

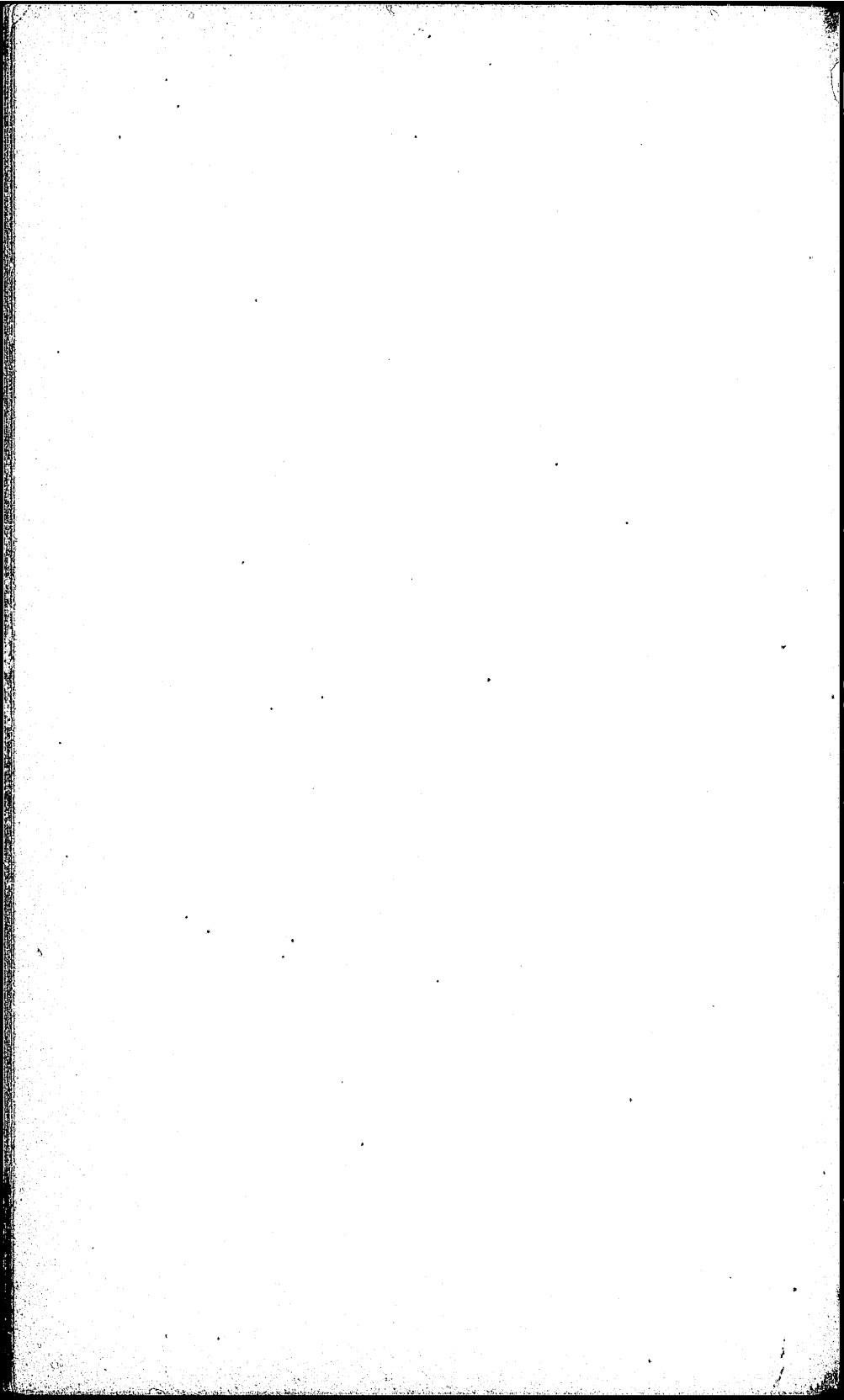
MASSACHUSETTS INSTITUTE OF TECHNOLOGY.

PRESIDENT'S REPORT

FOR THE

Year ending Sept. 30, 1873.

BOSTON:
PRESS OF A. A. KINGMAN.
1873.



PRESIDENT'S REPORT.

To the Corporation of the Institute: —

This report relates to the year ending Sept. 30, 1873, to correspond with the fiscal and school years as now established.

In my last report so much space was devoted to several of the departments, that it will only be necessary in this to indicate such changes as have taken place during the year.

Department of Chemistry. Professor Crafts' statement on pages 59 and 60 indicates the spirit and aim of the instruction, and alludes to such improvements as have been made in the Quantitative Laboratory to facilitate work.

The instruction in General Chemistry and Qualitative Analysis, given to students of the first and second years, has continued under the direction of Professor Nichols, and the system and thoroughness with which it has been conducted, leave nothing to be desired but ampler space. We have but one laboratory, accommodating about fifty students at a time, in which to do this work. While these classes were small, this laboratory answered the purpose fairly well; but since they have become so large, that each must be divided into two or more sections, its use has been largely increased, and an urgent need has been felt for larger and better ventilated laboratories.

Besides, it is found impossible at all times to prevent the odors from the laboratories from permeating other parts of the building. There is also a great want of proper rooms for storing glass-ware and chemicals, and laboratories for gas analysis and the various applications of chemistry.

The importance of a new building to accommodate this important department is daily becoming more apparent, not only for its own proper development, but also for the relief it will afford to other departments, which must for some time to come be accommodated in our present building.

At the last session of the Legislature, your application for a parcel of land on the Back Bay was successful, and it is certainly to be desired that such a building as we so much need may be erected thereon during the coming year.¹

Department of Geology and Mining Engineering. The courses of instruction in this department were fully detailed in my last report. During the year the Geology has been in the

¹An Act in addition to An Act incorporating the Massachusetts Institute of Technology. *Be it enacted by the Senate and House of Representatives, in General Court assembled, and by the authority of the same, as follows:*

SECTION 1. Perpetual right is granted to the Massachusetts Institute of Technology to hold, occupy and control free of rent or charge by the Commonwealth, for the uses and purposes of said Institute, a parcel of land situated in that part of Boston called the Back Bay, and described as follows: A lot in the form of a trapezoid lying at the intersection of Boylston street and Huntington Avenue, bounded by said street and avenue, and on the west by abutting land, as laid down on the selling plan of the Commissioners on Public Lands, and containing thirteen thousand one hundred and ninety-four square feet; said lot to be subject to the limitations and stipulations relative to lands of the Commonwealth on the south side of Boylston street, and to be reserved from sale forever.

SECTION 2. The right hereby granted to said Institute shall be held subject to the same stipulations in relation to membership, the reception of pupils, the erection of a building, and the care of the lot, as are created and established by the several acts relating to said Institute.

SECTION 3. In case said Institute appropriates said lot of land to any purpose or use foreign to its legitimate objects, then the Commonwealth, after due notice given, may enter upon said lot and take possession thereof, and the right of the said Institute to the use, occupation and control of said lot, shall thereupon cease.

SECTION 4. This act shall take effect upon its passage.

April 8, 1873.

Approved.

W. B. WASHBURN.

able hands of Professor Hunt, the value of whose instruction has been much abridged by the want of proper space for reinforcing the lectures by the corresponding laboratory work.

The department has also gained largely in the more complete equipment of the Mining and Metallurgical laboratories, which is due almost entirely to the zeal, energy, and excellent practical judgment of Professor Richards, to whose interesting report I respectfully ask your attention. We are indebted to Mr. Schubert for the drawings, and to another friend for the engraving of the cuts representing these Laboratories.

As part of the work of the department, I include the excursion made during the vacation just closed. At my request Professor Ordway has written a full account which I submit for your information. Excursions so systematically and ably conducted as this one, are of great advantage, not only to professors and students, but also, indirectly at least, to the industries to which they relate; and I heartily approve of Professor Ordway's suggestion, that such excursions should be annual and part of the recognized work of the school, and that some way may be found to aid those to whom the incidental expense may be burdensome.

It is only just to say that all of the excursions of past years would have been impossible had it not been for the ready and generous aid given us by railroads all over the country.

Department of Physics. Last year's report on this department related to the instruction given during the third and fourth years in the Rogers Laboratory of Physics. No important change in the method of instruction has been found necessary. The laboratory has gained somewhat in apparatus, but mainly in such things as have been designed and made in the building. You are respectfully referred to the report of Prof. Cross on the instruction in physics in the first and second years of the course. The publication of Professor Pickering's Laboratory Manual, and the printing of Professor Cross' notes, have greatly aided in the instruction.

Your thanks are due to Mr. J. C. Hoadley for a valuable collection of acoustic apparatus, a list of which you will find on pages 71 and 72. The urgent need of the department is a fund, the income of which can be used to keep the apparatus up to the latest date in all branches of the subject.

Industrial Design. In my last report I had the pleasure of announcing the intention of the Trustee of the Lowell Institute to establish in this Institute a course of instruction in Industrial Design. The vote establishing the department was passed Sept. 11, 1872, and the following circular was issued shortly after, which is inserted here as part of the history of the department.

LOWELL COURSE OF INDUSTRIAL ART.

The Trustee of the Lowell Institute having made provision for a special course of free instruction in Practical Design for Manufactures, open to pupils of both sexes, students will be received at the beginning of the school year in October, to whom will be taught the art of making patterns for Prints, Delaines, Silks, Paper-Hangings, Carpets, Oil-Cloths, etc.

The Course will embrace:—

1. *Original Design, or Composition of Patterns:*—

This comprises the making of original sketches for patterns, in light and shade, flat or shaded tints and in outline.

In connection with this work instruction will be given in the harmony of colors and in proportion.

2. *Secondary Design, or Variation of Patterns:*—

This comprises the alteration and adapting of patterns, either as to form, color, or the number of colors employed, simplifying them or making them more elaborate, and adapting them to different fabrics.

In connection with this work the study of the recognized styles will be taken up, and attention given to the peculiar requirements of various markets.

3. *The Making of Working Drawings:*—

Under this head is comprised the working out of sketches and designs, and putting them into the form and scale required by the manufacturer. Practice will be given in the method of adjusting patterns for printed goods to the size of the blocks or rollers employed, and in drawing out the patterns for carpets and other woven fabrics upon paper whose surface is divided into small squares, each representing a "pick" or thread.

4. *Technical Manipulations*:—

This comprises instruction in the use of instruments and colors, specially adapted to pattern drawing; also exercises in enlarging, reducing and copying patterns.

The class will be arranged in four divisions, corresponding to these four kinds of work. The student, on joining the class after passing the prescribed examination, will enter the fourth division and will be advanced to the third, and to the second, and so on to the practice of original design as rapidly as his proficiency permits. The more advanced students will have the assistance of the lower divisions in the drawing out of their designs.

Instruction will be given personally to each student over his work, with occasional general exercises.

Drawing from Memory. The designer needs to be familiar with the objects and forms in use in designing, so as to be able to reproduce without a copy the details of ornament, the appearance and texture of fabrics and of natural materials, and the forms and colors of leaves and flowers, which are the chief basis of decorative art. To this end special exercises in drawing and coloring from memory will constantly be given out.

Manufacturing Processes. A competent knowledge of the machinery and other appliances in use, and some familiarity with their working, is important to the designer. Without it his designs, however skilful, will be worthless. With a view to the acquisition of such knowledge the various processes of printing and weaving will be explained to the students, as may from time to time be needful, and excursions made to manufacturing establishments in the neighborhood where these operations may be witnessed upon a large scale.

It is intended that this course of study shall be thorough and practical, so that students may here qualify themselves to become draughtsmen or designers in manufacturing establishments, as their proficiency and capacity may determine.

The class will be provided with samples of textile fabrics, paper hangings, carpets and oil-cloths, both American and European, and with specimens of Oriental and other woven and printed fabrics selected for their artistic value and as illustrating the application of design to manufactures. To these will be added some examples of drawings made by pupils in foreign schools of design.

The class will be open to pupils of both sexes and will be under the personal direction of Mr. Charles Kastner, for fourteen years designer at the Pacific Mills, formerly Director of the Atelier Lebert in Paris, and nephew and pupil of M. Jean Baptiste Lebert, *Dessinateur*, of Mulhouse in Alsace.

It will open on Monday, October 7th, and will continue daily, except Sundays and holidays, until the end of May. Hours from nine till one, and from two till five o'clock, except Saturday afternoons. Regular and

punctual attendance will be strictly required. Students will supply their own instruments and materials.

Requirements of Admission:—

Applicants for admission to the Lowell Course of Industrial Art will be required to bring specimens of their work, exhibiting a thorough acquaintance with Free-hand Drawing, and some familiarity with the use of mathematical instruments, and of the brush in laying flat and graduated tints with India-ink and with color; all of which is an indispensable preliminary to the study of designing.

Entrance examinations will be held on the 4th and 5th of October at 9 A. M., at the Massachusetts Institute of Technology, Boylston St., Boston. Applicants will bring as many samples of their work as is convenient.

For copies of this circular address

SAMUEL KNEELAND,
Secretary.

*Mass. Inst. of Tech., Boylston St., Boston,
Sept. 20, 1872.*

A reference to Mr. Kastner's report, on page 66, will show what has been accomplished during the year in this department. It is my pleasure, as well as duty, to testify to the zeal and faithfulness of both teacher and pupils, and to express my entire satisfaction with the results. In judging of the quality of the work, it should also be remembered how little of proper preparation most, if not all the pupils, possessed at the beginning of the year. The fact that nearly all of them have returned, is the best evidence of their interest in the work.

It is important to the highest success of this department, that the pupils should remain until they are thoroughly qualified to enter upon their profession, and to this end I earnestly recommend that a course of not less than three years be marked out, and that to those pupils who successfully accomplish it, shall be awarded a diploma by the Corporation.

It is proper in this connection to state that all the expenses of the department for the year, in the purchase of samples of textile fabrics for illustrating the instruction, have been paid out of a contribution by James L. Little & Co., of two hundred dollars, and that Mr. John A. Lowell has placed a like sum at our disposal for the coming year.

Department of Military Science and Tactics. During the year we have availed ourselves of the Act of Congress, authorizing the detail of an officer of the army to give this instruction. Lieut. Zalinski entered upon this duty only in March last, but devoted himself so zealously and efficiently to the work for the small remaining part of the session that commendable progress was made towards putting the department in a satisfactory condition. Considering all the circumstances, enough was done to satisfy all reasonable expectations for the future, and particularly to show that if the discipline of the department is properly supported, it may be made a valuable element in the *morale* of the school. Lieut. Zalinski's suggestion of the need of a proper hall for the use of the department is fully endorsed; also the use which may be made of it for systematic gymnastic exercise. The adoption of a more serviceable and tasteful uniform is earnestly recommended.

Department of Mechanical Engineering. In June last Prof. Watson resigned the professorship of Mechanical Engineering and Mr. Channing Whitaker, a graduate in this department in the class of 1869, has been chosen to fill the vacancy.

It is important that this occasion should be improved in making such changes in the methods and facilities as the experience of the past seems to indicate. To this end I have asked Prof. Whitaker to suggest such a laboratory as will best aid in the education of mechanical engineers; and particularly in the solution of those experimental problems which lie at the foundation of all safe theory or practice. The delay in the issue of this report, also enables him to briefly indicate the plan of instruction which has been entered upon. Your attention is asked to his report, with the earnest wish that you will authorize the establishment of this laboratory at as early a day as possible.

Department of Architecture. Although this department was among the first established in the Institute, and was classed

with the engineering departments in the applications of the higher mathematics to Construction, it was hardly to be expected that it would at once take rank with these in the public demand and appreciation. In the first place, there were in this country neither written nor traditional precedents to serve as guides in the instruction, nor were there any suitable collections for illustration. On this account, Prof. Ware's first duty was to spend the better part of two years abroad, in examining the systems of architectural instruction, and in making the nucleus of the collections which have since served so efficiently in stimulating and promoting the work of the department. At first the department seemed to attract only those students who had, or fancied they had, some taste for art, and judged this field the one most likely to gratify the taste, and at the same time yield a reasonable prospect of support. But these students were seldom prepared by early and suitable mathematical training to take the engineering side of the course. They remained a longer or shorter time, pursuing such portions of the course as they were qualified to take, gaining more or less, in proportion to time and effort expended, but failing to reap the full benefit of the course in any particular or important sense.

We are happy to say that this early and not entirely satisfactory phase of the department, is gradually, but surely, passing away. Regular students of thorough preparation and recognized ability, are beginning to enroll themselves, and the class of 1873 is the first to represent the department among its graduates.

Each year is adding something to the appliances, but more in experience, and in improving the details of the instruction. The selection of concrete examples of immediate interest, which have not only stimulated the invention, but the industry, of the pupils, has been a marked feature of the past year.

Department of Descriptive Geometry, Stereotomy and Drawing. The subjects embraced in this department, although clearly allied, were formerly distributed, and the instruction lacked unity, and the proper coördination.

Professor Warren's report shows the order in which the several subjects are now given, but further experience is necessary to show whether the amount of graphical work required may not be somewhat diminished without serious detriment to the course. This will certainly be possible when the elements of mechanical and free-hand drawing can be required for admission, a time not far distant, so far as the State of Massachusetts is concerned.

Five small rooms have been put upon the drawing-room floor, which are used as offices for those Instructors who are mainly employed in this and the mathematical departments, to make them more accessible to those students who wish special assistance, and to aid in maintaining proper order.

Department of Civil and Topographical Engineering. The instruction in this department continues to maintain the same high character which has distinguished it from the first. Rankine's Civil Engineering is used as the basis of the theoretical instruction, and the corresponding field work is all that could be desired, both in method and thoroughness. A few large and somewhat expensive instruments are still needed, and also a few additional models of American bridges. These bridge models I hope we shall soon be able to make in our own building under the direction of the department. Last year's report was issued too early to include more than a reference to the excursion of 1872, under the direction of Professor Henck, whose brief report is included among those of the present year.

Departments of English and History, and of Logic and the Philosophy of Science. The reports of these two departments are so full, both as to the ground gone over and the methods of instruction, as to require no further remark on these points. There is, however, an important relation which these departments bear to the work of the school to which reference should here be made.

It is becoming more evident as time passes, and the profes-

sional work of the higher years is broadened and intensified by increased laboratory facilities, and by more special attention to the practical applications, that these departments can hope to do but little, if any more, than hold their present ground in the professional courses. All we can do for these courses is, by gradually raising the standard of admission, to gain more time for these subjects in the earlier years.

But there is another work of growing importance which these departments, with others, are called upon to perform in the school, and that is the work of a general as distinguished from a technical or professional education. The germ of such an education now exists in our science and literature course, and this course is gradually assuming a more marked character; but only in this, that having a less definite and specific aim than the professional courses, the ends can be accomplished by a more diversified range of subjects. Instead, therefore, of but one general course, several might be laid down, each equally fixed and equally valuable for the end in view; or, what would probably better accomplish the same end, we might graduate students in a larger number of departments, and thus secure a greater variety in the courses, and a better adaptation to the wants of particular students.

