allen Engine having a cylinder 16" diam., with 30" stroke, and making 120 revs. pr. m. The reciprocating parts of this engine weigh 1200 lbs.

*Governors. Abstract by the author, Wilfred Lewis.*

The purpose of the governor is to maintain the prime mover to which it belongs at a constant uniform speed. The object of

the present thesis is to show how far, theoretically, it is possible for a governor to accomplish this purpose. Accordingly, the principles upon which the various governors considered, depend for their action have been discussed. No special classification has been followed, but according to that given by Rankine, the governors contained in this thesis might all be comprised under the head of position governors, which might again be divided into those which are in principle either approximate or isochronous.

The common pendulum governor, originally invented by Watt, appears to have been the first form used on the steam engine. Beginning with this, its operation is, in the first place, considered independent of friction and resistances to be overcome by the collar, and then the effect of such resistances upon the speed of the engine is shown, and a formula deduced by which the proper weight for the balls may be calculated when these resistances are known, and any desired degree of sensitiveness assumed. This governor can in no case be perfectly isochronous, but there are several ingenious varieties, among which are mentioned the loaded pendulum governor, Porter's governor, and one or two peculiar devices for communicating the motion of the balls to the collar.

Under the subdivision of "isochronous governors" a description is taken from Rankine of his "Isochronous Gravity" governor and the parabolic pendulum governor.

Waters' spring governor and the Huntoon governor are also classed under the same division, and the principles discussed upon which their good qualities depend. As generally constructed, however, it is shown that in Waters' governor these principles are not perfectly complied with, but are sacrificed for the purpose of allowing the governor to be readily adjusted for different speeds.

The Huntoon governor differs in principle from most of the others, and seems to leave very little room for improvement.

*Cylinder Condensation. Abstract by the author, Thomas D. Plympton.*

This thesis gives the calculated results of an experiment upon cylinder condensation. The experiment is one of a series, made in the Mechanical Laboratory of the Institute during the winter of 1874-75, for George B. Dixwell, Esq. The pressure of the superheated steam was 70 lbs. per square inch. The temperature of the steam was 590° F. The real cut-off was about  $\frac{1}{4}$ .

I commence with a description of the apparatus used; and then of the manner of working up the results. I give the record of the most important readings, and the results of some preliminary experiments on the clearance and leakage of the engine. The following is a list of some of the results calculated from this experiment.

- (1.) The horse power produced.
- (2.) The total heat of the exhaust steam as derived from the calorimeter measurement.
- (3.) The weight of water used per horse-power per hour.
- (4.) The weight of steam in cylinder per stroke, from the pressure and volume given by the mean card, on the supposition that the steam is saturated.
- (5.) The equation of the expansion curve for each end of the cylinder, and the point of cut-off.
- (6.) The weight of steam passing through the cylinder per stroke from small tank measurement, which, when corrected for compression and leakage in and out, is the true weight of the steam in the cylinder.
- (7.) The pressure at different points of the stroke corresponding to this weight, on the supposition that it is dry, saturated steam.
- (8.) The temperature of the steam in the cylinder at different points of the stroke.
- (9.) The total heat of the steam in the cylinder at different points of the stroke.

*Abstract of Thesis on Steam Pumps. By F. T. Sargent.*

A pump is a device for passing a fluid through a tube. An early account of such a contrivance states that Danaus, an Egyptian, assisted by his fifty daughters, dug wells, and by means of pumps supplied the city of Argos with water. This was probably, the first water supplying company ever formed, dating somewhere about 1485 B. C. Some suppose, however, that Ctisibus, who was an Alexandrian, and lived 224 B.C., was the first to invent the pump. The pump was described by Hero, 150 B. C.

Among the first practical applications of steam was that of the Marquis of Worcester for raising water, about 1630. His device is often mentioned as a steam engine; it was, however, a steam pump, as will be seen from his description of it, in his century of inventions. But Worcester's pump was not used to any great extent.

In 1699, Capt. Thomas Savery improved on Worcester's pump, by combining with it a contrivance for producing a vacuum by the condensation of steam. This machine, however, would not raise water more than sixty feet. Newcomen improved on Savery's machine, and in 1714 built his first pumping engine. It could be placed on the surface near the mouth of the mine. Those previously used were placed in the shaft, one above the other, perhaps fifty feet apart. In 1720, Beighton applied the hand gearing. In 1775, Smeaton built a pumping engine having the parts so much better proportioned than those preceding it, that he increased the duty of the pump 50 per cent. Watt appeared about this time, 1776, with his pumping engine, making it a new machine, and in 1785 he had greatly perfected it. Engines are built, at the present time, having the same general features as Watt's engine of 1785.

But steam pumps were not to be limited to the mere draining of mines. They are now used for almost every imaginable purpose. Their demand has not exceeded the supply, if one

may judge from the vast number and variety manufactured. If we believe the makers, we shall conclude that each one in turn is "the best steam pump in the market." It is not my purpose to describe all the different styles and kinds, (this would be impossible,) but simply to give a short description of a few of the prominent ones.

After a short, general description of the manner in which steam pumps work, I have given more in detail a description of the contrivances for changing the motion of the valves at the ends of each stroke, and of any other peculiarities in the construction or the working of these pumps, that I have been able to discover.

In the case of several pumps that are said to have no dead point, I have been able, without much difficulty, to stop them so that they would not start again unless I helped them. Some steam pumps, on account of their long, and too slender piston rod, are liable to tremble considerably, when pumping against very much resistance. Where the resistance is great and where room is to be economized I should prefer one of the class in which the water and steam cylinders can be placed quite near to each other.

The numerous small steam passages of various steam pumps are objectionable, as they are liable to become choked with grease and dirt.

All the working parts of some of these pumps are inside of the body of the machine. They are well adapted for service in exposed and dusty places.

Among the pumps discussed are the Knowles,—Earle,—Blake,—Niagara,—Dayton,—Wright,—Eickemeyer,—Cameron,—Cope and Maxwell,—the Pulsometer, which is very much like a modification of Savery's pumps,—the Cornish pumping engine, the Leavitt pumping engine, and the Worthington Duplex pumping engine. The duty given by the Leavitt engine appears to be "the highest that has ever been obtained, by trial test, of any pumping engine in this country,"



the duty being 103,923,215 ft. lbs. per. hundred lbs. of coal consumed. Sixty or seventy Worthington engines are said to be used at the present time ; the duty is comparatively low, but the cost is correspondingly small.

*Locomotives. An abstract by the author, J. B. Stanwood.*

After giving a short historical sketch of the locomotive, the thesis divides into five distinct parts, which are enumerated and discussed as follows : —

1st. The description and the various uses of the locomotive. Locomotives are used for three distinct purposes, (a) for transporting passengers, (b) for transporting freight, (c) for switching or shunting cars at terminal points, thus arranging these cars into trains for the use of passenger and freight service. The engines for these separate duties have to be constructed differently, as the requirements of each demand ; these differences are stated, together with the reasons for them. A brief mention is made of Fairlie's and Meyer's locomotives and of engines used on heavy grades.

2d. Resistance and Traction. It requires work to move cars, on account of the resistance due to the friction at the rails and in the running gear, and the resistance offered by the atmosphere. The rule given by Mr. D. K. Clark (an English engineer) for calculating this resistance, is compared with a table given by Mr. M. N. Forney (an American engineer). The latter is preferred as it more nearly coincides with American practice.

Under the head of *Traction*, it is found that the power of the locomotive is proportional to its weight, within limits. The horse-power is deduced in two ways : one, by simply multiplying the resistance of the train in pounds, by the space passed over, in feet per minute. The product divided by 33,000 will be the horse power. The second way takes into account the size of the drivers, the piston pressure per square inch, and the diameter of the piston or cylinder.

3d. The Combustion of Fuel and the Evaporation of Water. Under this head are considered the values of anthracite, Cumberland (semi-bituminous) and bituminous coals for steam purposes, the results being deduced from a report by Professor W. R. Johnson to the Navy Department, upon American Coals. The advantage obtained by heating the feed-water before it enters the boiler, is discussed, and the amount, in dollars, that would be saved if the water were heated to  $150^{\circ}$  F., without any additional outlay for fuel, is calculated. This amounts to about \$80,000 for 225 locomotives for the space of one year. The Magoon Feed Water Heater is described and a figure of it given.

4th. The Boiler. Under this head, the proportions between heating and grate surface are given, Mr. D. K. Clark being taken as authority. The thickness of shell and the kinds of material used for its construction are stated, together with various methods used by builders in constructing them. The means of obtaining steam room by the use of domes and "wagon-top" boilers is described, together with a rule for the proper clearance for tubes, etc.

5th. The Cylinder. There are four important periods during one complete stroke of the piston. They are the periods of *Admission*, *Expansion*, *Exhaust* and *Compression* of the steam. Each is briefly discussed.

The efficiency of the locomotive G. Twichell, on the Boston & Albany Railroad, is deducted by comparing the amount of work which the coal that it consumes, is capable of doing, with the actual amount of work which the engine does. The result is satisfactory.

## DEPARTMENT OF MINING ENGINEERING.

*An Article on Salt. By Moses D. Burnet. (Abstract.)*

A short introduction is given. The subject is then treated under the following heads : —

1st. What constitutes a good salt.

2d. A short description of the salt manufacture, with a discussion of the properties taken advantage of, and the processes used to obtain purity in salt.

3d. Efficiency of pumping processes, as shown by analyses.

4th. Analyses of foreign and domestic salts, showing their comparative merits.

*The Stamps of Lake Superior compared. By C. W. Goodale.  
(Abstract.)*

In this thesis the author has striven to compare the different kinds of stamps from a theoretical point of view. He has calculated the mechanical power exerted per square inch of shoe surface of the stamp. A considerable amount of data has been collected, and a careful description given of the working of the three principal varieties of stamps, namely — the Ball steam stamp, the atmospheric stamp, and the fall or pestle stamp.

*Report on Burleigh Tunnel Ore, Colorado. Abstract by  
B. A. Oxnard.*

The ore which was given me to work up is one which comes from one of the veins discovered in running the Burleigh tunnel through the mountain, near Georgetown, Colorado. This enterprise, started by Eastern capitalists, was under the direction of Mr. Charles Burleigh, the inventor of the steam drill of the same name. These drills were exclusively used in the boring of the tunnel. At Georgetown were worked a number

of rich silver mines in this very mountain, and the tunnel was pierced with the double intention of, 1st, Discovering, if possible, new lodes; (as before stated, it was from one of this latter kind of lodes, the ore under consideration came). 2d, Ventilating, draining and otherwise, assisting in the working of the then existing mines.

The sample given me was supposed to be a fair one, indicating the relation between the mineral part and the gangue in the ore, also showing the average richness of the mineral part. It came to me in lumps and powder. The examination was begun by making a search for the minerals contained in it. The greater part was galena and zinc blende, in noticeable quantities, iron pyrites and some copper pyrites. The gangue was mostly siliceous, with little specks of mica here and there, and some feldspar and clay. There was also observed a little decomposed siderite, but not enough to give any trace of CO, in the analysis of the ore.

The work assigned to me was the extraction of the lead and silver from the galena, and that of the silver from the zinc blende. The blende for this did not have to be reduced to the metallic state. The weight of the ore sample was 214 lbs. 12 oz. I went all over this lot, breaking it into small pieces and putting aside a specimen of all the different minerals found, for blowpipe analysis. Their names have been given above. Another object of the picking and breaking up of the ore, was to sort out as much as possible of the galena which was free from blende, as this would save the trouble of separating it by jigging. The ore was thus divided into two lots, one consisting of pure hand-picked galena, the other, of mixed galena, blende, gangue, etc.

These lots by weight then were:—

Blende, galena, etc., portion . . . . .	176 lbs. 6 oz.
Galena (hand picked) . . . . .	33 " 6 "
Samples of minerals . . . . .	4 " 4 "
<hr/>	
214 lbs. 0 oz.	

Each portion of the ore was then crushed, first in a Blake crusher, and then between rolls, the galena to  $\frac{1}{40}$  in., the blende-galena to  $\frac{1}{4}$  in. After crushing, the portions weighed: —

Blende-galena portion . . . . .	176 lbs. 8 oz.
Galena (hand picked) . . . . .	33 " 2 "
	<hr/>
	209 lbs. 10 oz.

I explain the increase in weight of the galena-blende, by the fact that the galena being crushed first, some of the dust was not removed, but was taken up after with the blende-galena. After the crushing, each part was well mixed, and a sample was taken from each, of which a complete analysis was made.

The two samples being analyzed, first qualitatively and then quantitatively, were found to contain: —

#### ANALYSIS OF BLENDE-GALENA PART.

Lead . . . . .	36.00 per cent.
Zinc . . . . .	7.84 "
Iron . . . . .	9.81 "
Copper . . . . .	0.33 "
Sulphur . . . . .	21.22 "
Silver . . . . .	0.06 "
Gangue . . . . .	16.43 "
Water . . . . .	0.75 "
Undetermined . . . . .	5.56 "
Total . . . . .	<hr/>
	100.00 per cent.

#### ANALYSIS OF GALENA PART.

Lead . . . . .	73.60 per cent.
Zinc . . . . .	0.45 "
Iron . . . . .	4.19 "
Copper . . . . .	0.39 "
Sulphur . . . . .	16.33 "
Silver . . . . .	0.128 "
Gangue . . . . .	2.62 "
Water . . . . .	0.35 "
Undetermined . . . . .	1.942 "
Total . . . . .	<hr/>
	100.00 per cent.

## The ore after sampling weighed. —

Blende-galena portion . . . . .	171 lbs. 0 oz.
Sample ditto . . . . .	5 " 2 "
Galena portion . . . . .	31 " 6 "
Sample ditto . . . . .	0 " 10 "
Total . . . . .	208 lbs. 2 oz.
Dust lost in blende galena portion . . . . .	0 lbs. 6 oz.
Dust lost in galena portion . . . . .	1 " 2 "

The galena portion was now all ready to roast, having been picked so as to require no ore-dressing. It was therefore put aside for the time. The blende portion had to be dressed, so as to separate the galena, blende and gangue, from each other. The specific gravity of the two minerals differing very greatly, that of galena being from 7.25 to 7.70, and that of blende from 3.5 to 4.0, a very good separation could be effected by jiggling.

As a preliminary step, the ore was separated by sieves into five sizes, viz. : —

- 1st size, that which remained on  $\frac{1}{4}$  in. mesh.
- 2d size, that which passed  $\frac{1}{4}$  in., but remained on  $\frac{1}{8}$  in.
- 3d size, " "  $\frac{1}{8}$  in., " "  $\frac{1}{20}$  in.
- 4th size, " "  $\frac{1}{20}$  in., " "  $\frac{1}{40}$  in.
- 5th size, " "  $\frac{1}{40}$  in.

The first three sizes were put each separately on the jig. In this case the operation was made easier by the iron pyrites in the ores, which being intermediate in specific gravity between galena and blende, formed a bright thin layer between the other two minerals. It was of great importance that as little blende as possible should be mixed with the galena, as it would be in the way in the future work, but it did not make as much difference whether the blende was mixed with a little galena or not. The iron pyrites did not harm either part. The course I followed was this: After having skimmed off the gangue I skimmed off the blende and the layer of pyrites, leaving only the galena. Some of the galena was taken with the blende to make sure that no blende remained in the galena. This accounts for the rather high percentage of lead found in the blende part. The ore was put in so as to be about

three inches deep for the larger sizes, and about two inches for the smaller. I gave about one hundred strokes for each portion, and the separation appeared good in each case. The jig was a  $\frac{1}{30}$  in. sieve placed in a large tub of water, and suspended to a spring board above. A good deal of ore which had not passed in the dry sifting went through the  $\frac{1}{30}$  in. sieve. This was collected and treated on the shaking table, as was also the  $\frac{1}{40}$  in. product and that which had passed the  $\frac{1}{40}$  in. sieve. The principle of separation in the shaking table is to throw the ore up an inclined plane by means of a jerk at regular intervals, while water, between the jerks, causes it to go down. By regulating the stream and the slope of the table, the water may be made to carry off the blende and gangue, leaving the galena on the jerking table.

There were three parts from the jig, viz.: — galena, blende, and gangue portions. The gangue portion having been jigged several times to get all the mineral part out, was then put aside and not worked any more. The ore from the shaking table was also divided into three parts, viz.: — a galena portion, a mixture of gangue and blende, and a slime which was not worked.

The weights from the jig were: —

Gangue portion	.	.	.	.	.	.	20 lbs. 7 oz.
Blende portion	.	.	.	.	.	.	48 " 0 "
Galena portion	.	.	.	.	.	.	63 " 6 "
							<hr/> 131 lbs. 13 oz.

The weights from the shaking table were: —

Slime	.	.	.	.	.	.	2 lbs. 14 oz.
Blende and gangue portion	.	.	.	.	.	.	13 " 0 "
Galena	.	.	.	.	.	.	29 " 4 "
							<hr/> 45 lbs. 2 oz.

Samples were taken of the three portions from the jigs and two portions from the shaking table, and they were analysed for lead and zinc, and assayed for silver, with the following results: —

GALENA FROM JIG.							
Lead	.	.	.	.	.	.	70.36 per cent.
Zinc	.	.	.	.	.	.	0.75 "
Silver	.	.	.	.	.	.	0.103 "

## ZINC BLENDE FROM JIG.

Lead . . . . .	14.27	per cent.
Zinc . . . . .	20.75	"
Silver . . . . .	0.035	"

## GANGUE FROM JIG.

Lead . . . . .	6.28	per cent.
Zinc . . . . .	0.88	"
Silver. . . . .	0.013	"

## GALENA FROM SHAKING TABLE.

Lead . . . . .	62.65	per cent.
Zinc . . . . .	1.90	"
Silver . . . . .	0.087	"

## BLENDE AND GANGUE FROM SHAKING TABLE.

Lead . . . . .	14.15	per cent.
Zinc . . . . .	10.89	"
Silver. . . . .	0.035	"

The galena had now been separated from the rest of the ore and after drying and crushing to  $\frac{1}{40}$  in., the different parts weighed:—

Galena hand picked . . . . .	31 lbs. 6 oz.
“ from jig . . . . .	63 “ 6 “
“ from shaking table . . . . .	29 “ 4 “
Total Galena . . . . .	124 lbs. 0 oz.

An analysis of this gave:—

Lead . . . . .	69.35	per cent.
Silver . . . . .	0.106	"

(The per cent. in this case were calculated from the aliquot parts.)

This galena was roasted in a reverberatory furnace at a heat just below the fusing point of galena. The object of the roasting is to drive off the sulphur and this would be retarded by the caking of the galena. The ore is stirred constantly to expose every part of the ore. In this case, I failed to avoid caking by fusion, but the lumps thus formed were broken up as much as possible by the stirrer. The roasting went on for three and one-half hours, at the end of which time no more sulphur came off from the ore. A sample was taken at the end of two hours' roasting, also at the end of the roast, and they were analyzed for sulphur with the following results:—

Sulphur after 2 hours roast . . . . .	8.61	per cent.
“ “ $3\frac{1}{2}$ “ . . . . .	8.15	"
Before roasting, the hand picked galena contained	16.33	"



The roasted galena was then analyzed with the following results: —

Lead	:	:	:	:	:	:	:	59.28 per cent.
Silver	:	:	:	:	:	:	:	0.11 "
Weight roasted Galena	:	:	:	:	:	:	:	113 lbs. 11 oz.

The great loss of lead was in the lead fumes which went up the chimney during the roasting. The theoretical amount of lead to be got from the roasted ore was then 67 lbs. 6 oz., and the silver 0.125 lbs.

A flux was calculated for the roasted galena according to the percentage of sulphur and lead in it, which consisted of 52.4 lbs. magnetite and 4.9 lbs. charcoal dust, to 100 lbs. of ore. 60 lbs. of ore were mixed with the fluxes in the above proportions; but, one charge of ore of 15 lbs. having been tried, it was found by its action on the crucible, that there was too much iron for the amount of coal, and consequently 4 lbs. charcoal dust were added to the remaining 45 lbs. The result proved more satisfactory. The iron is put in to reduce the sulphide of lead to lead and to take up the siliceous impurities. The charcoal reduces the oxides of lead and iron that are formed. When the 45 lbs. ore gave out, each charge of 15 lbs. of ore was mixed with 2 lbs. charcoal and two thirds as much magnetite in proportion, as before. The estimate of magnetite was at first too large on account of an error in the estimation of the per cent. of sulphur in the roasted ore, which was caused by an impurity in one of the laboratory reagents.

The number of charges fused was 8, out of which, one charge went through the crucible and about 4 lbs. of metallic lead were lost. 7 of the 8 charges had 15 lbs. ore, and the 8th had 8 lbs. 10 ozs. The charges were smelted by being first well mixed with the fluxes, and then put into a black lead crucible and fused at a bright red heat from two to three hours until the whole mass was perfectly liquid. The charge was then poured into a mould. Great care had to be taken to heat the black lead crucible very gradually, as they are liable to crack if this is not done.

The result of the smelting consisted of the slag, matt and

51 lbs. 6 oz. crude lead. If the 4 lbs. lost by poor crucible were added to this it would give : —

Total lead obtained (about) . . . . .	55 lbs. 6 oz.
Theoretical amount of lead in ore . . . . .	67 " 6 "
Loss in slag and matt . . . . .	12 lbs. 0 oz.

This would show that between 17 and 18 per cent. of the lead had gone into the slag, matt and fume.

The crude lead was refined by fusing it, to drive off the sulphur, and by sweating it. This gave 47 lbs. 14 ozs. of refined lead, which was assayed for silver with the following result : —

Per cent. silver obtained in lead . . . . .	0.21
Weight silver . . . . .	0.101 lbs.
Loss on theoretical amount . . . . .	18 to 19 per cent.

The lead was melted in a cast iron pot and heated to driving. 2 lbs. 6 oz. of zinc (5 per cent. of the amount of lead) were melted in a black lead crucible, and just as oxide of zinc was beginning to be formed and to burn, it was poured into the molten lead and the bath having been thoroughly stirred, the zined lead was poured into ingots. The process of extracting silver out of lead, by means of zinc, is called "Parke's process" after the name of its inventor. It depends on the fact that when zinc and silver lead are mixed at a strong red heat nearly all the silver goes with the zinc.

It consists of 5 stages. 1st, Zincing the lead. 2d, Sweating off the pure lead from the argentiferous zinc lead, owing to the lower fusing point of pure lead. 3d, Refining the lead, thus obtained. 4th, Removing the zinc from the argentiferous zinc lead by distillation. 5th, Cupelling the argentiferous lead. The first stage I have already described. The ingots were then put on the sweating furnace, and the pure lead melted from the zined lead. The lead thus melted was refined by driving off the zinc, and it was then assayed for silver, giving 0.0038 per cent. Ag. Before refining, the weight of the lead was 38 lbs. After refining, it was 34 lbs. 5 oz. The loss was due to the escape of lead fumes as well as to the driving off of the zinc. The argentiferous zinc lead was then refined by distilling off the zinc at a bright red heat in a black lead crucible.

Charcoal was put on top of the molten liquid to reduce the litharge formed while the oxide of zinc burned off. The time taken to distil the zinc was two hours. The argentiferous lead was then poured into ingots and weighed 9 lbs. 1 oz. A sample of this was taken and assayed 0.855 per cent. Ag. The argentiferous lead was then cupelled in a cupel furnace. The furnace was first heated to a bright redness and the ingots of lead were put in one by one, and as they oxidized, the litharge was poured off. The ingots were put in 3 hours 30 minutes after the fire was started, and the button blicked 2 hours 23 minutes after the lead had been put in. The silver button weighed 22.7782 grs. or .0502 lbs. instead of the theoretical .0782 lbs. which had been put on the cupel.

The cupel was made by mixing 15 lbs. of bone ash, 2 oz. fire clay and 6 oz. litharge.