But these are suggestions which, if of any value, will in time be worked out by the Faculty of the school, and presented for your consideration.

The year has been one of marked progress in our educational work, and I close this report by thanking every member of the Corps of Instruction for the able and faithful service he has rendered in securing this satisfactory result.

Respectfully submitted,

J. D. RUNKLE.

SECRETARY'S REPORT: 1872 - 73.

In conformity with article 16, section 4, of the By-Laws of the Corporation, I herewith present the Annual Report of the Transactions and condition of the Institute for the eleventh year, 1872 - 1873.

There have been held during the year thirteen meetings of the Society of Arts; these have not been as well attended as usual, on account of the derangement of the business of many of the members by the fire of November last, as well as the prevalence of a dreaded epidemic, and the uncommon severity of the winter.

Dec. 11, 1872. Mr. John A. Coleman read a paper on the Application of Mill Heating and Fire Protection to the Warehouse System.

Dec. 12. Mr. Ernest Edwards made a communication, illustrated by many specimens, some executed at the meeting, on "Photography in the Printing Press," or the Heliotype Process.

Dec. 26. Mr. Wm. B. Whiting read a paper on Warehouse Construction, with special reference to protection against fire.

Jan. 9, 1873. Mr. E. H. Hewins continued the subject of the proper construction of fire-proof buildings, and of the best way to extinguish fires in the quickest and least destructive manner.

Jan. 23. Prof. W. A. Rogers, of Cambridge, exhibited and explained a machine of his own invention, for determining personal equation, or the interval which elapses between an event and its perception by an observer.

Mr. Crandall exhibited working models of machines, invented by himself, for simplifying and expediting some of the processes in the manufacture of pianos.

Prof. Pickering described a new Difference Engine, or Tabulating Machine, the invention of Mr. George B. Grant, of Cambridge, comparing it with the celebrated Difference Engine proposed by Sir Charles Babbage some fifty years ago.

Feb. 13. Mr. A. Tacchella exhibited a working model of his combined fire ladder and escape, and hose elevator.

Mr. S. P. Sharples then addressed the Society on the subject of the disposal of slaughter-house waste and dead animals by means of chemical processes, which convert them into various non-offensive compounds of great value in the industrial arts.

Feb. 27. Mr. McMurtrie read a paper, illustrated by drawings on the blackboard, and by an extensive series of specimens, on the Tilghman process for engraving and cutting glass, stone, etc., by the use of a sand blast.

March 13. Mr. Edmund H. Hewins made a communication, illustrated by diagrams and drawings, on the Gilbert Elevated Street Railway of New York City.

Mr. Henry A. Page explained his system of suspended street cars, by which many of the inconveniences and expenses of the ordinary horse-railroad may be avoided.

March 27. The business of the meeting was the report of a Committee appointed to consider the best method of securing a greater interest in, and fuller attendance at, the meetings of the Society.

April 10. Mr. C. Millard made a communication on the Diamond-Saw Quarrying Machine, adapted to all kinds of rock cutting and dressing, illustrated by a carefully made sketch on the blackboard of nearly the size of the machine. What the

saw does for wood, it is claimed that this machine will do for stone.

April 24. Col. Jacob J. Storer addressed the Society on the best means of disposing of the waste of slaughter-houses and other animal refuse of large cities.

May 8. Mr. J. R. Robinson made a communication on the cause of the explosion of steam boilers, analyzing several cases which he had been called upon to examine.

May 22. Mr. H. P. Langley exhibited a new form of grate bar, by which ashes and light clinkers may be removed without opening the fire door.

Mr. Grosvenor exhibited in operation a very simple and effectual form of steam pump, with no movable parts except three or four automatically moving ball valves.

Mr. McMurtrie exhibited in operation, and explained by diagrams, Nye's Automatic Steam Vacuum Pump, now in use in this city for raising salt water.

There have been elected during the year 9 associate members, the list now comprising 336 members. One life member and 4 associates have died during the year, viz., Messrs. Savage, Dexter, Frothingham, Lynch and Sears. Nine have resigned during the year.

The School of Industrial Science has had a very satisfactory attendance, 375 students having enrolled themselves, viz.: Resident Graduates, 5; Regular Students of 4th Year, 32; of 3d, 27; of 2d, 61; of 1st, 115. Students not Candidates for a degree and Special Students, 4th Year, 24; 3d, 42; 2d, 31; 1st, 16. Students in Practical Design, of whom 13 are females, 22; total 375, or 111 more than last year; of these nearly five-sixths are from Massachusetts, principally from Boston and vicinity; 25 others are from New England, viz., from Maine, 5; Vermont, 4; New Hampshire, 7; Rhode Island, 6; Connecticut, 3; from other States there are, from New York, 9; Pennsylvania, 7; Ohio, 14; Illinois, 7; Kentucky, 3; Minnesota, 3; Indiana, 2; California, 2; Kansas, Delaware, Wisconsin and

Iowa, 1 each; from foreign countries, the Azores and Teneriffe, 3; Japan, 2; Sandwich Islands, 1; and British Provinces, 1.

Thirty-three professors and teachers have been connected with the school, and several advanced students have rendered assistance in drawing and surveying. The fees from students will reach \$47,000, about \$10,000 more than last year, and considerably more than the estimate of the Treasurer in May last.

The School of Design, under the auspices of Mr. Lowell, has proved a great success, and bids fair to be one of the most important aids to the industrial arts.

The Lowell courses this year have been as follows: 18 lectures on Descriptive Geometry, commencing Nov. 11, by Prof. Lanza; 18 lectures on Systematized French Pronunciation, French Conjugation and Idiomatic French, by Instructor Lévy, Nov. 11; 18 lessons in Machine Drawing, by Instructor Schubert, Nov. 12; 10 lectures on the Laws of Life and Health, by Prof. Kneeland, Nov. 12; 10 lectures on Modern History, by Prof. Atkinson, Nov. 13; 18 lectures by Prof. Hunt, on Chemical and Physical Geology, Nov. 29; 18 lectures on Experimental Mechanics, by Prof. Cross, Dec. 16; 10 lectures on Logic, by Prof. Howison, Jan. 22; 18 lectures on Translation of Lessing's Nathan the Wise, by Instructor Krauss, Jan. 20.

The same causes operated, as in the case of the Society of Arts, to render these courses less well attended than usual.

The Corporation have held eight meetings during the year, including the one of to-day, May 14th.

At the meeting of June 13, 1872, it was voted to establish advanced courses of study, and to change the title of the Degree conferred by the Institute to that of Bachelor of Science.

Sept. 11, 1872. Voted to establish the "Lowell School of Industrial Art," Mr. Lowell having offered to pay the salary of the head of said school.

Dec. 11. Solid Geometry and the rudiments of French, were added to the requirements for admission, and the fees were raised to \$200 per annum. Mr. Charles P. Otis was

appointed Professor of Modern Languages, and the detail of Lieut. Zalinski, U. S. A., as Military Instructor, was requested from the War Department. It was also voted that the financial year of the Institute begin and end on the 1st of October in each year. The use of the large hall was granted to Trinity Church as a place of worship.

Dec. 27. A Committee was appointed to petition the Legislature for a piece of land between Huntington Avenue and Boylston St., for a Chemical Laboratory.

Feb. 12, 1873. The Degree of Bachelor of Science was conferred on eleven graduates of the Institute.

April 9. A letter was read from the Governor's Secretary, stating that the land asked for had been granted. At the same meeting Mr. Bowditch read a letter from an unknown friend of the Institute, giving the sum of \$25,000, to be devoted to the payment of salaries.

A Committee was appointed to obtain plans for the new building, and also one to devise means for raising the money for its erection.

SAMUEL KNEELAND, *Sec.*

REPORT OF THE WORK IN LOGIC AND THE PHILOSOPHY OF SCIENCE.

To the President of the Massachusetts Institute of Technology.

I have the honor to present the subjoined account of what has been done in this, the first year of my duties as Professor of Logic and the Philosophy of Science, and of what I shall aim to accomplish in the future.

On the opening of my work in October, 1872, it became at once manifest that, under the existing arrangement of the courses of study in the several departments of the Institute, sufficient time for preparing my subjects was absolutely beyond the control of the great majority of the students in the two upper classes. After careful consultation, I asked and obtained the warrant of the Faculty to adjust my plans of instruction to the temporary exigencies of the general work by confining all preparation, on the part of the students of the then Third and Fourth Years to my actual hours of lecture, and by reducing the scale of work, both in amount and in minuteness, to correspond with this change. I mention the foregoing facts, to account for what might otherwise seem the small amount of instruction attempted this year in the Third and Fourth Classes. The actual work in these has been as follows:—

I. In the Fourth Year, so much, and only so much, of the Theory of Induction has been given, as seemed absolutely indispensable for a foundation of the Philosophy of Science. This

has included a pretty thorough discussion of the conception of Induction as a mental process, of the processes subsidiary to it— Observation and Experiment, Classification, Nomenclature and Terminology, and Hypothesis — and, finally and most especially, of the nature, conditions, and canons of the Five Scientific Methods — those of Agreement, of Difference, of Double Agreement, of Concomitant Variation, and of Residues. The method of instruction has consisted in the careful reading with the class of Fowler's text,¹ in the explanation, illustration and expansion of the same, so far as required and as permitted by the allotted time (two hours a week for the first half of the year), and in the careful and thorough criticism of the doctrines advanced by the author, or quoted by him. Free questioning on the part of the class has been encouraged, and oral examinations have been conducted from lecture to lecture, as the occasion seemed to require; these have been supplemented by one or two written ones. The precise objects aimed at have been (1.) to furnish each student with such a clear comprehension of the process of Induction, and of its conditions, as would render him distinctly conscious of his mental steps in any scientific investigation which he might be called to conduct; and (2.) to teach by a thorough example the true method of reading and mastering a subject, as presented by a scientific writer.

At the final examination for degrees, held May 27, 1873, the following paper was presented to the class. It will enable one to form a very fair judgment upon the nature of the work attempted, as it is similar in character to the paper used at the semi-annual examination, though somewhat more difficult.

[Examination of the Fourth Year's Class in Logic, May 27, 1873.]

Examine carefully the following investigation, and write down the *precise* proposition sought to be established by it. Then state by which of the Four Experimental Methods the reasoning is governed, and write out an analysis of the investigation, so as to show exactly

¹A *Treatise on Inductive Logic*, by Thomas Fowler, M. A., Oxford: at the Clarendon Press.

the points in which it agrees with the Essential Elements of the Canon corresponding to the Method.

"The north-east wind is known to be specially injurious to a great many persons. Let the inquiry be — What circumstance or quality is this owing to? By a mental analysis we can distinguish various qualities in winds — the degree of violence, the temperature, the humidity or dryness, the electricity, and the quantity of ozone. We then refer to the actual instances, to see if some one mode of any of these qualities uniformly accompanies this particular wind.

"Now, we find that, as regards *violence*, easterly winds are generally feeble and steady, but on particular occasions are stormy; hence we cannot attribute their noxiousness to the intensity of the current.

"Again, while often *cold*, they are sometimes comparatively *warm*; and although they are more disagreeable when cold, yet they do not lose their injurious character by being raised in temperature; so that the bad feature is not coldness.

"Neither is there one uniform degree of *moisture*; they are sometimes wet, and sometimes dry.

"Again, as to *electricity*, there is no constant electric charge connected with them, either positive or negative, feeble or intense; the electric tension of the atmosphere generally rises as the temperature falls.

"Farther, as respects *ozone*, they have undoubtedly less of this element than the south-west winds; yet an easterly wind at the sea-shore has more ozone than a westerly wind in the heart of a town.

"It would thus appear that the depressing effect cannot be assigned to any one of these five circumstances. When, however, we investigate closely the conditions of the north-easterly current, we find that it blows from the pole to the equator, and is for several thousand miles close upon the ground; whereas, the south-west wind, coming from the equator, descends upon us from a height. Now, in the course of this long contact with the ground, a great number of impure elements — gaseous effluvia, fine dust, microscopic germs, etc. — may be caught up and remain suspended in the lower stratum breathed by us. On this point alone, so far as we can at present discover, is the coincidence of all the instances of the east wind constant and uniform.

"If, then, our elimination be supposed complete, there is a proof that the deleterious influence is due to the circumstance last named."

Does the investigation satisfy the conditions of the Canon, and is the conclusion valid?

The responses of the class to this paper were highly satisfactory, almost without exception; as indeed they also were, in almost as high a degree, to the examinations previously conducted.

Nothing more in Logic or Philosophy has been attempted with this class, and it is therefore necessary to show how my time has been spent with them during the second half of the year. It was my desire to advance somewhat into the detail of the Philosophy of the Sciences, especially into that of Mathematics; but the Government having expressed a strong desire that the subject of Political Economy should be presented, at least in clear outline, and having requested me to step aside from the strict line of my labors long enough to perform the duty of giving the necessary instruction in that subject, I complied, but found it impracticable to accomplish anything valuable without occupying all that remained of my time with this class. The time since February, 1873, has accordingly been given to Political Economy. I have read with the class, in a manner similar to that pursued in the case of Fowler's *Logic*, Mr. Walker's treatise on the *Science of Wealth*, taking pains to present the points in which other leading writers differ from him, and to develop with especial clearness both sides of the great dispute between Protection and Free Trade. The class have shown great interest in the subject, and at the final examination, held May 12, 1873, not a single member was conditioned, while the great majority passed at a very high grade. The paper set is subjoined, and I cannot at this point forbear remarking upon the general excellence of the English writing in the papers presented by the class; it was terse, clear, and in almost every case, noticeably free from defects of every kind.

[Examination of the Fourth Year's Class in Political Economy, May 12, 1873.]

1. Show how the action of the three elements — Desire, Labor, and Wealth — renders the realm of Political Economy an ever-expanding one, and how it is that they render Political Economy a *positive science*.

2. Define *Wealth*, in its strict, scientific sense.

3. Define *Value*, show what are its two essential conditions, and point out the ambiguity, in the ordinary use of the term, which must be carefully avoided in Economic Science.

4. Define *Labor*, and prove that the service of slaves, or any other involuntary work, is not labor in the economic sense.

5. Define *Capital*, and show why the distinction sometimes made between "active" and "idle," or "productive" and "unproductive" capital, is futile.

6. What are the three principal modes of Production, and what the three conditions of its highest success?

7. State some of the principal advantages of Division of Labor, show its limitations, and point out some of its evil tendencies, which need to be counteracted.

8. What is the conclusive argument in favor of Free Trade, from a strictly economic, or merely *monetary* point of view; and what is the equally conclusive argument in favor of Protection, as a policy sometimes absolutely necessary, though temporary?

9. What are the essential conditions of a good Currency? Show that neither a Credit Currency nor a Mixed Currency can satisfy these conditions, and why. State the advantages of a Mercantile Currency over one of Coin.

10. State some of the advantages and disadvantages of the Direct and the Indirect methods of Taxation, and show why it is necessary always to make the indirect method Discriminating.

II. In the Third Class, the work of the year has been confined to the elements of Formal Logic. We have covered the ground of the Classification of Terms, of the Distinction between Extent and Intent, of Definition, of Division, of the Classification of Propositions, of their analysis into Subject, Copula, and Predicate, and have advanced into the Doctrine of Inferences as far as through the principles of Immediate Infer-

ence, so-called. The method pursued has been essentially the same as with the Fourth Class, except that there has been a more decided effort to teach principles by examples. Fowler's text¹ has been made the basis of the instruction, and has been amplified when necessary, and criticised where it seemed to call for that treatment. The variations of view among the leading logicians have been presented, the different doctrines criticised, and the whole presentation of principles has been supplemented by oral and written practice upon examples. The time has been too short for the performance of the work in the best manner, and yet, considering all the circumstances, I have been highly pleased with the results. Subjoined are the two examination-papers used at the semi-annual and annual examinations respectively, from an inspection of which the scope and character of the work may be seen. The success of the class is indicated by the fact that only one member was conditioned at the final examination.

[Examinations of the Third Year's Class in Logic.]

I.—Semi-Annual Examination, January, 1873.

1. Write an original example, not in blank symbols, but in significant real terms, of each of the proposition-forms *I* and *Y*.
2. Point out all the respects in which the following proposition violates the conditions of a formal-logical definition:—

A Constitution is a document revealing the principles from which a National Life germinates, and which control the organization of a community for the purposes of government, or of the administration of the public interests.

3. Give an example of correct definition, by defining with precision a *Mathematical Limit*.
4. Point out all the errors in the following professed Division:—
The members of a community into Capitalists, Operatives, Catholics, Protestants, Merchants, Mechanics, and Agriculturists.

5. Give a correct and *complete* division of *Plane Figure*, down to its *infimæ species*.

¹ *A Treatise on Deductive Logic*, by Thomas Fowler, M. A. Oxford: at the Clarendon Press.

6. Reduce the following proposition to its regular logical form, so as to exhibit distinctly its subject, copula, and predicate :—

None but the brave deserve the fair.

7. Reduce the same to its logical skeleton, by substituting literal symbols for its subject and predicate, specifying the precise words for which the symbols stand, and then name the form (A, E, I, O, U, or Y) under which it falls.

8. Apply the directions in Question 6 to the following proposition :—

All that glitters is not gold.

9. Apply to the same proposition, the directions in Question 7.

10. Rewrite the proposition of Question 8 in such words as to bring out distinctly (1) its meaning *in extenso*, and (2) its meaning *in intenso*.

II. — Annual Examination, May, 1873.

1. In the following expressions, specify which of the italicised terms are General, and which are Singular :—

None but *the brave* deserve the fair.

Man's inhumanity to man makes countless *thousands* mourn.

A bird in the hand is 'worth two in the bush.

2. In the following, distinguish between the italicised terms that are Distributed, and those which are Undistributed, stating in each case the principle which determines the decision :—

Socrates was wise.

No man is infallible.

Some men of genius have been destitute of talent for affairs.

3. Of the terms *Animal* and *Brute*, which has the wider Extent, and why? Of *Conic* and *Ellipse*, which has the deeper Intent, and why? Why cannot the Extent or Intent of *Body* and *Spirit* be compared?

4. Divide the term *Students of the Massachusetts Institute of Technology*, down to its *species infima*, in accordance with the rules of Logical Division.

5. Point out the respect in which the following statement violates the Laws of Definition :—

A T-square is a sort of straight-edge.

6. Write (1) the Residuals, and (2) the Contraries, of the following terms :—

North, Probable, Black.

7. Write all the possible Opposites of the proposition *No philosophers are materialists*, and name the Grade of Opposition in which each stands.

8. Why would it not follow, upon disproving the foregoing proposition, that all philosophers are spiritualists? What *would* follow?

9. Convert the proposition *All observations are liable to error*, and state whether the conversion is Simple or Accidental.

10. Given the proposition *Some historians are not trustworthy*, (1) as true, and (2) as false, write all the legitimate Inferences by Opposition. Why can no Inference by Conversion be drawn from it? What is the legitimate Inference by Permutation, or Residuated Opposition?

The remainder of my work has been with the First Year's class, and has consisted in lectures upon the rudiments of Formal Logic, with especial reference to their application in the science of Language in general, and in that of the English language in particular. I felt that the attempt to present such a subject to a class at once so large and so inexperienced in such topics, and to present it, moreover, by lectures alone to a class as yet wholly without practice in taking notes, was, to say the least, an experiment. Nevertheless, from the peculiar nature of the views I felt obliged to present, no other course seemed open. I have therefore lectured to the class once each week during the entire year, giving up an hour at intervals to the business of testing, by proper questioning upon doctrines and examples, the comprehension of principles, and occasionally adding other hours devoted to a repetition of difficult matters in a more familiar form than that of the original lecture. A large, and, as it seems to me, decidedly valuable part of my work with this class, has consisted in a careful and sufficiently frequent revision of all their note-books, for the purpose of correcting errors, not merely of detail, but in the whole conception and plan of note-taking. The rapid and remarkable improvement of the class in this respect during the year, has more than repaid the drudgery of the process.

The results in the subject itself have perhaps been as good

as we had any reason to expect. From the subjoined papers, it will be seen that, while the work has been strictly rudimental, there has been no attempt to evade its difficulties. Upon the first, used at the semi-annual examination, some thirty-five were dropped or conditioned, out of a class of one hundred and fifteen. But of these, all but two made up their work successfully on the two papers marked II. and III. On the final paper, out of a class of seventy-six, three were conditioned, and none failed.

[Examinations of the First Year's Class in Logic.]

I.—Paper used at the Semi-Annual, January, 1873.

State under which of the Three Divisions in the Science of Language, each of the First Seven of the following statements belongs:—

I. The essential qualities of Style are clearness, appropriateness, and vitality. These it must have, no matter what the topic treated of, nor the end aimed at; what other properties it shall exhibit, will depend upon the nature of the subject in hand, the specific object to be gained in presenting it, or the special form of the composition.

II. If the thing denoted by an English verb occurs in what is called present time, the form of the verb changes to correspond with the number of the subject, provided the latter be in the third person.

III. A Noun is the name of any object of sense or subject of thought.

IV. The Possessive Case (*'s*) precedes the noun on which it depends.

V. One of the most effective means for giving vitality to style is the judicious use of metaphors; but a metaphor is an edge-tool, and the inexpert need to be wary in handling it.

VI. In the following expression from Ben Jonson's Eulogium of Shakspeare, namely,—

————— Soul of the age,
Th' applause, delight, and wonder of our stage,
My Shakspeare, rise!

all that precedes the word *rise* is the Compellative, or title of the person to whom the Imperative [*rise (thou)*] is addressed. *My Shakspeare* is the basis of this Compellative, and is modified by the appositive phrases, *Soul of the age*, and *Th' applause, delight, and wonder*

of our stage. It is noteworthy that this basis is complex, while the second appositive phrase has a compound base, *th' applause, delight, and wonder*. Of the Imperative, *thou* (understood) is the subject and *rise* the predicate; the copula is not symbolized.

VII. In the same expression, we may notice the forcible use of metaphor in the phrase *Soul of the age*, and the skillful metonymy in the expressions *applause, delight, and wonder*. Here the effect is put for the cause; Shakspeare *produced* applause, delight, and wonder, and the vivaciousness of the metonymy lies in the fact that the poet thus makes him appear so completely the life and soul of the effect he produces, as to be actually present in it, and utterly identified with it.

VIII. In the statement *Mercy is twice bless'd*, point out exactly how the Inner Aspect of Expression is exhibited.

IX. Show also in what consists the Outer Aspect, as presented in the same saying.

X. Exhibit the triune form of the proposition in the following exclamation, which Milton makes Death address to Satan:—

Back to thy punishment, false fugitive!

II. — Paper used to re-examine conditioned men, March 7, 1873.

I. In each of the following sentences numbered (1), (2), and (3), there are marked defects; in the case of each, state, *with the reasons for your opinion*, whether the defects are *logical, grammatical, or rhetorical*:—

(1.) The distance of the line from the origin is constant; but it's inclination to the axis of x is variable.

(2.) The line's inclination has variation in an unlimited gradation.

(3.) The inclination of the line may be changed at pleasure, and is therefore invariable; but the distance constant.

II. Point out which of the Three Forms of Universal Language is exhibited in each of the following expressions, taken as a whole:—

(4.) Because some men are hypocrites, is no reason for supposing that all men are so.

(5.) Merely to think of the hypocrisy of some men —

(6.) Alas! to think of the hypocrisy of some men!

(7.) Just think of the villany of some people.

(8.) Some plausible people are villains at heart; because they do not hesitate to act basely whenever they feel sure that they will not be detected.

(9.) The deep-seated, crafty, unsuspected villany of many men that might be named.

III. Rewrite the following proposition in such words as, without in the least changing its meaning, will bring out distinctly the three elements of its triune form:—

(10.) A man may smile and smile, and be a villain.

III.—*Paper used in Final Examination of conditioned men, April 9, 1873.*

1. How many, and what, elements are to be found in every proposition?

2. How do you reconcile the apparent discrepancy between the answer you have just given, and the form of such a proposition as *We-think*?

3. And how can you make out the requisite number of elements in *Go to the ant, thou sluggard*?

4. Above all, how can you find them in such a proposition as *Bethink thee*?

5. Is this a proposition:—*Better late than never*?

6. Is this:—*Brighter than all the stars of heaven*?

7. Is this an argument:—“Smith went to California, because he wanted to try a miner’s life”?

8. Or this:—“He lay down and slept; for he was weary”?

9. Or this:—“Any side of a triangle is shorter than the circuit of the other two; for it is a straight line joining the same two points that they join by a broken line”?

10. Rewrite the following argument, so as to display in their proper order the three elements of its triune form, putting down (1) the Major Premiss, (2) the Minor Premiss, and (3) the Conclusion:—

“Because the shadows point westward, it is still morning.”

IV.—*Paper used at the Annual Examination, May, 1873.*

1. Suppose that a certain piece of English were placed before you, and that you were required to criticise it (1) in respect to *purity*, (2) in respect to *propriety*, and (3) in respect to the *coherency and consistency of its propositions and their parts*, in which of the Three Divisions of the Science of Language would the three parts of your work respectively fall?

2. Decide, with regard to each of the following expressions considered as a whole, whether it is a Term, a Proposition, or an Argument, giving the reasons for the decision in each case:—

(a.) If I mistake not, it is with *Meister* as with every work of real and abiding excellence, the first glance is the least favorable.

(b.) One of the only three men of genius that have ever lived.

(c.) Is thine eye evil, because I am good?

(d.) There could no longer be any doubt of the prisoner's guilt; for he had committed suicide at the moment when new evidence, of an important and damaging character, was about to be brought forward.

(e.) That the court which tries him be pure, and the jury instructed in the cause; that the work be not condemned for wanting what it was not meant to have, and by persons nowise called to pass sentence on it.

3. Write the list of the Ten Categories, in their proper order, and state their principal use (1) in connection with the doctrine of Terms, and (2) in connection with that of Propositions.

4. Decide which of the following terms are Substantive, and which Attributive:—

(a.) The least favorable.

(b.) The first glance.

(c.) Every work of real and abiding excellence.

(d.) Of real and abiding excellence.

(e.) As with every work of real and abiding excellence.

5. Decide which of the following terms are Singular, and which General:—

(a.) Court.

(b.) The court which tries him.

(c.) Goethe.

(d.) Fidelity.

(e.) Persons nowise called to pass sentence on the work.

6. In the case of the Singular terms among the foregoing, distinguish between those which are Abstract, and those which are Concretely Individual.

7. In the list of terms in Question 5, point out those which are Simple, and those which are Multiple. In the case of the latter, state whether they are Complex or Compound. Finally, see whether

there is, among any of these terms, or among their component parts, an example of a Complemental term; and, if you find one, specify it.

8. Define the distinction between the Extent (or Denotation) and the Intent (or Connotation) of a term, and illustrate it in the case of the term *circle*.

9. Resolve the following propositions into Subject, Copula, and Predicate, without enlarging, restricting, or otherwise altering the meaning of either:—

(a.) Goethe is by many of his countrymen ranked at the side of Homer and Shakspeare.

(b.) To many of them I could do no justice.

(c.) What work was ever as the workman wished and meant it?

(d.) For this purpose, the most that I had room to say is said.

(e.) It is not tears which her fate calls forth.

10. In each of the following, give the final import of the predicate, by naming the category under which it falls:—

(a.) Fidelity is all the merit I have aimed at.

(b.) The duty of a translator is simple and distinct.

(c.) Some of these I may have failed to see.

(d.) The hero of the *Meister* is a milksop.

(e.) Goethe wrote *Meister's Apprenticeship* in his forty-fifth year.

For the future, I would recommend that the work from my chair begin with the second half of the Second Year, and continue throughout the Third and the first half of the Fourth, closing with the semi-annual examination of the latter. I should distribute the topics over that period as follows:—

SECOND YEAR:—Formal Logic,—Doctrine of Terms, Propositions, and Immediate Inference.

THIRD YEAR, *First Half*:—Formal Logic,—Doctrine of the Syllogism, and of Fallacies.

THIRD YEAR, *Second Half*:—Philosophy of Science,—Theory of Induction.

FOURTH YEAR:—Philosophy of Science,—Logical structure of the various Sciences, especially of Mathematics; Theory of the Calculus; Philosophic Place and Value of the several Natural Sciences.

Of course it is to be understood that more time is to be given to these topics hereafter than we have been able to command the present year. The student must have ample time for the preparation of the subjects which have been assigned to my chair — time additional to that occupied with me in the lecture-room. I believe, however, that provision has already been made for this, at least in part, by a re-arrangement of the details in the other courses of instruction. When all our plans are completed, I cannot but believe that this department will fully realize all that was hoped for from it by those who urged its establishment.

Respectfully submitted,

GEORGE H. HOWISON.

Boston, June 5, 1873.

REPORT OF THE DEPARTMENT OF DESCRIPTIVE GEOMETRY, STEREOTOMY, AND DRAWING.

To the President :—

The subjects composing this department were formerly distributed among several other departments ; but, with the rapid growth of the school were formed into a new and distinct one, a year ago. The present is thus the first report relating to it, separately.

For this reason, as well as on account of a comparatively general unfamiliarity with the scope and meaning of its first two sub-titles, it seems due to the subject to present the matter, methods and work of the department, somewhat fully, however summarily, in a first report.

This may be conveniently done under distinct heads, as follows :—

I. *The definition of the department.* Descriptive Geometry may be popularly defined as the *geometry of drawing* ; or, more exactly, as the system of principles, and exact operations founded upon them, by which all regular objects, both singly and in all possible combinations, can be so truly represented upon flat surfaces, that, from the drawing, the original can be constructed as it exists in the mind of the designer.

Stereotomy means literally the cutting of solids ; as in Stone Cutting, Carpentry, and the shaping of mechanical pieces so as to produce certain motions by their combined action.

But, by the same refinement of speech by which *solid* geometry treats definite portions of space as empty volume, rather than as material bodies, stereotomy includes, in a geometrical sense, the cutting of immaterial as well as material forms, the cutting of the portion of space darkened by an opaque body, by a surface, which thus receives the shadow of that body ; and the cutting of the immaterial cone of rays from a body to the eye, by a plane, which thus contains the perspective or picture of that body. Stereotomy thus embraces, in full, Shades and Shadows ; Perspective ; the shaping of mechanical organs relative to the motions they will produce, or the stereotomy of mechanism ; the shaping of the elements of structures relative to their affording convenient and appropriate bearings, or the stereotomy of masonry, carpentry, and metal structures, as in stone-cutting, and roof and bridge articulations.

Drawing includes, *first*, the drawing of the many diagrams of a general character illustrative of the body of theory pertaining to Descriptive Geometry and Stereotomy ; *second*, the preparation of finished working drawings of actual or proposed structures and machines ; also free-hand and topographical drawing ; and considerable preliminary drill in the merely manual operations in the use of instruments and drawing materials.

From this exhibit, it is at once evident that the department, reaching as it does nearly every member of a large institution, is an extensive one ; so much so, as already found by trial, that my foremost recommendation for the future is, that at the earliest opportunity all of the *second* branch of drawing just named be coupled with Geodesy, or the whole of Engineering field practice, and set off as a new department of Geodesy and Drawing ; leaving the title of the present department to be Descriptive Geometry and Stereotomy. I suggest the union of geodesy with drawing, having for many years, in a former position, seen the smooth and excellent practical working of the

obviously natural plan of putting the construction of all maps of surveys in charge of the same hands that conduct the surveys themselves.

II. *The actual present composition* of the department now defined, is as follows; the subjects being arranged as given in the four successive years of the Institute course of study:—

FIRST YEAR.

1. Construction of Problems of points, lines, polygons and circles, in plane geometry.
2. The use of drafting instruments and materials.
3. Elementary, general and applied Projections; or rudimentary and practical Descriptive Geometry.
4. Elementary Perspective, both of Forms and Shadows.
5. Elementary free-hand drawing.

SECOND YEAR.

6. Descriptive Geometry.
7. Shades and Shadows.
8. Topographical drawing.
9. Free-hand drawing.

THIRD YEAR.

10. Machine description and drawing.
11. Structure drawing from measurement.
12. Maps of land and line surveys.

FOURTH YEAR.

13. Stone-cutting.
14. Various professional drawing assigned by different departments.

III. *The work done.* Something has been accomplished during the past year in each of the above fourteen subjects, though less, it being a first and experimental year, than may be hoped for in future.

In the *first year* there were about thirty exercises per man, of mingled instruction, interrogation, or blackboard demonstration, upon the body of principles, or theory, connected with the numerous additional drawing exercises; the whole occupy-

ing about ten hours per week. In these exercises an aggregate of not less than forty rationally constructed, not copied, plates, nine inches by thirteen inches in size, were made by each student, besides the execution of many plates in Free-hand Drawing.

In the *second year* there were about forty class exercises, as above, on the theory of the subjects pursued, connected with the construction of about sixteen plates, ten inches by fourteen in size, in Descriptive Geometry and Shades and Shadows, besides those made in Free-hand landscape and object drawing, and in Topographical drawing.

In the *third year*, owing to excess of other work, a little only was done in Shades and Shadows and in Machine Drawing, in the first half of the year. But a very satisfactory beginning was made in the second half, with the drawing of various roofs, bridges, and other structures in the vicinity, suited to the various professional courses chosen by different students. The class entered on this work with gratifying and commendable zeal, and made drawings, from measurements of a drilling machine, the new Providence Railroad Depot roof-truss, the Lowell Railroad drawbridge, an iron road bridge at Waltham; and of smelting and gas furnaces, all under instruction; also maps of surveys.

With the *fourth year* class, various hindrances prevented more than a bare beginning of a course in stone-cutting; and the construction by each student of one bridge drawing, generally one of several bridges visited during the preceding summer.

To the three regular architects of the Third and Fourth Years united, a short course in Higher Perspective of Forms and Shadows was given, with the peculiar pleasure always arising from the instruction of a small class of interested and uniformly qualified students. A short special course in Elementary Projections of bodies and of their shadows was also given to the Special students of architecture belonging to the Third Year.

IV. *Remarks and suggestions.*

a. *The force of instruction* for accomplishing the foregoing work has consisted of one professor, three official assistants — two of whom gave but a part of their time to the department — and six student assistants. This may or may not seem a large force, but it must be remembered that while the occupants of some chairs seldom or never come in contact with more than a dozen students, the present is one of several of the more comprehensive departments, whose instructions extend to nearly all of our three hundred and fifty students.

It seems generally better to have official, rather than student instructors; and, with the present number of students, I would urge the advantage of employing the full time of three official assistants, or its equivalent, with from two to four student assistants, according to the nature and amount of their services.

b. *Methods.* These have embraced, under the head of *instruction*, brief familiar exposition, accompanied by Models and Diagrams and the expounding of text-books, with careful pointing out of cardinal principles and directions for proper use of the book in order to gain a clear view and firm grasp of the subject. Also under the head of *recitation*, individual and general interrogation, blackboard demonstrations, and regular and informal written examinations.

In reflecting on the character of the many examination papers looked over during the year, it has occurred to me, often and forcibly, that in some things they are not a full substitute for oral examinations, though on the whole decidedly preferable, independently of the size of the school. Their strong point, to my mind, is in the opportunity they afford for each man to tell substantially all he knows of the subject in hand, or at least enough to enable the examiner to form, generally, a sure judgment in each case.

Their weak points thus far noted are two. First, their undoubted tendency to encourage a slighting of daily term work, and a "cramming" at the end, on the part of all who do not study from principle, or fondness for learning; that is, if

the *final* term papers, only, are wholly or mainly relied on to determine the student's standing. This defect could be obviated by making the student's standing depend on the mean of the results of all the tests applied to him, or at least of all his written examinations.

The second defect, of very different nature from the last, is that written papers are liable to betray perplexing ambiguities as to what the writer really means, and wasteful misunderstandings of either the point or the scope of the questions; defects arising not from obscurity in the question to the well-prepared student, but to a mistiness or incompleteness in a less perfect student's knowledge, while nevertheless he is not grossly deficient. Now any exact subject may be said to embrace facts, principles, and problems. The latter only would seem to be most fully provided for by examination papers. But in ten minutes, by the clock, from twenty to forty questions, by actual count, according to their character and the readiness of the student, can be asked on facts and principles in which ambiguities and misapprehensions can, unless in cases of real deficiency, be instantly corrected, and a very telling exhibit secured of the quality of the student's command of his subject. Now it takes at least ten minutes to look over an examination paper. If, then, some way could be devised to divide ten to fifteen minutes between oral and written examination, I would submit that more comprehensive and certainly decisive results could be attained, to say nothing of the superior life and interest of an oral examination.

c. *New models.* A perfect set of models can doubtless only be built up gradually, as found by experience to be wanted. The more immediate needs of the department in this regard are, a set of about fifty cheap, simple objects, such as any carpenter can make, for use in drawing perspectives of actual objects, from measurement; a couple of bridge models costing about \$150 each, and a small appropriation, to be drawn upon from time to time for approved and specified models in Descriptive Geometry, Mechanical Elements, and Stone-cutting.

The foregoing are all the topics that have occurred to me as being of interest relative to my department, to those having the welfare of the school in charge; to whom, and chiefly to yourself, they are respectfully submitted.

S. EDWARD WARREN,

Prof. of Descriptive Geometry, Stereotomy, and Drawing.

DEPARTMENT OF ENGLISH AND HISTORY.

Pres. J. D. Runkle:—

SIR:—I hereby present the following report of my doings during the past year in the departments of English and History.