		Per cent. Ag.	Wt. Ag in lbs.	Loss Ag since last operation.	Per cent. Pb.	Weight Pb.	Loss Pb since last operation
124 lbs.	Galena	0.103	.1314		69.35	86 lbs.	
118 lbs. 11 oz.	Roasted Galena	0.11	.1252	.0062	57.23	67 lbs. 6 oz.	18 lbs. 10 oz.
51 lbs. 6 oz.	Crude lead				100.0	51 lbs. 6 oz.	16 lbs. 0 oz.
4 lbs.	Loss by accident						
47 lbs. 14 oz.	Refined lead	0.21	.1005	.0247	99.8	47 lbs. 14 oz.	3 lbs. 8 oz.
9 lbs. 1 oz.	Argentif. lead	0.815	.0782		99.2	9 lbs. 1 oz.	4 lbs. 8 oz.
34 lbs. 5 oz.	Comm'l (refined)	0.0038	.0013	.0210	100.0	34 lbs. 5 oz.	43 lbs. 6 oz.
0502 lbs.	Silver button	100.0	.0502	.0293	.0	0	9 lbs. 1 oz.
Lead obtained.							34 lbs. 5 oz.
Silver obtained				.0502			Total lead in ore, 86 lbs. 0 oz.
				.1314			total silver in ore.

	0.1314 lbs.	Loss of lead.	Loss of silver.
Silver in the ore . . .	86 " 0 oz.	18 lbs. 10 oz.	0.0062 lbs.
Lead in the ore . . .		12 " 0 "	} 0.0247 "
Loss from roasting . . .		4 " 0 "	
Loss from smelting . . .		3 " 8 "	
Loss by accident . . .			} 0.0223 "
Loss from refining . . .		4 " 8 "	
Loss from zincing . . .			
Sweating and distilling . . .		9 " 1 "	} 0.0280 "
Loss from refining lead, with silver taken out		34 " 5 "	
Loss from cupelling . . .			} 0.0502 "
Lead obtained . . .			
Silver obtained . . .			

The zinc portion was carefully worked, roasted, ground with salt, and re-roasted and amalgamated, but owing to an accident at the last moment the yield of silver was greatly reduced. In the place of .021 of a lb. of silver which the ore contained, only .003 were extracted.

*Working of an ore of Silver and Lead from Newbury, Mass.*

*Abstract by Wm. H. Shockley.*

This thesis describes the situation of Newbury, the story of the discovery of the mine, a mention of the gneiss rocks in which it is found, and quotations of analyses of the vein stone. The ore that was worked was float ore from the Chipman Lode. The ore presented the usual appearance of a float ore being covered with oxide of iron and various decomposed minerals. An examination was made of the mineral species, and the following were detected. Galenite, quartz, siderite, limonite, hematite, pyrite, chalcopyrite, tetrahedrite, malachite, azurite, zinc blende, crocoisite, kaolin. The principal mineral constituents are galena, quartz and pyrite.

A partial analysis of the ore gave:—

		<i>Calculated Minerals.</i>	
		<i>No. 1.</i>	<i>No. 2.</i>
Silica . . . .	16.18	Quartz, 13.61 . .	13.61
Lead . . . .	45.39	Sphalerite, 1.21 . .	1.05
Copper . . . .	1.33	Chalcopyrite, 3.84 . .	1.65
Zinc . . . .	.81	Pyrite, 14.81 . .	15.31
Iron . . . .	8.34	Kaolin, 5.17 . .	5.17
Alumina . . . .	2.23	Siderite, .53 . .	.53
Sulphur . . . .	16.70	Galenite, 52.68 . .	52.55
Carbonic acid . . . .	.20	Limonite, 5.10 . .	5.72
Ferric oxide . . . .	5.10	<hr/> 96.95	<hr/> Tetrahedrite, 2.15
Silver . . . .	.20		97.74
Gold . . . .	.002		
Undetermined (As, etc.),	3.52		
	<hr/> 100.00		

No. 1 is calculated directly from the ore analysis. Now if we assume the galena to have 19 per cent. Ag. (and this assumption is warranted by the assays) we shall have the galena in the ore (52.41 per cent.) taking 10 per cent. of the silver,

and if the remainder be assumed to constitute the 4.65 per cent. of the tetrahedrite, (which the assay shows to be the case) we shall have the basis for the result given in the second column.

The value of a ton of this in currency is (gold, 1.15) : —

907 lbs lead,	\$54.46
58.32 oz. silver,	86.81
.58 oz. gold,	13.89
	<u>\$154.96</u>

An examination was made of the various qualities of galena to see how the silver was distributed. The results of the assays are : —

	Per cent.	oz.	
Coarse galena from 30' below surface,	.35	102	\$131.65
Medium galena from ore,	.09	29.16	37.61
Fine " "	.22	65.90	85.01
Tetrahedrite "	4.65	1357.19	1750.77
" from Chipman Shaft	2.30	670.68	865.17
Other tetrahedrites have varied from \$500-\$1300.			

#### DETAILS OF WORKING ORE.

*Weight = kilogrammes.*

The ore was in large lumps weighing from 10 to 30 kilos. The first operation was to break up these lumps and pick out the ore to be worked. At the same time pieces were picked out and examined for the minerals.

The weight of the whole lot was 816.41 kilos., the amount picked out 324.97 kilos., this being as near as possible fair sample of the whole. The ore was passed through a small Blake crusher and then through rollers; these operations were to crush the ore so it might be fit for roasting. The ore was then sampled, passed through a  $\frac{1}{20}$ " sieve, the portion remaining on the sieve was rerolled until it was judged to be about  $\frac{1}{20}$ ". The loss in crushing was .34 kilos., the sample taken out weighed 6.40 kilos., so that the ore now weighed only 311.13; the loss of 7.64 kilos. was due to sifting, rolling, and to the fact that some of the ore was overlooked and remained behind. The ore was divided into eight charges, each of 39 kilos.; it was roasted in two reverberatory furnaces, each charge being roasted four hours. A sample was taken at the end of two hours, and also

when the charge was drawn ; these samples were analyzed for sulphur ; the results of these analyses will be found farther on.

After the ore was roasted it was put in the larger of the two furnaces and agglomerated. A sample was taken of this agglomerated ore and analyzed so as to furnish data for calculation of slag, etc. The object of agglomerating the ore, was to make it strong enough to stand the pressure of the fuel and fluxes.

The percentage of sulphur before roasting the ore was 16.70 per cent. The following table shows the per cent. of sulphur removed by roasting.

<i>No. of the charge.</i>	No. 1.	2.	3.	4.	5.	6.	7.	8.
Sulphur after 2 } hours roast'g, }	7.36	7.85	6.60	7.09	not deter.	10.13	5.70	9.51
Sulphur after 4 } hours roast'g, }	4.18	6.23	4.90	4.97	not deter.	4.85	4.36	5.77

The ore after being agglomerated weighed 251.5 kilos.; a sample was taken and a partial analysis made, so that there might be data enough to calculate the amount of fluxes to be used. After these calculations were made, the ore was run in the blast furnace. The details as to the run will be found in the tables on pages 22 to 30 inclusive. A slag from the Revere Copper Works was used to start the furnace with. It was found after running some time that the proportion of flux and ore was too great for the fuel, so the charge was altered by taking only three-fourths the amount of ore and flux to the fuel; after this the furnace worked well.

The calculations were to have a basic slag; the fluxes used were puddle cinder and limestone; the exact composition of the puddle cinder was not known at the time of the calculation, but it was judged that it contained about 20 per cent.  $\text{SiO}_2$  to 70 per cent.  $\text{FeO}$ , and acting on this supposition the following charge was calculated:—

40 lbs. ore.  
25 lbs. puddle cinders.  
3 lbs. limestone.  
3 shovels coke.

This charge was afterwards changed to

30 lbs. ore.  
18½ lbs. puddle cinder.  
2½ lbs. limestone.  
3 shovels coke.

This change was made in order to bring the layers of fuel nearer together.

The analysis of the puddle cinder afterwards made and of the roasted agglomerated ore are below.

<i>Puddle Cinder.</i>	<i>Ore.</i>
FeO, 70.62	FeO, 17.11
SiO <sub>2</sub> , 15.43	SiO <sub>2</sub> , 18.47
Al <sub>2</sub> O <sub>3</sub> 9.42	Al <sub>2</sub> O <sub>3</sub> 2.57
	S, 3.27

Now this gives in each charge the following amounts:—

	SiO <sub>2</sub>	Al <sub>2</sub> O <sub>3</sub>	CaO	FeO	S
Ore,	7.39	4.03	0	6.84	1.31
Puddle cinder,	3.86	2.45	0	17.65	0
Limestone,	0	0	1.68	0	0

After allowing sufficient iron to remove the sulphur as FeS the calculation of the per cents. of the components in the slag is as follows:—

	SiO <sub>2</sub>	Al <sub>2</sub> O <sub>3</sub>	CaO	FeO	Pb
Calculated Slag	29.56	9.23	4.41	56.77	0
Actual Slag, as obtained,	30.54	9.71	4.66	48.86	2.44

The discrepancy between the calculated slag and the slag actually obtained is due to two causes; viz., the dissolving of silica from the bricks and the charging of the Revere Slag at sundry times during the run. The analysis of the Revere Slag is:—

FeO, 41.86  
CaO, 9.96  
SiO<sub>2</sub>, 37.00  
Al<sub>2</sub>O<sub>3</sub>, 6.21

The furnace was started with Revere Slag, and the first twelve kettles consisted of this and were laid aside. The remaining products were slag and lead, and a small quantity of iron matte. The lead and slag were separated, and gave 220.42 kilos. slag, 82.54 kilos. lead. There was 90.71 kilos.

foul slag, *i. e.*, slag containing too much metallic lead to be thrown away, consisting of nozzles, furnace bottom, and bits of the total slag with adhering lead. This slag was crushed and sifted; the part remaining on the sieve, jigged; the portion going through the jig treated on the Spitz-lütte. The products from these operations were smelted, and 8.16 kilos. of lead obtained; this was put with the cake lead, increasing its weight to 90.70 kilos. From each cake as it was broken up, a piece of pure slag was picked out; these bits were crushed and sampled and an analysis made of the sample. It is to this analysis that I have reference when speaking of slag, page 20. An analysis was also made of the total slag—it gave 290 per cent. Pb, *i. e.*, 6.39 kilos. Now the amount of lead that should have been obtained is 143.95, the amount that was obtained is 90.71 k.; this with the amount in the slag = 97.10 k. or 67.45 per cent., thus showing a loss in the operations of smelting and roasting of 32.55 per cent.

I am not able to state how much of this loss is due to roasting nor how much is due to smelting. The loss is probably caused by fumes, and it must be caused by volatilization, because all the products have been assayed for lead and none has been found, save as stated.

The cake lead was now refined. It was attempted to do this in a crucible by skimming, but this was found impracticable on account of the great impurity of the lead. The lead was, for the foregoing reasons, run into ingots and sweated. The resultant lead, 62.5 kilos. was quite pure and was all ready to be zinced. This lead was assayed for silver and gave .448 per cent. or 280.31 grms Ag.

There was formed during this process of refining, quite an amount of skimming. There was also quite an amount of dross left on the sweating furnace. Both of these compounds contained a large amount of copper. They were smelted and from the smelting was obtained 7.7 kilos. lead, containing .341 per cent. Ag. or 26.26 grammes; and 12.70 kilos. lead with .332 per cent. Ag. or 42.16 grms. The 7.7 kilos. was from the



skimmings, the 12.70 k. from the dross. The loss of lead by this operation was 7.74 kilos.; the loss of silver cannot be told.

The lead obtained from the smelting of the skimmings and dross was very rich in copper; now it was desired to remove the silver from the lead by zincing. Copper is a detriment to this process and therefore it was advisable to remove it (*i. e.*, the copper). The method devised for doing this depends on the greater affinity of sulphur for copper than for lead. If galena and copper are heated in a reducing atmosphere, lead is set free and copper matte (sulphide of copper) is formed. Taking advantage of this fact, the copper was removed from the lead. The maximum amount of copper that could be present, being known, enough galena was added to change this to sulphide, also a sufficient amount of pyrrholine, magnetic pyrites, was added to make a matte of the formula ( $\text{Cu}_2\text{S FeS}$ ) and the fusions were made. The results were very good, a matte rich in copper and a lead very free from copper were obtained.

Weight of lead, 15.25 kilos.

" " matte, 5.90 "

The subsequent operations of desilverizing the lead, cupelling to fine silver and recovering the lead from the various products, yielded very unsatisfactory results, owing to defects in the cupel furnace and other apparatus.

*Treatment of a Silver Ore from Silver Islet, Wood's Location, Ontario, Canada, Lake Superior. Abstract by the author, H. L. J. Warren.*

The ore was of low grade, the assay value being only about \$10 to the ton. The silver was present in three modifications, native, sulphuret, and argentiferous galena. In securing a good concentration of the valuable minerals was found the main difficulty in its treatment. These were present in such minute particles, and the gangue was of so refractory a nature, consisting chiefly of calcite with a small amount of heavy spar, which, after the ore was passed through a  $\frac{1}{16}$  mesh, were

reduced to a large extent to a fine powder, which so completely enveloped the ore itself when treated on the jig, or bump table, that no satisfactory separation could be made. After a number of fruitless attempts the bump table furnished two products, a slime, and the remainder of the ore. These were then treated by the spitzlütte of Rittenger, which in the end gave quite satisfactory results. The following table shows the final products both those of value and the waste. It explains itself.

<i>Rich concen- trated mineral.</i>	<i>Weight in kilo- grams.</i>	<i>Percent. of silver.</i>	<i>Value of silver.</i>	<i>Waste products and slimes.</i>	<i>Weight in kilo- grams.</i>	<i>Per ct. of silver.</i>	<i>Value of silver.</i>
Original ore	81.5	.0286	\$0.93	Original slime	18.6	.013	\$0.098
Product A.	.654	.2351	.0061	Spitzlütte slime	5.7	.005	.011
" B.	.065	1.2563	.032	2d bump table slime	1.3	.016	.008
" C.	.081	.8751	.628				
" D.	.163	.0935	.006				
" E.	.109	.310	.013	Product H.	8.7	.008	.027
" F.	1.431	.307	.175	" K.	2.8	.007	.008
" G.	.051	.164	.040	" M.	3.4	.010	.014
" H.	.651	.473	.009	" P.	4.5	.009	.016
" I.	1.383	.096	.053	" R.	6.2	.011	.027
" J.	.810	.197	.064	" W.	3.8	.019	.029
" K.	.741	.099	.029	" V.	4.9	.017	.025
Total	6.105		0.51	" X.	3.6	.020	.029
Totalsmelt'g pro.	6.105	.241	.59	" Z.	3.9	.009	.014
Accounted for	77.8		.91	" D.	4.3	.008	.013
Loss	3.3		.62		71.7		0.319

*Working of an Ore from Middletown, Ct., by Wm. R. Webster.*

(No abstract furnished.)

#### DEPARTMENT OF ARCHITECTURE.

*Design for the buildings for a City Water Works. Abstract by the author, Amos J. Boyden.*

The problem for solution in this thesis required designs for an Engine House and Stand Pipe Tower in the public park of a small city, together with such other buildings, or architectural adornments, as would be conducive to the convenience or pleasure of visitors to the park.

In the design, the plan of the engine house resolves itself into three parts, as follows: —

1st, that part devoted to the government of the works, occupying the front of the building, and two stories in height. The principal rooms on the first floor of this part are, an office with adjoining ante-room, a visitors' room, a commissioners' room and a lavatory. These rooms are ranged along the main entrance hall, from which a stairway leads to the second floor, and to the basement.

On the second floor are five large well lighted rooms and a bath room. This floor is designed for the use of the resident engineer and his family.

2d. Part second of the building consists of the engine room and an adjoining boiler room, the floor of which is four feet lower than that of the engine room. A gallery runs around the engine room, access to which is gained from the first landing of the stairs from main hall to second floor.

3d. Wings one story in height extend from the engine room and from the boiler room to the retaining wall in the hill side, into which they run several feet. The boiler room wing is designed for a coal house, and is so situated that the coal may be dropped from the carts directly into the bins.

The engine house wing is divided into a machine shop and a carpenters' shop.

A chimney shaft 106 feet high is situated near the boiler room, on the axis of the plan.

The water is to be forced a distance of about 600 feet to the stand pipe tower, which is 160 feet high, 24 feet square at the base, and 20 feet square at the top. Adjoining the tower is a small gate house.

The most architectural building in the park is a refreshment hall, containing waiting rooms for ladies and gentlemen, a hall for pleasure parties, and various smaller rooms shown on the accompanying plans. As in the engine house, wings extend to the retaining wall, the flat roofs of which give access to the

hall, while the rooms below may serve as ice house, and cellar, and the well lighted part as kitchen.

The required thickness of the retaining wall, 24 feet high, was calculated and found to be 7.65 feet at the base. The roof trusses of the engine house are large primary trusses, composed of two wooden rafters, connected by an iron tie rod, the rafters being supported by three small secondary trusses. The stresses in the various pieces of one of these trusses have been calculated. The required sectional area of the rafters was found to be 29.06 square inches.

Calculations were also made for the required indicated horse power of the engines.

#### DEPARTMENT OF CHEMISTRY.

*Anthracene Pressings. Abstract by the author, Leonard P. Kinnicutt.*

My thesis can be divided into the following principal topics:

1. Historical notice of the discovery of Anthracene.
2. Description of the manufacture of Anthracene.
3. Anthracene Pressings.
4. The partial separation of the Hydro-Carbons, which compose these pressings, into four principal products, by means of the difference of their solubility in alcohol.
5. The determination of Anthracene in the four products, by means of Suck's test.
6. Forming crystals, by treating each of the four products with a solution of picric acid.
7. The finding of Phenanthrene in the pressings.
8. The Phenanthrene colors, and the value of Phenanthrene in the future.
9. The value of a quantitative test for Phenanthrene.
10. Testing the different methods by which it would seem possible to determine Phenanthrene quantitatively.

11. The comparison of the different methods, and the reasons for changing Phenanthrene into Phenanthrene Quinine, for the determination of Phenanthrene in this investigation.

12. The determination of Phenanthrene in the four different products.

13. The general result of my work.

#### DEPARTMENT OF PHYSICS.

*Report of a series of experiments made with a Holtz Machine.  
Abstract by the author, S. J. Mixter.*

1. An account of previous measurements of electrical machines by Moscart and Rossetti.

2. The machine used in my experiments was made by Mr. E. S. Ritchie. It has a single plate 2 feet in diameter. The motor was a small high pressure steam engine, having a cylinder 2 inches in diameter, and  $3\frac{1}{4}$  inches stroke. The work was measured by a form of dynamometer first used by Huyghens; the principle involved is, that the work transmitted through a belt equals the speed of the belt into one-half of the difference in the weights which balance on the two sides of the driven pulley. The strength of the current was measured by a galvanometer made from the secondary coil of a resistance coil, having a resistance of 6,313 ohms, and whose constant was accurately determined.

3. Various series of experiments were made to determine the work converted into electricity.

(a.) Amount of work required to run the machine when discharged and charged, varying the length of the spark.

(b.) On the absolute strength of this current, and the amount of work converted into electricity. From the results obtained the electromotive force and interior resistance were calculated.

Curves representing the several series of observations are given.

## DEPARTMENT OF SCIENCE AND LITERATURE.

*The Empire of Austria. By Wm. A. Prentiss. Abstract.*

Area and physical features ; Component parts of the Empire ; Ethnology ; Vegetable and mineral products ; Statistics of Commerce ; Early history and growth of the Empire ; Present constitution and government ; Austria since Sadowa ; Present position and prospects ; List of authorities referred to

*Switzerland. By James Liddell Arnott.*

(Abstract not received.)

## THE DEPARTMENT OF ARCHITECTURE.

The founders of the Institute of Technology included Architecture among the branches first to be provided for, and a professorship in this department was established and the chair filled on the opening of the school in 1865. This appointment was made and accepted, however, on the understanding that the work of instruction should not be begun until proper apparatus had been collected, and opportunity given for studying the methods of professional instruction employed in architectural schools abroad. In the spring of 1866, accordingly, Professor Ware asked leave of absence and remained abroad until the end of the following year, examining the foreign schools, consulting personally with the architects in charge of them or with others who were familiar with their working, and collecting casts, photographs, drawings and other materials of instruction, which the generosity of some friends of this undertaking had given him the means of purchasing.

### THE ARCHITECTURAL MUSEUM.

The collections thus begun have gradually increased in amount and value until they will compare for interest and for serviceableness with those anywhere put at the disposition of architectural students, supplemented as they are by the collections of the Museum of Fine Arts, established in the immediate

neighborhood, and by the treasures of the Boston Public Library, whose trustees, as well as those of the Boston Athenæum, have done everything in their power to increase the facilities for their use. Some unusually favorable circumstances rendered these collections, even at the outset, much more extensive and valuable than was reasonably to be looked for, especially in respect of mediæval sculpture and carvings, and architectural drawings. A large and almost unique collection of casts from Lincoln and Southwell minsters, fortunately fell into our hands, which was afterwards supplemented by considerable additions from French Gothic work of the same period. To the generosity of the late Mr. Ernst Benzon, formerly a merchant of Boston, we were indebted for an unusually good collection of school drawings, made by students in architecture at the École des Beaux-Arts in Paris, and at the French Academy in Rome. These have been added to, as circumstances have favored, until we now have a series of works, illustrating every stage of study, which for completeness and extent, as well as for intrinsic merit and usefulness as examples to the student, is hardly to be found elsewhere, even in the ateliers of the École des Beaux-Arts itself. These collections were largely augmented by the kindness of many gentlemen, mostly architects, who, both in England and on the Continent, as well as on this side the water, evinced a kindly interest in our undertakings and gave not only photographs of their works, but tracings and lithographic copies of working drawings, with specimens of specifications, estimates, bills of quantities, and various forms of business papers. We are under special obligations to Mr. Waterhouse, Mr. Withers, Mr. Norton, Mr. Nash, Mr. Rickman, Mr. Keeling, Mr. Edis and the late Mr. Papworth, in London, to Mr. Bryce in Edinburgh, and the late Mr. Thomson in Glasgow, and to M. Viollet-le-Duc, M. Charles Garnier and M. Lesoufachér in Paris. M. César Daly, a constant friend of this country, presented to the department his valuable work illustrating the domestic architecture of the Second Empire, and the French Minister of Public Instruction,



M. Duruy, acting through our minister, General Dix, put at our disposition a number of illustrated works relating to the architectural history of France, among which are the magnificent monograph of the Cathedral of Chartres, and the two volumes entitled the "Statistique Monumentale de Paris." The Institute of Scottish Architects, and the Architectural Publication Society of London, added a number of valuable publications, while the Royal Institute of British Architects, not only presented us with a complete set of their valuable and interesting Proceedings, but were good enough to put us upon their books, so that we have since continued regularly to receive the papers they have published. The *Société Centrale des Architectes* in Paris also send us the papers they from time to time put forth. This beginning of a library was largely added to in the summer of 1872, by means of a fund specially collected for the purpose, so that the books on the shelves now number three hundred and fifty volumes, most of which are excellently suited to the wants of the students and are constantly consulted by them. These books, as well as the photographs, prints and drawings, which also have been largely added to from year to year, are at all times accessible to the students, and are freely used by them. It has not been found that this freedom has been abused to the injury of the collections, and the advantage to the school is so great that it is worth while to run a considerable risk, rather than limit their serviceableness.

Besides the casts, photographs, books and drawings, the most noticeable thing in the collections is the stained glass, a part of which has been purchased, but it is in great part the gift of the makers. It is arranged on four movable screens and comprises work by Messrs. Morris & Co., Lavers, Barraud and Westlake, Heaton, Butler and Bayne, Clayton and Bell, Cottier & Co., J. T. Lyon, and G. E. Cook of London, and Messrs. Cook, and McPherson & Co., of Boston, besides some fragments of mediæval work.

A detailed memorandum of these collections is given in the Appendix.

## COURSE OF INSTRUCTION.

The Museum was arranged during the spring and summer of 1868 and the department opened with four pupils, in October of that year. This number has gradually increased until there are now thirty-two students in attendance, ten of whom are regular students in the Institute, pursuing a four years' course of study, and taking architecture in addition to the mathematical and scientific work pursued in other departments of the school. The other twenty-two are special students, pursuing a two years' course which is confined to the strictly professional work. The special students, however, give all their time to their studies, the same as the others; the plan of having students spend part of the day in architects' offices and part at the school was tried for a year or two, but it did not prove satisfactory in any respect, and is now given up.

This professional work consists chiefly in successive exercises in architectural drawing and design, introductory to which are given lectures, with practical exercises, in shades and shadows and in the elements of architecture, beginning with the orders and giving simple rules for laying them out, and going on to doors, windows, staircases, arcades, vaults, domes and roofs. The history of architecture is then taken up, the Greek and Roman history first, which is gone over with every class as soon as they have completed these elementary studies, followed by the history of the Mediæval and of the Modern styles, which for convenience are taken up in alternate years. The more advanced students have lectures once a week on the theory of architecture, and upon the arts specially related to building, such as stained glass, mosaic, color, carving, etc. Once a week throughout the year is a lecture upon specifications and working drawings; carpentry and its related subjects being taken up one year and masonry, etc., the next, so that the whole course occupies two years. This subject is necessarily treated in a somewhat superficial manner, since it is the object of the department to give the instruction that cannot be obtained in

architects' offices, leaving students to learn what can there best be learned during the term of their service as draughtsmen. But the rapid survey these lectures afford is found to be worth the small amount of time it consumes, serving as a sort of review of the subject to those who are already familiar with it, and as a serviceable preparation for office work to others. To both it is useful, as giving a more comprehensive view of the subject than office experience is apt to afford.

Instruction is also given in Perspective, Descriptive Geometry, Stereotomy and Free-hand Drawing. The practice in architectural drawing begins with elementary exercises in india ink, with the pen and with the brush, followed by exercises in the use of india ink and color, beginning with architectural details or fragments on a large scale, and going on to plans, elevations and details, first copied from books, and, the next year, drawn from actual measurement of buildings in the neighborhood of the school. Drawings have, in this way been made of King's Chapel, the First Church, the Central Church, Emmanuel Church and some others, the spires of Park Street Church, the Old South, Hollis Street Church, and Christ Church in Salem Street, of the principal railway stations in Boston, and of a number of dormer windows and doorways, and details of cast and wrought iron work and of ornamental brick work.

The practice in design begins with simple problems intended as practice in the use of the orders, and goes on gradually to the higher class of monumental work, and to buildings of complicated and difficult plan. Among the subjects of these exercises have been the following: — A Porch to a Private House, a Drive-way, a Campanile, a Peristyle, a Staircase under a vault or dome, the employment of four (or six) columns, a Boat House and Billiard Room, a Pavilion between two Bridges, a Monumental Bridge, the restoration of a Pompeian House, a Lamp Post, a Fountain, a Chimney-Piece, a Vestibule, a Small Museum, a Memorial Library, a Memorial School House, a Railroad Station, an Artist's House, a Monumental Chapel, a Catholic Church, Water Works in a Pub-

lic Park, an Iron Kiosk, a Casino, a Dwelling House, a School of Chemistry, a School of Medicine and a School of Architecture. As the class become more advanced, details upon a larger scale are often required. The time allowed for these problems varies from a couple of days to a couple of months according to the difficulty of the work, the experience of the students, and the number and size of the drawings required. Each class do ten or twelve of these exercises in the course of the year.

The subjects, as will be noticed, are most of them somewhat out of the line of daily experience. More practical problems would require for their solution more practical experience than such classes as these can possibly have had, involving for their solution numerous considerations of detail, which it would not do to slight, but which students in the beginning of their studies are not prepared to entertain. Work of this kind, on the other hand, while it taxes their powers to the utmost, both in the execution of the drawings and in the design, does not demand, for its satisfactory performance, any greater resources either of knowledge or skill, than they have at command. Besides, its remoteness from daily use and observation, not only stimulates the imagination and fancy, but necessitates the study of the books and of the work of the best masters.

The classes are made up, besides the regular students of the Institute, of boys just from school, of mechanics wishing to become draughtsmen in offices, of draughtsmen who have already had office experience and who wish to learn what an office does not give, and of graduates of colleges who desire to enter upon their profession in the most rapid and intelligent way. It is not possible to lay down a strict course of study that shall equally meet all the wants and occupy all the time of persons varying so much in personal training. But the special work of the school is new to all alike and serves equally well for all as their chief interest and object of study. Moreover, the largeness of the company is an advantage, and all would suffer if they were broken up into smaller groups. The work done is equally in-

structive to all, whether the result is more or less excellent in conception or in execution. In point of fact, although at the beginning of the year there is great difference in the work, by the end of the year it is often hard to tell the work of the beginners from that of the more experienced hands. Meanwhile the resources of the establishment are open to all, and as much is done, and as much is learned in volunteer work, especially tracing and sketching, not to speak of reading, as is accomplished under the requirements of the programme. The students learn much more than they are taught, and what they thus teach themselves is not likely to be forgotten.

### ARCHITECTURAL PROBLEMS.

*December 1.*

#### AN OPEN PORCH BEFORE A PRIVATE HOUSE.

The house to which this porch or portico belongs is supposed to be situated in the principal street of a city, the steps of the porch descending to the sidewalk. The upper platform or landing is to be raised nine steps from the sidewalk, the threshold of the front door forming a tenth step. This platform is to be about one hundred square feet in area, more or less. The steps must not be more than six or seven inches high, nor less than twelve inches wide. Balustrades must not be more, nor much less, than three feet in height. The whole is to be constructed of stone, and is to conform in its proportions and its details to the regular rules for the Five Orders. The whole problem is to be regarded as an exercise in the practical application of those rules. If arches are used, they will accordingly be semi-circular.

**REQUIRED:** *A Plan*, showing the platform, steps, sidewalk, and the beginning of the vestibule of the house, the horizontal section being taken at half the height of the columns, and cutting through the front wall of the house and the front doorway.

*An Elevation*, showing the front of the porch towards the street, and the main doorway at the back of the porch.

*A Section*, taken through the middle of the porch, and extending to the vestibule.

All these drawings to be made on half an Imperial sheet of Whatman paper, stretched, to a uniform scale of a quarter of an inch to the foot, and finished in pencil, with the shadows cast in India Ink. Color may be added, if desired. The elevation will be set above the plan, on the same

vertical axis, and the section at the side of the elevation. A side elevation may be added, if desired.

This sheet of drawings must be handed in on Monday, December 8.

#### A TEMPLE TOMB.

December 3.

It is the custom in some countries to erect over a grave or tomb a small temple or oratory, just large enough to cover it, containing an altar where a single mourner may offer prayers for the dead.

It is required to design such a structure, making it in the form of a small Grecian temple, with two columns, *prostyle*, all the details being Greek rather than Roman in character. The plot of ground is supposed to measure six feet by twelve.

REQUIRED : *A Plan, Section, and two Elevations*, on a uniform scale of half an inch to the foot, with details one-eighth full size, all on an Imperial sheet.

#### A DRIVE-WAY.

December 9.

The object of a Drive-way is almost the same as that of a porch ; it differs only in that it serves as a shelter, not only to pedestrians, but to those who come in carriages. The proposed structure would be part of a rich private house erected on a public square. It must be sufficiently large for a carriage to pass freely under, and at the same time give access to the main hall of the house. The plan must be so arranged that pedestrians need not meet the carriages, in order to avoid accidents. The greatest dimensions of this structure must not exceed 500 square feet. The doorway must be about four steps above the roadway, with proper steps and platforms between.

REQUIRED : *A Plan, Section and Two Elevations*, on a uniform scale of one-eighth of an inch to the foot, to be drawn in pencil, shaded with India ink, with or without color, the sections to be tinted in carmine, the plan in vermilion, and the whole to be drawn upon a half-sheet of Imperial Whatman, the top of the paper being the narrowest, and to be cut up to a uniform size of 21 inches by 14 inches, with a border within.

The drawings will be handed in on Monday, December 16, at half-past three o'clock in the afternoon. The adjacent parts of the house may be indicated.

#### A PORTICO IN A GARDEN.

December 17.

This little building is supposed to be erected at the extremity of a garden attached to a palace. It is intended for rest and shelter for persons walking in the garden, and also for the reception and protection of a number of

bas-reliefs and statues. It forms the principal object in looking across the garden from the windows of the palace, and should have the architectural character appropriate to its position and uses. It must be of only one story in height, and may be covered either by an inclined roof or by a terrace surrounded by balustrades. There must be in some part walls for the bas-reliefs. But, in general, the structure is not enclosed, and the roof is supported by arcades or colonnades. The width of these openings should not be much less than five nor much more than ten feet. Mansard roofs are not to be used. The greatest linear dimension must not exceed eighty feet. The building must comprise, within or around it, seats for conversation, steps, fountains, vases, &c.

REQUIRED : *A Plan*, on a scale of one-sixteenth of an inch to the foot, showing the arrangement of the garden in the neighborhood of the portico; *A principal Elevation*, and a *Section*, on a scale of one-eighth of an inch to the foot. This difference of scale will be found convenient in practice, as the total dimensions shown on the plan can be laid off on each side of symmetrical axes in elevation.

The whole to be drawn on two-thirds of a sheet of Whatman, the border lines enclosing the sketch being 17 and 19 inches long. To be handed in, drawn in pencil, shaded in pencil or India ink, and tinted, on Wednesday, December 24, at half-past three o'clock. Put your names and the date *on the back of the drawings*, with a minute of the time spent upon them, beginning with this morning's hour.

#### A PERISTYLE.

December 29.

We suppose a public building, built on three sides of a hollow square, to be entered by a porch or portico, of six Corinthian columns, surmounted by a pediment and preceded by flights of steps, and situated at the bottom of the court-yard. Elsewhere the court-yard is surrounded by a colonnade, which is interrupted by the portico, and which is of much smaller dimensions. It may be of either order. Arches are not permitted. The hexastyle portico will have columns twenty-five feet high, including base and capital. The size of the others is left to the taste and judgment of the designer.

REQUIRED : *An Elevation* of the portico, showing both orders, on a scale of a quarter of an inch to the foot.

*A Side Elevation*, showing a section of the colonnade, to the same scale.

*A Plan*, on a scale of an eighth of an inch to the foot, showing the entrance doorway or doorways and indicating the vestibule within.

These to be drawn on a single sheet of Whatman's Imperial and cut up to a uniform size of 18 inches by 28. To be finished, with the shadows cast in India ink, either in pencil or line, with or without color, on Monday,

January 12, at 3.30 P. M. Put on the back of drawing name, date, and number of hours' work.

#### A FLOWER STAND.

January 2.

This little structure is for the sale of flowers in a public square or park. It must be constructed of iron, open on three sides at least, with projecting roof to give shade. It may be raised on a platform of stone, with balustrades; and is to cover, exclusive of the platform, about one hundred square feet.

REQUIRED: *A Plan*, on a scale of a quarter of an inch to a foot; an *Elevation*, double that scale; and details, showing the construction, on a scale of one inch to a foot. All on a single Imperial sheet.

#### A GRAND STAIRCASE.

January 12.

This staircase is supposed to occupy the central hall or vestibule of some public building, such as a State House, Library, or Museum, in which the principal rooms are in the second story. It must be built of stone or marble. The hall or vestibule is to be covered by a vaulted or domed ceiling, and may be lighted either from above or by windows on one side, where the hall may be supposed to come to an external wall. The form of this hall, as well as that of the vault above and the disposition of the stairway itself, and the means of supporting them, is left to the judgment of each student. The staircase will extend only from the ground floor to the main floor, and the area of the hall will be about 2,000 or 3,000 square feet. The height of stories is not fixed.

REQUIRED: I. *A Plan* of the Hall taken at the level of the main story looking down upon the staircase, and showing three doorways, by which access is had to the principal apartments.

II. *Two Sections* taken vertically, at right angles to each other, showing the design of the staircase, of the vaulted or domed roof, and of the hall or vestibule in both stories. All on a uniform scale of  $\frac{1}{2}$  in. = 1 ft.

The drawings will be on half sheets of Imperial paper, and will be inked in and colored, with the shadows cast. A brown-paper sketch will be made on Tuesday morning, January 13, and the drawings handed in on Thursday evening, January 22.

#### A BILLIARD ROOM.

February 4.

This little building is situated on a bank, ten or fifteen feet above a stream navigable for row-boats and wherries, and surrounded elsewhere by gardens, of which it is a principal ornament. It comprises, besides the Billiard Room itself, the following parts:—

1. A Porch, open or enclosed.



2. A semi-circular Veranda, in the Ionic order, without arches.  
 3. A Belvidere, covering the whole or a part of the building, covered by a roof, but without walls, and communicating with a staircase. This staircase may be either external or internal.

4. A landing for boats, on a level with the water below, with proper steps and balustrades leading up to the garden and Billiard Room.

The Billiard Room itself is to be eighteen feet wide by twenty-four feet long in the clear, exclusive of niches, alcoves, recesses, and seats for spectators of the game. It must be lighted by windows in the side walls, the arrangement and composition of which constitute a chief point in the problem. But light from the roof, over the billiard table, may also be introduced if desired. The table is six feet by twelve.

The walls and cornice of the building are to be of light-colored stone or marble, as also the steps and balustrades. The ceilings may be of wood or plaster, and the roof and eaves of the Belvidere may be of wood.

REQUIRED: *A Plan*, showing the adjacent parts of the garden, steps, landing, &c., on a scale of an eighth of an inch to the foot.

*A Principal Elevation*, showing the steps down to the landing, on the same scale.

*A Section* and another Elevation, on a smaller scale.

*A Plan of the roofs*, looking down.

The whole to be drawn on a single sheet of Whatman's paper, fourteen inches by nineteen inches, finished as a sketch in pencil and color, with the shadows cast in India ink. To be handed in on Monday, February 16, at half-past three o'clock, P. M.

#### A CAFE.

February 8.

This building, which is supposed to stand in a park or pleasure garden, must contain:—

1. The café itself, with proper kitchen, serving rooms, supper rooms, and a lodging for the proprietor.

2. A little theatre for singing and dancing, with the stage under cover, but the orchestra and audience out of doors in a garden.

3. Porticos, or covered walks, enclosing this garden,

The greatest dimensions of the plan must not exceed 100 feet.

REQUIRED: *Plan, Section, and Elevation*, finished in color or India ink on a uniform scale of sixteen feet to the inch.

#### A POMPEIAN HOUSE.

February 21.

REQUIRED: To take the plan of some house at Pompeii, as given by Mazois, Zahn, Sir William Gell, Falkener, or any other accessible author-

ity, or in the plan of Pompeii, and to draw it out on a convenient scale, say one eighth of an inch to a foot. Also, to make a section on a larger scale, through the different *Cavædia*.

The whole to be finished in color, the ruined parts being restored, the roof added, and the decorations copied or adapted from photographs and prints.

The whole to be finished and handed in on Tuesday, March 10.

#### THE USE OF FOUR COLUMNS.

March 5.

A wealthy amateur of the arts is in possession of the shafts of four columns of rich marble, which he wishes to make use of in the erection of a small building or monument. As these columns can serve equally well to form part of a great variety of structures, each student is left free to choose the subject of his composition. It may be a fountain, well, portico, tomb, or any other structure whatever.

These columns are to be taken as twelve feet long, exclusive of base and capital, which are to be supplied. Any substructure or base that the nature of the composition may require may be added.

REQUIRED: *A Plan and Elevation*, both on a scale of one fourth of an inch to the foot, finished in pencil, with the shadows cast, with or without color. To be handed in Tuesday morning, March 10, along with the Pompeian Houses.

#### A MONUMENTAL BRIDGE.

March 13.

It is supposed that two neighboring nations, having settled by arbitration a question of boundary, agree to erect over a stream, which forms the frontier determined upon, a bridge, which shall at the same time serve to promote friendly intercourse and to preserve the memory of their compact, as an example to future generations. The stream at the point selected lies a hundred feet below the level of the proposed road, which passing along the slope of the mountain which forms one bank, until it reaches the narrowest part of the ravine, here crosses to the opposite side. The engineers report that good foundation for masonry may be had, if desired, in the bed of the stream. It is necessary to erect at each extremity of the bridge one or two small buildings to serve as custom-houses, with lodgings for the officer in charge, and a guard-room in which to quarter a dozen men on occasion, besides a room for the inspection and weighing of baggage and merchandise. There should also be a small lock-up for the detention of smugglers and other prisoners. Also a gate across the road. From one of these custom-houses to the other the length of the bridge is one hundred feet, and its width, within the parapets, thirty feet, comprising a carriage-way and two narrow foot-ways. In the centre of the bridge, over the middle of the

stream and marking the exact boundary, is to be a triumphal arch, or Arch of Peace, of such character and dimensions as may best suit the rest of the composition. The carriage-way may here be reduced, if desired, to ten feet. The custom-houses, bridge, and arch are all to be built of light-colored stone or of marble, and are all to form part of a single architectural composition.

REQUIRED: *A Plan, Elevation, and Section*, showing the Arch of Peace, all on a single Imperial sheet, drawn to a uniform scale of twelve feet to the inch. Sketches to be made by Wednesday, P. M., March 18, and finished drawings to be handed in on Monday, March 30, at half-past three o'clock, P. M.

Sketches to be on the scale of 24 inches to the foot. Give the number of hours' work, from this date.

#### A SCHOOL OF ARCHITECTURE.

April 1.

We suppose that the vacant lot belonging to the Institute and adjoining the present building has been devoted to our own use, and that the Department is called upon to say what sort of a building is needed for its accommodation. To this end the class will furnish sketches, embracing the following points, with such further suggestions as their observation and experience may supply.

1. An Entrance Hall.
2. Proper staircases.
3. A Public Lecture Room to seat about 200 persons.
4. A Museum of Casts, accessible to the public, and convenient to the lecture room.
5. A Museum of Building Materials and Models.
6. Two small Lecture Rooms for 100 students each, one for history and design, one for construction.
7. One or more rooms for Library and Reading Room.
8. One or more rooms for Architectural Drawing, with accommodations for 100 students.
9. A room for Crayon Drawing, from casts and from the life, and a room for modelling in clay and plaster.
10. A Laboratory for Carpentry, Masonry, Painting, Metal-work, etc.
11. A Carpenter's Shop.
12. Four private rooms, two large and two small.
13. Proper provisions for W. C., Wash Rooms, etc.
14. A Lift or Dumb Waiter, and proper Ventilating Shafts.

The building to be built of brick and stone, with two stories each fifteen feet high, and a basement in which may be put some of the rooms. It is desired that the whole building shall cover about 6,000 square feet, and

that it shall not exceed 110 feet in any dimension. The Lecture Rooms should give six or eight square feet to each person, inclusive of aisles and platform. The sketches to be handed in on Tuesday afternoon, April 14, and to comprise two plans and two elevations, in pencil, on a scale of one-sixteenth of an inch to the foot, with the shadows cast in India ink.

#### A RAILWAY STATION.

*April 4.*

A railroad, with double track, is supposed to pass under the main street of a country village. It is proposed to cross it by an arched bridge of a single span, and to build the station upon this bridge. It is to be of wood, stone, or brick, and iron, and to comprise, besides the ordinary waiting-rooms, baggage-rooms, and offices, convenient verandahs, and covered stairways leading down to the platforms, on a level with the tracks.

**REQUIRED:** *A Plan, Section, and two Elevations*, on a scale of eight feet to an inch, and a third elevation and a plan of the roofs on a smaller scale, all on one sheet of Imperial.

**ALSO:** A portion of the building drawn out on a scale of half an inch to the foot, with details on a scale of one inch to the foot.

**STUDENTS WHO ARE CANDIDATES FOR A DEGREE** will present these drawings as part of their Graduating Thesis, and will submit along with them calculations of the strength and stability of the principal parts of the structure.

The work must be done by the 15th of May.

## APPENDIX.

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### CORPORATION FOR 1875-76.

President,

JOHN D. RUNKLE.

Secretary,

SAMUEL KNEELAND.

Treasurer,

JOHN CUMMINGS.

#### Committee on the School of Industrial Science,

JOHN AMORY LOWELL, *Chairman*,  
EDWARD ATKINSON,  
THOMAS T. BOUVÉ,  
J. ELIOT CABOT,  
GEORGE B. EMERSON,

EDWARD S. PHILBRICK,  
JOHN D. PHILBRICK,  
WILLIAM B. ROGERS,  
J. BAXTER UPHAM,

Treasurer, *ex-officio*.

#### Committee on Finance,

HENRY P. KIDDER, *Chairman*,  
J. INGERSOLL BOWDITCH,  
WILLIAM ENDICOTT, JR.,

JOHN M. FORBES,  
JAMES L. LITTLE,  
SAMUEL D. WARREN,

Treasurer, *ex-officio*.

#### Committee on the Museum,

ERASTUS B. BIGELOW, *Chairman*,  
CHARLES H. DALTON,  
JOSEPH S. FAY,  
AUGUSTUS LOWELL,  
HORACE McMURTRIE,

E. R. MUDGE,  
M. D. ROSS,  
STEPHEN P. RUGGLES,  
NATHANIEL THAYER.

#### Committee on the Society of Arts,

MARSHALL P. WILDER, *Chairman*,  
PHILLIPS BROOKS,  
J. WILEY EDMANDS,  
CHARLES L. FLINT,  
JAMES B. FRANCIS,

J. C. I. JADLEY,  
FRED. W. LINCOLN,  
SAMUEL K. LOTHROP,  
ALEXANDER H. RICE,  
HENRY B. ROGERS.

#### On the Part of the Commonwealth,

HIS EXCELLENCY, GOVERNOR ALEXANDER H. RICE.

HON. HORACE GRAY, *Chief Justice of the Supreme Court*.

HON. JOSEPH WHITE, *Secretary of the Board of Education*.

**COMMITTEES**  
**TO VISIT AND INSPECT THE SEVERAL DEPARTMENTS**  
**OF THE SCHOOL.**

---

*Civil Engineering.*

EDWARD S. PHILBRICK.  
 C. H. DALTON.  
 C. L. FLINT.  
 J. B. FRANCIS.  
 JOHN D. RUNKLE.

*Mining Engineering.*

T. T. BOUVÉ.  
 JOS. S. FAY.  
 H. P. KIDDER.  
 E. S. PHILBRICK.  
 M. D. ROSS.

*General and Analytical Chemistry.*

W. B. ROGERS.  
 T. T. BOUVÉ.  
 J. WILEY EDMANDS.  
 S. D. WARREN.  
 M. P. WILDER.

*Natural History.*

JOHN CUMMINGS.  
 G. B. EMERSON.  
 H. B. ROGERS.  
 W. B. ROGERS.  
 M. D. ROSS.

*English and History.*

G. B. EMERSON.  
 WM. ENDICOTT, JR.  
 AUGUSTUS LOWELL.  
 E. R. MUDGE.  
 N. THAYER.

*Mechanical Engineering.*

E. B. BIGELOW.  
 W. B. ROGERS.  
 C. H. DALTON.  
 J. C. HOADLEY.  
 F. W. LINCOLN.

*Architecture.*

J. B. UPHAM.  
 PHILLIPS BROOKS.  
 J. ELIOT CABOT.  
 G. B. EMERSON.  
 JOHN M. FORBES.

*Industrial Chemistry and Metallurgy.*

T. T. BOUVÉ.  
 EDWARD ATKINSON.  
 J. L. LITTLE.  
 H. B. ROGERS.  
 W. B. ROGERS.

*Physics.*

W. B. ROGERS.  
 J. INGERSOLL BOWDITCH.  
 J. D. PHILBRICK.  
 STEPHEN P. RUGGLES.  
 J. B. UPHAM.

*Philosophy and Political Economy.*

J. ELIOT CABOT.  
 PHILLIPS BROOKS.  
 WM. ENDICOTT, JR.  
 S. K. LOTHROP.  
 AUGUSTUS LOWELL.

*Modern Languages.*

AUGUSTUS LOWELL.  
EDWARD ATKINSON.  
J. ELIOT CABOT.  
C. L. FLINT.  
J. D. PHILBRICK.

*Mechanics.*

J. D. RUNKLE.  
J. INGERSOLL BOWDITCH.  
J. C. HOADLEY.  
E. S. PHILBRICK.  
STEPHEN P. RUGGLES.

*Free Hand and Mech. Drawing.*

J. D. PHILBRICK.  
PHILLIPS BROOKS.  
C. H. DALTON.  
H. P. KIDDER.  
J. B. UPHAM.

*Military Science and Tactics.*

J. B. UPHAM.  
C. H. DALTON.  
E. R. MUDGE.  
H. McMURTRIE.  
A. H. RICE.

*Mathematics.*

J. D. RUNKLE.  
J. B. FRANCIS.  
J. A. LOWELL.  
H. McMURTRIE.  
A. H. RICE.

*Industrial Design.*

J. A. LOWELL.  
EDWARD ATKINSON.  
J. L. LITTLE.  
E. R. MUDGE.  
A. H. RICE.

*Descrip. Geometry and Stereotomy.*

E. S. PHILBRICK.  
J. B. FRANCIS.  
J. C. HOADLEY.  
H. McMURTRIE.  
J. D. RUNKLE.

*Museum and Collections.*

STEPHEN P. RUGGLES.  
EDWARD ATKINSON.  
AUGUSTUS LOWELL.  
M. D. ROSS.  
J. D. RUNKLE.