The difficulty of securing a sufficient amount of time for English studies has continued to embarrass me, and must continue to do so, so long as the preparation for the school continues so imperfect. Practically a large majority of our regular students have to crowd four-and-a-half to five years' mathematical and scientific work into four years; and this leaves but a small amount of mental energy to be devoted to studies not strictly professional. There is one, and only one remedy for this difficulty, and that is a better preparation; and that not more, or even so much in English and mathematical as in elementary scientific study. In consequence of the very defective condition of school instruction in science in this country, our students have practically to begin the study of the very rudiments of physics, chemistry and the different branches of natural history at the age of sixteen or seventeen, a period of life at which, if our schools were perfectly organized, these elements would all have been acquired. By this postponement these studies become unnaturally difficult of acquirement, and the necessity of making up these untimely arrears of professional study stands in the way of the success of the English department, by depriving it

of the time which might otherwise be devoted to English studies. An addition has this year been made to the requisites for admission on the side of mathematics: it is to be hoped that the time is not far distant when improvement in school teaching will allow us to assume the possession of a reasonable amount of knowledge of the elements of physical science on the part of young men of the age required for admission.¹

Till that time comes, no proper balance can be established between English and scientific studies within the school. The time required for making up arrears in professional studies *must* be taken from that which should be devoted to general training. The professional student comes for a distinct purpose; he wishes, for instance, to be made an engineer, and he must be trained so thoroughly in engineering studies that his bridge will not break down through faults of construction. It would be small comfort to his employers if that should happen, that he could report in Addisonian English, and with unimpeachable logic the precise reasons why it broke down. It is better, if the choice must be made, even that his report should contain English words misspelled, through the defects of his primary school learning, than that his bridge should prove defective; though his literary deficiencies cannot be considered otherwise than unfortunate, and the misspelling engineer can hardly claim that he has received a complete or symmetrical education. All that can be said is that his not having received it within four years cannot be imputed as a fault to the Institute of Technology.

What course to take under such circumstances has been to me from the beginning a very puzzling question. To exact from the students the amount of mental effort which would be required by a course of English studies pursued with the same thoroughness as is required in their scientific studies, is obviously impossible; for the complaint is now very general that our students are overworked, and to add to minds already over-

¹ Even now I think it would be feasible to require an entrance-examination in one or more of the excellent "Science Primers," now in course of publication in England.

burdened with scientific study the amount of labour required for the thorough study of all the great subjects which a properly conducted english course contains, would be simply to break down the student altogether. On the other hand, to reduce requirements in English to the paltry minimum of correct spelling, and the writing of business letters, would be to abandon all claim on the part of our institution to being called a place of liberal education.¹ I cannot claim that I have completely overcome the difficulty, for it is in its nature unsurmountable; and a teacher in the English department of the Institute must for the present, be contented with very modest, not to say incomplete and imperfect results. One consideration has guided me in the course I have pursued in my literary and historical instruction, and it is a very important one in connexion with such studies, that they are precisely of a kind where much may be done, by proper effort on the part of the instructor, to implant taste and excite curiosity even where the opportunity is wanting for systematic or exhaustive study. The mathematics required by the engineer are a precise and definite subject, to be thoroughly mastered by the student within a given period, as an absolutely essential qualification for his degree. A knowledge of literature and history is no such definite quantity, and by its very nature is not to be arrived at by such precise methods. Taste cannot be taught, nor a knowledge of history be communicated in twelve or any other definite number of lessons, though a knowledge of geometry may; but it may make an infinite difference to the student in after life whether some love and appreciation of literary and historical studies was or was not implanted in his mind in the course of his school education; and that love and appreciation may be instilled by methods different from the rigid and exhaustive ones required in the purely disciplinary part of his studies. It may

¹ It is a point upon which I am not qualified, and do not presume, to give an opinion how far our present scientific courses might be curtailed of scientific superfluities, but I am clearly of opinion that if there are any such superfluities they should be sacrificed in preference to any part of the student's general training.

fairly be maintained, therefore, that while in the latter case the main stress of the labour falls upon the student, and his success depends upon the amount of his hard work, there is learning of a different kind where the burden of the labour falls upon the instructor, and his difficult task is so to digest his materials as to produce a valuable result with only a minimum of effort on the part of the pupil. This seems to be the part to be played by instruction by lectures on subjects which cannot, either through their very nature, or through adverse circumstances, be dealt with by more rigorous methods. And in my judgment it would be a gross mistake to undervalue such instruction, if only it be good of its kind. From the very nature of things, and the vastness of the field of knowledge, every man's acquisition must consist of two parts, that which he knows systematically and thoroughly, and that which he knows partially, and only well enough to appreciate and desire to know better. To be equally master of all subjects, is given to no finite mind. It is much, if in education we teach the student to avoid the presumption of undervaluing the subjects with which he is unacquainted. That the student of science should at least be partially acquainted with literary and historical studies is infinitely better than that he should have no knowledge at all; and where a taste for such studies is not by some means implanted in school or college, it is rarely, and by accident, that it is acquired amidst the engrossing occupations of after life.

Such a course will undoubtedly be inferior in point of systematic thoroughness to the professional part of the student's instruction. It will draw less on the memory, while, on the other hand, it will aim to cultivate taste and judgment, excite curiosity, and lead to a love of extra professional reading and the acquisition in after life of knowledge on subjects which should interest the student as a man and a citizen. Many of the topics it deals with are such as had better not be handled by rigidly systematic methods; a taste once excited, a complete knowledge must be left to the voluntary efforts of after years. To make enforced tasks of what should be pleasurable mental efforts — ef-

forts which are nothing if not pleasurable — is the way in which literary instruction is too often overlaid and smothered by scholastic pedantry. Some of the best results of these studies are such as cannot well be gauged by competitive examinations or exhibited in answers to sets of printed questions.

I do not mean that such instruction can dispense with all labour on the part of the student, or that there are no methods of testing its results; I only mean that the amount of his voluntary labour may more safely be reduced to a minimum and that the amount of absolute knowledge must be very much less than that of the subject on which the stress of his mind has been exercised. Even though it may be impossible for the student to acquire the same amount of knowledge of the details of history as of the details of chemistry, he may at least gain at school an adequate conception of what the study of history really is, may have it exemplified by the more or less detailed treatment of some one period, may acquire something of what may be called the historic sense, and the habit of looking at political and social questions, whether of the present or the past, from a historic point of view. This is not every thing; but it is better than entering life without any historic training, or with only the schoolboy notion of history as being a dry collection of names and dates. In one sense it is superficial; but in another sense such instruction, addressed to young men whose minds are beginning to mature, and who are learning to think independently on important subjects, may be made to contribute to one of the most precious results of all training, namely, the habit of vigorous independent thought on subjects outside the narrow limits of their professional practice.

It has thus been my not very easy task to try to awaken a loving and real interest and an adequate appreciation of studies in the pursuit of which I could not throw the burden of much labour on the students themselves. I have heretofore erred mainly in attempting too much — not too much for what the Institute ought to be, and is destined to become, but too much for what it really is at present. The experience of a good many mis-

takes has enabled me to improve somewhat this year upon the results of the past sessions, and to report more definitely what I can reasonably expect to accomplish in the future.

I began this year with the new class with instruction from a school treatise on rhetoric and composition. This is not properly work for the Institute, but it may fairly be placed beside the necessary review of algebra and geometry with which the mathematical work begins. Every well-instructed young man of sixteen or seventeen should bring with him, as the result of the last years of his high school training, fair ability to write his mother-tongue, and a good knowledge of the elementary principles of rhetoric. It would be making a liberal estimate to say that fifty per cent. of our classes have attained such a standard, and it is a difficult question to answer, where a class has to be instructed as a whole, whether the instruction should be addressed mainly to the superior or to the inferior half. Where a class cannot be graded according to proficiency, the practical result is a compromise, which sometimes bears rather hard on the older and superior students: but my judgment inclines me more and more to the plan of taking up my subjects as nearly as possible at the point where I ought to begin, supposing the elementary instruction to have been altogether satisfactory. To do otherwise is to put a premium on insufficiency, and to degrade the function of the Institute. The bad spelling of a portion of the students has called forth much criticism, but it is a question whether the true remedy is to set students of seventeen down to spelling-lessons again.¹ So elementary lessons in the structure of sentences suited to the capacities of children furnish very uninviting food to young men. Young men cannot be turned into children again, and it is not desirable that they should be. Nature and life have been maturing their minds if school has not been instructing them

¹ For the benefit of students who have not studied Greek and Latin, I purpose hereafter to give some special lessons in the spelling and derivation of technical terms derived from those languages, the department in which the students' spelling is apt to be weakest.

properly, and though the loss arising from imperfect elementary training may not be wholly made up by any plan, yet I am confident that the principle of taking up my subjects in a manner adapted to the student's age rather than to his want of literary attainments, by producing a more living interest in the subject, involves less loss than too much belated attention to the making up of elementary deficiencies. Either doctrine, it is true, may be carried to an extreme. A teacher may, on the one hand, easily lecture over the heads of his pupils, while he may on the other, destroy all vital interest in the higher and most valuable parts of his subject by a too pedantic attention to petty details. I have tried to adopt an intermediate course. While taking the ground that the Institute does not offer itself to the public as a teacher of spelling, or punctuation and the rudiments of grammar and composition, I have given as much incidental help as possible, by causing written exercises to be corrected, and by going rapidly over the elementary parts of a school rhetoric.

I proceed, however, to a more mature and manly style of exercises as soon as possible, throwing the burden of making up elementary deficiencies from that time upon the student himself. These elementary deficiencies have arisen mainly from carelessness arising from lack of interest in school lessons, and make themselves up very rapidly whenever a living interest in literary subjects has once been excited. Deficiencies in spelling are made up if the student acquires a habit of reading; and the power of expressing his thoughts in clear and simple language is the gradual result of his whole mental discipline, when it is accompanied by even a minimum of practice in that direction. The power of expressing thoughts in writing on any subjects on which they have ideas to express, possessed by our present senior class will compare, I think, not unfavorably with that of any similar body of young men who have had no more time to bestow upon the subject than they have had.

I attach but little value to the writing of "Compositions," or the study of treatises on rhetoric after the usual fashion of

our schools. It is the cardinal principle of all good writing that a man must have something to say, and the desire to say it. Young men who have read and thought but little, have very little to say, and with them the enforced practice of composition degenerates into the habit of diluting a very few thoughts with a great number of words, than which no habit can be more fatal to good thinking. It would seem wiser to prepare for the time when they may themselves have something worth saying by occupying them with the study of writers of established excellence. And in this way every good manual in every department of study, except the most technical, is really a constant and most valuable exercise in the study of English; and the learning to think clearly on scientific subjects, is excellent training for thinking clearly on subjects non-scientific. It is in this way I am glad to explain the real progress made by our students in their matters of English where so little labour can be directly bestowed on the subject.

What can be accomplished directly amounts practically to this:—A review, at the beginning, of the rules for good writing laid down in the Rhetorics, accompanied with an insufficient amount of practice. With the Rhetorics still in hand, as books of reference, I propose to follow this with the critical reading of good specimens of modern English as studies in style and expression, with the occasional task of a written analysis of some good specimen of an English essay, or an original paper on some subject previously discussed in the class-room. These practical exercises are accompanied by a series of lectures on the history of English literature, which take the shape of a commentary on some short manuals of English literature and English history, which the students will be required to have in hand simply as books of reference. *Lessons* in such manuals are, in my judgment, worse than futile. The only labour required of the students in connexion with these lectures, will be that of taking notes, and the examinations will be conducted with the students' manuals and note-books open before them; the examination not being intended as an exercise of memory,

but as a test of their interest, their taste, their attention and good judgment. The want of a lecture-room equipped with proper facilities for writing, has hindered me from fully realizing this plan; and I respectively suggest that such a lecture-room is an absolute necessity to the English department.

The course in History has been conducted on substantially the same plan, except that for the sake of economizing time and assisting students in their study of foreign languages, the manuals used have been in the French language.

With the second class I have devoted the two lessons per week to the subject of modern history, beginning with the middle of the fifteenth century, and using the French "Histoire des Temps Modernes" of Duruy, as my manual. My custom has been to translate it slowly with oral comments, the class having the text in their hands. This was the exercise for about one-half the time, the class being required to make each week a short bit of written translation as an exercise in English. The other half has been occupied with lectures and oral lessons on the period in hand, with abundant reference to collateral reading. I have endeavored, in my treatment of the period to which we have confined ourselves, to give the students my idea of the proper method to be pursued in studying history, if they should have leisure for it hereafter, and of the true objects to be kept in view as the proper aim of the study. I have connected the study of a past era with as much information respecting the present condition of the countries as the time allowed. Having been obliged to give these lessons to a large class in a lecture room destitute of any accommodations for writing, I have not been able this year to insist upon as much systematic note-taking as I could have wished.

I have devoted the one hour per week assigned me with the third class to a similar translation with oral comments of Guizot's "Civilization in Europe." The book is the best I can find for the purpose, that of giving a brief and clear outline of the philosophy of the history of modern Europe to students who have not time to study it in detail. It is also a model of

perspicuous style, and it is the general verdict of the class that they have derived much assistance in mastering the language from this sort of exercise.

With the fourth class I have occupied my single hour per week chiefly with the discussion of subjects connected with contemporary history and politics. During the first half of the term the students themselves frequently occupied the hour with the reading of their own papers — reports on topics selected by themselves, or abstracts of pamphlets or review articles loaned to them by me for the purpose. Very good papers of this kind were read to the class, and it is very much to be regretted that more time cannot be devoted to such exercises. During the latter part of the term I have given a few lessons on contemporary history, based upon the statistics of Martin's Statesman's Year-book, with a view to making the students somewhat familiar with the present aspect of European affairs and with the resources and present social and political condition of the leading nations. I am greatly impressed with the importance of making a knowledge of the living history of the day the leading object of the historical instruction in such a school as ours.

The use of French manuals has been so far successful that I intend to try the experiment of a German manual as the foundation of my lessons on constitutional history to the fourth class, next year.

With the students in the department of "Science and Literature" I have read Shakespeare's Merchant of Venice and selections from Chaucer's Canterbury Tales, in the carefully annotated editions published in the Oxford Clarendon Press Series of English Classics, reading along with them some good specimens of criticism. It would be difficult to make Shakespeare and Chaucer otherwise than interesting, and the exercises are very well as far as they go. But it is, I think, much to be desired that English studies should eventually be made to play a leading and not a subordinate part in the course in "Science and Literature." The students who enter this department

are, as a rule, not looking forward to the practice of either of the technical professions, but come to the school rather for purposes of general education, and with the desire to procure for themselves the best general preparation for active life. They are not therefore under the same pressure in regard to purely scientific study as the students who are aiming at a technical degree. I am of opinion that the "Science and Literature" course therefore should be something more than what it is at present, a mere miscellany made up of odds and ends of the regular scientific studies, but something distinctively different — a course in which English studies should enter as a solid and disciplinary part of the student's training. The number of students in this department is now sufficient to form a class — the instruction of Prof. Howison leaves nothing to be desired in the department of logic, and this year will give us additional facilities for thorough instruction in modern languages and a favorable opportunity seems offered for arranging a course of study of a less technical character than that of the chemist, architect, or engineer, in which foreign living languages, the English language and its literature, civil history, the elements of municipal, as well as constitutional law, physical, political and economical geography, and other studies which go to form the future man of business, shall take the place of that portion of the higher mathematics and purely professional scientific training which such students would omit. It will be for the Government of the Institute to say whether such an enterprise shall be undertaken. A strong argument in its favor must always be, that a valuable *systematic* course of study might thus be provided for a large number of students who, through want of scientific preparation, or inaptitude for higher mathematical studies, at present either drop into all kinds of miscellaneous specialties, or drop out of the school altogether. For a good many years to come it seems likely that a large number of students will continue to enter our school who are either unable to compete for our strictly scientific degrees, or do not desire to take them, and it seems

highly desirable that something more systematic should be provided for them than our frequent "special" and "partial" courses. It would be altogether undesirable that the high standard at present set for the attainment of our purely scientific degrees should be lowered in order to meet the wants of students unapt or disinclined to higher scientific studies. I think it is not too much to say that for these students the Institute has already at its command the materials for forming a parallel course of study, equal in disciplinary value and in practical usefulness to the strictly scientific courses which are now so thoroughly carried out.

I must again respectfully represent to the Government that the wants of the English department are great in every direction. It needs a lecture room of its own, equipped with proper accommodations for writing, and with facilities for the exhibition of maps and other apparatus, and in immediate connexion with a larger and better-appointed reading-room. In the reading-room it needs a larger collection of well-selected books of reference. In addition to books of reference, it is very much to be desired that it should have a selection at least of the best works of standard English and American writers.

All which is respectfully submitted,

W. P. ATKINSON,

Professor of English and History.

REPORT OF AN EXCURSION MADE IN THE VACATION OF 1872-73.

In the summer of 1872, a party of twelve students, under my charge and that of Instructor Hoyt, visited some of the principal bridges of the country, and other works of interest to engineers. The party went first to Albany, to inspect the bridge over the Hudson; thence to Philadelphia, where the Baldwin Locomotive Works were visited; thence to the bridge and iron works at Phoenixville, where, by the kindness of Mr. Coffin, the various steps in the manufacture of iron bridges, beginning with the ore, were observed, and much valuable information gained; thence to Pottsville, to visit the coal region and the steep gradients on the Broad Mountain tracks; thence to the railroad shops at Reading, where Mr. Paxon, the master machinist, conducted the party through the works and pointed out many interesting processes in the manufacture of engines and cars; thence to the Bessemer Steel Works near Harrisburg, where Mr. Felton, the President of the company, gave the party an opportunity of seeing the whole process of manufacturing steel; thence to Pittsburgh, where the Keystone Bridge Works were visited under the guidance of Mr. Linville, and the various parts of the great steel arches of the St. Louis bridge over the Mississippi were seen; thence to the Oil Regions, by the Alleghany Valley Railroad, as far as Peters-

burg; thence to Cincinnati, where the new railroad bridge and the suspension bridge were the principal objects of interest; thence to Louisville, where the bridge over the Ohio, and the canal around the falls, and the Louisville Bridge Company's works were visited — these last under the guidance of the company's engineers, Messrs. Vaughan and Trafton; thence over the Louisville and Nashville Railroad as far as Cave City, to see the bridges on the line and to visit Mammoth Cave; thence to St. Louis, where the abutments and piers of the great bridge over the Mississippi and the Water Works were visited.

At St. Louis the students were divided into six parties, and to each party was assigned one of the principal bridges, which was to be visited and studied in all its details, with a view of giving a full description of the work, accompanied with accurate drawings. The party was, in effect, here broken up, as its members had generally to return by different routes, in order to study the works assigned to them. This report should not close without a grateful acknowledgement of the courtesies so generally shown to the party by the railroad companies, and by the engineers, master machinists, and others connected with the establishments visited.

JOHN B. HENCK,

Prof. of Civil and Topographical Engineering.

PROFESSOR ORDWAY'S REPORT ON THE VACA-
TION EXCURSION OF 1873.

President Runkle :—

DEAR SIR :— Visits to manufactories and metallurgical works have always proved a most important adjunct to the instruction given by us in Chemical Technology, and I am happy to say that the past year has witnessed no diminution in the number and variety of these excursions. It is very pleasant to find so much liberality as we have experienced on the part of gentlemen in charge of establishments not generally open to visitors, and to learn that our manufacturers take so much interest in the work and objects of the Institute.