## OFFICERS OF INSTRUCTION.

---

**President.****JOHN D. RUNKLE, PH.D., LL.D.****JOHN D. RUNKLE, PH.D., LL.D.***Walker Professor of Higher Mathematics.***JOHN B. HENCK, A.M.,***Hayward Professor of Civil and Topographical Engineering.***WILLIAM R. WARE, S.B.,***Professor of Architecture.***WILLIAM P. ATKINSON, A.M.,***Professor of English and History.***GEORGE A. OSBORNE, S.B.,***Professor of Mathematics.***EDWARD C. PICKERING, S.B.,***Thayer Professor of Physics, and Director of the Rogers Laboratory.***SAMUEL KNEELAND, A.M., M.D.,***Professor of Zoölogy and Physiology.***JOHN M. ORDWAY, A.M.,\****Professor of Metallurgy and Industrial Chemistry.***JAMES M. CRAFTS, S.B.,***Professor of Organic Chemistry.***ROBERT H. RICHARDS, S.B.,***Professor of Mining Engineering, and Director of the Mining and Metallurgical Laboratories.***THOMAS STERRY HUNT, LL.D.***Professor of Geology.***GEORGE H. HOWISON, A.M.,***Professor of Logic and the Philosophy of Science.***WM. RIPLEY NICHOLS, S.B.,***Professor of General Chemistry.***CHARLES P. OTIS, PH.D.***Professor of Modern Languages.***CHARLES H. WING, S.B.,***Professor of Analytical Chemistry.***HENRY L. WHITING, U. S. Coast Survey,***Professor of Topography.***HENRY MITCHELL, A.M., U. S. Coast Survey,***Professor of Physical Hydrography.***ALPHEUS HYATT, S.B., Custodian of the Boston Society of Natural History,***Professor of Paleontology.*

\* The instruction in Botany is at present given by Prof. Ordway.



- WILLIAM H. NILES, PH.B., A.M.,  
*Professor of Physical Geology and Geography.*
- LIEUT. E. L. ZALINSKI, U. S. A.,  
*Professor of Military Science and Tactics.*
- CHANNING WHITAKER, S.B.,  
*Professor of Mechanical Engineering.*
- CHARLES R. CROSS, S.B.,  
*Professor of Physics and Descriptive Astronomy.*
- GAETANO LANZA, S.B., C.E.,  
*Professor of Theoretical and Applied Mechanics.*
- EUGENE LETANG,  
*Assistant in Architecture.*
- WILLIAM E. HOYT, S.B.,  
*Instructor in Civil Engineering and Stereotomy.*
- JULES LUQUIENS, PH.D.,  
*Instructor in Modern Languages.*
- CHARLES KASTNER,  
*Lowell Instructor in Practical Design.*
- WEBSTER WELLS, S.B.,  
*Instructor in Mathematics and Descriptive Geometry.*
- THOMAS E. POPE, A.M.,  
*Instructor in Quantitative Analysis.*
- FRANK B. MORSE, S.B.,  
*Instructor in Free-hand Drawing.*
- HENRY N. MUDGE,  
*Instructor in Mechanical and Free-hand Drawing.*
- WILLIAM FOSTER,  
*Assistant in the Mining and Metallurgical Laboratories.*
- FRANCIS T. SARGENT, S.B.,  
*Assistant in Mechanical Engineering.*
- J. AUSTIN KNAPP, S.B.,  
*Assistant in Mechanical Engineering.*
- LEWIS M. NORTON,  
*Assistant in Quantitative Analysis.*
- CHARLES C. R. FISH,  
*Assistant in General Chemistry and Qualitative Analysis.*
- WILLIAM E. NICKERSON,  
*Assistant in General Chemistry and Qualitative Analysis.*
- WILLIAM O. CROSBY,  
*Assistant in Palaeontology.*

## CONDITIONS OF ADMISSION.

To be admitted as a regular student of the first year's class, applicants must have attained the age of sixteen years, and must pass a satisfactory examination in arithmetic (including the metric system of weights and measures), algebra through equations of the second degree, plane and solid geometry, including spherical geometry, French grammar through regular and irregular verbs, and the first two books of Voltaire's "Charles XII" (*i.e.*, about sixty pages) or the equivalent of the same, English grammar, including, especially, the ability to detect the parts of speech, to use correctly the conjugation of verbs regular and irregular, to classify terms as Singular, General, and Universal, and to analyze phrases and sentences, English composition, rhetoric (so much as is included in the first part of Bain's Rhetoric, or its equivalent), history of the United States, and geography. In general, the training given at the best High Schools, Academies, and Classical Schools, will be a suitable preparation for this School.

Graduates of Colleges will, in general, be presumed to have the requisite attainments for entering the third year as regular students, and may do so on satisfying the department which they purpose to enter that they are prepared to pursue their studies to advantage. Such students, if deficient in any of the scientific studies of the first two years, will have opportunities for making them up without extra charge, and will be required to pass an examination in them before entering upon the studies of the fourth year. Should they be already proficient in any of the general studies of the third and fourth years, they will be excused, if they wish, from attendance on the exercises in these subjects.

## REGULAR COURSES.

## ALL COURSES. — FIRST YEAR.

		No. of Exercises	Hrs. per week
1	Algebra finished . . . . .	45	3
	Plane and Solid Geometry reviewed . .	15	3
	Plane and Spherical Trigonometry . .	30	3
2	General Chemistry . . . . .	60	6
	General Chemistry . . . . .	30	2
	Qualitative Analysis . . . . .	30	4
3	Structure of the Sentence . . . . .	30	2
	Rudiments of Logic . . . . .	30	2
4	French . . . . .	90	3
5	Mechanical Drawing and Elements of Descriptive Geometry and Perspective .	90	6
	Free Hand Drawing . . . . .	90	3
6	Physiology and Hygiene . . . . .	30	2
7	Military Tactics . . . . .	90	3

## I. CIVIL ENGINEERING.

## SECOND YEAR.

		No. of Exercises.	Hrs. per week.
1	Analytic Geometry . . . . . 1st half	45	3
	Calculus . . . . . 2d half	45	3
2	Descriptive Geometry . . . . . 1st half	30	2
	Mechanical Drawing . . . . . 1st half	30	4
	Surveying . . . . .	60	2
	Topographical and Plan Drawing . . . . . 2d half	30	4
3	Physics (Lectures) . . . . .	90	3
4	French finished, German begun . . . . .	90	3
5	Rhetoric and English Literature, or Descriptive Astronomy . . . . . 1st half	30	2
6	English Literature, or Physical Geography . . . . . 2d half	30	2
7	Military Science . . . . .	24	1

## THIRD YEAR.

1	Survey and Location of Roads. . . . . 1st half	45	6
	Construction of Roads . . . . . 2d half	20	6
	Water supply, Drainage, etc. . . . . 2d half	25	6
	Field Practice . . . . .	30	3
	Stereotomy . . . . . 1st half	30	4
	Bridge and Roof Construction . . . . . 2d half	30	4
2	Calculus . . . . . $\frac{1}{2}$ year	25	3
	Applied Mechanics . . . . . $\frac{1}{2}$ year	65	3
3	German . . . . .	90	3
4	Physical Laboratory . . . . .	60	2
5	Outlines of Zoology, or History . . . . . 1st half	30	2
6	General Geology, or Political Economy . . . . . 2d half	30	2

## FOURTH YEAR.

1	Stability of Structures . . . . . 1st half	20	6
	Strength of Materials . . . . . 1st half	25	6
	Structures of Stone . . . . . 2d half	15	6
	Structures of Wood . . . . . 2d half	10	6
	Structures of Metal . . . . . 2d half	20	6
	Topography (Field Practice) . . . . . 2d half	10	
	Physical Hydrography . . . . . 2d half	10	
	Structure Drawing . . . . . 2d half	45	6
	Building Materials . . . . . 2d half	10	3
2	Water power and Water wheels . . . . . 2d half	25	4
3	Metallurgy of Iron . . . . . 1st half	30	2
4	Applied Physics . . . . . 1st half	30	2
5	German . . . . . 1st half	45	3
6	Philosophy of Science . . . . . 1st half	45	3

In addition to the prescribed studies, optional studies, selected from other courses, may be taken.

## II. MECHANICAL ENGINEERING.

## SECOND YEAR.

		No. of Exercises	Hrs. per week.
1	Analytic Geometry . . . . . 1st half	45	3
	Calculus . . . . . 2d half	45	3
2	Descriptive Geometry . . . . . 1st half	30	2
	Mechanical Drawing . . . . . 1st half	30	4
	Principles of Mechanism . . . . . 1st half	30	2
	Principles of Mechanism . . . . . 2d half	60	4
	Machine Drawing . . . . . 2d half	30	4
3	Physics (Lectures) . . . . .	90	3
4	French finished, German begun . . .	90	3
5	Rhetoric and English Literature, or Descriptive Astronomy . . . . . 1st half	30	2
6	English Literature, or Physical Geography . . . . . 2d half	30	2
7	Military Science . . . . .	24	1

## THIRD YEAR.

1	Machinery and Millwork . . . . . $\frac{3}{4}$ year	80	6
	Strength of Materials . . . . . $\frac{1}{4}$ year	40	6
	Mechanical Laboratory . . . . .	30	2
	Machine Drawing . . . . .	60	4
2	Calculus . . . . . $\frac{1}{4}$ year	25	3
	Applied Mechanics . . . . . $\frac{3}{4}$ year	65	3
3	German . . . . .	90	3
4	Physical Laboratory . . . . .	60	2
5	Outlines of Zoology, or History . . . . . 1st half	30	2
6	General Geology, or Political Economy . . . . . 2d half	30	2

## FOURTH YEAR.

1	Principles of Thermodynamics . . . . . 1st half	90	6
	Mechanism of the Steam Engine . . . . . 2d half	50	8
	Water power and Water wheels . . . . . 2d half	70	8
	Machine Drawing . . . . .	90	6
	Mechanical Laboratory . . . . .	105	7
	Building Materials . . . . . 2d half	10	3
2	Metallurgy of Iron . . . . . 1st half	30	3
3	German . . . . . 1st half	45	3
4	Philosophy of Science . . . . . 1st half	45	3

In addition to the prescribed studies, optional studies, selected from other courses, may be taken.

## III. MINING ENGINEERING.

## SECOND YEAR.

		No. of Exercises.	Hrs. per week.
1	Analytic Geometry . . . . . 1st half	45	3
	Calculus. . . . . 2d half	45	3
2	Qualitative Analysis . . . . . 1st half	45	6
	Drawing . . . . . 1st half	30	2
	Mineralogy. . . . . 2d half	45	6
	Botany . . . . . 2d half	30	2
3	Physics (Lectures) . . . . .	90	3
4	French finished, German begun . . . . .	90	3
5	Rhetoric and English Literature, or Descriptive Astronomy . . . . . 1st half	30	2
6	English Literature, or Physical Geography . . . . . 2d half	30	2
7	Military Science . . . . .	24	1

## THIRD YEAR.

1	Chemical Laboratory. . . . .	150	10
	General Quantitative Analysis (Lectures) . . . . . 1st half	30	2
	Mining Engineering. . . . .	90	3
	Assaying . . . . . 2d half	15	3
	Structural Palæontology . . . . . 2d half	15	2
2	Calculus. . . . . $\frac{1}{2}$ year	25	3
	Applied Mechanics . . . . . $\frac{1}{2}$ year	65	3
3	German . . . . .	90	3
4	Physical Laboratory . . . . .	60	2
5	Outlines of Zoology, or History. . . . . 1st half	30	2
6	General Geology, or Political Economy . . . . . 2d half	30	2

## FOURTH YEAR.

1	Ore dressing . . . . . $\frac{1}{2}$ year	15	3
	Metallurgy . . . . . $\frac{1}{2}$ year	45	3
	Drawing . . . . . 1st half	30	2
	Mining and Metallurgical Laboratory . . . . . 2d half	75	10
	Chemical Laboratory . . . . .	150	10
2	American Geology . . . . . 1st half	40	3
	Coal and Ore Deposits . . . . . 2d half	15	3
	Building Materials . . . . . 2d half	10	3
	Chemical Geology . . . . . 2d half	15	3
3	German . . . . . 1st half	45	3
4	Philosophy of Science . . . . . 1st half	45	3

In addition to the prescribed studies, optional studies, selected from other courses, may be taken.

## IV. ARCHITECTURE.

## SECOND YEAR.

SECOND YEAR.			No. of Exercises	Hrs. per week.
1	Analytic Geometry . . . . .	1st half	45	3
	Calculus . . . . .	2d half	45	3
2	Descriptive Geometry . . . . .	1st half	30	2
	Mechanical Drawing . . . . .	1st half	30	4
	Shades, and Shadows . . . . .	2d half	30	2
	The Orders. . . . .	1st quar.	16	2
	Greek and Roman Arch. History . . . .	2d quar.	14	2
	Architectural History and Design . . .	2d half	30	2
3	Physics (Lectures) . . . . .		90	3
4	French finished, German begun . . . .		90	3
5	Rhetoric and English Literature, or De- scriptive Astronomy . . . . .	1st half	30	2
6	English Literature, or Physical Geography	2d half	30	2
7	Military Science . . . . .		24	1

## THIRD YEAR.

1	Theory of Architecture . . . . .	1st half	15	1
	Architectural History and Design . . .	2d half	30	2
	Stereotomy . . . . .	1st half	30	4
	Mechanical Drawing . . . . .	1st half	30	4
	Architectural Drawing . . . . .		150	10
	Specifications and Working Drawings .		30	1
2	Calculus . . . . .	$\frac{1}{2}$ year	25	3
	Applied Mechanics . . . . .	$\frac{1}{2}$ year	65	3
3	German . . . . .		90	3
4	Physical Laboratory . . . . .		60	2
5	Outlines of Zoology, or History . . . .	1st half	30	2
6	General Geology, or Political Economy .	2d half	30	2

## FOURTH YEAR.

1	Architectural History and Design . . .		30	1
	Architectural Ornament and Detail . .		30	1
	Specifications and Working Drawings .		30	1
	Architectural Drawing . . . . .		150	10
2	Stability of Structures . . . . .	1st half	20	6
	Strength of Materials . . . . .	1st half	25	6
	Structures of Stone . . . . .	2d half	15	6
	Structures of Wood . . . . .	2d half	10	6
	Structures of Metal . . . . .	2d half	20	6
	Building Materials . . . . .	2d half	10	3
3	Applied Physics . . . . .	1st half	30	2
4	German . . . . .	1st half	45	3
5	Philosophy of Science . . . . .	1st half	45	3

In addition to the prescribed studies, optional studies, selected from other courses, may be taken.

## V. CHEMISTRY.

## SECOND YEAR.

		No. of Exercises.	Hrs. per week.	
1	Qualitative Analysis . . . . .	1st half	45	6
	Mineralogy. . . . .	2d half	45	6
2	Chemical Philosophy . . . . .	1st half	45	3
	Botany . . . . .	2d half	30	2
3	Physics (Lectures) . . . . .		90	3
4	French finished, German begun . . . .		90	3
5	Rhetoric and English Literature, or Descriptive Astronomy . . . . .	1st half	30	2
6	English Literature, or Physical Geography	2d half	30	2
7	Military Science and Tactics . . . . .		24	1

## THIRD YEAR.

	Chemical Laboratory . . . . .		150	12
	General Quantitative Analysis (Lectures)	1st half	30	2
	Quant. Anal., Special Methods (Lectures)	2d half	30	2
	Industrial Chemistry . . . . .	2d half	45	3
2	Chemical Physiology . . . . .	1st half	30	2
	Structural Palæontology . . . . .	2d half	15	2
3	German . . . . .		90	3
4	Physical Laboratory . . . . .		60	2
5	Outlines of Zoology, or History . . . .	1st half	30	2
6	General Geology, or Political Economy .	2d half	30	2

## FOURTH YEAR.

1	Chemical Laboratory . . . . .		150	15
	Organic Chemistry (Lectures) . . . .		60	2
	Metallurgy . . . . .	$\frac{1}{2}$ year	45	3
	Drawing . . . . .	1st half	30	2
2	American Geology . . . . .	1st half	40	3
	Chemical Geology . . . . .	2d half	15	3
	Coal and Ore Deposits . . . . .	2d half	15	3
	Building Materials . . . . .	2d half	10	3
	Assaying . . . . .	2d half	10	
3	Applied Physics . . . . .	1st half	30	2
4	German . . . . .	1st half	45	3
5	Philosophy of Science . . . . .	1st half	45	3

In addition to the prescribed studies, optional studies, selected from other courses, may be taken.

## VI. METALLURGY.

## SECOND YEAR.

		No. of Exercises.	Hrs. per week.	
1	Qualitative Analysis . . . . .	1st half	45	6
	Mineralogy . . . . .	2d half	45	6
2	Chemical Philosophy . . . . .	1st half	45	3
	Botany . . . . .	2d half	30	2
3	Physics (Lectures) . . . . .		90	3
4	French finished, German begun . . . . .		90	3
5	Rhetoric and English Literature, or Descriptive Astronomy . . . . .	1st half	30	2
6	English Literature, or Physical Geography . . . . .	2d half	30	2
7	Military Science . . . . .		24	1

## THIRD YEAR.

	Chemical Laboratory . . . . .		150	12
	General Quantitative Analysis (Lectures) . . . . .	1st half	30	2
	Quant. Anal., Special Methods (Lectures) . . . . .	2d half	30	2
1	Industrial Chemistry . . . . .	2d half	45	3
2	Chemical Physiology . . . . .	1st half	30	2
	Structural Palæontology . . . . .	2d half	15	2
	Assaying . . . . .	2d half	15	3
3	German . . . . .		90	3
4	Physical Laboratory . . . . .		60	2
1	Outlines of Zoology, or History . . . . .	1st half	30	2
5	General Geology, or Political Economy . . . . .	2d half	30	2

## FOURTH YEAR.

6	Ore-dressing . . . . .	$\frac{1}{2}$ year	15	3
	Metallurgy . . . . .	$\frac{1}{2}$ year	45	3
	Drawing . . . . .	1st half	30	2
	Mining and Metallurgical Laboratory . . . . .	2d half	75	10
	Chemical Laboratory . . . . .		150	10
2	American Geology . . . . .	1st half	40	3
	Coal and Ore Deposits . . . . .	2d half	15	3
	Building Materials . . . . .	2d half	10	3
	Chemical Geology . . . . .	2d half	15	3
3	German . . . . .	1st half	45	3
4	Philosophy of Science . . . . .	1st half	45	3

In addition to the prescribed studies, optional studies, selected from other courses, may be taken.



## VIII. PHYSICS.

## SECOND YEAR.

		No. of Exercises.	Hrs. per week.
1	Analytic Geometry . . . . .	1st half 45	3
	Calculus . . . . .	2d half 45	3
2	Qualitative Analysis . . . . .	1st half 45	6
	Quantitative Analysis . . . . .	2d half 45	6
	Chemical Philosophy . . . . .	1st half 45	3
	Botany . . . . .	2d half 30	2
3	Physics (Lectures) . . . . .	90	3
4	French finished, German begun . . . . .	90	3
5	Rhetoric and English Literature, or Descriptive Astronomy . . . . .	1st half 30	2
6	English Literature, or Physical Geography . . . . .	2d half 30	2
7	Military Science . . . . .	24	1

## THIRD YEAR.

1	Physical Laboratory . . . . .	120	4
	Physics (additional Lectures) . . . . .	60	2
2	Calculus . . . . .	$\frac{1}{2}$ year 25	3
	Applied Mechanics . . . . .	$\frac{1}{2}$ year 65	3
	Strength of Materials . . . . .	2d half 30	4
3	General Quantitative Analysis (Lectures) . . . . .	1st half 30	2
	Chemical Physiology . . . . .	1st half 30	2
	Chemical Laboratory . . . . .	1st half 45	6
4	German . . . . .	90	3
5	Outlines of Zoology, or History . . . . .	1st half 30	2
6	General Geology, or Political Economy . . . . .	2d half 30	2

## FOURTH YEAR.

1	Physical Research . . . . .	150	10
	Advanced Physics . . . . .	30	2
	Photography . . . . .	1st half 15	4
	Lantern Projections . . . . .	1st half 15	4
2	Chemical Laboratory . . . . .	2d half 75	10
3	Practical Astronomy . . . . .	1st half 30	3
	Mechanical Engineering . . . . .	1st half 15	3
4	Principles of Thermodynamics . . . . .	1st half 60	4
5	American Geology . . . . .	1st half 40	3
	Chemical Geology . . . . .	2d half 15	3
	Coal and Ore Deposits . . . . .	2d half 15	3
	Building Materials . . . . .	2d half 10	3
6	German . . . . .	90	3
7	Philosophy of Science . . . . .	1st half 45	3
	Political and Industrial Geography . . . . .	2d half 30	

In addition to the prescribed studies, optional studies selected from other courses, may be taken.

## VII. NATURAL HISTORY.

## SECOND YEAR.\*

		No. of Exercises.	Hrs. per week.
1	Chemical Philosophy . . . . . 1st half	45	3
	Botany . . . . . 2d half	30	2
2	Qualitative Analysis . . . . . 1st half	45	6
	Mineralogy . . . . . 2d half	45	6
3	Physics (Lectures) . . . . .	90	3
4	French finished, German begun. . . . .	90	3
5	Rhetoric and English Literature, or Descriptive Astronomy . . . . . 1st half	30	2
6	English Literature, or Physical Geography . . . . . 2d half	30	2
7	Military Science . . . . .	24	1

## THIRD YEAR.

1	General Quantitative Analysis (Lectures) . . . . . 1st half	30	2
	Comparative Zoology . . . . . 2d half	45	3
	Chemical Laboratory . . . . .	150	10
2	Chemical Physiology . . . . . 1st half	30	2
	Structural Palæontology . . . . . 2d half	15	2
3	German . . . . .	90	3
4	Physical Laboratory . . . . .	60	2
5	Outlines of Zoology, or History . . . . . 1st half	30	2
6	General Geology, or Political Economy . . . . . 2d half	30	2

## FOURTH YEAR.

1	Special Zoology, Special Geology, Special Botany, or Special Stratigraphical Palæontology	} Laboratory	180	12
2	American Geology . . . . . 1st half			
	Coal and Ore Deposits . . . . . 2d half		40	3
	Building Materials . . . . . 2d half		15	3
	Chemical Geology . . . . . 2d half		10	3
3	Applied Physics . . . . . 1st half		15	3
4	German . . . . .		30	2
5	Philosophy of Science . . . . . 1st half		90	3
	Political and Industrial Geography . . . . . 2d half		45	3
			30	2

In addition to the prescribed studies, optional studies, elected from other courses, may be taken.

## IX. SCIENCE AND LITERATURE.

## SECOND YEAR.

		No. of Exercises.	Hrs. per week.
1	Rhetoric and English Literature . . . . .	90	3
	Elements of Philosophy . . . . . 2d half	45	3
2	Chemical Philosophy . . . . . 1st half	45	3
	Botany . . . . . 2d half	30	2
3	Physics (Lectures) . . . . .	90	3
4	French finished, German begun . . . . .	90	3
5	Descriptive Astronomy . . . . . 1st half	30	2
	Physical Geography . . . . . 2d half	30	2
6	Military Science . . . . .	24	1

## THIRD YEAR.

1	History . . . . .	90	3
2	Advanced French . . . . .	90	3
3	German . . . . .	90	3
4	Physical Laboratory . . . . .	60	2
5	Outlines of Zoology . . . . . 1st half	30	2
	General Geology . . . . . 2d half	30	2
6	History of Commerce and Industry . . . . . 1st half	30	2
	Political Economy . . . . . 2d half	30	2

## FOURTH YEAR.

1	Earlier English Literature . . . . . 1st half	45	3
	Science of Language . . . . . 2d half	45	3
2	Business Law . . . . . 1st half	30	2
	Political and Industrial Geography . . . . . 2d half	30	2
3	American Geology . . . . . 1st half	40	3
	Chemical Geology . . . . . 2d half	15	3
	Coal and Ore Deposits . . . . . 2d half	15	3
	Building Materials . . . . . 2d half	10	3
4	German . . . . .	90	3
5	Constitutional History . . . . .	60	2
6	Philosophy of Science . . . . . 1st half	45	3
	Applied Physics . . . . . 1st half	30	2

In addition to the prescribed studies, optional studies selected from other courses, may be taken.

## X. PHILOSOPHY.

## SECOND YEAR.

		No. of Exercises.	Hrs. per week.	
1	Applied Logic . . . . .	1st half	45	3
	Elements of Philosophy, viz., . . . . .	2d half	45	3
	(a) Its Definition and General Problems (5 lectures)			
	(b) The Solutions proposed by the several Schools (10 lectures).			
	(c) Résumé of Terminology (5 lectures) . . .			
	(d) Outlines of Psychology (25 lectures) . . .			
2	French finished, German begun . . . . .		90	3
3	Analytic Geometry . . . . .	1st half	45	3
	Calculus . . . . .	2d half	45	3
4	Physics (Lectures) . . . . .		90	3
5	Chemical Philosophy . . . . .	1st half	45	3
6	English Literature . . . . .	2d half	45	3
7	Military Science . . . . .		24	1

## THIRD YEAR.

1	Philosophy : Critical History of Modern Systems . . . . .		150	5
	(a) Descartes, Spinoza, Locke. (1st half, 75 lectures.)			
	(b) Leibnitz, Berkeley, Hume. (2d half, 60 lectures.)			
	(c) Reid, the Transition to Kant. (2d half, 15 lectures.)			
2	Advanced French . . . . .		90	3
3	German . . . . .		90	3
4	History . . . . .	1st half	30	2
	Political Economy . . . . .	2d half	30	2
5	Physical Laboratory . . . . .	1st half	30	2
	General Geology . . . . .	2d half	30	2

## FOURTH YEAR.

1	Philosophy : Critical History of Modern Systems . . . . .		150	5
	(a) Kant and Fichte. (1st half, 75 lectures.)			
	(b) Schelling and Hegel. (2d half, 75 lectures.)			
2	Philosophy of Science, viz., . . . . .	1st half	45	3
	(a) Theory of Induction—its precise nature as a Mental Process, its Conditions of Application, and its Five Auxiliary Methods (20 lectures).			
	(b) Classification of the Natural Sciences, with discussion of their Logical Connexion, and of the Logical System of each (10 lectures).			
	(c) Same treatment of the Mathematical Sciences (5 lectures).			
	(d) Logical Theory of the Calculus (10 lectures)			
	Science of Language . . . . .	2d half	45	3
3	German . . . . .		90	3
4	Earlier English Literature . . . . .	1st half	45	3

In addition to the prescribed studies, optional studies selected from other courses, may be taken.

## ARCHITECTURAL DEPARTMENT.—BOOKS.

Shelf. No.

- A. 1. Barbazat's Iron-work. 4to. 1867.  
 2. Ferme Ornée, Rural Improvements. 4to. 1795.  
 3. Rural Architecture.  
 4. Highland Cottages. Lang. 1848.  
 5. Domestic Economy (Heating and Cooking). C. Sylvester. 4to. 1819.  
 6. Rural Architect. J. Gandy. 4to. 1806.  
 7. Iron-work. Duceil Fils. 4to. 1867.  
 8. Crunden's Designs. 1785.  
 9. Downing's Landscape Gardening. 1841.  
 10. Béton Coignet. L. F. Beckwith. 8vo. 1868.  
 11. Carpenter's Ancient Carpentry. 1736.  
 12. Haupt on Bridge Construction. 1868.
- B. 1, 6. Fergusson's Handbook. 2 Vols. 3 copies. 1855.  
 7, 10. " History. 3 Vols. 1868.
- C. 1-3. Stuart's Dictionary of Architecture. 3 Vols.  
 4. Rickman's Gothic Architecture. 1862.  
 5, 6. Parker's Glossary. 2 Vols. 1841.
- D. 1-6. Murray's English Cathedrals. 6 Vols.
- E. 1-5. Gwilt's Encyclopedia of Architecture.  
 6-7. Billington's Architectural Director. 2 Vols. 1848.  
 8. Chambers's Civil Architecture. 4to.
- F. 1. Grüner's Fresco Decoration in Italy. Text.  
 2, 3. Proceedings of the American Institute of Architects. 2 Vols. 18 -1875.  
 4. Archæological Proceedings. Winchester. 1865.  
 5. Essex Archæological Society. 1848.  
 6-20. Papers of Architectural Institute of Scotland. 1850-1858.
- G. 1. Architectural Drawing Book. R. S. Burn. 1857.  
 2. Architectural Design. R. S. Burn. 1853.  
 3. Woodward's Rural Art. 1868.  
 4-29. Weale's Series.  
     6. Mechanics. Tomlinson.  
     16. Orders of Architecture. Leeds.  
     17. Styles of Architecture. Bury.  
     18. Principles of Design. Garbett.  
     19. Art of Building. Dobson.  
     23. Brick Making. Dobson.

Shelf. No.

G. 4 29. Weale's Series (*continued*).

- 25. Masonry and Stone Cutting. Dobson.
- 29. } Drainage and Sewage. Dempsey.
- 30. }
- 35. Quarrying Stone. Burgoyne.
- 36. Dictionary of Terms.
- 42. Cottage Building. Allen.
- 44. Foundations and Concrete. Dobson.
- 45. Limes, Mortars, etc. Burnell.
- 57. Warming and Ventilation. Tomlinson.
- 111. Arches and Piers. Bland.
- 116. Acoustics. T. R. Smith.
- 123. Carpentry and Joinery. 2 Vols.
- 124. Roofs. 2 Vols.
- 127. Architectural Modelling. Richardson.
- 128. Vitruvius. Gwilt.
- 130. Grecian Architecture. Earl of Aberdeen.
- 132. Dwelling Houses. Brooks.

- H. 1. Ruskin. Stones of Venice. 3 Vols.
- 2. " Seven Lamps of Architecture.
- 3. " Two Paths.
- 4. " Political Economy of Art.
- 5-9. " Modern Painters.

## I. Documens Inedits sur l'histoire de France.

- 1. Iconographie Chrétienne.
- 2. N. D. de Noyon. Text. Vitet.
- 3. Chateau de Gaillon. Text.
- 4. Statistique Monumentale de Paris. Text.
- 5-6. Architecture Monastique. Lenoir. 2 Vols.

## 7-11. Dictionnaire du Mobilier Français. Viollet le Duc.

- J. 1-10. Dictionnaire Raisonné de l'Architecture Française. 10 Vols.

K, L, }  
M, N. }

Revue Generale de l'Architecture. 33 Vols.

- O. 1. Entretiens sur l'Architecture. Viollet le Duc. 1863.
- 2. The same. Translated by H. Van Brunt. 1875.
- 3-5. Traité de la Chaleur. 3 Vols. Peclet. 1845.
- 6. Edifices de Rome Moderne. Le Tarouilly (Text). 1860.
- 7. Nouvelles Inventions pour bien Bastir. Philibert de l'Orme. 1561.

P, Q, }  
R, S. }

- T. 23. The Builder. 1843-1849, 1861, 1862, 1869, 1870.

Papers of the Royal Institute of British Architects.  
17 Vols.

*Shelf. No.*

- U. 1-5. Britton's Antiquities. 5 Vols. 1807.  
 6. Westminster Abbey. Neale. 1856.  
 7. Godwin's London. 1839.  
 8. Knight's Cyclopædia of London. 1851.
- V. 1-4. Study Book of Mediæval Art. 4 Vols. T. H. King. 1868.
- W. 1. Grammar of Ornament. (Small ed.) Owen Jones. 1856.  
 2, 3. Brandon's Gothic Analysis. 2 Vols. 1858.  
 4. Pugin's Gothic Ornament. 1854.  
 5-8. The Workshop. 4 Vols.
- X. 1-4. The Architect. Vols. V, and VI, 1871; VII, 1872; X, 1873.
- Y. 1, 2. Architecture Civile et Domestique. Verdier and Cattois. 1864.  
 3. Architecture Polychrome. Hittorff. (Text.) 1851.  
 4. Monuments du Musée National à Naples. 1867.
- Z. 1-5. Moniteur des Architectes. 5 Vols. 1866-1870.
- AA. 1-7. Gazette des Architectes. 1863-71.
- BB. 1, 2. Traité d'Architecture. L. Reynaud. Text. 1863.  
 3, 4. Perspective; Text and Plates. Adhémar.  
 5. Perspective Linéaire. Thibault.  
 6. Traité d'Architecture. Simonin and Thierry.
- CC. 1. Annales de la Soc. Centrale des Architectes. 1875.
- DD. 1. Le Chateau d'Anet. R. Pfnor. 1869.  
 2. Fragments. Bourgerel. 1862.
- EE. 1. Architecture Funéraire. C. Daly.
- FF. 1. Architectural Monuments of Egypt.  
 2. Compositions Antiques. Boucher.  
 3. Miscellaneous Elevations and Sections.
- GG. 1-3. Expédition de Morée. A. Blouet. 3 Vols. 1838.
- HH. 1. Grammar of Ornament. (Large ed.) O. Jones. 1856.  
 2. Grüner's Fresco Decorations. (Plates.) 1854.
- II. 1-3. L'Asie Mineure. Texier. 3 Vols. 1839.
- JJ. 1-9. Croquis d'Architecture. Intime Club. 9 Vols. 1867-1876.
- KK.
- LL. 1. La Cathédrale de Chartres. 1867.  
 2. Hotel de Ville de Paris. Calliat. 1851.  
 3. Chateau de Gaillon. (Plates.)  
 4. Notre-Dame de Noyon. (Plates.) 1845.  
 5. Miscellanea. Albertolli. 1796.
- MM. 1-4. Building Examples. 4 Vols. Henry Laxton. 1867.
- NN. 1, 2. Architectonische Studien. Stuttgart.

- Shelf. No.*
- OO. 1-6. Edifices de Rome Moderne. (Plates.) Le Tarouilly.  
3 Vols. in 6.
- PP. 1-2. Traité d'Architecture. L. Reynaud. (Plates.) 2 Vols.
- QQ. 1. Chambers' Civil Architecture. 1768.  
2-5. Sharpe's Parallels. 4 Vols.
- RR. 1. Maisons de Plaisance de Rome. Percier and Fontaine.  
1809.  
2. Maisons, Edifices et Monuments Publics de Paris.  
Krafft and Thiollet. 1849.  
3. Foro Trajano. Albertolli. 1835.
- SS. 1-4. Ruines de Pompei. 4 Vols. Mazois. 1824.
- TT. 1. Architecture Polychrome. (Temple of Empedocles.)  
(Plates.) Hittorff.  
2. Expedition to Sicily. (Plates.) Hittorff.
- UU. 1-2. Statistique Monumentale de Paris. 2 Vols. Albert  
Lenoir. 1867.
- VV. 1. Piranesi. 1750.  
2. Recueil d'Architecture. F. L. Scheult. 1795?  
3. Gally Knight's Italy. Second Series. 1843.
- WW. 1. New Law courts, Plans and Sections. Scott. 1868.  
2. New Courts of Justice. Garling. 1867.  
3. New Law courts, Plans and Sections. Street. 1868.  
4. Deutsch-mittelalterlichen Baukunst. (Plates.) Kallen-  
bach. 1847.  
5. Die Badische Eisenbahn. (Plates.)
- XX. 1. Durand's Parallèle.
- YY, ZZ, } 32. Illustrated London News. 32 Vols. 1851 to 1872, in-  
AB-AF. } clusive.  
Missing, 1851, January-June 1852, 1855, 1859, 1860,  
1863, July-Dec. 1868, July-Dec. 1870, 1871.
- AG. 1-4. The Graphic. 4 Vols. 1871, 1872.
- AH. 1, 2. Annales de la Construction. 2 Vols. Text. 1855-1859.  
3, 4. " " " " Plates.  
5, 6. Architectural Notes. Plates and text. (Lithographed.)
- AI. 1, 2. Renaissance Monumentale en France. 2 Vols. Berty,  
1864.  
3. Sei Fabbriche in Firenze. Callesi. 1851.  
4. Normand's Parallèle.
- AJ. 1. Unedited Antiquities of Attica. 1832.  
2-5. Antiquities of Athens. 4 Vols. Stuart and Revett. 1812.  
6, 7. Palladio. 2 Vols.



*Shelf. No.*

- AK. 1. Nesfield's Mediaeval Architecture. 1862.  
 2. Norman Shaw's Sketches on the Continent. 1858.  
 3. Specifications of New Foreign Office. G. G. Scott.  
 4. Academy of Design. P. E. Wight. 1866.  
 5. Cottages for the Laborer. Wood. 1792.  
 6. Grüner's Terra Cotta Work in Italy. 1867.  
 7-11. Architectural Association Sketch Book. London, 1868-1873.
- AL. 1. Ungewitter. Zeigel-und-Stein arbeiten.  
 2. " Gothischen Mödeln.  
 3. " Mittelaltlicher ornamentik.  
 4. Brick Construction. Degen.
- AM. 1-3. Edifices Publics en France. 3 Vols. 1825-1850.  
 4-8. L'Architecture Privée. 5 Vols. Daly. 1864.
- AN. 1-7. L'Art pour tous. Lieber. 7 Vols.  
 8. Ecole des Beaux-Arts. Vogel. 1795.

## DEPARTMENT OF ARCHITECTURE. PHOTOGRAPHS.

*Portfolio.*

- A. Venice. Palaces. 25.  
 B. St. Mark's. 22.  
 C. Churches. 44.  
 D. Miscellaneous. 36.  
 E. Ducal Palace. 32.  
 F. Florence. 53.  
 G. Genoa, Milan. 30.  
 H. Pisa, Parma. 21.  
 I. Padua, Vicenza, Piacenza. 18.  
 J. Orvieto, Bologna, Pistoja, Siena, Perugia. 19.  
 K. Verona. 15.  
 L. Lucca, Ancona, etc. 20.  
 M. Miscellaneous Europe. 30.  
 N. Naples, Paestum. 24.  
 O. Frescoes and Mosaics. 57.  
 P. Pompeii. 45.  
 Q. Busts, Armor, Vases, Bas Reliefs. 43.  
 R. Ravenna. 40.  
 S. Statues. 52.  
 T. The Old Masters. 56.  
 U. Raphael and Michael Angelo. 54.  
 V. Normandy. 29.

*Portfolio.*

- W. French Chateaux. Oxford. 24, 26.
- X. Rome. 45.
- Y. Rome. 50.
- Z. Rome. 48.
- AA. England. York, Durham. 36.
- BB. Salisbury, Bristol, Chichester, 33.
- CC. Norwich, Lincoln, Ely. 31.
- DD. Winchester, Romsey, Arundel, Parish Churches. 45.
- EE. Scotland. Edinburgh. 53.
- FF. Glasgow, etc. 33.
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ENVOI DE ROME. *The Antiquities of Cori.* Mr. Emmanuel Brune.

1. Details of the Temple of Hercules and of that of Castor and Pollux, in line, with the dimensions.
2. Corinthian Capital from Temple of Castor and Pollux, with Base and Architrave. One-half full size.
3. Doric Entablature of Temple of Hercules, with Capital and Base; one-quarter full size.
4. Doorway of the same, one-tenth full size.
5. Frontispiece. Various Fragments, one-quarter full size.
6. The Doric Order of the Temple of Marcellus. Copy of the original of Mr. André.

GRAND PRIX DE ROME. *1st Accessit.*

*A Monastery.* Mr. Felix Escalier.

7. Ground Plan.
8. Principal Elevation.
9. Section of the church, showing the decoration.
10. Perspective. Bird's Eye View.
11. Study of Plan for the same. Mr. Adrien Forget.

PROJETS RENDUS.

*The House of a Sculptor.* Mr. Albert Tissandier.

12. Plans.
13. Principal Elevation.
14. Rear Elevation.
15. Section.

*A Hippodrome, with Stables.* Mr. Escalier

16. Plans.
17. Elevation.
18. Section.

*An Italian Villa.* Mr. Escalier

19. Plan with Gardens.

20. Second Plan and Section.
21. Elevation.  
    *A Hospital for Women.* Mr. Forget.
22. Plans.
23. Elevation.
24. Section.  
    *A Church.* Mr. Eugene Létang.
25. Plan.
26. Elevation.
27. Section.  
    *A Small Museum.* Mr. Létang.
28. Plan, with grounds.
29. Elevation.
30. Section.  
    *An Hotel-de-Ville.* Mr. Létang.
31. Two Plans and Sections.
32. Elevation.  
    *A Palais d'Industrie.* Mr. Létang.
33. Plan.
34. Section.
35. Elevation.  
    *A Mairie.* Mr. Létang.
36. Plan.
37. Section.
38. Elevation.  
    *An Archiepiscopal Palace.* Mr. Forget.
39. Plan.
40. Elevation.  
    *A Museum of Natural History.* Mr. Létang.
41. Plans.
42. Elevation.
43. Section.

#### PROJETS DE DECORATION.

- A Ball Room.* Mr. Escalier.
44. Section.  
    *A Pulpit and Canopy.* Mr. Forget.
45. Elevation. (Sketch in India Ink.)

#### PROJETS D'ORDRE.

- A Flower Market in the Tuscan Order.* Mr. Escalier.
46. Plan Section and Elevation, in line.
47. Detail of the Order.
48. Frontispiece. Perspective View.

- A Peristyle in the Corinthian Order.* Mr. Létang.
49. Plan and Section.
50. Elevation.
51. Frontispiece. Detail of the Order.
- An Academy of Music in the Ionic Order.* Mr. Létang.
52. Plan and Section.
53. Elevation.
54. Frontispiece. Detail of the Order.
- The Same.* Mr. E. Calinaud.
55. Elevation.

#### PROJETS DE CONSTRUCTION.

- A Restaurant at a Railway Station. Construction Générale.* Mr. Létang.
56. Plan and Elevations.
57. Woodwork.
58. Ironwork.
59. Stonework.
- A Church. Construction Générale.* Mr. Victor Hoyot.
60. Plan and Elevations.
61. Details on larger Scale.
62. Woodwork.
63. Stonework.
64. Ironwork.
- A Salle de Pas Perdus. Construction en Fer.* Mr. Létang.
65. Plan and Elevation.
66. Section and Details.
67. Details.

#### OTHER LARGE ARCHITECTURAL DRAWINGS.

- Six Competition Drawings for a Church at Lille.* Mr. Calinaud.
68. Plan.
69. Front Elevation.
70. Side Elevation.
71. Rear Elevation.
72. Longitudinal Section.
73. Transverse Section.
74. Pavilion of the Old Louvre.
75. Interior of a Modern English Church.
76. Design for a Lighthouse. Mr. Rozier and Mr. Létang.
77. Design for an Observatory. Mr. Létang.

## LARGE PRINTS.

1. Fac Simile of Perspective View of a Greek Temple. Mr. Viollet-le-Duc.
2. Fac Simile of Perspective of the Baths of Caracalla. Mr. Viollet-le-Duc.
3. Fac Simile of Original Drawing of Front of Cologne Cathedral. One-half size.
4. Fac Simile of Original Drawing of Front of St. Stephen' at Vienna.
5. Bird's Eye View of Paris, in 1845.

## DEPARTMENT OF ARCHITECTURE. CASTS.

## GREEN ROOM (LIBRARY),

1. Roman decorated moulding. Pantheon.
2. " " "
3. " " " "Jupiter Tonans."
4. " " "
5. Fragment of Colossal Pilaster, from the Villa Medici.
6. Leaf from the same.
7. Roman Acanthus. Vatican.
8. Another. Rome.
9. Another.
10. Greek Bas Relief. Fragment of Vase.
11. Another.
12. Portion of Greek Scroll. Athens.
13. Roman Acanthus.
14. " Cymatium, decorated.
15. French " " Paris.
16. Acanthus, from Nature.
17. Gothic Capital from Notre Dame.
18. Another.
19. Roman Rosette. Paris.
20. " " Rome.
21. Hand.
22. Fist.
23. Three colossal Ears.
24. Eagle's Head. Rome.
25. Eye, and part of Nose.
26. Another.
27. Female hand.
28. Foot.

- 29. Ram's head from Candelabra, Vatican.
- 30. Another. Modern.
- 31. Bunch of Grapes.
- 32-40. Casts of Fruit.
- 41-44. Casts of Fruit and Leaves.
- 45, 46. Casts of Leaves and Flowers.
- 47. Lion's Leg.
- 48. The same, beneath the Skin.
- 49. Roman Egg and Dart Moulding. Temple of Jupiter Tonans.
- 50. Greek Egg and Dart Moulding.
- 51-55. Five Greek Anthemions, from Funeral Monuments.
- 56-61. Six " " from Terra Cotta Cornices.
- 62-64. Three Pilaster Capitals. Roman.

## RED ROOM.

*Casts from Angel Choir, Lincoln Cathedral; round the top of the Room.*

- 65. Angel with Scroll.
- 66. Virgin and Child. Angel bearing Censer.
- 67. Christ showing his Wounds. Angel bearing a Soul in a Napkin.
- 68. Angel with Censer.
- 69. Angel with Lute.
- 70. Angel with Scroll and Palm-branch.
- 71. Angel with Lute. (Duplicate of 59.)
- 72. Angel with Falcon.
- 73. Angel bearing a Soul in a Napkin.
- 74. Angel crowned, with Harp. (? King David.)
- 75. Angel with closed Book.
- 76. Angel with open Book.
- 77. Angel with Viol and Bow.
- 78. Angel with Scroll.
- 79. Portion of Arch. Moulding below Spandrels, with Woman's Head as Corbel.
- 80. The same, with Head of a Lady.
- 81. " with Head of a Man.
- 82-103. Twenty-two similar Heads of Priests, Women, Negroes, Men, and Fools.
- 104-107. Four Carved Bosses.
- 108-113. Six Square Pieces of Foliage.

*South side of Room. Gothic Sculpture and Carvings.*

- 114. Group. King and Queen. Lincoln.
- 115. " Doctors Disputing. "
- 116. " Lady and Courtier, with Lap Dogs. Lincoln.



- 117-121. Five Grotesque Heads. French.
- 122. Carved Head in Stone. Modern.
- 123. " Wood. "
- 124. Small Head and Moulding. Southwell.
- 125. Corbel, with Mask and Foliage, from Palace of Louis IX.
- 126. Colossal Head of the Virgin, from Central Doorway, Rheims Cathedral.
- 127, 128. Angels with Musical Instruments. Notre Dame, Paris.
- 129, 130. Angels with Candle-sticks. St. Denis.
- 131. "*Vierge à la Coquille*," from Choir of Notre Dame, outside.
- 132. Colossal Head of the Prophet Ezekiel, Rheims Cathedral.
- 133. Corbel with Mask and Foliage, from Palace of Louis IX.
- 134, 135. Gargoyles, from Notre Dame.
- 136. Statuette. Nanthilde, St. Denis.
- 137-139. Three Misereres. Rouen.
- 140. Corbel with Angels singing.
- 141. Statuette. St. John.
- 142. Head. Godfrey de Bouillon.
- 143. Angel from Arch of Doorway, Notre Dame.
- 144. Censer. Notre Dame.
- 145. Triptych.
- 146. Censer. Chartres.
- 147-150. Four Monks, from Tombs of Dukes of Burgundy, Dijon.
- 151. Sitting Monk. Amiens.
- 152. Moulding with Lily.
- 153. Ivy.
- 154. Foliage.
- 155. Grotesques and Foliage. Flamboyant.
- 156. Foliage. Flamboyant.
- 157, 158. Weeping Monks. "*Pleureurs de Bourges*," from the Monument of Jean, Duc de Berri.
- 159-164. Six Casts from Ivory Carvings.
- 165-169. Five Panels from North Doorway of Rouen Cathedral.
- 170-172. Three Sculptured Crosses. Chartres.
- 173, 174. Two Sculptured Corbels.
- 175. Hands holding Book. Chartres.
- 176. Another.
- 177, 178. Sculptured Embroidery. Chartres.
- 179-187. Nine Heads from Choir Screen. Chartres.
- 188, 189. Foliage from Southwell Minster.
- 190. Mistletoe, Lizard and Snake. French.
- 191. Boy Climbing. French.