In the department of Mining and Metallurgy it is a part of our plan to give students opportunities for more extended and continuous attention to actual mining, ore-dressing, and smelting operations, than the regular course of study in term time admits. In accordance with this idea, a long planned expedition to the Adirondac iron region has been successfully carried out since the close of the school year.

Arrangements were made for a party of nine students, together with Prof. Richards and myself, and on the morning of June 24th we met at the Lowell depot, arrayed in garments

suitable for rough usage, each furnished with note-books, hammer and haversack, blanket and poncho, and the minimum of baggage required for a three weeks' tour. Our first destination was Warren, N. H., where we spent the afternoon in visiting the lead and zinc mine, which has been worked, at intervals, for many years. The present happens to be a stand-still period, and as the underground part of the mine was filled with water, we had to be content with examining the extensive open cut and the large piles of zinc ore at the surface. Still there is much to be learned there, and we were amply repaid for our three mile' walk. The next day we proceeded by rail to 'North Lisbon, on foot to Franconia Village, and then by wagon to Franconia Notch, and back to Lisbon. At Franconia we devoted some time to the old charcoal iron furnace, which is in pretty good condition, though it has not been in blast since 1859. The fact is, Franconia is not now favorably situated with respect to fuel, as wood is too scarce to supply an iron furnace many years, and the village is too far inland to allow the use of anthracite. We were shown good specimens of copper ore which has lately been found in the town, but had not time to visit the opening from which it came. We reached Lisbon at a late hour, but were up betimes the next day, and improved the morning hours in visiting the stamp mills originally built for treating the gold bearing quartz of a mine about two miles north of the village. The machinery was afterwards run to powder a rock from Lyman, which was in great demand not long ago, on account of its supposed virtues as a fertilizer, and lately Dr. Ray, whom some of us met two years ago in Colorado, has reopened the gold mine, and is using the mill for extracting the precious metal by a peculiar process of amalgamation. Dr. Ray reports the quartz as containing \$35 worth of gold to the ton of rock, and at this rate the mine should pay, if the separation of the gold is properly conducted. It seems to us that chlorination is the proper method of treatment.

Lisbon was not included in the route originally laid out, and

it was not thought best to tarry for the sake of visiting the mine. So at half past eight we were in the cars bound for Ely, Vt.; and at one o'clock, after a short stage ride, we found ourselves at West Fairlee. After securing quarters and disposing of a very acceptable dinner, we walked on a mile and a half to the adjacent town of Vershire, and made a preliminary examination of the extensive copper mine and smelting works of the Vermont Copper Mining Co. This reconnoissance enabled the professors to make, in the evening, a systematic allotment of parts for the morrow, so that each student should be responsible for the full and exact observation of some particular branch of the work, besides gaining a general knowledge of the whole. By the kindness of Messrs. Daniel and William Long, the skilful gentlemen in charge of the establishment, and of Mr. Ely, the President of the Company, every thing was opened to our inspection, and we are indebted to them for devoting much of their time to us during our stay at Vershire and West Fairlee. The next day we crowded into an ore car, and with crouched heads, rode into the horizontal adit nine hundred feet, and then, in company with Capt. Pascoe, explored the mine below and above, coming out into the hot summer air at a point high up the hill. The captain also conducted us into a lower horizontal drift, which is being carried forward rapidly with the aid of the Burleigh drill to intercept the deeper parts of the workings. After a needful lunch the afternoon was devoted to a close study of the picking, washing, and smelting operations. We had hardly expected to find in New England a copper mine turning out nine hundred tons or picked ore per month, and it was to be regretted that so little time had been allotted to this rich mineral region. Two weeks might well be given to the copper mines of Vershire and the adjoining towns, Corinth and Strafford, together with the unworked lead mines of the neighboring town of Thetford.

Saturday morning a conveyance was procured for ourselves and baggage to the railroad at Sharon, and, while the horses were resting at noon, we made a somewhat hurried detour on

foot to the copperas works and copper mine at Strafford. The manufacture of sulphate of iron was in full operation, but the mining was suspended for the time being. Night found us at Burlington, ready to enjoy a Sabbath of rest. The great lumber interests of Burlington did not immediately concern us, but before the arrival of the steamer on Monday most of the party took occasion to visit the pleasant grounds of the University of Vermont. A strong wind somewhat delayed the passage of the boat southward, but we arrived at Port Henry in season for dinner. Thus in somewhat less than seven days we reached the chief point for which we started. Here centres the present iron interest of the Adirondac region, and here are to be seen the sources of the ore which is shipped to all parts of the country. Commencing work at once, we called on Mr. Foote, the obliging Superintendent of the Bay State Iron Co.'s furnaces, and were soon engaged in studying the smelting of magnetic iron ore, with anthracite coal, in furnaces of the most approved construction. These two high furnaces turn out over fifty tons of pig iron in twenty-four hours. A little more than half a mile south, the Cedar Point Iron Co. are building a new furnace, for which Whitwell's regenerative stove will be used. Mr. Witherbee, the Superintendent, is the first in the United States to adopt this blast heater, and this is the first anthracite furnace in which the recent invention is to be tried. Walking down to Cedar Point in the evening, we had a good chance to see the great number of elementary parts which enter into the making up of the iron smelting works of the present time.

Tuesday was devoted chiefly to the examination of the famous Cheever ore beds, a mile and a half north of Port Henry furnaces. In the forenoon we went by a long stairway, down a steep incline, into the middle bed, which has an average thickness of some six feet, and is of unknown extent. After the dinner hour we were lowered in the iron bucket, half at a time, down the perpendicular shaft three hundred and twenty-five feet in depth, to the lower bed. This vein of clear, solid magnetic ore is from five to fifteen feet thick, and the

working has extended over many acres underground. There was ice in the bottom, and the air of the mine stood at 38° F. After travelling about a long distance in this atmosphere, and coming up one of the inclined shafts, by an almost interminable stairway, into the open air of a hot July day, we found the contrast more striking than agreeable. Any farther vigorous effort was not felt to be desirable, but due attention was given to the inclined railway by which the picked ore descends three-fourths of a mile to Lake Champlain, drawing back the empty cars or coal to run the engines for hoisting and pumping. Three rails are here made to do the duty of four, by having a really double track where the ascending and descending cars meet each other. Wednesday was spent in a closer study of the blast furnaces with all their appurtenances, and a pleasant evening row on the lake to the old fort at Crown Point closed our explorations from Port Henry as a base. Early next morning we proceeded, with all our baggage, to Mineville, seven miles distant, over the Lake Champlain and Moriah Railroad,—a road built solely for transporting ore, and very remarkable for making an ascent of thirteen hundred feet in going the seven miles. About thirteen hundred tons of ore per day are taken from the immense deposits among the hills, over this road to the Lake, to be carried thence by canal boats or cars to all parts of the country. Under the guidance of Mr. Roe, Superintendent of the Port Henry Iron Co.'s mines, we were lowered down an open cut into a bed a hundred feet thick, and how much more is not yet known. Here is mining indeed, or it might almost as well be called quarrying. With so vast a vertical face exposed, the horizontal progress is slow, and the underground working is as yet of moderate extent. There was ice in the lower part of the open cut. It is said to be too cold to work in winter at the bottom of the mine, and the workmen are then kept on higher levels. After traversing the underground openings we ascended by ladders. The hoisting machinery at this mine is of admirable construction, and the power for pumping is transmitted from the engine house

down into the shaft by wire ropes like the ropes used for hoisting.

Near by is the old Sanford ore bed, in which the magnetite was at first found largely mixed with apatite, and was therefore of little value, though a preposterous scheme was set on foot to work this vein for the sake of the phosphate of lime, which was cleansed by means of magnets and made into a fertilizer. It did not pay; but it is found that the ore improves as the vein runs deeper, and work has been resumed in the Sanford bed by Witherbee, Sherman & Co. During the noon hour we went to the New Ore bed half a mile off,—a bed remarkable for yielding very large crystals of magnetite. Three of us descended some nine hundred feet, by the inclined stairway, to the heading, where a few men are kept at work. The ore needs some picking, and it has to be carted to the railroad, so that the cost is enhanced, but it is in demand on account of its purity. The Barton bed, high up the hill, crops out in many places for a distance of half a mile, and in years past has been worked by several openings. Most of the excavations are abandoned and full of water, but the Bay State Co. are still smelting some of this ore. While a heavy shower was clearing up, we found time to dispose of the ample dinner which had been made ready for us. In the latter part of the day we visited the charcoal blast furnace of Witherbee, Sherman & Co., about two miles away. This is an old furnace remodelled and modernized, and it presents some notable peculiarities. Everything is well arranged and the work is conducted with skill. The charcoal is made in a set of rectangular kilns close by the furnace. The ore is carted from a distance. From the increasing scarcity of wood, this furnace must in a few years be numbered among the things that were.

The growth of Mineville has been rapid, and there is little house room to spare. We had therefore to bring our blankets into requisition, in sleeping on the floor of some unfinished rooms in a new house. The hard pine mattress proved no hindrance to sleep, and the morning of July 4th found us well

rested and ready to move onward, a patriotic relaxation from work being deferred till the next week. It was not easy to procure conveyance on the national holiday, but at length we proceeded by wagon to New Russia to study the bloomery forge there. Work was suspended, but there was all the better chance to examine the apparatus that pertains to this American improvement on the oldest and simplest method of making tough iron. In the establishment at New Russia there are four forges, each capable of turning out three hundred pounds of blooms every three hours. We were busily occupied an hour or two in noting the roasting stacks, stamps, elevator, jiggers, blower, heating pipes, forges, cranes, trip-hammer, steam boilers, and engine, — each one giving special heed to his assigned details, and subjecting the good-humored workmen to a thorough catechizing. Another ride of some miles brought us to Elizabethtown in good season. After tea there was still enough daylight left to allow us to look into a well appointed bloomery, not now in blast, which showed some modifications not seen at New Russia.

It was now unanimously decided to make a diversion to Tahawus, or Mt. Marcy, in the wilderness. So on Saturday, leaving all superfluous baggage at Elizabethtown, we secured a wagon to take us to the head of Keene Flats, on the Ausable River. And here, tormented by myriads of black flies, but having comfortable rooms and plenty to eat, we spent a quiet Sunday. There is no morning service at Keene Flats, and it seemed not inconsistent with the proper observance of the day to take a walk of a mile and a half into the woods, and view a most romantic waterfall. The crumbling away of a thin trap dyke has here made a gap in the high, precipitous rock, and through this channel a little stream from the Giant of the Valley falls down a hundred feet or more. Farther up the stream occurs another pretty fall of perhaps twenty-five feet. In the afternoon, all who chose rode with our worthy landlady to attend divine service in the little red school house at the Flats.

They told us that the ascent of Tahawus usually takes three

days,— the guides are paid by the day,— but we determined, if possible, to spend the night of Tuesday in Elizabethtown. Rising therefore before daybreak, we got through our breakfast, took two days' rations in our haversacks, strapped on our blankets and ponchos, and began the march through the woods at five o'clock. The guide carried the fresh meat in his knapsack, a pail of butter and a hatchet in his hand, and the heavier part of a hundred pound skiff on his shoulders. Four miles and a half of an up hill and exceedingly rough road brought us to the lower Ausable Lake. Here, borrowing a second skiff, we all embarked, with cautious balancing, for a two mile row over a smooth sheet of water, surrounded by scenery of the most imposing grandeur, the like of which is hardly to be found in the wildest parts of New England. The skiffs were left turned upside down on the farther shore, and then another walk of a mile and a half along the stream brought us to the outlet of the upper Ausable Lake. Making smudges, which hardly checked the savage voracity of the flies and mosquitoes, we waited impatiently till the guide had gone to a hut a mile beyond for his grid-iron, kettle, and frying pan. Those who had a chance for a fair fight could make out to endure entomological trials; but the one who undertook to find the boiling point of water with the hypsometer when a thousand insects were maliciously waiting to pounce on him at the critical moment of observing the thermometer, did not consider it a pleasant experiment. At length, girding ourselves for a climb over Bartlett Mountain, we had a chance during the next two hours to test pretty fully the strength of our lungs, ankles, and knees. The four mile tramp to Camp Marcy, by a faint trail leading over mossy stones, tangled roots, and prostrate trees, with our food and blankets to carry, was very much like hard work, but as this was our holiday sport, we tried to make light of it, though with indifferent success. In due time we joyfully greeted the camp, which consisted of some crotched uprights with cross poles that supported one end of some large slabs of arbor vitæ bark, the other ends resting on the ground. Here was a brook of clear

cold water supplied by the Haystack. Here we washed and lunched. Here we piled our packs on the ground and covered them with a large slab of freshly peeled bark. Then, with a few hammers and other slight encumbrances, we were off for the final ascent. From Camp Marcy to the top of Tahawus is hardly a mile, but the rarity of the air was increasing, breathing did not go on unconsciously, and frequent halts were needed, to allow the adjustment of the system to outward circumstances. Still, as compared with the previous march under burdens, the climb was easy and rapid, and at half past four o'clock we were on the highest spot in New York. The thermometer stood at 60° F. Water boiled at 202.5° F.

Who would be so rash as to attempt a description of the soul-expanding scene which here delighted our eyes for an hour and a half, and which will remain in memory a joy forever? Farther on, in the solitary depths of the unlimited forest, lay the Saranac Lakes, invitingly spread out, and the whole view called up for the time each one's latent love of a roving life — but Tahawus was to be the remotest point of our journey. Lake Champlain in the remote distance suggested thoughts of home, and the declining sun recalled the consciousness that the way back to camp could be followed only by daylight. So in jubilant mood we commenced the return by walking, sliding, running, scrambling, leaping on bare rocks and mossy banks, through groves of old fir trees scarcely two feet high, through shallow streams, peat basins, tangled brush, and slippery earth, down the half clad mountain side. Arrived back at the lodging place, the guide, with some help, made a large fire to light up the camp and get ready the supper of broiled mutton, fried mutton, fresh bread, toasted bread, and tea without milk. A few more tender members of the party chose the well ventilated bark shelter and lay rolled in blankets with feet to the fire. The rest, like the guide, scorning luxurious indulgence, spread their ponchos in the open air. A midnight tour of inspection showed the outsiders to be all in the cool enjoyment of a noiseless oblivion, but, somehow, at dawn of day, two or

three were found to have yielded to the attraction of the central fire. At 5.30 A.M., July 8th, the thermometer stood at 42° F. All were up bright and fresh, and with appetites keen for a breakfast with the same sumptuous bill of fare as we had nine hours before. We left Camp Marcy with very light haversacks, but Bartlett Mountain was no tamer than the day before. Near the outlet of the lower Ausable pond we were conducted round to the Rainbow Fall, which comprises several high, slender cataracts of wondrous beauty and wildness. Then it began to rain, and ponchos came in use. After the remaining four mile walk through the wet woods, we arrived back at Mrs. Beede's in a forlorn looking condition, but with merry hearts. After a dinner of civilized life, the wagon in waiting took us back to Elizabethtown. The next day a pleasant ride of eight miles brought us to Westport, with time enough before the arrival of the southward bound steamboat to allow full inspection of an unsuccessful manufactory of steel from iron sponge. This inoperative show of wasted money was well worth seeing, as a palpable illustration of one of those often invented plausibilities which find ready endorsement among men of some experience who ought to know better; and which captivate monied men who are ready to believe that in a new business the ordinary laws of profit and loss do not hold. A charcoal iron furnace, long out of blast, is to be seen on the north side of the bay of Westport, but it did not seem likely to reward us for a long walk that way.

At noon the steamer hove in sight, and we were soon on the way to Ticonderoga. In taking the four mile stage ride from the landing to the higher level of Lake George, we unexpectedly passed a new bloomery forge in full blast, and much regretted that there was not a spare day to allot to this and the iron and plumbago mines on the mountain near by. From the deck of the steamer on Lake George, could be seen the four large circular charcoal kilns which supply fuel for the bloomery. Situated on the lake shore, at the outlet, they are each provided with an inclined track for hauling the floated wood up out

of the water to the top of the kiln. The mountains surrounding Lake George are well wooded, and ought always to be kept so. The lake affords easy transport to the kilns. Hence to the forge is an easy, down hill road, and the falls furnish water for all the needed machinery; so Ticonderoga is a most admirable location for this branch of the iron business. It seems strange, that with all the study and skill that have been brought to bear on the iron manufacture, the best iron should still be economically made by the bloomery forge, which is but a slight modification of the primitive apparatus used centuries ago. But bloomeries are by no means out of date yet. The afternoon sail over the length of Lake George combined recuperative rest with calm, positive enjoyment, and it came in at just the right time of the week to suit our needs. The next morning, instead of waiting at Caldwell for the regular stage, we chartered an ample express wagon to take us earlier to Glen's Falls, so as to have time to see the falls, the limestone formation, the very large saw mills, the paper mill, the marble saws, and some of the many perpetual lime kilns of the Jointa Lime Co. These kilns turn out, from the black stone quarried close at hand, about one hundred and twenty barrels each of very white lime every twenty-four hours, being fired with slabs from the saw mills at the falls. The kilns and store-houses are built all along the canal, so that the chance for shipment is the very best.

Taking the cars a little after eleven o'clock, we arrived in Saratoga at noon, and there stopped over one train to view the Springs, and make a physiological test of the various waters. No positive results, except a few wry faces, followed these deep and frequent potations. After our arrival at Troy, there was still daylight enough left for a visit to Cohoes Falls. At nine o'clock we went to the Bessemer Steel Works, below Troy, to see a "blow" by night. The complete working of one conversion and the beginning of another, finished out for us this long day of sight seeing. The sun had been some time above the horizon when we began work the next forenoon. A due

regard to our financial resources suggested the propriety of a short stay in the city, and West Stockbridge was decided on as our next sleeping place. So the forenoon was spent in a close study of the Bessemer Works, and the rest of the time, before a late dinner, was mostly devoted to the two blast furnaces of the Rensselaer Iron Works, in which they melt a mixture of red hematite from Rome, N. Y., magnetic ore from the Adirondac region, and brown hematite from down the Hudson, with anthracite from Pennsylvania.

Journeying on to Albany, and from Albany to State Line, we sent forward the commissary committee, in a hired wagon with the baggage, to look out for quarters at West Stockbridge. The committee were happily surprised to learn that, in anticipation of our coming, free accommodations for our whole party had been provided through the generous hospitality of Edward L. Baker, Esq., President of the West Stockbridge Iron Co. We were by no means loth to acquiesce in the arrangement, for Sunday was coming, and what could be better than to have a day of rest among the Berkshire hills? Saturday morning Mr. Bliss, agent of the West Stockbridge Iron Co., was ready to go with us wherever we desired. Making suitable provision for the repair of wasted muscle, we proceeded first to the Leete Ore Bed, a large deposit of carbonate of iron and brown hematite, about a mile and a half from the village. Here we viewed the open workings, and then lighting our candles we went down the shaft and took a long tramp in the several levels underground.