- 192, 193. Two Spandrels, with Foliage. Southwell Minster.  
 194, 195. Two Spandrels, with Figures.  
 196. Panel from Tomb of St. Firmin. Amiens.  
 197. Imp, from wall at side of the Choir. Lincoln.  
 198-207. Ten Angels, in panels, with Musical Instruments.  
 208. Three panels, with similar angel.  
 209. Figure from Niche. Man and Dog.  
 210. Figure from Niche.  
 211-217. Seven Bosses from Cloisters of Lincoln Cathedral. (The originals in Wood.)  
 218. Panel with Quatre-foils.  
 219. Spandrel with Foliage.  
 220. Spandrel with Half-figure.  
 221. Spandrel with Bat, from Choir and Screen. Notre Dame.  
 222. Spandrel with Grape-vine. Notre Dame.

*West side of Room.*

- 223-224. Byzantine Capitals from Bonn.  
 225. Byzantine Scroll. Man and Animals. Bonn.  
 226. " Men Fighting. "  
 227. Byzantine Panel.  
 228. Another.  
 229, 230. Two Capitals from Aix-la-Chapelle.  
 231. Large Capital from Moissac.  
 232. Small Byzantine Capital.  
 233. Large Byzantine Arch Moulding. Germany.  
 234-235. Two small Byzantine Capitals.  
 236-237. Two Fragments of Byzantine Columns.  
 238. Pilaster with Scroll. Chartres.  
 239, 240. Two Crockets from Notre Dame.  
 241. Crocket.  
 242, 243. Two Poppy Heads.  
 244, 245. Two small Corbels. Notre Dame.  
 246. Panel. Fleur-de-lys. Notre Dame.  
 247. Gothic Leaf.  
 248. Leaf.  
 249-266. Eighteen Fragments of French Gothic Foliage.  
 267-280. Fourteen Small Gothic Capitals. French.  
 281-284. Four Small Spandrels, Carved. French.

*North side of Room. Gothic Carvings.*

- 285, 286. Two Capitals from Notre Dame. (Duplicates of 17 and 18.)
- 287, 288. Two Capitals from Aix la Chapelle. (Duplicates of 229, 230.)
- 289. Capital from Lincoln.
- 290. Crocket Foliage.
- 291. Clustered Capital.
- 292. Boss from Notre Dame.
- 293. Capital from the Sainte Chapelle.
- 294. Corbel from Noyon.
- 295. Boss.
- 296. Capital from the Sainte Chapelle.
- 297. Corbel from Palace of Justice. Paris.
- 298. Boss from the Sainte Chapelle.
- 299. Double Capital from Notre Dame.
- 300. Boss. French.
- 301. Capital from Temple Church.
- 302. Boss. French.
- 303. Perforated Foliage from Arch. From Door to N. Aisle of Choir, Lincoln.
- 304. Fragment of Iron-Work. Notre Dame.
- 305. Panel Foliage with Crocket, Chartres.
- 306, 307. Two Crockets.
- 308. Flamboyant Clustered Bases.
- 309-311. 3 Cornice Mouldings with Crockets.
- 312. Moulding with Grape Leaves. Notre Dame.
- 313-316. Large Mouldings, with Foliage.
- 317. Moulding with Fig Leaves. Ste. Chapelle.
- 318, 319. Moulding with Foliage, two Pieces. Notre Dame. Porte St. Anne.
- 320. Small Base, with Toes.
- 321-323. 3 large Toes, from Bases.
- 324. Toes from Double Base.
- 325, 326. Two Small Panels with Foliage.
- 327-331. Five Pieces of Diaper-work. Foliage.
- 332-335. Four " " from Lincoln.
- 336. Fragment of Early English Foliage.
- 337. Panel with face.
- 338-340. Three Pieces of Tudor Flower.
- 341. Enriched Early English Moulding.
- 342. Gothic Arch Moulding, with Foliage.
- 343. Small Niche with Corbel and Canopy.
- 344-351. Nine bits of Moulding.

- 352-357. Six Pieces of Foliage.  
 358. Fragment of Corbel.  
 359-366. Eight Capitals from Chapter House. Southwell.  
 367-374. Eight Clustered Capitals. Southwell (?)  
 375. Misereres. The Resurrection, with Mary Magdalen and the Gardener.  
 376. The Good Samaritan.  
 377. King's Head, with Tudor Flowers on the Crown and Collar of Fleur-de-lys.  
 378. King on Throne, between two Griffins.  
 379. The Ascension.  
 380. The same, with Angels swinging Censers.  
 381. Duplicate of 375.  
 382, 383. Knight and Four Dragons. (Duplicates.)  
 384, 385. Samson and the Lion. (Duplicates.)  
 386, 387. Elephant and Castle. (Duplicates.)  
 388. Duplicate of 379.  
 389. Finial from the Cantilupe Chantry, Lincoln.  
 390, 391. Two Decorated Niches, with Figures. Southwell.

*East side of Room. Greek and Roman Sculpture.*

392. Mask of Venus of Arles.  
 393. Mask of Jupiter.  
 394. Mask of Caracalla.  
 395. Venus of Milo (reduction).  
 396. Minerva. (From Bronze.)  
 397. Victory. (From Bronze.)  
 398. Euterpe (reduction). Louvre.  
 399. Head. Bacchante.  
 400. Head. Neapolitan Psyche.  
 401. Head of "*Joueuse d'osselets*."  
 402. Head of Somnus. (From Bronze.) London.  
 403. Head of Indian Bacchus (reduction).  
 404. Faun of the Capitol (reduction).  
 405. Germanicus (reduction). Louvre.  
 406. Silenus and Bacchus (reduction). Louvre.  
 407. Faun Piping (reduction). Vatican. Janus Head.  
 408. Head of Jupiter Trophonius. (From Bronze.)  
 409. The "*Joueuse d'osselets*" (reduction).  
 410. Fates from Parthenon (reduction), restored.  
 411. Muse (reduction).  
 412. Apollo Musagetes (reduction).

- 413. Muse (reduction).
- 414. Plato. (Terra Cotta, Bronzed.)
- 415. Caracalla. " "
- 416. Socrates. (Terra Cotta, Bronzed.)
- 14 Casts from small Antique Bronzes.

- 417. Dancing Girl.
- 418. Etruscan Figure.
- 419. Jester.
- 420. Cæsar.
- 421. Jupiter.
- 422. Antinous.
- 423. Boxer.
- 424. Flute-player.
- 425. Antinous.
- 426. Meleager.
- 427. Theseus.
- 428. Ball-player.
- 429. Gladiator.
- 430. Hercules.
- 431. Two Masks.
- 432. Horse's Head from Parthenon.
- 433. Eagle, from the Vatican.

## GRAY ROOM.

*South side of Room.*

- 434. Bas Relief. Griffin. Vatican.
- 435. Honey-suckle Ornament from Pompeii.
- 436. Scroll.
- 437. Patera. Temple of Jupiter Tonans.
- 438, 439. Two small Rosettes.
- 440. Base Moulding. From Pedestal of Trajan's Column.
- 441. Chain Ornament.
- 442. Foliage.
- 443-450. Eight Rosettes from Tomb of the Scipios.
- 451. Acanthus Foliage.
- 452. Greek Moulding.
- 453. Moulding and Lion's Head. Metapontus.
- 454-473. Twenty Slabs from the Frieze of the Parthenon. (Reductions).
- 474-482. Nine Duplicates of the above.
- 483, 484. Group of Orpheus and Eurydice. (Duplicates.) (Reduction.)
- 485-501. Seventeen Pieces. The whole Frieze of the Choragic Monument of Lysicrates, representing Bacchus transforming the Pirates into Dolphins.

- 502-504. Three Acanthus Leaves.  
 505. Flower.  
 506. Flower with Pine Cone.  
 507. Flower with Poppy-head.  
 508. Flower from Capital of Temple of the Sibyl Tivoli.  
 509. Egyptian Bas Relief.  
 510. " " Head of Cleopatra.  
 511. Egyptian Bas Relief.  
 512. Scroll from Choragic Monument.  
 513. Scroll from Tomb of the Scipios.  
 514. Roman Acroterium. Villa Pamphili Doria.  
 515. Renaissance Pilaster.

*West side of Room.*

516. Capital of Antæ. Minerva Polias.  
 517. Ionic Volute. Athens.  
 518. Horse's Head. Vatican.  
 519. Corinthian Capital. Modern.  
 520. The same. Pilaster Capital.  
 521. Horse. By Bailey.  
 422. Eagle. By Bailey.  
 523, 524. Acroteria from Parthenon. (Duplicates.)  
 525. Corner Capital from Erechtheum.  
 526, 527. Capital of Antæ, Erechtheum. (Duplicates.)  
 528. Architrave and Door Cap. Erechtheum.  
 529. Support of Table. Pompeii.  
 530. Renaissance Panel.  
 531. Another.  
 532. Leg to Table with Lion's Head and Foot. Capitol Museum.  
 Two Casts from Terra Cotta. Campana Collection.  
 533. Bacchante, Faun, and Infant Bacchus.  
 534. Castor and Pollux.  
 535, 536. Two Renaissance Medallions.  
 537. Colossal Head of David. Michael Angelo.  
 538. Cast of Greek Acroterium. Athens.

*North side of Room.*

539. Capital from Alhambra.  
 540. Moorish Panel.  
 541. Pilaster. Chateau de Gaillon.  
 Four Casts from Terra Cotta. Campana Collection.  
 542. Two Priestesses.  
 543. Scroll-work with Winged Victory.

- 544. Paris and Helen.
- 545. Helen and Menelaus.
- 546. Renaissance Bracket. Vatican.
- 547, 548. Two Modillions. Modern.
- 549. Console. Modern.
- 550. Honeysuckle Ornament.
- 551. Another, from the Erechtheum.
- 552. Another.
  - Eleven small Bas Reliefs.
- 553. Bacchanal and Panther.
- 554. Corybantes dancing. Vatican.
- 555. Faun dancing.
- 556. Mercury and part of a Group. Louvre.
- 557. Bacchus and Three Fauns.
- 558. Faun dancing.
- 559. Smaller figure, like No. 558.
- 560. Faun dancing. Villa Albani.
- 561. Pastoral Group.
- 562. Victory and Bull. Vatican.
- 563. Greek Inscription.
- 564. Large Alto Relievo, from end of the Vienna Sarcophagus.
- 565-572. Eight Acanthus Leaves. Modern.
- 573. Fragment of Cornice.
- 574, 575. Two Pilaster Panels.
- 576. Another.
- 577. Capital of Pilaster, same as No. 541.
- 578. Large Acanthus Leaf.
- 579, 580. Two Sets of small Rosettes. Modern.
- 581, 582. Two Guilloche Mouldings.
- 583. Set of Enriched Mouldings. Modern.
- 584. Profile Head. Full Size. Trajan's Column (?)
- 585. Head from Arch of Titus.
- 586. Another.
- 587. Two others.
- 588. Group from Trajan's Column. Four Soldiers.
- 589. Another. Soldier watering his Horse.
- 590. Upper part of Group. Five Soldiers going into battle.
- 591. " " Four Barbarian Captives.
- 592. " " Six Roman Citizens.
- 593-633. Forty-one Heads from Trajan's Column.
  - Soldiers, Citizens, Barbarians, Women and Horses.
- 634. Alto Relievo of the Battle of the Amazons, from a Sarcophagus at Vienna.

*East side of Room. French Renaissance.*

- 635, 636. Doric Capital and part of Rusticated Pilaster. Louvre.
- 637. Lion's Head, from the Hotel Carnavelet. Jean Goujon.
- 638. Pilaster Capital, with part of Enlablement.
- 639. Frieze, with Laurel Leaves. Chateau de Gaillon.
- 640. Key-stone, enriched. Chateau de Gaillon.
- 641. Lion's Head, from Nature. Bussy.
- 642-645. Four Capitals from Tomb of Louis XII. St. Denis.
- 646. Lioness' Head, from Nature. Bussy.
- 647. Door Knockers. Louis XIV.
- 648. Cartouche Frieze. Door of St. Maclou, Rouen.
- 649. Cartouche, with Cupid. Door of St. Maclou, Rouen.
- 650. Mask of Pan. Louvre.
- 651. Lion's Head.
- 652. Rosette. Modern.
- 653. Anatomical Figure by Michael Angelo.
- 654. Bracket.
- 655. Slave by Michael Angelo. Statuette.
- 656. Bracket with Cupid.
- 657. Head of Michael Angelo's Slave. Louvre.
- 658. The same reduced.
- 659-666. Six Pilaster Panels.
- 667, 668. Two Small Pilasters from Tomb of Louis XII. St. Denis.
- 669. Small Figure of a Lion. Rouiliard.
- 670. Another, smaller.
- 671. Tiger. Rouiliard.
- 672. *Ecorché*, Horse. Bonheur.
- 673. " Man. Houdon.
- 674, 675. Two others. Coudron.
- 676. Mask. Pan.
- 677. Head. Nondescript. Modern.
- 678. Statuette. Milo of Crotona.
- 679. Bracket. (Duplicate of No. 654.)
- 680. Prisoner, by Michael Angelo. Statuette.
- 681. Bracket, with Cupid.
- 682. Mask of the Virgin, by Michael Angelo.
- 683. Statuette by Pradier. Woman carrying Water.
- 684. Bust by Pradier.
- 685-688. Four Pilasters from Tomb of Louis XII.
- 689. Figure from Tomb in the Church at Brou. The Virgin.
- 690. Another.
- 691. Another. St. Elisabeth.



692. Wing.
693. Bust of Diane de Poitiers. Jean Goujon.
- 694-697. Casts of Four small Vases.
- 698-702. Casts of Five Shells.
703. Mask.
704. Another.
705. Duplicate of No. 677.
- 706-708. Three small Cupids by Fiammingo.
- 709, 710. Two others, in Alto Relievo, larger, supporting a Cartouche.  
Two Bas Reliefs from the Chateau d'Anet. Jean Goujon.
711. Angel with the Cross.
712. Angel with the Pillar.
713. Infant, from the lid of the Vase containing the Heart of Francis I. St. Denis. Jean Goujon.
714. Bas Relief from Tomb of Francis I. St. Denis.
715. Cupid from Court of the Louvre. Jean Goujon.
- 716, 717. Two heads by Fiammingo.
718. Small Capital.
719. Panel with Fleur-de-lys.
720. Panel with Crescent.
- 721, 722. Two Panels with Arabesque Griffins. St. Maur, near Paris.
723. Woman's Hand, from Nature.
724. Colossal Renaissance Hand.
- 725-728. The Four Seasons. Casts from the Terra Cotta Models of the Sculptures of the Fountain in the Rue de Grenelle. Bouchardon.
- 729, 730. Two Panels. Rome.
731. Head of John the Baptist. Donatello. Baptistry. Florence
- 732-743. Twelve Vases, Casts from the Hildesheim Treasure.
- 744-746. Three Fragments of Casts of Central American Sculpture.

#### STAINED GLASS.

##### *First Screen.*

- Ruth in the Cornfield. Messrs. Morris & Co., London.
- Head of David. Messrs. Lyon & Co., London.
- Virgin and Child, in Canopy. Messrs. Lavers & Barraud.  
London.
- Medallion, with Head of Milton. The same.
- Two Panels of Quarry Work. The same.
- One Panel of Mosaic Work, in Color. The same.
- Two Panels with Flowers. Messrs. Heaton, Butler & Bayne, London.
- Grisaille of Rolled Glass. The same.

*Second Screen.*

Two specimens of Grisaille work. Messrs. Cottier & Co., Glasgow.  
 Figure of Architecture. Messrs. Cook & Co., Boston.  
 Two grisaille panels, with medallions. The same.

*Third Screen.*

Two pieces consisting of fragments. Ancient English work.  
 Specimen of Heraldic work. Messrs. Heaton, Butler & Bayne.  
 Mosaic of Rolled glass. The same.  
 Grisaille of Rolled glass. The same.  
 Grisaille with small head. Messrs. Lavers & Barraud.  
 Two specimens of quarry-work. The same.

*Fourth Screen.*

Grisaille work. Messrs. Clayton & Bell, London.  
 Four Medallions with Angels. The same.  
 Five Medallions set in Grisaille work. Messrs. G. E. Cook & Co., London.  
 Two small panels.

## TILES, TERRA COTTA, ETC.

Four large Specimens of Mosaic, Encaustic and Majolica tilework, by  
 Messrs. Maw & Co. Broseley.  
 Two Hundred other Tiles. The same.  
 Six Tiles, illustrating Æsop's Fables. Messrs. G. E. Cook & Co., Lond.  
 Four of Painting and the Graces. The same.  
 Four pieces of Painted Tile Work. Messrs. Simpson & Co.  
 One Hundred Neapolitan Tiles.  
 Sixteen Ancient Tiles from Chapter House, Salisbury.  
 Twenty-four Modern Reproductions of Pompeian Vases.  
 Three Modern Neapolitan Cups.  
 Seventeen small Copies of Statuary in Terra Cotta.  
 Two Specimens of Salviati's Venetian Mosaic.

## MODELS.

Models of the Five Orders of Vignola, with Entablatures and Pedestals,  
 by Brucciani.  
 Five Models belonging to the Boston Athenæum.  
 The Unitarian Church at Baltimore, showing Dome and Pendentives.  
 The Parthenon.  
 Shakespeare's House at Stratford.  
 Two smaller Models.  
 Model of a Dwelling House.

## Three Models in Cork.

The Temple of Neptune at Poestum.

The Temple of the Sibyl at Tivoli.

An Etruscan Tomb.

## Two Models of Window Finish.

Model of Door, and Door Finish.

Twenty Models of Joinery, published by the Frères Chrétiens.

Six Models of Framing, " " "

## MISCELLANEOUS ARTICLES.

Thirty-six specimens of Ornamental Woods.

Thirty-six Specimens of Italian and other Marbles.

Small specimen of Pompeian Decoration.

Fragment of Opus Reticulatum.

Fragments of Roman Bricks.

Fragment of Vaulting Stone from Salisbury Cathedral.

Three Specimens of Scotch Granite, polished.

Specimen of Béton Coignet.

Specimen of Ransome's Patent Stone.

Large Wooden Corinthian Capital from Brattle Street Church.

Console and Modillions from the same.

## LECTURE DIAGRAMS.

1. Elementary Mouldings.
2. Proportions of the Five Orders.
3. " " Tuscan Order.
4. " " Doric Order.
5. " " Corinthian Order.
6. Origin of Doric Order.
7. The Roman Doric Order.
8. Another. "
9. The Greek Doric Order.
10. Another. "
11. The Roman Ionic Order.
12. The Greek Ionic Order.
13. Assyrian Bas Relief.
14. Persian Capitals.
15. Lycian Tomb.
16. Another.
17. Another.
18. Another.

19. Egyptian Capital. Colored.
20. Assyrian Ornament.     "
21. Another.
22. Roman Vaulting.
23. Early Gothic Vaulting.
24. Lierne Vaulting. Oxford Cathedral.
25. Fan Vaulting. Peterborough Cathedral.
- 26-29. Four Diagrams of Gothic Vaulting. Plans.
30. Three Half-timbered Houses.
31. French Gothic Capital.
32. Gothic Mouldings.
33. Gothic Bases.
34. Architectural Map of Greece, with the Colonies.
35.         "         Map of Italy.
36.         "         Map of France.
37.         "         Map of England.
- 38-40. Three Diagrams of Curvilinear Perspective.
41. General Diagram of the Perspective of Planes.
42.         "         "         "         Perspective of Shadows.
- 43-70. Diagrams of the Frères Chrétiens.
- 71-76. Six Cartoons for the Stained Glass in the First Church.  
Messrs. Lavers & Barrand.
- 77-79. Three Cartoons for the Stained Glass in the First Church.  
Messrs. Heaton, Butler & Bayne.
- 80, 81. Two Cartoons for the Stained Glass in the First Church.  
Messrs. Lyon & Co. and Saunders & Co.

FOURTEEN PAINTED DIAGRAMMS LOANED BY THE LOWELL INSTITUTE.

1. Elementary Lines.
2. Trusses.
3. Egyptian Capitals and Columns.
4. Façade of Temple of Apollinopolis Magna.
5. Section through the Parthenon.
6. St. Paul's, *extra muros*. Rome. Interior.
7. Salisbury Cathedral, from the S. W.
8. Gothic Doorway and Capitals.
9. St. Peter's. Rome.
10. Villa Capra, near Vicenza.
11. Pompeian Palace. Vicenza.
12. English Manor House.
13. Christ Church. Cambridge.
14. Trinity Church. New York.

SUMMARY OF THE COLLECTIONS OF THE DEPARTMENT  
OF ARCHITECTURE.

- 378 Books.
- 2240 Photographs.
- 465 Card Photographs.
- 660 Stereoscopic Views.
- 250 Glass Slides.
- 810 Drawings.
- 963 Prints and Lithographs.
- 77 Drawings from the Ecole des Beaux-Arts, etc.
- 746 Plaster Casts.
- 35 Specimens of Stained Glass.
- 32 Architectural Models.
- 95 Lecture Diagrams.
- Also Tiles, Terra Cotta, and various miscellaneous articles.

## ALUMNI OF THE INSTITUTE.

The degree is Bachelor of Science (S. B.) in the department of I, Civil and Topographical Engineering; II, Mechanical Engineering; III, Mining Engineering; IV, Architecture; V, Chemistry; VI, Metallurgy; VII, Natural History; VIII, Physics; IX, Science and Literature; X, Philosophy. Present residence and occupation are given, so far as known.

## GRADUATES IN 1868.

Ellery C. Appleton, III, Allentown, Pa. Engineer for Lehigh Coal and Navigation Co.

Nelson W. Conant, III, Columbus, Indiana. Farmers' Bank.

Frank R. Firth, I, Deceased.

Eli Forbes, IX, Clinton, Mass. Chemist at Lancaster Mills.

Charles C. Gilman, III, Marshalltown, Iowa. Chief Engineer, Central Railroad of Iowa.

Charles E. Greene (A.M., Harv. Coll.), I, Ann Arbor, Mich. Professor of Civil Engineering, University of Mich.

Albert F. Hall, II, Charlestown, Mass. Draughtsman at G. F. Blake Manufacturing Co., Boston.

William E. Hoyt, I, Boston, Mass. Instructor in Civil Engineering and Stereotomy, Mass. Inst. Tech.

Robert H. Richards, III, Jamaica Plain, Mass. Professor of Mining Engineering, Mass. Inst. Tech.

Walter H. Sears, I, Plymouth, Mass. Civil and Hydraulic Engineer, Boston.

Charles A. Smith, I, St. Louis, Mo. Professor of Civil and Mechanical Engineering, Washington University.

Joseph Stone, I, Manchester, N. H., Agent Manchester Mills.

Bryant P. Tilden, III, Philipsburg, Montana. Practising Assayer.

James P. Tolman, III, Boston, Mass. Supt. Silver Lake Co. for manufacturing steam packing, etc.

## GRADUATES IN 1869.

William H. Baker, Helena, Montana. Chief Draughtsman, Surveyor General's Office.

Howard A. Carson, I, Providence, R. I. Assistant Engineer, Providence Water Works.

J. Rayner Edmands, II, Boston, Mass. Practising Mechanical Engineer.

William R. Nichols, V, Boston, Mass. Professor of General Chemistry, Mass. Inst. Tech.

Channing Whitaker, II, Lowell, Mass. Professor of Mechanical Engineering, Mass. Inst. Tech.

## GRADUATES IN 1870.

Edward K. Clark, II, Boston, Mass. Assistant Engineer Mass. State Board of Health.

Charles R. Cross, IX, Jamaica Plain, Mass. Professor of Physics and Descriptive Astronomy, Mass. Inst. Tech.

Russell H. Curtis, I, Boston, Mass. Civil Engineer, 12 West St.

Charles W. Hinman, III, Boston, Mass. State Inspector of Gas and Gas-Meters.

Sampson D. Mason, I, Logansport, Indiana. Treasurer and Chief Engineer, Detroit, Eel River and Illinois R.R.

N. Frederic Merrill, V, Cambridgeport. Supt. of the Boston Works of the Boston and Colorado Smelting Co.

Theodore F. Tillinghast, I, New Bedford, Mass. Private business.

Edmund K. Turner, I, Marblehead, Mass. Civil Engineer, in employ of Fitchburg R.R.