As the Hudson Co.'s extensively worked bed on the other side of the road is but a continuation of the same vein, it did not seem worth the while to go below the surface again, but making an inspection of the upper works, we returned to the weigh-house of the Leete bed, and attended to our midday meal. Taking a look at the rude, but effective, apparatus used for washing dirt from the ore with the water pumped up out of the mine, we went on to the Richmond furnace. Here we found a single blast furnace, in a convenient situation,

together with two round, and four rather odd-looking, conical kilns for making charcoal, and an excellent arrangement of revolving, perforated drums for washing ore. Everything is kept in the best of order, and there is a general appearance of deserved prosperity. The ore bed near by is worked by an open cut, but the mine is inferior to those in West Stockbridge, and most of the ore used at the furnace is brought from those beds. The return did not prove very tiresome, and after tea we took a short evening walk to Truesdell's lime kilns and the quarry from which the limestone is taken. Mr. Truesdell burns in perpetual kilns, with two side fires, using a mixture of wood and Cumberland coal. As the stone approaches white marble in purity, the lime is of excellent quality. A little farther on we came to the anthracite furnace of the Pomeroy Iron Co. in time to see the charge of molten iron tapped off. Night gave a favorable opportunity for seeing the gases burn in the air-heating stoves, and under the boilers.

A quiet rest over Sunday, which began for most of us after sunrise, prepared us for the labors of the coming week. But the heat of the weather on Monday was too intense to allow any very severe effort. We started immediately after breakfast to make a more thorough study of the anthracite furnace in the village. All the minerals collected since leaving Ticonderoga were packed and forwarded to Boston by express. A wagon was secured to take along our luggage and meet us at noon. We commenced the onward march by visiting an old abandoned manganese mine, not far from the hotel. Two or three miles farther on is the Cooke bed, which was found, when formerly worked, to yield an ore too rich in phosphorus. But this mine is now being reopened by Mr. Can of New York, in hope of finding better ore lower down. The Steven's bed was next visited, though it has never been opened to any extent; but the ore crops out all along the brook, and this locality illustrates well what surface indications are. Another warm walk of a mile or so, brought us to the main point of interest, the Cheever Ore Bed; and here the wagon was waiting for us

with a welcome lunch. Refreshed by this, we put ourselves under the guidance of the captain of the mine, lighted our candles, and went down vertical ladders seventy feet to the fifth level.

A long walk in this, and another descent of thirty feet, brought us to the lowest of the seven levels. The bed is from four to eight feet thick, and is highly inclined. It is worked by a series of horizontal drifts extending many hundred feet each way from the hoisting shaft. There is a great deal of water to be pumped, and the working is so managed that the water all runs to a well in the lowest level, and is thence forced to the surface. The well will soon be carried down to a ninth level, and while the eighth and ninth drifts are worked, the upper ones will be in process of closing out. After getting some idea of the general character of the mine, and observing the operation of removing the pillars and closing out a level, we remounted by another shaft to the surface. Near by is the Old Hill Bed, which is worked by a very deep open cut. This is really a continuation of the Cheever, and, like that, yields a compact brown hematite of excellent quality. Nowise reluctant to take seats in the wagon, we rode on to the Andrus Bed, an abundant deposit of uncommonly compact ore, which shows at the surface of the ground, and is taken out by an open cut of moderate depth. Though the ore is very hard, and free from intermixture, it is so seamed that no blasting has hitherto been required. And now parting from our kind friend, Mr. Bliss, we resumed our ride, and were soon in Shaker Village, waiting for the cars. Two of us visited the Shaker Ore Bed, near the depot, and found only a large open cut now filled with water. It has not been worked for many years, but there is said to be a prospect of starting it again.

At length the train came along, and a short ride brought us to Pittsfield ready for tea, and a stroll about the town. Hoosac Tunnel was now the great point of attraction, and at a late hour in the evening we took the cars for North Adams, arriving at ten o'clock. Betimes next morning a commodious wagon, with

a stout team, was chartered for the day. Zigzagging up the western side of Hoosac Mountain, with a buoyant appreciation of the glorious prospect, and riding on a mile or two in the elevated valley, we found ourselves alongside the huge pile of stone which indicates the busy location of the central shaft. Without much ado we all entered the iron cage, with a guide, and descended one thousand and thirty feet in less than two minutes. Lighting candles we went on in water ankle deep to the heading, twelve hundred feet westward. When the noise of drilling, the outgushings of compressed air, the shouts of the miners, the dripping of water overhead, the continual foot bath, and the dodging of cars, ceased to be agreeable, we returned, and parting with our very civil guide at some distance east of the shaft bottom, picked our subterranean way, two miles and a half, to the eastern portal, over rough stones and smooth road, wet walking and dry paths, through narrow places and full sized portions, in lonely stretches and spots where busy workmen, with hard drill and powder, were trimming the ragged roof into a smooth arch, among standing cars and moving trains, through various strata of cool, warm, smoky, clear, almost stagnant air. Coming out again into the light of day, we turned into the ravine beside the eastern entrance, and climbed up to the romantic cascades at the confluence of two little streams falling from the mountain above. The next thing was to find the driver, who had gone on above ground to one of the hotels in Florida, and was supposed to have ordered our dinner. A meal of fried trout proved to be the result of this forethought. Riding up the eastern declivity of the mountain, across the depression, and down the panoramic western side, we went to the western shaft and inspected the air condensers and hoisting machinery, and viewed from a safe distance the nitroglycerine manufactory. Then a drive to the western portal and back to the hotel, finished out a well improved day. The evening was very pleasantly spent, by invitation, at the office of the State Engineer, Mr. Frost, who very kindly explained

the peculiarities of the nice underground surveying carried on in connection with the work of the Tunnel.

It was determined to spend the next night in Boston or at home, but by making an early start there would still be time, between two trains, for a visit to the emery mill and mine at Chester. Reluctantly passing by the charcoal iron furnace at Cheshire and the glass works at Berkshire, we reached Chester at ten o'clock. The factory happened to be stopped for lack of water, but there was nevertheless a good chance to see the Blake's crushers, the many sets of steel crushing rolls which need very frequent renewal, the sorting sieves, the washing tubs for removing the soft gangue rock, the driers, the dust floater, the continuous magnetic separators for taking out the iron ore, and the finished products, which are said to be turned out at the rate of three tons per day. Very near the mill is the vein of emery mixed with magnetic iron ore in a gangue of chlorite. It lies almost vertical, and it would be almost impossible to work it were it not for the intermixture of soft rock with the desired mineral. Some of us examined the horizontal drifts carried in at the base of the hill, and those just started higher up the steep hill side. Others improved the spare minutes in culling choice minerals from the rubbish heaps. The number of species found here makes this a delightful place for the mineralogist.

Wednesday evening at six o'clock we separated, to meet again on two subsequent days, for exchanging notes and squaring accounts.

Thus the expedition itself took twenty-three days, and the amount of money spent by each member of the party was about fifty-six dollars. This somewhat exceeded the estimated cost of the trip, but we rode more, and went farther, than was proposed at the outset, and it seemed to be felt by all that the time and money had been well and profitably spent. Work had been assigned to all singly and collectively, each being made in turn chairman of a committee of the whole with a definite subject to report upon. Every one had shown an earnest

disposition to make the most of the opportunities afforded. Perfect harmony prevailed throughout, and we may be sure that the nine young men who could be kept in close and constant intimacy for three weeks, without even a trifling discord, will always look back with unalloyed pleasure to the Adirondac Expedition of 1873.

To the Superintendents of several of the principal railroads in New England we are much indebted for favors in the way of transportation. Beyond these lines there was no way but to pay full fares.

The Professors who went are more than ever impressed with the proved value of such tours, and they would hope that something of the kind may hereafter be carried out every year. Then each student of Mining Engineering will have, during his connection with the Institute, two chances of becoming acquainted with actual mining and smelting. Our experience in this expedition suggests that it may be well to undertake less at a time, and make the time somewhat shorter. In going over much ground rapidly there is little chance to have a full discussion of one object while it is fresh in mind, before proceeding to another. Yearly journeys of moderate extent, rather than less frequent tours embracing a large circuit, seem likely to secure well digested ideas, and those shared by a larger number of students. By shunning expensive hotels and not being over nice about quarters, it may reasonably be expected that, aside from railroad and stage fares, the expenses for each individual could be kept within two dollars a day. This for a trip of fifteen or twenty days taken twice, does not make a large amount, and yet for some students it would be a serious addition to the regular expenses for instruction. We ought to have the means of assisting those in limited circumstances to go on the annual tour of observation.

The proper and timely development of the industrial resources of our country certainly can be insured only by having young men coming forward well trained to fill places where scientific skill is needed. And a little reflection will convince

every friend of sound education that there should be chances given for studying operations as they are carried on in real life. It is clear that no course of instruction can claim a reasonable degree of completeness which does not make provision for rendering the student's knowledge in some measure specific, and thus overcoming the not uncommon repulsion between theory and practice. May we not hope then, that at no distant day, we shall have a special fund yielding interest enough to lighten materially the outlay on the part of each individual, and thus render certain the continuance of these expeditions year by year?

Sept. 2, 1873.

Respectfully yours,

JOHN M. ORDWAY.

REPORT UPON THE CHEMICAL LABORATORIES FOR THIRD AND FOURTH YEARS' STUDENTS.

To the President:—

Some improvements in apparatus have been made in the laboratories with a view to increasing the facilities for rapid and effective work ; and at present nearly all the conveniences of this kind which are in use in the best schools in Europe, have been introduced, so far as the space and the arrangement of rooms devoted to the chemical department have allowed.

The thirty places in the third year's laboratory have been provided with Bunsen's filter-pumps, at an expense of less than thirty dollars, and it is believed that these contrivances will enable the student to perform a much larger number of analyses than heretofore during the time allotted to the chemical course.

In regard to the practical training of the students, two points have been kept in view.

In the first place, the course in general analysis has been made to cover as wide a field as possible, the analyses being chosen to illustrate general methods, applicable to a number of special cases, so that the experience might serve as a preparation for the ordinary work of an analytical chemist.

In the second place, those students who appeared to have

acquired the necessary skill in the routine work of the laboratory, have been encouraged to investigate unsolved problems in chemistry in order to give them an opportunity to educate their ingenuity, as well as their powers of observation.

The longest course of laboratory work pursued in this country scarcely gives a student sufficient experience to deal with original investigations advantageously, but still something has been accomplished in this direction, and four very creditable papers have been prepared this year for publication in a scientific journal.

Three of these are devoted to the investigation of analytical methods, and announce the discovery of new facts. A fourth deals with an important problem in general chemistry, namely, the direct formation of bodies of the petroleum oil class from their elements without the intervention of coal, or any organic matter, and also makes its contribution of new facts to science.

The professor of analytical chemistry has also prepared a paper for publication, and it is hoped that each year the contributions to chemical science from the Institute of Technology may not be wanting.

The course of study in the theory of chemistry has been carried on this year, as last, with the aid of a German textbook, and the class has acquired considerable familiarity with the language, as well as an acquaintance with chemical facts.

J. M. CRAFTS.

June 16, 1873.

REPORT ON THE INSTRUCTION IN THE DEPARTMENT OF MILITARY SCIENCE AND TACTICS.

To the President : —

In compliance with your request, I have the honor to submit the following brief report upon the instruction in my department during the short portion of the session in which it was under my direction.

Upon assuming charge of the military department in March, 1873, I found that the majority of the students looked upon the instruction as an unmeaning drudgery, and the time devoted to it as nearly wasted. It cannot be surprising, therefore, that comparatively little had been accomplished, and that discipline existed but in name. It has been my aim to impress the students with the idea that the military instruction is given to them, not for the purpose of making them soldiers, but that they may be more efficient citizens, that it is the duty of every citizen to make himself efficient to serve the country as a soldier in case of war, and that they should faithfully attend and receive the military instruction from a sense of duty and honor, rather than from a sense of obligation.

It must be remembered that a mere knowledge of drill is not all the military knowledge which is required to make an efficient officer. He should have a knowledge of discipline, and

the proper mode of maintaining and enforcing it; a knowledge of feeding, clothing, marching and encamping troops; the methods of procuring food, clothing, arms and ammunition, and the mode of preserving and accounting for public property. It was the lack of all this which caused us to lose a greater number of lives by disease, than by the bullet of the enemy, in our late war. The time now allotted to the military instruction is barely sufficient for imparting effective instruction in Infantry drill. The drill tends to improve the carriage of body and general physique of the students, therefore it should not be looked upon as a portion of their mental effort, and counted as such in regulating the mental burden of each student. It should rather be considered as a physical exercise, the tendency of which is mental relaxation. I am desirous of securing an additional hour per week, to be devoted to theoretical instruction in the method of organizing, disciplining and clothing troops; the care and responsibility of public property, and mode of acquiring and accounting for it; the duties in camp, on the march, and in the presence of the enemy, and the general principle of field fortifications, ordinance and gunnery. In short, I would wish to give such instruction as would enable the students to become efficient and capable Captains and Lieutenants of volunteers.

When I assumed charge, the corps of students was armed with muzzle-loading rifles, furnished by the State Government. They were partly uniformed, wearing an unlined blue flannel blouse and a naval cap, with the letters, M. I. T., embroidered thereon. The blouse is unshapely, and affords no protection from cold, being too thin even for under wear during winter. I respectfully recommend the adoption of a uniform of Chasseur cap, blouse and pants of Cadet gray cloth, trimmed with black. The blouse and pants may be procured at a cost of twenty-two dollars and twenty-five cents (\$22.25), and are of such material and manufacture as to afford due protection from the weather, and are neat and serviceable as a uniform. From a personal consultation with the students of the present

second year class (then first year), I have ascertained that the feeling in favor of the adoption of a neat and serviceable uniform, such as I have mentioned, is nearly unanimous. If habitually worn by the students when not at drill (and I have reason to believe that many will do so), it will be an economy for them, as it costs much less for the uniform than for a suit of civilian clothes of the same quality of material and manufacture. I most earnestly request that the aforementioned uniform may be adopted, as it is desirable that the students should feel a pride in belonging to the Institute of Technology, and honored in wearing the uniform of its Cadet Corps. It will tend to develop interest in the instruction, and will be of material assistance in raising the tone of the department.

We have received from the U. S. Government for the use of the students, the following Arms and Equipments, viz.:—
 Two hundred (200) Cadet breech-loading rifles (same size as used at West point); one hundred and fifty (150) sets Infantry equipments; twenty-seven (27) non-commissioned officers' swords, and twenty-seven (27) non-commissioned officers' belts.

Two (2) light six (6) pounders and carriages.

Two (2) caissons and equipments for a section of Light Artillery.

Eight (8) signal kits (complete), including staffs, flags, torches, shades, extinguishers, nippers, wormers, scissors, funnels, canteens, lamp-wicking, matches, and haversacks.

Four (4) telescopes.

Four (4) marine glasses (binocular).

Four (4) manuals of signals.

Two hundred (200) signal code cards.

I respectfully call attention to the necessity of a hall or building in the immediate vicinity of the Institute to be used for drill, and as an armory. Much valuable time is now lost in going to, and coming from, the present hall. A hall or building suitable for this purpose may also be used as a gymnasium. In this connection I may be pardoned for adverting to the importance of introducing a system of obligatory daily gymnastic

exercises in conjunction with the military department. It is neither necessary nor desirable that the students should be made gymnasts, but simply that they should be required to go through a series of daily exercises under the supervision of a physician, or other competent person. The exercises should be comparatively light, and of such a nature as to preclude the possibility of even the weakest student being injured thereby.

The discipline of the Corps of Cadets has improved somewhat since the students have been made to understand that the Cadet officers would be fully supported in the execution of their duty, and that in rendering a prompt obedience to their officers they were not rendering it to the persons, students, but to the authority which they represent, *i. e.*, the Faculty. I have endeavored to establish and maintain, as nearly as the circumstances would admit, the discipline and routine observed in regular service. The trial of a student for "disobedience of orders," and "conduct unbecoming a gentleman," by a court martial composed of his fellow students, has had a beneficial effect upon the tone and discipline of the Corps of Cadets. The system of official correspondence and responsibility for public property involves some extra labor on the part of certain officers and non-commissioned officers. The ordnance and signal property are taken care of and accounted for by two Cadet officers ranking as Second Lieutenants. Other public property is taken care of, and issued upon proper requisition, previously approved by me, by the Quartermaster of the Corps. Invoices and receipts are regularly exchanged whenever public property is transferred. Monthly returns for property received and issued are required from Captains commanding companies, and other officers responsible for public property.

Each commissioned officer responsible for public property is assisted by a non-commissioned officer, who is of a junior class, and selected for his capability to succeed to the office for which he is thus serving an apprenticeship. The Adjutant attends to the duties usually attended to by Adjutants in regular service, *i. e.*, issuing orders, receiving reports and excuses, making de-

tails, and acting at all times as the official organ of the Commandant. He is assisted by a Sergeant-Major, who is selected from the first year's class, with the view of succeeding the Adjutant in the next year. The general rule which should be observed in the appointment and promotion of officers and non-commissioned officers should be, that officers and sergeants should be selected from the second year's class, and corporals from the first year's class. The selection of officers in the succeeding year should then be *first* made from the corporals of the preceding year. As the commissioned officers retain their positions but for a single year, it is a great burden to require them to purchase their swords and belts, and I therefore recommend that these articles be purchased by the Institute, and loaned to the officers, holding them responsible for any damage thereof, other than the ordinary wear and tear. In order to increase still more the dignity and importance of the officers and non-commissioned officers of the Corps of Cadets, and thereby increase the emulation, and inspire the discipline, it would be advisable to issue regular commissions and warrants, as also to enter their names in the printed catalogue of the Institute.

Respectfully submitted,

E. L. ZALINSKI,

1st Lieut., 5th U. S. Art'y.

REPORT UPON THE LOWELL COURSE OF PRACTICAL DESIGN.

On the 7th of October, 1872, the above course was commenced, with eight pupils, none of whom had any idea of the working of patterns, and all were unprepared to "trace" with pencil, or "outline" with the brush—two most important essentials in the work of designing.

The management of *colors* used for making patterns is also a very difficult matter with beginners. After a few weeks of trial, however, a rapid improvement was discovered, and the instructor was gratified to observe that the American youth of both sexes were easily taught, and were quick in comprehending and overcoming these difficulties. In November, the number of students had increased to thirteen, and after January, 1873, the number was twenty-five, all of whom exhibited a great interest in their work, and devoted themselves assiduously to its details. The first object to be attained in this department, or *atelier* of design, was a good execution, and all the energy of the instructor was devoted to this purpose—neatness in execution being a desideratum in designing. The course of study has been the same as that pursued in the *ateliers de dessin* in Paris. These ateliers are the nurseries of designers, who originate patterns for carpets, silks, robes, paper hangings, delaines, prints, etc., and sell them to all the manufacturers of

the world. In these ateliers there are apprentices, composers, and finishers, who produce from year to year, or from season to season, the most novel patterns. The apprentice prepares the colors, and begins to trace and paint patterns. After this, if sufficiently expert, he becomes a finisher, and the finisher completes the pattern which has been composed, and partially painted, by the composer. We believe that the success of the school is due in a great measure to the fact that we have strictly followed the above plan.

The bulk of the work accomplished by the students thus far has been in copying patterns, the few *original* designs executed by them being introductory to next year's work. No instruments are used except the dividers for making the "repeat" and correct distances, and a ruler for lines; all the other portions being strictly "free-hand drawing," and executed with the brush, in color, to give the patterns the same appearance as the calico, delaines, etc., when finished.

The hours of study are daily, from 9 A. M. to 5 P. M. The instructor in this department takes pleasure in stating that his pupils have all shown great application, and constantly increasing interest in their work, and he expresses highest confidence as to the success of making first class designers in this atelier, when so excellent a spirit is evinced among the students, and where so goodly a share of inventive genius is apparent among the American pupils — the girls as well as the boys.

Respectfully submitted,
CHARLES KASTNER.

June 2, 1873.

REPORT UPON THE INSTRUCTION IN PHYSICS IN THE COURSE OF LECTURES.

To the President: —

During the past year the facilities of the lecture-course in Physics have been largely increased in several ways. The printing of a portion of the notes which the classes were formerly obliged to copy from the blackboard, has greatly lessened the drudgery formerly attendant upon the earlier portions of the subject, and a marked improvement has consequently been noticed in the attainments of the classes, as shown by their various examinations, so that at the last annual examination fewer were conditioned in the Physics of the first and second years than has before been the case since the writer assumed the position of lecturer, while the average rank was at the same time proportionally higher.

Another partial change has largely contributed to bring about this desirable result. Instead of devoting half of the hour allotted to the exercise in oral questioning, a method which seems singularly ill-fitted for the thorough examinations of classes as large as those which we now have, the lecture is made to consume a somewhat greater proportion of the time than formerly. An interval of fifteen minutes after the beginning of the exercise is given, during which time the student may copy any

figures which are to be taken from the board, or call for a redemonstration of any proposition or explanation of any difficult point, which may have suggested itself since the previous lecture. The knowledge of the class is tested by a series of informal written examinations held, on an average, once a fortnight, and usually occupying half an hour. These are substituted for the oral examinations formerly given before every lecture, and as the burden of examining carefully so large a number of papers is so great as to preclude the possibility of doing it so frequently, a portion of the papers — usually about a quarter of the whole number — are examined each time. This system has proved very successful in practice. In addition to this, occasional examinations are held, lasting for one hour. The ranks attained by each student at these times are registered in a book kept for the purpose, and together with the ranks attained at the regular annual and semi-annual examinations, form part of the records of the department.

The student is in no case required to prepare a lesson for recitation. The subject is fully discussed in a lecture, and the important points brought to notice. The first portion of the course, occupying the second half of the first year, is devoted to a thorough discussion of Mechanics, as it is only by a clear understanding of the fundamental principles of force and motion that the student can profitably pursue the latter part of the physical course. The lectures of the second year are devoted to the subjects of Sound, Light, Heat, Magnetism and Electricity. It is always the endeavor to combine the theoretical and the practical as far as possible; to teach the student what physical investigation really is, the care necessary to avoid errors, the corrections to be applied to observed results, and the perseverance without which no research of any value can be conducted. It is hoped that as the number of our students increases, it may be possible to establish additional series of lectures for those taking the course in Science and Literature.

While the mathematical demonstration of physical principles is given whenever practicable, the lectures are very fully illus-

trated by experiments. And as the success of the instruction in elementary physics depends very largely upon the number and quality of the instruments which we possess for the experimental illustration of the lectures, it will be advantageous to speak somewhat at length upon this subject.

It has been the custom of the writer to devote most of his spare time during the winter months of each year to the strengthening of some particular portion of his course of lectures. The principle followed is to plan the apparatus with special reference to the work of the Institute, and, whenever possible, to have it constructed in the building, or at least by workmen under immediate supervision. In this way the collection of apparatus has been largely increased at a comparatively slight expense. There are, however, certain large pieces of apparatus which cannot be constructed to advantage in this manner, and for which a specific appropriation outside of the regular amount allotted to the Physical Department will be needed, unless the necessity is obviated by individual generosity.

During the winter of 1872-73 the subject of Mechanics of Solids was worked up. The apparatus for illustrating this portion of physics was somewhat meagre, but there are now only a few additional pieces of apparatus necessary to render it quite complete. The collection comprises all the instruments necessary for the experimental verification of the laws of oblique and parallel forces, statical moments, centre of gravity, the mechanical powers, laws of motion, pendulum and friction. The subjects of elasticity, mechanics of liquids and mechanics of gases, are less completely illustrated, though the apparatus relating to them is sufficiently extensive for most present purposes.

The acoustic apparatus is exceedingly full, comprising almost all of the more important instruments made by Kœnig, of Paris, the first European constructor, together with many pieces of home manufacture. Besides the large collection presented to the Institute some years since by Mrs. Hemenway, the recent generous gift of Mr. J. C. Hoadley for this specific

purpose has enabled us to obtain from Paris a number of new instruments, among which the following are especially worthy of notice : —

Electric interrupter, with three tuning-forks, designed to keep up a continuous vibration by means of electricity.

Tuning-forks giving 256, 261, 264 double vibrations per second, respectively, being the middle C of the Physical, French and German pitch.

Set of ten steel cylinders, giving tones ranging from 4,096 to 32,768 double vibrations per second, for determining the upper limit of audibility in individual cases.

Kœnig's apparatus for measuring the velocity of sound within small distances; comprising an electric interrupter giving ten vibrations per second, a standard fork, furnished with a mirror, for the accurate adjustment of the interrupter by the optical method, and two electric sounders beating tenths of a second automatically under the influence of the interrupter.

Mach's apparatus for showing that the pitch of the note given by a sounding body is raised when the body is approaching the ear, and lowered when receding from it.

Harmonic flute for determining the velocity of sound in air or gas, by Wertheim's method.

Set of eight closed organ-pipes, comprising the gamut next above middle C.

Discs of brass for sympathetic vibrations of plates.

Apparatus of Count Schaffgotsch for studying singing flames, with whirling jet for repeating the experiment first suggested by Prof. Wm. B. Rogers, showing the alternate extinguishing and relighting of the flame.

Free reed and resonant tubes, for studying the laws of reed pipes.

Two organ-pipes having an interval of a fourth, giving their resultant tone when sounded together; also a large pipe in unison with this resultant tone.

Manometric gas-flame attachment to Kœnig's interference

apparatus, for studying the phenomena of interference of sound by means of the eye.

Crova's apparatus for illustrating by projection the various phenomena of wave motion. This apparatus is furnished with seven glass circular discs, upon which the necessary curves are traced, so that by their revolution before a vertical slit the movements of particles transmitting vibrations are illustrated, thus exhibiting the rationale of the progression of a sonorous wave reflection of an isolated wave, continuous reflection phenomena of organ-pipes, interference, etc.

Besides these the collection comprises several minor pieces of apparatus which have not been mentioned, and also a series of large tin tubes for exhibiting the phenomena of singing flames upon an extensive scale.

In this connection should also be mentioned a valuable set of pipes for illustrating the most important organ stops, presented by Messrs. E. and G. G. Hook and Hastings. The pipes are tuned to the same note, and comprise the Doppel Flute, Harmonic Flute, Flute, Trumpet, Hautboy, Vox Humana, Viola, Viol d'Amour, and other stops, which, together with the various sets of pipes previously belonging to the Institute, are amply sufficient for explaining the practical construction of the organ. It would be a desirable addition to our cabinet if we were to obtain specimens of other instruments used in the orchestra, of which we have several, although our collection is small.

The subject of optics is illustrated by means of the valuable collection of instruments purchased some years since by Prof. Rogers. There are, however, many deficiencies. The apparatus relating to heat is also in an unsatisfactory condition.

The department has received a gift of samples of a number of aniline dyes, for the study of their absorption spectra, from Messrs. Rumpff & Lutz, of New York, through the kindness of their agents, Messrs. Wm. F. Freeman & Co., of this city.

The most defective portion of the apparatus designed for lecture-room use, is that relating to Electricity and Magnetism,

upon which a considerable sum must be spent in order to make it a fair representation of the present state of electrical science.

Taking into consideration those additional pieces of physical apparatus most needed in the course of lectures upon that subject, our most pressing needs are (1) a new and large air-pump of modern construction, (2) a powerful Ruhmkorff induction coil, (3) an electro-magnet of considerable size, suitable for exhibiting the phenomena of diamagnetism, (4) some form of chronograph. There are constant embarrassments resulting from the absence of these almost indispensable instruments, and it is hoped that some means may be found to remove the deficiency before long, so that the department may be enabled to bring its apparatus to that state of completeness which should characterize the collection of the Institute.

It is also desirable that before the beginning of another year the subject of Photography may receive a more systematic treatment than hitherto. The following is presented as a brief outline of a suitable course.

Introductory lectures, treating of the history of photography, résumé of the chemical and physical principles involved, sketch of the optical portions of photographic apparatus, forms of portrait and other objectives, and preparation of reagents; methods of taking negatives on collodion, both wet and dry, methods of taking positives on collodion, paper, etc.; processes of photographing microscopic and telescopic objects. In addition to these topics the lectures should treat of carbon-photographs and the modern photo-mechanical processes, the Albortype, Heliotype, and Woodburytype. The department is already in possession of an extensive illustrative collection of prints by these methods, and our thanks are due to Messrs. J. R. Osgood & Co. and the "New England Photo-Plate Printing Co." of Boston, Mr. Rockwood, of New York, and the "American Photo-Relief Co." of Philadelphia, for aid in forming it.

The subject thus discussed should at the same time be taught practically by requiring students to take negatives from appa-

tus, prints, buildings, and other objects, and to make from these positives on both paper and glass. If possible in the time allotted, the dry methods should also be taught. In addition to this, special students in physics should acquire the ability to execute negatives from microscopic objects, and regular students in certain courses might be required to furnish specimens of their work before being graduated by the Institute. If the necessary apparatus could be supplied shortly there is no reason why such a course should not be opened regularly at the beginning of the next school year.

Finally, it should be kept in mind that while our apparatus was never before in so good condition as at present, yet additions are necessary every year in order to keep pace with the advance of science.

All of which is respectfully submitted.

CHARLES R. CROSS,

Assistant Prof. of Physics.

MINING AND METALLURGICAL LABORATORIES.

President J. D. Runkle.

DEAR SIR:—The purpose of these laboratories is to furnish the means of studying experimentally the various processes of ore-dressing and smelting. Ore may here be subjected to the same treatment, and by the same kind of machinery and other appliances as are in use at the best mines and metallurgical works in this and other countries.

This may at first appear to be a strong statement, as such a laboratory might be made to cover acres of ground, and to cost thousands of dollars, if we were to include all the demands made by the immense iron interest of the day. But when viewed from the position which the Institute assumes towards these laboratories, it will be seen to be not only possible but practicable to build and to carry on such an enterprise.

Our aim is to have one representative machine of each class. Thus one automatic hydraulic jigger will serve to illustrate all automatic jiggers used in this country, and abroad, and when this is thoroughly comprehended, the student will be able readily to understand all others. In like manner, one kind of reverberatory furnace for roasting gold and copper ores will, for the present, be made to represent all kinds. Practical instruction in the elements of the subject is to be sought for, rather than the scientific completeness which can only be acquired by following closely all the details in some large smelting establishment. And of course we have neither the time nor the means for imparting all the niceties of every special branch.

In systematizing this department there have been many unavoidable delays, and many difficulties to overcome, some of which will be presently mentioned; but it is fully expected that the laboratory will be in thorough working order for the use of the class in mining during the year 1873-74.

The mining laboratory has, at present, in successful operation, some of the most approved ore-dressing and mill machinery now in use in California and Nevada, for gold and silver ores; consisting of a Blake crusher, a five stamp battery, an amalgamating pan, a separator and concentrator, complete in every respect, and capable of treating half a ton of ore in a day of ten hours; the arrangement of these machines is shown in the accompanying cut. The laboratory also contains a hydraulic-jigger, a Rittinger shaking table, a Whelpley and Storer pulverizer, and a Sturtevant fan-blower; all of which, with the exception of the jigger, are shown in the cut.

New machines and furnaces will be from time to time added, as occasion requires.

The metallurgical laboratory contains (*a*) a cupelling furnace, arranged upon the German plan, capable of cupelling fifty pounds of lead at a time; (*b*), a blast furnace capable of smelting five hundred pounds of copper ore in a day of ten hours, having a cross section of twelve by eighteen inches, and one tuyere in the rear; (*c*), (*d*), roasting and smelting reverberatory furnaces; (*l*), (*l*), (*l*), a forge, anvil, and bellows; (*f*), (*g*), (*h*), (*i*), crucible and muffle assay furnaces; (*k*), a large kettle, which may be used for smelting lead (Parkes' process), or as a large sand bath for chemical purposes. The coal bins are placed under the large mortar.

The experimental work of this laboratory is carried on by the students under the immediate supervision of the professor. When a class of students begins work in the laboratory, each is assigned a sufficient quantity of ore to work upon. He first determines the minerals contained in the ore, samples it, ascertains its value and character by analyses and assays, and makes such other preliminary examinations as may serve to indicate in

a general way the proper method of treatment; and then goes to work on the given quantity, twenty to five hundred pounds, according to the subject, making assays at every step, to ascertain where the loss takes place, and the amount of loss. He also takes account of the amount of power, water, fuel, labor, and chemicals expended, so far as it is practicable to do so.

Such was the plan of 1872-73.

Now it is evident that, in starting a new laboratory of this character, it is by no means easy to settle beforehand the details of a proper course of practical exercises. Our work during the past year has been mainly tentative. We have been trying to discover the best way of giving instruction. It was found that a student, when doing all the work himself, could accomplish but little in the way of obtaining accurate and useful results; for such operations require very much more time than any one would anticipate. Accordingly the following plan has been arranged for the coming year:— a student will receive an ore, examine and prepare it, but at the time when any machine or furnace work is to be done, he will have assistants from his own class, the work to be divided among the assistants, each attending to his assigned part, while the leader exercises a general supervision. At the end of the day each one must hand in a full and carefully written account of his work to the leader, who in turn prepares from these daily statements his final report for presentation to the professor.

By and by another student in turn becomes leader of a party, receiving a new ore to investigate, and so on until each one of the class has learned the duties of workman and superintendent, and the prescribed metallurgical course is ended. It is believed that in thus throwing the whole responsibility of a few simple things on each student, the work will be more thoroughly done, and the reports will be fuller and of far greater value. The student in charge, being free from all details of work, by constantly watching all his men, may be as confident of the correctness of his results as if he had performed all the work himself. The ores will be chosen for the

different students in such a manner that they may represent as large a variety of metallurgical work as possible.

There are no suitable text-books to be found to direct the student in this branch of his studies. "Percey's lead" has been at hand for consultation in respect to experiments on silver and lead. Watt's Dictionary and Kustel's processes of gold and silver extraction, are also used for reference; Plattner's Probirkunst has been used for gold gas-chlorination.

In fact, such is the state of the metallurgical literature, that a large number of expensive books are needed to cover what might be reduced to a tolerably small compass; for instance, the student does not want to know, when smelting lead by the reverberatory furnace, that nine different methods are in use in Germany and England. If at his first glimpse of the subject, he is brought face to face with nine different processes, all of which are nearly identical, he is confused, and fails to see why to choose one over another. He needs to know the principles and details of the processes which are most feasible for this laboratory; and hence, when suitable processes have been selected, it may be best to put them in book form and make a laboratory text expressly for this work. This can hardly be done without the experience of a year or two more.

In this report some reference should be made to the spirit with which students have taken hold of this work. The tone of feeling among them has shown that they have thoroughly appreciated the character, the use, and the demands of these laboratories. All work has been most cordially and carefully done, and it seems well nigh certain that when the resources of the laboratory are developed, which will undoubtedly be accomplished the coming year, the students will reap far more benefit from this course than was at first anticipated, when the difficulties were not only not overcome, but had not yet been discovered.

When preparing a young man for the possibility of filling responsible positions in after life, there seem to be three very important qualities to be developed in him; he needs scientific

attainments, capacity for organizing and directing work, and character or tone. Mere scientific attainments are to be derived more especially from books and lectures, while quick, ready judgment, inventive skill, self-reliance and directive power can be brought out only by practical work, such as the laboratories furnish. The character or tone developed in the student depends in no small degree on the influences around him. When the instructor joins heartily with students in their hard work, and contributes to its full success, the experience of the past warrants us in believing that an earnest, determined enthusiasm will be the prevailing spirit among them. Energetic, persevering effort is best induced by the living example of those who show the power of overcoming difficulties.

During the past year the old arrangement of studies, which was prepared before the laboratory was opened, has been continued; and as this allowed but one or two hours at a time for laboratory work, students have often been obliged to neglect lectures and recitations in order to finish an experiment which lasted a whole day. Thus irregularities were necessitated injurious alike to students and professors. For the coming year a new tabular view of studies has been arranged, which fully admits the demands for time made by metallurgical work. About four weeks during February or March, are set apart for continuous laboratory work, and during that time the student is to have no calls outside to distract his attention from a subject which requires his whole inventive power.

The want of an assistant has been very much felt while getting the work started. Too much manual labor was performed by the Professor while planning his work; he fully appreciates the impossibility of doing hand and head work together, and with this in mind the present system of class instruction has been planned.

An assistant has been appointed for the coming year, and it is hoped that with such aid much more will be accomplished than has hitherto been possible.

A few examples of the work performed during the past year are here cited:—

ILLINOIS LODE, CENTRAL CITY, COLORADO, BY GEORGE PHILLIPPS.

This is essentially an argentiferous gold ore, containing sufficient copper to be worth saving, and a considerable percentage of arsenic and antimony.

The ore was found to contain the following minerals:—

Gold bearing minerals:—Pyrites, gray copper, copper pyrites, zinc blende, galena, and a loose, black substance, which contained copper, sulphur, iron and arsenic, and seemed to be the result of decomposition of gray copper.

Gangue or vein stuff:—Quartz, feldspar, pyrites in grains, carbonate of iron in small crystals.

The ore was easily separated by hand into three lots, gray copper, pyrites, and dust. After being finely pulverized, the whole was roasted, with the exception of 15 lbs. of pyrites. The total weight was 68 lbs., containing 4.7414 grams of gold and 16.305 grams of silver. The pulverized ore was then mixed with coal dust and iron ore and smelted for matt. This matt was again pulverized, roasted and treated with sulphuric acid, which removed the copper as sulphate. The copper was precipitated by iron, and then dried and fused in a crucible. This copper was all lost by an accidental crack in the crucible. Some of the silver was undoubtedly carried with the copper as sulphate.

The residue from sulphuric acid was melted with oxide of lead and a little sand, yielding 8 lbs. 7 ozs. of lead carrying silver and gold. This lead, when cupelled, yielded 2.38 grams of gold and 9.40 grams of silver, which were separated from each other by nitric acid. It will be seen that nearly half the gold and silver originally recognized in the ore by assay were lost in the final result. This loss has not been satisfactorily accounted for, from the hasty manner in which the work was done.