Daniel W. Willard, II, Jamaica Plain, Mass. Sheep raising in Wyoming Territory.

L. F. J. Wrinkle, III, Virginia City, Nevada. Surveyor General's Office.

## GRADUATES IN 1871.

Foster E. L. Beal, I, Ames, Iowa. Professor of Civil Engineering, State Agricultural College.

Addison Connor, (A. B., Tufts Coll.), I, South Framingham, Mass. Boston Water Works.

Henry M. Cutler, I, San José, Cal. Not heard from.

Elmer Faunce, III, Kingston, Mass. Out of employment.

Edward H. Foote, I, Somerville, Mass. Practising Civil Engineer.

Frank L. Fuller, I, Grantville, Mass. Civil and Hydraulic Engineer, 7 Exchange Place, Boston.

Henry M. Howe (A. B., Harv. Coll.), III, Boston. Travelling in Europe on professional business.

Albert H. Howland (A. M., Amherst Coll.), I, Boston, Mass. Civil Engineer, 12 West St.

G. Russell Lincoln, III, Steel Works P. O., Pa. Chemist of Pennsylvania Steel Works.

William A. Pike, I, Orono, Maine. Professor of Civil and Mechanical Engineering, Maine State College.

George H. Pratt, V, South Boston, Mass. Supt. Bayside Alkali Works.

Edward W. Rollins, III, Golden, Colorado. Resident Engineer and Cashier Col. Central R.R. Co.

Walter W. Smith, II, Dayton, Ohio. Manufacturer of Steam Pumps and Hydraulic Machinery.

- Charles F. Stone, III, Waltham, Mass. Student at Law.  
 Almarin Trowbridge, Jr., II, Charlestown, Mass. Unemployed.  
 Isaiah S. P. Weeks, I, Charlestown, Mass. Office of T. and J. Doane,  
 Civil Engineers.  
 Randal Whittier, V, Boston, Mass. Instructor in Mathematics, Boston  
 University.

## GRADUATES IN 1872.

- Calvin Francis Allen, I, Providence, R. I. Assistant Engineer, Providence Water Works.  
 Benjamin E. Brewster, III. Not heard from.  
 William B. Dodge, I, Beverly, Mass. Engineer's Office, State Lunatic Asylum, Danvers, Mass.  
 Frederic A. Emmerton, V, Joliet, Ill. Chemist of Joliet Iron and Steel Co.  
 J. Amory Herrick, V, Nashua, N. H. Supt. of Steel department of Nashua Iron and Steel Co.  
 James M. Hodge, III, New York. Assistant Engineer Erie Railway.  
 Bradford H. Locke, III, Central City, Colorado. Mining Engineer and U. S. Deputy Surveyor.  
 Charles S. Minot, V, Germany. Student of Natural History.  
 Walter Shepard (A. B., Harv. Coll.), I, Harrison Sq. Assistant Engineer Boston and Albany R. R.  
 Richard S. Soule (A. B., Harv. Coll.), II, Altoona, Pa. Mechanical Engineer's Office, Motive Power Department, Penn. R.R.  
 Clarence S. Ward, III, Boston, Mass. Lawyer, 35 Court St.

## GRADUATES IN 1873.

- Amory Austin (A. B., Harv. Coll.), V, 40 Kilby St., Boston. Not heard from.  
 George W. Blodgett, I, Boston, Mass. Boston Water Works.  
 William E. Brotherton, I, Cincinnati, Ohio. Bookkeeper, Bank of Gilmore, Dunlap & Co.  
 Samuel A. Fabens, Jr., I, Deceased, March 14, 1875.  
 Samuel M. Felton, Jr., I, Pittsburg, Pa. Gen. Supt. Pittsburg, Cincinnati and St. Louis Railway Co.  
 Frederick L. Fisher, I, Medway, Mass. In business (Fisher & Taylor).  
 Clarence L. Howes (A. M., Amherst Coll.), I, Hanover, Mass. Not heard from.  
 Frederic Guild, Jr., IX, Boston, Mass. In Leather Business.  
 William D. Harris, I, Boston, Mass. Unemployed.



William A. Kimball, II, 38 Park Row, N. Y. N. Y. Belting and Packing Co.

William C. May, V, Boston, Mass. Student.

Frank B. Morse, I, Boston, Mass. Instructor of Drawing, M. I. T., and Warren Academy, Woburn.

George Phillipps, III. Not heard from.

Henry A. Phillips, IV, Chicago, Ill. Studying abroad.

Robert A. Shailer, I, Chicago, Ill. Engineer in employ of American Bridge Co.

Charles E. Stafford, III, Steel Works P. O., Penn. In charge of Open Hearth Steel department of Pa. Steel Works.

Ellen H. Swallow (Mrs. R. H. Richards) (A. M., Vassar Coll.), V, Jamaica Plain.

S. Everett Tinkham, I, Boston, Mass. City Engineer's Office.

Frank W. Very, V. Not heard from.

Webster Wells, I, Boston, Mass. Instructor in Mathematics and Descriptive Geometry, M. I. T.

Randal Whittier, S. B., I, Boston, Mass. Instructor in Mathematics, Boston University.

Francis H. Williams, V, Boston, Mass. Student, Harvard Medical School.

Louis F. Wood, V, Boston. Supt. Color Manufactory, Wellesley.

#### GRADUATES IN 1874.

Herbert Barrows, I, Reading, Mass. Employed in Civil Engineering.

George H. Barrus, II, Reading, Mass. Engaged with Mr. George B. Dixwell upon experiments on cylinder condensation.

William T. Blunt, I, East Somerville, Mass. Draughtsman for Boston Harbor Commission.

George E. Doane, I, Middleboro, Mass. Observer U. S. Coast Survey.

William B. Dowse, IV, Boston, Mass. Not heard from.

Joseph S. Emerson, I, West Newton, Mass. Newton Water Works.

Elliot Holbrook, I, Providence, R. I. Teacher of Mechanical Drawing, etc., Warner's College.

Aechirau Hongma, I, Tokio, Japan. Government Engineer.

Charles P. Howard, I, Hartford, Ct. J. L. Howard & Co., Railway and Car Builders.

Frank H. Jackson, III, Boston, Mass. A. Jackson & Son, dealers in Fertilizers and Chemicals.

Willis H. Myrick, II. Died, Oct. 17, 1875.

Herbert B. Perkins, I, Monson, Mass. Teacher of Mathematics and Physics, Monson Academy.

Frank H. Pond, II, Dayton, Ohio. Assistant Supt. Brownell and Kielmeier Manufacturing Co.

Edward S. Shaw, I, Cambridge, Mass. Pursuing advanced professional studies, partly at M. I. T.

Francis H. Silsbee, II, Manchester, N. H. Draughtsman at Manchester Mills.

Arthur W. Sweetser, I, So. Williamstown, Mass. Teacher in Greylock Institute.

Robert C. Ware, IX, Salem, Mass. Student in M. I. T.

Stephen H. Wilder, IX, Cincinnati, Ohio. In Rolling Mill.

#### GRADUATES IN 1875.

Samuel E. Allen, I, South Framingham, Mass. Boston Water Works.

James L. Arnott, X, Thompsonville, Ct. Not heard from.

Amos J. Boyden, IV, Foxborough, Mass. Draughtsman for Stone & Carpenter, Architects, Providence, R. I.

Moses D. Burnett, III, Syracuse, N. Y. Student in Medicine.

H. K. Burrison, I, East Boston, Mass. Draughtsman for Park Commissioners, and Sec. Boston and Northwestern R. R. Co.

Christopher A. Church, I, Woonsocket, R. I. Woonsocket Woolen Mills.

Frank S. Dodge, I, Beverly, Mass. In employ of Gen. Thom., U. S. Engineer, Portland, Me.

Edgar S. Dorr, I, Mt. Auburn, Mass. Unemployed.

William C. Edes, I, Bolton, Mass. Engineering work for Bureau of Statistics of Labor.

Charles W. Goodale, III, Boston, Mass. Boston and Colorado Smelting Works.

Edward A. W. Hammatt, I, Newton Centre, Mass. Unemployed.

Edward A. Handy, I, Boston, Mass. South Boston Flats Improvement.

James H. Head, II. Died August 18, 1875.

Thomas Hibbard, II, West Roxbury, Mass. Draughtsman, Atlantic Works, E. Boston.

William F. Huntington, I, Springfield, Mass. Bookkeeper, Chester Paper Co., Huntington, Mass.

Leonard P. Kinnicutt, V, Worcester, Mass. Studying in Europe.

J. Austin Knapp, II, Boston, Mass. Assistant in Mechanical Engineering, Inst. of Tech.

Wilfred Lewis, II, Phil., Pa. At William Sellers & Co., Machine Works.

Samuel J. Mixer, VIII, Boston, Mass. Student, Harv. Medical School.

Benjamin A. Oxnard, III, Brooklyn, N. Y. Assistant Supt. and Chemist Fulton Sugar Refinery.

Thomas D. Plimpton, II, Walpole, Mass. Student at Law.

William A. Prentiss, IX, Holyoke, Mass. Wire Manufacturing.

Francis T. Sargent, II, Malden, Mass. Assistant in Mechanical Engineering, Mass. Inst. Tech.

William H. Shockley, III, New Bedford, Mass. Resident Graduate Mass. Inst. Tech. .

James B. Stanwood, II, Cincinnati, Ohio. Apprentice in R. R. Machine Shop.

H. L. J. Warren, III, Ore Knob, Ash Co., N. C. Metallurgist, Ore Knob Copper Co.

William R. Webster, III, Coshocton, Ohio. Coal Inspector for the Pittsburgh, Cincinnati and St. Louis Railway Co.

William F. Sargent, I, Sargentville, Maine. Unemployed.

LIST OF MEMBERS  
OF THE  
SOCIETY OF ARTS  
OF THE  
MASSACHUSETTS INSTITUTE OF TECHNOLOGY,  
SEPTEMBER 30, 1875.

HONORARY MEMBER.

\* Prof. Daniel Treadwell, Cambridge, Mass.

LIFE MEMBERS.

Allen, Stephen M. . . Boston.	Fay, Mrs. Sarah S. . . Boston.
Amory, William . . . "	Forbes, John M. . . . "
Atkinson, Edward . . . "	Forbes, Robert B. . . . "
Baker, William E. . . . "	Foster, John . . . . . "
*Bancroft, E. P. . . . . "	Gaffield, Thomas . . . . "
*Beebe, James M. . . . . "	*Gardner, G. A. . . . . "
Bigelow, E. B. . . . . "	Gardner, John L. . . . . "
Bowditch, J. I. . . . . "	Gookin, Samuel H. . . . . "
Bowditch, Mrs. J. I. . . . "	*Grant, Michael . . . . . "
Brimmer, Martin . . . . . "	Greenleaf, R. C. . . . . "
Browne, C. Allen . . . . . "	Grover, Wm. O. . . . . "
Bullard, W. S. . . . . "	
Colby, Gardner . . . . . "	Hemenway, Mrs. M. . . . . "
Cummings, John . . . Woburn.	Hoadley, J. C. . . . Lawrence.
Dalton, Chas. H. . . Boston.	*Huntington, Ralph . Boston.
Davenport, Henry . . . . . "	
Dupee, James A. . . . . "	Johnson, Samuel . . . . . "
Edmands, J. Wiley . . . . . "	Kidder, Henry P. . . . . "
*Eldredge, E. H. . . . . "	Kuhn, Geo. H. . . . . "
Emerson, George B. . . . . "	
Endicott, Wm., Jr. . . . . "	*Lawrence, James . . . . . "
Fay, Joseph S. . . . . "	Lee, Henry . . . . . "
	Lee, John C. . . . . "
	* Lee, Thomas . . . . . "

\* Deceased.

Little, James L. . . Boston.

Lowell, John A. . . "

Lyman, Geo. W. . . "

Matthews, Nathan . . "

McGregor, James . . "

Mudge, E. R. . . "

Nichols, Lyman . . "

Norcross, Otis . . "

\*Pierce, Carlos . . Canada.

Preston, Jonathan . Boston.

Pratt, Mrs. William . . "

Pratt Miss . . . . . "

Richardson, Geo. C. . . "

\*Richardson, J. B. . . "

Rogers, Henry B. . . "

Rogers, William B. . . "

Ross, M. Denman . W. Roxbury.

Ross, Waldo O. . . . . "

Ruggles, S. P. . . Boston.

\*Savage, James . . . . . "

Sayles Henry . . . . . "

Sayles, Mrs. Willard . . . . . "

\*Sears David . . . . . "

Shaw, Mary S. . . . . "

\*Skinner, Francis . . . . . "

\*Stetson, Joshua . . . . . "

Thayer, Nathaniel . . . . . "

Thorndike, John H. . . . . "

Tobey, Edward S. . . . . "

\*Turner, J. M. . . . . "

\*Upton, George B. . . . . "

Walcott, J. H. . . . . "

Wales, Geo. W. . . . . "

Wales, T. B. . . . . "

Wales, Miss . . . . . "

\*Whitney, Joseph . . . . . "

#### ASSOCIATE MEMBERS.

Adams, James . . . Charlestown.

Ames, Isaac . . . Boston.

Amory, T. C. . . . . "

Anderson, Luther W. Quincy.

Appleton, Thos. G. . Boston.

Atkinson, Chas. F. . . . . "

Atkinson, Wm. P. . . . . "

Atwood, Nat'l E. . Provincet'n.

Austin, Edward . . . Boston.

Barber, Lyman L. . Charlestown.

Barnard, James M. . Boston.

Batchelder, John M. Cambridge.

Beal, James H. . . Boston.

Bender, Richard W. . . . . "

Bigelow, A. O. . . . . "

Bigelow, Jacob . . . . . "

Bishop, Chas. J. . . . . "

Blaney, Henry . . . . . "

Bôcher, Ferdinand . . . . . "

Bolles, M. Shepard . . . . . "

Bond, George W. . W. Roxbury.

Bond, W. S. . . . . "

Boott, William . . . Boston.

Bourne, William . . . . . "

Bouvé, T. T. . . . Boston.

Bowditch, Ernest W. Brookline.

Bowditch, Wm. I. . . . . "

Browne, Causten . . Boston.

Buckingham, C. E. . . . . "

Cabot, Edward C. . . . . "

Cabot, Samuel . . . . . "

Carey, A. C. . . . . "

Carpenter, Geo. O. . . . . "

Carruth, Charles . . . . . "

Clapp, Wm. W. . . . . "

Clarke, E. H. . . . . "

Clinch, John M. . . . . "

Cummings, Nath'l . . . . . "

Curtis, Frederick . . . . . "

Dana, Edward A. . . . . "

Danforth, I. W. . . . . "

Danforth, James H. . . . . "

Davies, Daniel . . . . . "

Davis, Barnabas . . . . . "

Davis, F. J. . . . Waltham.

Delano, Jos. C. . . New Bedford.

Denny, Henry G. . . Boston.

Dewson, F. A. . . Boston.  
 Dix, John H. . . "  
 Dixwell, J. J. . . "  
 Doane, Thomas . . "  
 Dresser, Jacob A. . . "  
 Dunklee, B. W. . . "  
  
 Eastman, Ambrose . . "  
 Eliot, Charles W. . Cambridge.  
  
 Farley, Noah W. . Boston.  
 Farmer, Moses G. . . "  
 Fitch, Jonas . . . "  
 Flint, Charles L. . . "  
 Forbes, Franklin . . Clinton.  
 Francis, James B. . Lowell.  
 Fuller, H. Weld . . Boston.  
 Fuller, Horace W. . . "  
  
 Gardner, James B. . . "  
 Gibbens, Joseph M. . . "  
 Grandgent, L. H. . . "  
 Guild, Chester . . . "  
 Guild, Henry . . . "  
  
 Hall, Andrew T. . . "  
 Hall, Thomas . . . "  
 Hamblet, James . . . "  
 Haven, Franklin . . . "  
 Hayes, S. Dana . . . "  
 Heard, John T. . . . "  
 Henck, John B. . . Brookline.  
 Henshaw, John A. . Cambridge.  
 Hewins, Edmund H. Boston.  
 Hilton, William . . . "  
 Holmes, O. W. . . . "  
 Homans, C. D. . . . "  
 Houghton, Charles . . "  
 Hubbard, Charles T. . "  
 Hyde, George B. . . . "  
 Hyde, Henry D. . . . "  
  
 Jackson, J. B. S. . . . "  
 Jasper, Gustavus A. . . "  
 Jenks, Lewis E. . . . "  
  
 Kehew, John . . . . "  
 Kneeland, Samuel . . . "  
  
 Lamson, Chas. D. . . . "  
 Langley, H. P. . . . "  
 Lanza, Gaetano . . . . "  
 Lawrence, A. A. . . . "

Lee, Francis L. . . . Boston.  
 Lee, Thomas J. . . . "  
 Leuchars, R. B. . . . "  
 Lewis, Charles W. . . Charlestown.  
 Lewis, Wm. K. . . . Boston.  
 Lincoln, F. W. . . . "  
 Little, James L., Jr. . . "  
 Little, John M. . . . "  
 Lothrop, Sam'l K. . . . "  
 Lowe, N. M. . . . . "  
 Lowell, John . . . . "  
 Lyman, Theodore . . Brookline.  
  
 Mansfield, A. K. . . . Boston.  
 Markoe, G. F. H. . . . "  
 Marshall, H. N. F. . . . "  
 Mason, Robert M. . . . "  
 May, F. W. G. . . . Dorchester.  
 May, John J. . . . . "  
 McBurney, Charles . . Boston.  
 McMurtrie, Horace . . . "  
 McPherson, W. J. . . . "  
 Merrill, N. F. . . . Cambridge't.  
 Montgomery, Hugh . . Boston.  
 Moore, Alex. . . . . "  
 Morse, John T. . . . . "  
 Morse, Samuel T. . . . "  
 Munroe, William . . . . "  
  
 Nichols, James R. . . Haverhill.  
 Norton, Jacob . . . . Boston.  
  
 Ordway, John M. . . W. Roxbury.  
  
 Page, Edward . . . . Boston.  
 Page, W. H. . . . . "  
 Parsons, Wm. . . . . "  
 Paul, J. F. . . . . . "  
 Peabody, O. W. . . . . "  
 Perry, O. H. . . . . . "  
 Philbrick, Edward S. . . "  
 Philbrick, John D. . . . "  
 Pickering, E. C. . . . . "  
 Pickering, H. W. . . . . "  
 Plumer, Avery . . . . . "  
 Pope, Edward E. . . . . "  
 Prang, Louis . . . . . "  
 Pratt, George W. . . . . "  
 Pratt, T. Willis . . . . "  
 Putnam, J. P. . . . . "  
  
 Quincy, Edmund . . . Dedham.  
 Quincy, Josiah . . . . Boston.

Revere, Joseph W. . Boston.  
 Rice, Alexander H. . "  
 Richards, R. H. . "  
 Ritchie, E. S. . . Brookline.  
 Robbins, James M. . Milton.  
 Robinson, J. R. . . Boston.  
 Rotch, Benj. S. . . "  
 Royce, H. A. . . "  
 Ruggles, John . . . "  
 Runkle, John D. . Brookline.  
 Russell, LeBaron . Boston.  
 Salisbury, D. Waldo . "  
 Sawyer, Edward . Newton.  
 Sawyer, Timothy T. Charlestown.  
 Sears, Philip H. . . Boston.  
 Shedd, J. Herbert . . "  
 Sherwin, Thos. . . Dedham.  
 Shimmin, Chas. F. . Boston.  
 Shurtleff, A. M. . . "  
 Sinclair, Alex. D. . . "  
 Smith, Chauncy . . Cambridge.  
 Snow, S. T. . . Boston.  
 Sonrel, Antoine . . Winchester.  
 Sprague, Chas. J. . Boston.  
 Stackpole, G. W. . . "  
 Stevens, Benj. F. . . "  
 Stimpson, Fred. E. . . "  
 Storer, Frank H. . . "  
 Strater, Herman, Jr. . . "  
 Sturgis, John H. . . "  
 Sullivan, Richard . . "

Thompson, Wm. H. . Boston.  
 Trowbridge, John . Cambridge.  
 Tufts, John W. . . Boston.  
 Tuxbury, Geo. W. . . "  
 Upham, J. B. . . . "  
 Urbino, S. R. . . . "  
 Walworth, J. J. . . . "  
 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. . . . "  
 Whitaker, Channing . Lowell.  
 Whitman, Herbert T. . Boston.  
 Whitmore, Wm. H. . . . "  
 Whiton, David . . . . "  
 Wilder, Marshall P. . Dorchester.  
 Williams, H. W. . . . Boston.  
 Winthrop, Robert C. . . "  
 Wright, John H. . . . "  
 Wyman, Morrill . . Cambridge.  
 Zalinski, E. L. . . . Boston.

## PREPARATION FOR ADMISSION.

*Preparation for Admission.*—In order to afford to instructors and others a somewhat definite idea of the requirements for admission to the school, the following statements and suggestions are made.

*Arithmetic.* — The candidate will be expected to be familiar with the ordinary operations of arithmetic in both simple and compound numbers, with common and decimal fractions, with the computation of interest, etc. In the metric system a general knowledge will be required of the origin and advantages of the system, of the manner of designating the multiples and divisions of the units of length, capacity, etc., and especially of the relation existing between the measures of weight and those of length and capacity. Ability to perform ordinary arithmetical problems in the metric system will be required, but no stress will be laid upon the conversion of the ordinary United States weights and measures into the corresponding values of the metric system; as, however, the metric weights and measures are used constantly immediately on the students' entering upon the work of the school, practical familiarity with them is very desirable.

*Geography.* — A good elementary knowledge of the motions of the earth, of the mathematical measurements and divisions of its surface, and of the outlines of physical and political geography is required. The candidate for admission should be able to correctly define any of the principal physical features of the earth's surface, such as peninsulas, gulfs, etc.; he should be able to locate and describe the chief natural and political divisions, and the most important mountain chains, river-systems, etc. A more complete knowledge of North America and Europe is expected than of the other continents, but minute details and statistics, such as the lengths of rivers and heights of mountains, are not required. Practice in free-hand map draw-



ing from memory is earnestly recommended, and proficiency in the art will receive the merit it so justly deserves.

The following may serve as an illustrative example of the nature of the questions the candidate is expected to answer.

1. Define latitude — North Temperate zone — mountain — ocean — border-sea — kingdom — republic — state — town.

2. Draw rapidly an outline map of South America, making it as complete as time will permit.

3. Draw a map of the State, Province, or country where you reside, representing as many of its features as you conveniently can.

4. In what latitude is New York city? What countries, cities, or seas of the Eastern World have nearly the same latitude?

5. Give a geographical description of Italy. Also one of the State of New York.

6. In what sections of the United States is cotton an important agricultural product?

7. To which race do the Japanese belong? Give some idea of the national character of the French.

8. What is the capital of Kansas? of Georgia? of Holland?

9. Give the boundaries of the States of Kentucky, California and Connecticut. Where is Mount Shasta? Name the great mountain regions of the globe.

*English Grammar.* — In English Grammar, candidates must be able to distinguish at sight between the several parts of speech, and to give the proper inflections of nouns, pronouns, adjectives, and verbs; especially the comparison of irregular adjectives, the principal parts of irregular verbs, and, in all verbs, the exact forms corresponding to the distinctions in mood and in tense. Particular attention should be paid, in preparing for the Institute, to distinguishing prepositions from conjunctions, and subordinate conjunctions from co-ordinate. The same is true in regard to demonstrative, indefinite, relative, and interrogative pronouns.

Candidates must also know how to classify terms (whether single words or phrases) into substantives and attributives, and must be familiar with the subdivisions of substantives into sin-

gulars, generals, and universals. They must have a good degree of skill in separating sentences into subject, copula, and predicate; and, in case these terms are complex, must know how to separate them into base and determinant, and how to tell whether the determinant *changes* the meaning of the base or merely *unfolds* it. In case the meaning is *changed*, they must be able to show whether the modifiers are objective, or signify some other relation, *e. g.*, time, place, cause, comparison or possession.

In regard to all the foregoing matters, teachers should aim to secure *practical skill in applying the distinctions to examples*, rather than a mere knowledge of their definitions. *In the examination for admission, this skill in practice will be made the vital point.*

[The less familiar of the foregoing distinctions may be defined as follows:—

A *singular* term is one that denotes absolutely but one object of a kind, whether that object be a solitary individual or a solitary group of individuals. A singular may therefore be either a proper or a collective noun, or any phrase equivalent to either. For example, Julius Cæsar, London, this city, the committee, the cities of the plain.

A *general* term is one that denotes more than one object of a kind, but less than all the possible members of it. It may do this either (1) by naming any *one* of them *indeterminately* (as *man, a man, some man or other*), or (2) by naming several *distributively* (as *men, some men, five men*), or (3) by naming *all* within certain limits — all the *actual* cases as contrasted with all *possible* cases (as *men*, in the sense of *most men* or *all men hitherto* or *all men now living*). For example, cities, all the continents, the continents.

A *universal* term is one that denotes absolutely all the objects of a kind, *i. e.*, all *possible*, future as well as present and past. For example, truth, the true, duty, the beautiful, space, time, causality, all triangles, every circle.

The *base* of a complex term is that word, or combination of words, in it that expresses the starting-point of the thought denoted by the whole term. For example, man, in the term "good man"; good man, in the term "every good man."

The *determinant* of a complex term is the word, or combina-

tion of words, added to the base, and characterizing it. For example, good, in the term "good man"; every, in "every good man"; of all times, in "the wise and good of all times."

All the other distinctions mentioned above, are to be taken according to the customary usage in treatises on grammar.]

*English and American History.* — The examination in this subject will be upon the period of the American Revolution beginning with the accession of George III.; and a better and more thorough knowledge of this portion of history—but rather of the causes of the revolution and the lives and characters of the chief actors than a minute acquaintance with the details of military transactions, will be expected than can be obtained from the mere study of the names and dates of a school compendium.

*Rhetoric.* — In Rhetoric the examination will be confined to those parts of any school manual which give the rules for the construction of sentences and treat of the qualities which characterize a good style. The object of this examination will be to test the candidate's ability to write good English, and as a preparation for it, *practice* in English composition is strongly recommended in preference to the study of the remaining portions of the Rhetorics.

*French.* — The essential part of the *French requirement for admission* to the school is the grammar, or knowledge of the forms and structure of the language, and we would offer with this in view the following suggestions in regard to the preparatory study.

a. The *verb* should be made the main study, and the other parts of speech in proportion to the closeness of their relation to the same.

b. The *regular conjugations* should be mastered before taking up the study of the irregular ones, and so of the other regular forms and usages as compared with the exceptions and idioms.

c. Next to the verb in importance comes the pronoun, particularly the *personal pronoun*, the form and value of which depends mainly upon its relation to the verb, whether as sub-

ject, direct object, *dative*, or as connected by a preposition, a careful analysis alone eliciting the specific relation in each case; hence the importance of a thorough analytical training.

d. The amount of *reading matter* is not so much for the sake of the knowledge of words and its intrinsic value, as to afford a sufficiently wide field for exercise in analysis and the discrimination of forms, quality being more important than quantity, and accuracy essential.

e. In regard to pronunciation, it is more important that the student have an accurate conception of the nasal, e, é, è, and u sounds, the connection of words, and the division into syllables, than greater fluency with less accuracy.

*English Literature.*—The examination will be upon the literary history of the latter part of the Eighteenth and the early part of the Nineteenth century. The candidate will be expected to be familiar with the names and general character of the leading writers of that period, and to show an acquaintance, from actual reading, with some portion of its literature.

*Algebra.*—Besides possessing ability to perform ordinary algebraic operations, the candidate must be able to solve simple and quadratic equations with two or more unknown quantities, and must understand theoretically and practically the involution of algebraic expressions, the extraction of square and cube root, fractional and negative exponents and radicals.

Besides readiness in the solution of examples, it is important that the student should be well drilled in the principles involved and be able to state them clearly and concisely. For example, besides ability to solve readily a quadratic equation, he should also be familiar with the few fundamental properties of the quadratic roots, and particularly with the conditions upon which equal and imaginary roots depend.

While the theory of logarithms is not at present required, it is extremely desirable that students should early become familiar with their use, and teachers are earnestly advised to put into their hands Professor J. M. Peirce's four place tables, or Bowditch's five place tables, or Bremiker's six or seven place tables, and show them how much time familiarity with their use will

soon enable them to gain in all numerical work. Nor need this be a blind use ; for as soon as the student understands what an exponent is, and that the multiplication, division, the involution and the evolution of numbers are affected by the addition, subtraction, multiplication and division of exponents, he has only to learn that the exponent is a logarithm, to use the tables intelligently.

*Geometry.* — In plane and solid (including spherical) geometry, the amount contained in the standard text-books on the subject will be required ; and care should be taken to apply all propositions, which find frequent use, to numerical examples.

## LOWELL FREE COURSES OF INSTRUCTION.

### 1865-1866.

1. *Elementary Mathematics*. Eighteen lectures, by Professor Runkle.
2. *Descriptive Geometry*. Eighteen lectures, by Professor Watson.
3. *Chemistry of the Non-metallic Elements*. Eighteen lectures, by Professor Storer.
4. *The Metals*. Eighteen lectures, by Professor Eliot.
5. *English Language and its Literature*. Eighteen lectures, by Professor Atkinson.
6. *French*. Eighteen readings, by Professor Bôcher.

### 1866-1867.

1. *Chemical Manipulations*. Thirty practical lessons, by Professors Storer and Eliot.
2. *Mathematics*. Eighteen lessons, by Professor Runkle.
3. *Navigation and Nautical Astronomy*. Eighteen lessons, by Professor Osborne.
4. *Elementary French*. Eighteen lessons, by Professor Bôcher.
5. *Grammar, Rhetoric and Composition*. Ten lessons, by Professor Atkinson.

### 1867-1868.

1. *Geometry and Trigonometry*. Eighteen lessons, by Professor Osborne.
2. *Calculus*. Eighteen lessons, by Professor Runkle.
3. *Elementary German*. Eighteen lessons, by Instructor Krauss.
4. *Chemical Manipulations*. Thirty lessons, by Professor Storer.
5. *Natural History*. Ten lessons, by Professor Kneeland.
6. *Languages and General Grammar*. Ten lessons, by Professor Atkinson.

### 1868-1869.

1. *Qualitative Chemical Analysis*. Thirty lessons, by Professors Eliot and Storer.
2. *Mining, and the Mineral Resources and Deposits of the United States*. Eighteen lectures, by Professor Rockwell.
3. *English History and Literature*. Eighteen lectures, by Professor Atkinson.
4. *Comparative Physiology and the Laws of Life*. Eighteen lectures, by Dr. Kneeland.
5. *French*. Eighteen lessons, by Professor Bôcher.

## 1869-1870.

1. *Outlines of Zoology.* Eighteen lectures, by Dr. Kneeland.
2. *Mineral Resources of the United States.* Ten lectures, by Professor Rockwell.
3. *Elementary Algebra and Trigonometry.* Eighteen lectures, by Professor Osborne.
4. *Sound.* Ten lectures, by Professor Pickering.
5. *English History and Literature.* Eighteen lectures, by Professor Atkinson.
6. *Mechanical and Machine Drawing.* Twenty-four lessons, by Instructor Schubert.

## 1870-1871.

1. *Elementary French.* Eighteen lessons, by Professor Bôcher.
2. *Physiology and Hygiene.* Eighteen lectures, by Professor Kneeland.
3. *Descriptive Geometry applied to the Arts, with corresponding exercises in Mechanical Drawing.* Fifteen lectures, by Professor Watson.
4. *General Chemistry.* Fifteen laboratory lectures, by Assistant Professors Richards and Nichols.
5. *Qualitative Analysis.* Fifteen laboratory exercises, by Assistant Professors Nichols and Richards.
6. *Modern History and Literature.* Eighteen lectures, by Professor Atkinson.

## 1871-1872.

1. *English Writers of the 18th and 19th Centuries.* Ten lectures, by Professor Atkinson.
2. *Progressive Development of Life in the Geological Ages.* Eighteen lectures, by Professor Kneeland.
3. *Elementary German.* Eighteen lessons, by Instructor Krauss.
4. *Elementary French.* Eighteen lessons, by Instructor Lévy.
5. *Elementary Chemistry.* Twenty lectures, by Professors Richards and Nichols.
6. *Experimental Chemistry.* Twenty-four laboratory exercises, by Professors Richards and Nichols.
7. *Experimental Physics.* Twenty-four laboratory exercises, by Professor Pickering.

## 1872-1873.

1. *Chemical and Physical Geology.* Eighteen lectures, by Professor T. Sterry Hunt.
2. *Experimental Mechanics.* Eighteen lectures, by Professor Cross.
3. *Modern History.* Ten lectures, by Professor Atkinson.

4. *Logic with special reference to its connection with English Analysis.* Ten lectures, by Professor Howison.

5. *Laws of Life and Health.* Ten lectures, by Professor Kneeland.

6. *Systematized French Pronunciation, French Conjugation, Idiomatic French.* Eighteen lectures, by Instructor Lévy.

7. *Translation of Lessing's Nathan der Weise, with a Philological and Critical Commentary.* Eighteen lectures, by Instructor Krauss.

8. *Elements of Descriptive Geometry.* Eighteen lectures, by Instructor Lanza.

9. *Machine Drawing.* Eighteen lessons, by Professor Schubert.

#### 1873-1874.

1. *Logic. An Examination of the system of J. S. Mill.* Eighteen lectures, by Professor Howison.

2. *Sound.* Eighteen lectures, by Professor Cross.

3. *Machine Drawing* for advanced students. Twenty-four exercises, by Instructor Schubert.

4. *Elementary Descriptive Geometry.* Eighteen lectures, by Professor Lanza.

5. *Chemistry: Qualitative Analysis.* Twenty-four laboratory exercises, by Professor Nichols.

6. *Architectural History and Design.* Eighteen lectures, by Professor Ware.

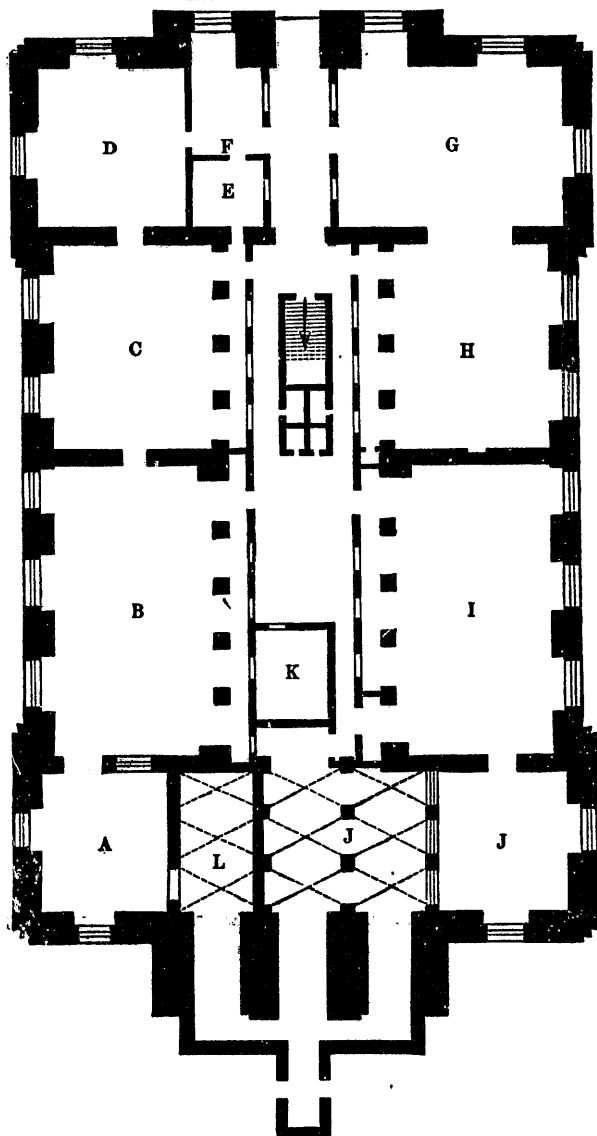
7. *Elementary German.* Eighteen lessons, by Instructor Krauss.

#### 1874-1875.

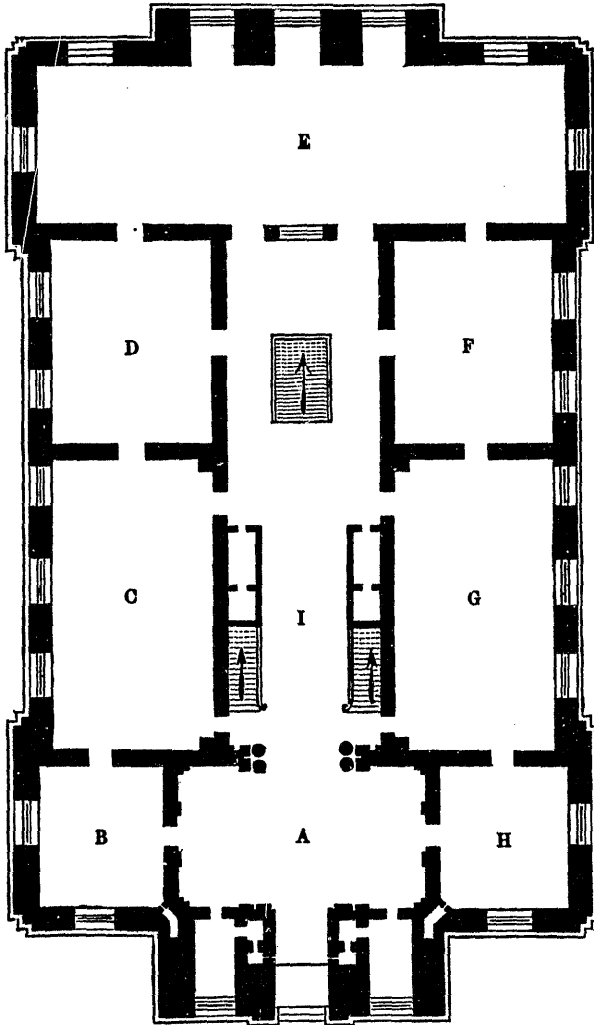
For reports upon the Courses of 1874-75, see pp. 94-104.



## BASEMENT FLOOR.

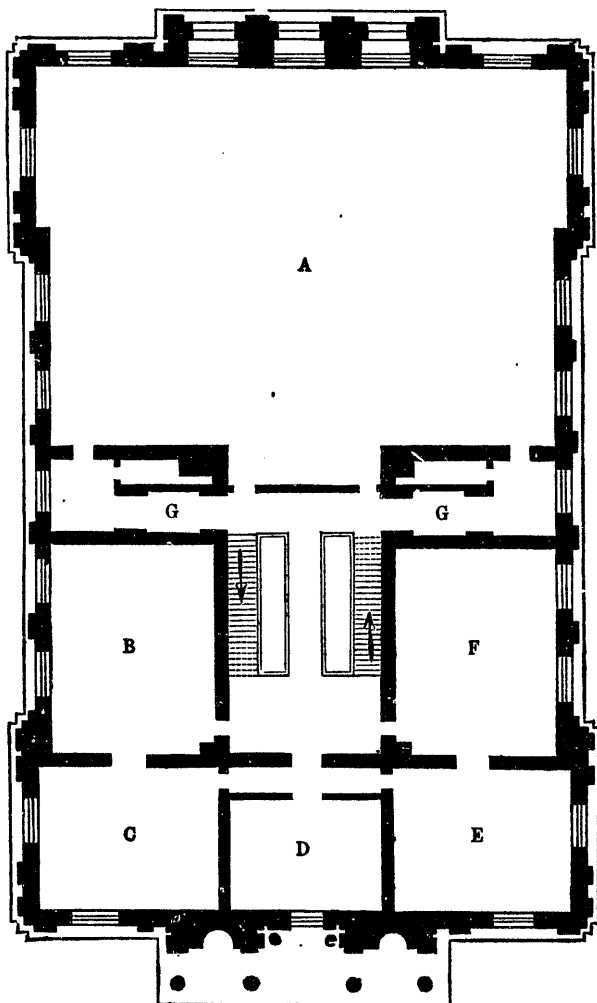


- A. Professors' Chemical Laboratory, 25' 0" by 22' 11".
- B. General and Qualitative Chemical Laboratory, 49' 7" by 34' 0".
- C. Quantitative Chemical Laboratory, 35' 8" by 34' 0".
- D. Quantitative Chemical Laboratory, 29' 4" by 24' 0".
- E. Balance Room, 8' by 18'.
- F. Professor Wing's Private Laboratory, 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. Mechanical Engineers' Laboratory, 25' 0" by 69' 14".
- K. Daily Chemical Supply Room, 14' 6" by 12' 0".
- L. Boiler Room, 15' by 26' 0".

**FIRST STORY FLOOR.**

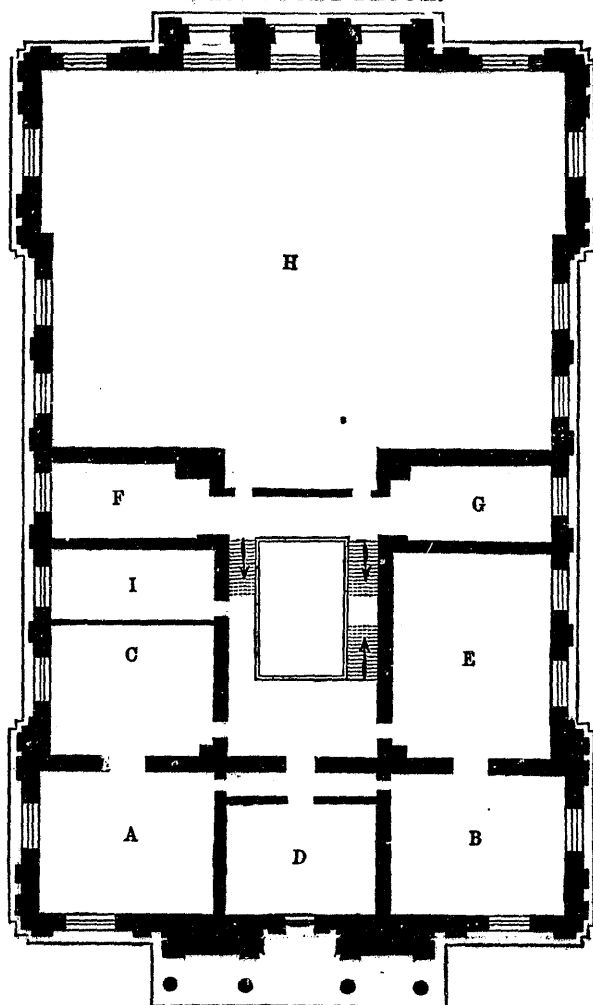
- A. Entrance Hall, 42' 2" by 25' 0".
- B. President's Office, 25' 0" by 22' 11".
- C. Physical Lecture Room, 49' 7" by 28' 3".
- D. Physical Laboratory and Apparatus Room, 35' 8" by 28' 3".
- E. Physical Laboratory and Apparatus Room, 92' 0" by 27' 10".
- F. Geological Lecture Room, 35' 8" by 28' 3".
- G. Society of Arts Room, 49' 7" by 28' 3".
- H. Secretary's Office, 25' 0" by 22' 11".
- I. Stairway Hall, 37' 3" by 28' 10".

## SECOND STORY FLOOR.



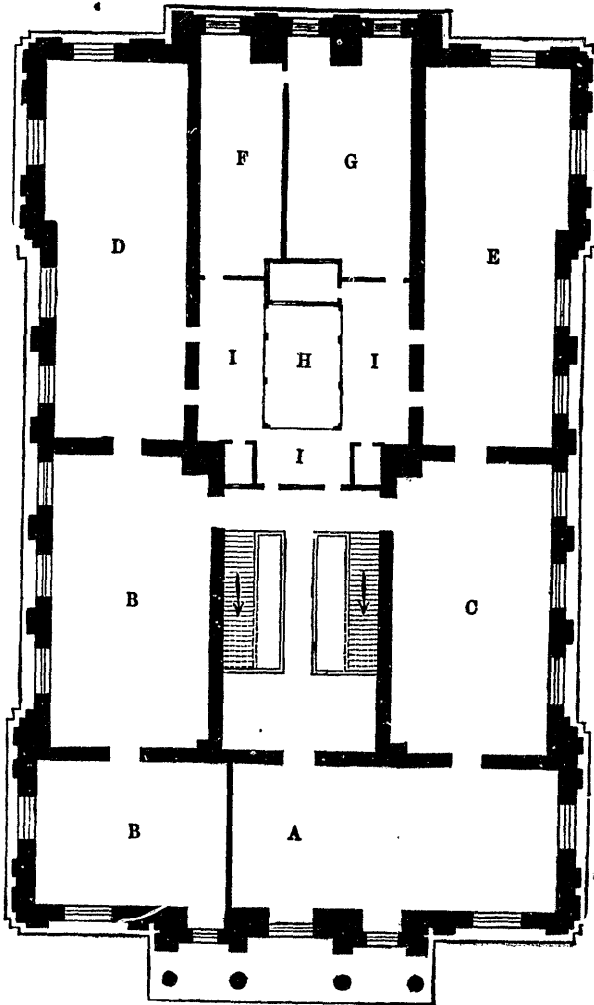
- A. Huntington Hall, 32' 0" by 65' 5".
- B. Mathematical Lecture Room, 34' 9" by 28' 3".
- C. Civil Engineering Lecture Room, 32' 2" by 25' 0".
- D. Modern Language Lecture Room, 26' 2" by 20' 6".
- E. English Lecture Room, 32' 2" by 25' 0".
- F. Mathematical and Astronomical Lecture Room, 34' 9" by 28' 3".
- G. G. Passageways to Huntington Hall.

## HALF STORY FLOOR.



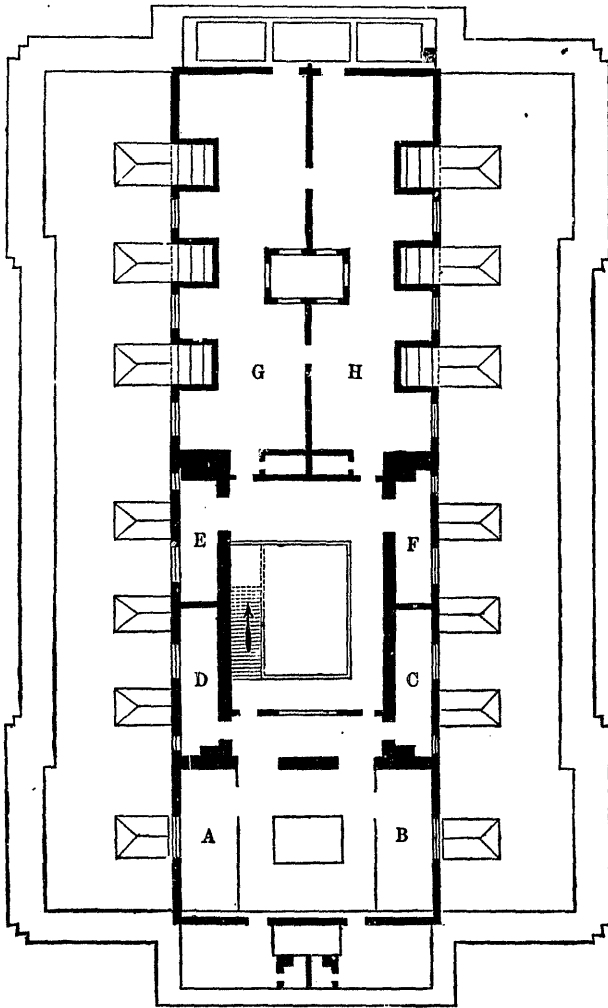
- A. Architectural Museum, 32' 2" by 25' 0".
- B. Architectural Library and Study Room, 32' 2" by 25' 0".
- C. Architectural Museum, 28' 3" by 20' 9".
- D. Natural History Lecture Room, 26' 2" by 20' 6".
- E. Prof. Richards' Lecture Room, 34' 9" by 28' 6".
- F. Prof. Atkinson's Study, 28' 3" by 14' 2".
- 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. 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 28' 0".
- E. First Year's Drawing Room, 65' 5" by 28' 0".
- F. Mechanical Engineering Lecture Room, 37' 0" by 17' 0".
- G. Mathematical and Descriptive Geometry Lecture Room, 37' 0" by 22' 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. Osbourne'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".