COPPER ORE. LAST CHANCE LODE, RAILROAD MINING DISTRICT,
NEVADA.

This ore was presented by Mr. J. W. Revere, who superintended the metallurgical work himself.

The ore contained red oxide of copper (cuprite), red oxide of iron (hematite), silicate of zinc (calamine), and a little galena, and also a small percentage of silver.

Two partial analyses were made of a sample of the ore, by Miss E. H. Swallow.

	No. 1.	No. 2.
SiO ₂	8.37	8.43
Cu	19.87	20.44
Fe ₂ O ₃	35.50	34.10
	<hr/>	<hr/>
	63.74	62.97

The ore, amounting to 656 lbs., was treated in the blast furnace, and with it was used from time to time old copper slag, lime, puddle furnace cinder, and sand, according to the condition of the furnace. Iron pyrites from Strafford, Vt., was also used to prevent the possibility of salamanders of iron forming in the furnace. The amounts used were:—

Copper ore	656 lbs.
Old copper slag	292 "
Puddle slag	91 "
Lime	35 "
Sand	31 "
Pyrites	109 "
Coke	240 "

The yield of crude copper was 67 lbs., and of copper matt 77 lbs. 2 ozs., which, latter, when roasted and smelted with charcoal gave 41 lbs. 8 ozs. of copper; yielding a total of 108 lbs. 8 ozs., which in a partial analysis made by Mr. A. H. Pearson is shown to contain

	No. 1.	No. 2.
Lead	2.32	4.67
Copper	88.70	89.61
Silver	trace	trace

No. 1 is from the 41 lbs. 8 ozs. No. 2 is from the 67 lbs. of copper. The result shows that of the 131.2 lbs. which the ore contained, 108½ lbs. were saved, and 22.7 lbs. were unaccounted for in the yield. This loss results from three causes:— 1, the furnace did not clear itself at the end of the run, a considerable amount of ore was left

mixed with coke and slag; 2, the slag undoubtedly carries as much as $\frac{3}{4}$ of one per cent. of copper, but the amount has not yet been determined; 3, the loss in handling the matt and copper about the tap hole of the furnace. Of the 20 per cent. of copper 16.5 per cent. was saved.

REFUSE OBTAINED FROM THE CELLAR OF A TYPE FOUNDRY WHICH WAS BURNT OUT DURING THE BOSTON FIRE, NOV., 1872.

An experiment was tried by Mr. A. H. Pearson, with the view to answer two questions:—What amount of type metal the refuse contained, and what was the most feasible method of recovering the metal for the owners of the type foundry.

One hundred and eighty pounds of the refuse, when examined, seemed to contain sand, mortar, bricks, stones, shoe-pegs, charcoal, tacks, nuts, bolts, nails, etc., and type metal in the form it assumed, when, in the melted condition, it dropped into the sand.

At the outset it was evident that a water separation for the sand and metal would be needed.

The refuse was washed by means of a powerful hose, which carried away the lighter material and saved the heavier, and yielded three products:—

- (a.) Coal, shoe-pegs, etc.
- (b.) Sand.
- (c.) Residue.

(b.) Sand weighed 100 lbs., and by assay yielded 1.73 per cent., which is probably small enough to reject in a mere temporary operation, like the recovery of metal lost in a fire.

(a.) Shoe-pegs, etc., contained no metal.

(c.) Residue which contained nearly all the metal was treated on a hydraulic jigger of one-sixteenth inch mesh sieve and yielded,

- (d.) Skimmings.
- (e.) Metal.
- (f.) Siftings.

(e.) The metal was melted with charcoal in a large crucible, and yielded 34½ lbs. of good ingot type metal worth 11 cents per lb.

(d.) The skimmings weighed 20½ lbs., and yielded 9.04 per cent.

of metal to assay, or in actual weight about 2 lbs. of metal which was not saved.

(f.) Siftings from the last jigger were treated on a thirty-second inch mesh jigger, and yielded three products:—

- (g.) Skimmings.
- (h.) Metal.
- (i.) Siftings.

(h.) Metal when fused together gave 13 lbs. 2 ozs. of good ingot.

(g.) Skimming, weighed 8 lbs. 2 oz., and contained 19.3 per cent. or about 1 lb. 9 ozs. of metal.

(i.) Siftings weighed 8 lbs., and contained 53 per cent. of metal, or a little over 4 lbs.

Summing up the results, we find that the amount of ingot metal obtained was

(e.) Metal	34 lbs. 8 ozs.
(h.) " "	13 " 2 "
	47 " 10 "

And that the amount of metal allowed to pass by was

(b.) Sand	1 lb. 11 ozs.
(d.) Skimmings	2 " 0 "
(g.) Skimmings	1 " 9 "
(i.) Siftings	4 " 0 "
	9 " 4 "

The metal in (i.) siftings was in good condition to save, and would have been treated on the large scale.

This experiment upon type metal has been introduced into this report to show how certain investigations may be made in these laboratories, as incidental and entirely subservient to the course of instruction.

Respectfully yours,

ROBERT H. RICHARDS,

Professor in charge of Mining and Metallurgical Laboratories.

THE INSTRUCTION IN ARCHITECTURE.

President Runkle:—

DEAR SIR: The instruction in the department of Architecture has, during the last year, followed the course laid down in the Catalogue, only differing from the work of the previous year in the organization of an advanced or Post-graduate course of study, in accordance with the recently adopted policy of the school. This has been effected, as was proposed in my last report, by separating from the undergraduate work the subjects of practical construction, specifications, and working drawings which the undergraduates have not time to pursue to advantage. Many of the special students have taken this advanced course in construction in the place of the scientific study of construction with which the regular students are occupied, simultaneously with the undergraduate course of design. The Post-graduate course of Design has not yet been organized.

Three Regular Students, and about twenty Special Students, have been in attendance through the year. Besides the studies strictly belonging to the course, Professor Warren has given the students in architecture special instruction in Descriptive Geometry, and I have myself given them a course of lectures on Perspective and the Perspective of Shadows. Mr. Létang has also given daily instruction in charcoal drawing during a

part of the year. The study of the history of architecture has been pursued more systematically than in previous years, the development of styles from the fifth century before Christ to the reign of Charles the Fifth being followed with a text-book, with lectures and such illustrations as our collections afford. The Trustees of the Boston Athenæum have kindly allowed us to use their excellent library of architectural works to supplement the deficiencies of our own.

The subjects upon which the class of design have been occupied, after the elementary work with which the year opened, are as follows: — 1. A monumental column; 2. An artist's house; 3. A railway station; 4. A monumental chapel; 5. A private museum of painting and sculpture; 6. A campanile; 7. The employment of four columns; 8. A pavilion between two bridges; 9. A village church; 10. A grand staircase under a vaulted ceiling or dome; 11. A Natural History building; 12. A school of chemistry; 13. A military and naval tomb. This last was drawn and designed in perspective.

Most of these works have been photographed on a small scale, as a memento and record of the year's work.

The collections have not been materially increased during the year, but a good deal of work has been done in arranging and cataloguing the books and photographs, and although not increased in numbers they are much more serviceable than they have hitherto been.

I am very truly

Your obedient servant,

WILLIAM R. WARE.

DEPARTMENT OF MECHANICAL ENGINEERING.

President Runkle: —

DEAR SIR: The professional instruction in this department is given in four courses: the mathematical, the practical, the graphical and the excursions. To complete the facilities we still greatly need an *experimental laboratory*, especially arranged with reference to this department.

In the first three courses the work is taken up in the same order, as in Professor Rankine's works on "Mills and Mill-work," and "Steam Engine and other Prime Movers," which are used as text-books. All these courses are carried on together with the same class; each approaching the same subject from a somewhat different standpoint. In the mathematical course Professor Rankine's demonstrations are usually given; but care is taken to collect from his several books and papers all he has given upon a particular subject, that the simplest as well as fullest discussion may be presented to the class.

In the practical course the entire attention is given to the applications of the theory, as involved in practice. Applications, as far as possible, are made to existing engineering works, and to problems as they occur in practice.

In the graphical course the instruction is chiefly based upon good examples of American practice; and it is intended that

each exercise in theory, or practice, shall be supplemented by a drawing exercise covering the same ground. The subject of gearing happens, just now, to be the subject under discussion in the theoretical and applied courses; and the corresponding graphical work is making working drawings of a pair of bevel gears, designed by James B. Francis, Esq., of Lowell, and which now transmit the power produced by one of the largest turbines in the world. These gears have epicycloidal teeth; and as there are correct and approximate methods of drawing such teeth, students will draw them by different methods, and thus be able, by an actual comparison, to judge of their comparative correctness.

The excursions course is proving a very important one. Once a fortnight, or oftener, visits are made to establishments where machines are in use, or in process of construction. Each student is held responsible for some particular part of a machine or operation, which he must report upon, either in words, or by measurement and sketches. Afterwards a summary of all these reports is made for the benefit of the whole class, and as the basis of such further instruction upon the particular subject under consideration as may be desired. For the present I am indebted to Professor Lanza for valuable aid in the theoretical course, and to Mr. Schubert in the graphical course.

I am aware that a mechanical laboratory was a particular feature in the plan of instruction, as developed by President Rogers; and I beg respectfully to suggest that if we would see this department of the Institute take its proper position, the establishment of such a laboratory should no longer be delayed. After the conferences which I have had with yourself and Prof. Pickering upon this subject, I venture to submit the following outline of a mechanical laboratory, with such details as to use as a machine shop, and as an experimental laboratory, as time would permit.

In the first place this laboratory should be furnished with a certain number of the more important machine tools, and all

the adjuncts necessary to their use. Each student in the department should, early in his professional course, be required to become somewhat familiar with these tools by actual use, that they may afterwards be used to better advantage as models and types in the higher theoretical and practical instruction. If, at the same time, this laboratory should be used for the construction of models to illustrate the instruction in this as well as other departments of the Institute, it would furnish the student an excellent opportunity to see the great difference which often exists between drawings made to illustrate a design, and those which the experienced draughtsman will make for the actual construction of that design, for the purpose of securing the end sought with the least expenditure of materials and labor.

Another important part of the outfit for such a laboratory is the apparatus for making tests of power, efficiency, etc. Engineers are often called upon to make such tests in practice, and it is exceedingly desirable that students should have an opportunity during their professional course, to become acquainted with the means, and have practical experience in making such tests.

Such a laboratory should be supplied with its own steam boiler and engine especially designed and arranged for experiment; then, with thermometers, pyrometers, barometers, an indicator, a transmission dynamometer, an absorption dynamometer, a calorimeter, a chronograph, and apparatus for weighing and measuring, we could perform experiments to determine:—weight of fuel burned; weight of water evaporated; temperature of fire; temperature of escaping gases; waste of fuel in escaping gases; barometric pressure; pressure of steam in boiler; pressure of steam in cylinder; speed of engine; indicated power of engine; effective power of engine as measured by transmission and absorption dynamometers; value of Joule's equivalent; experiment on safety of boiler; comparative pressure and temperature of steam; latent heat of steam; evaporative power of various fuels; air required for combustion and dilution; distribution of fuel and air; rate of

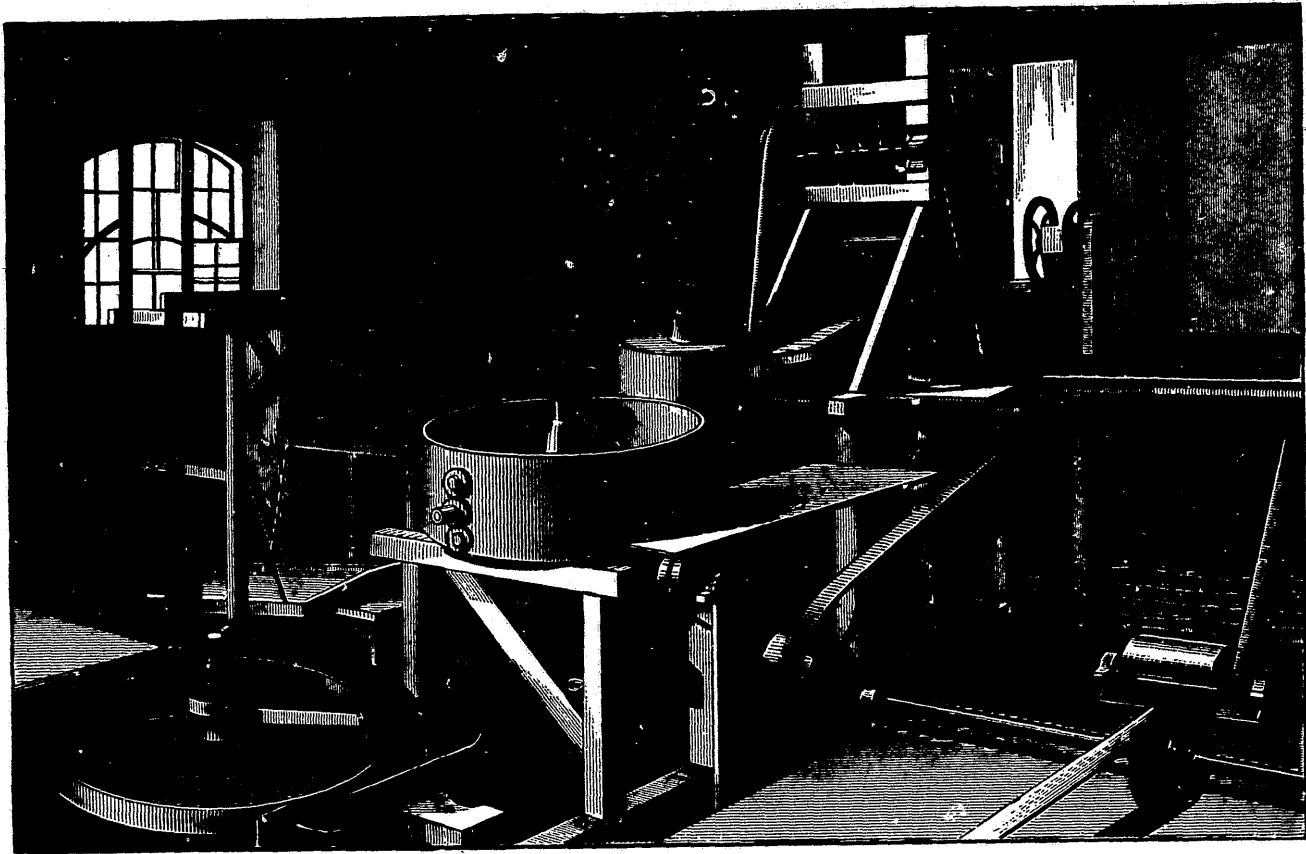
combustion ; heating and cooling of gases and vapors by compression and expansion ; proper and improper methods of setting valves ; effects produced by superheating and wire-drawing steam ; value of wrapping substances, as felts, cements, etc. ; effects of steam jackets ; efficiency of governors ; uniformity or ununiformity of motion of fly-wheels, etc.

Such are some of the many experiments which could be readily performed in the laboratory for the instruction of students. But new questions are constantly arising, and this laboratory should always be prepared for their examination and solution.

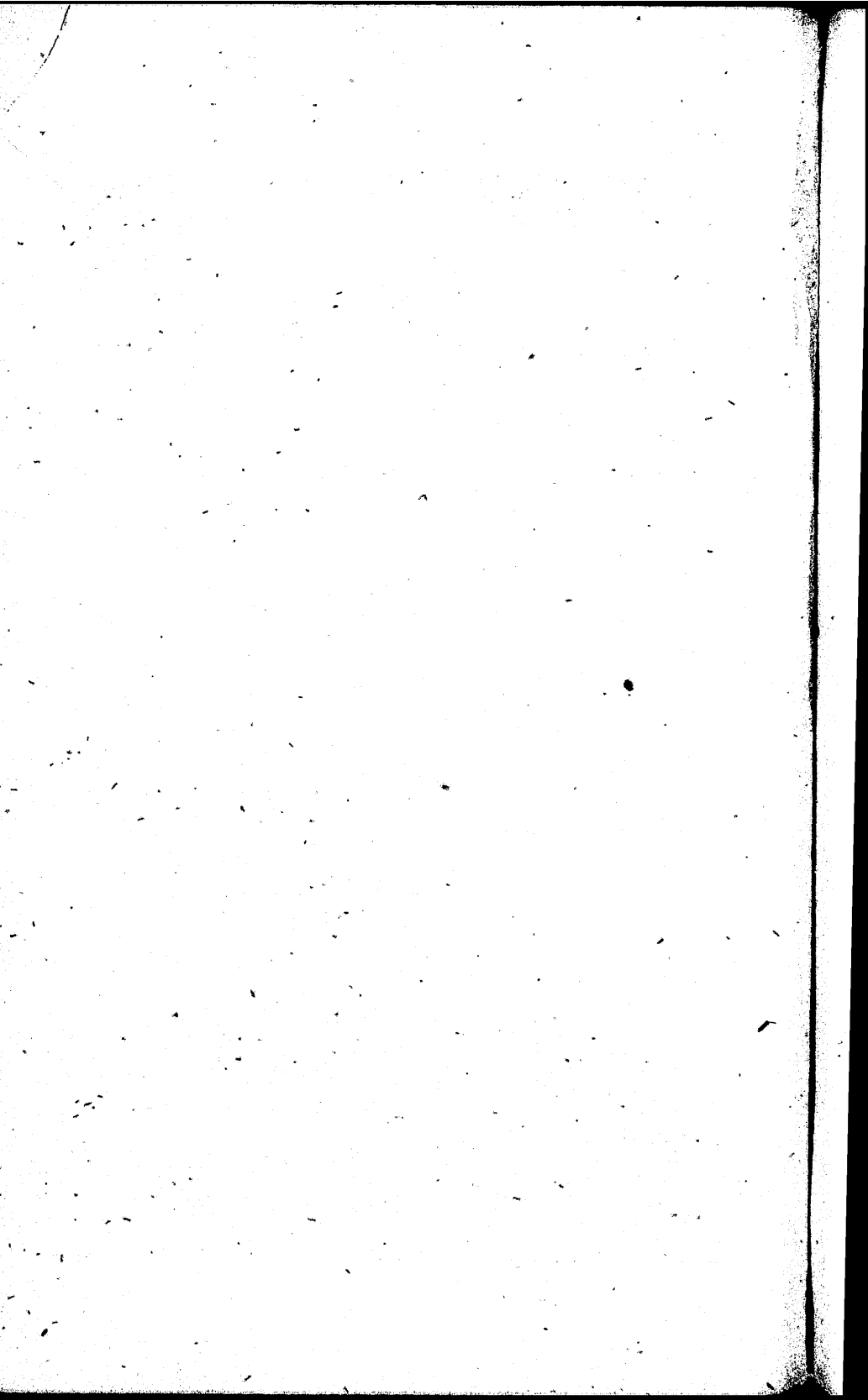
Very respectfully yours,

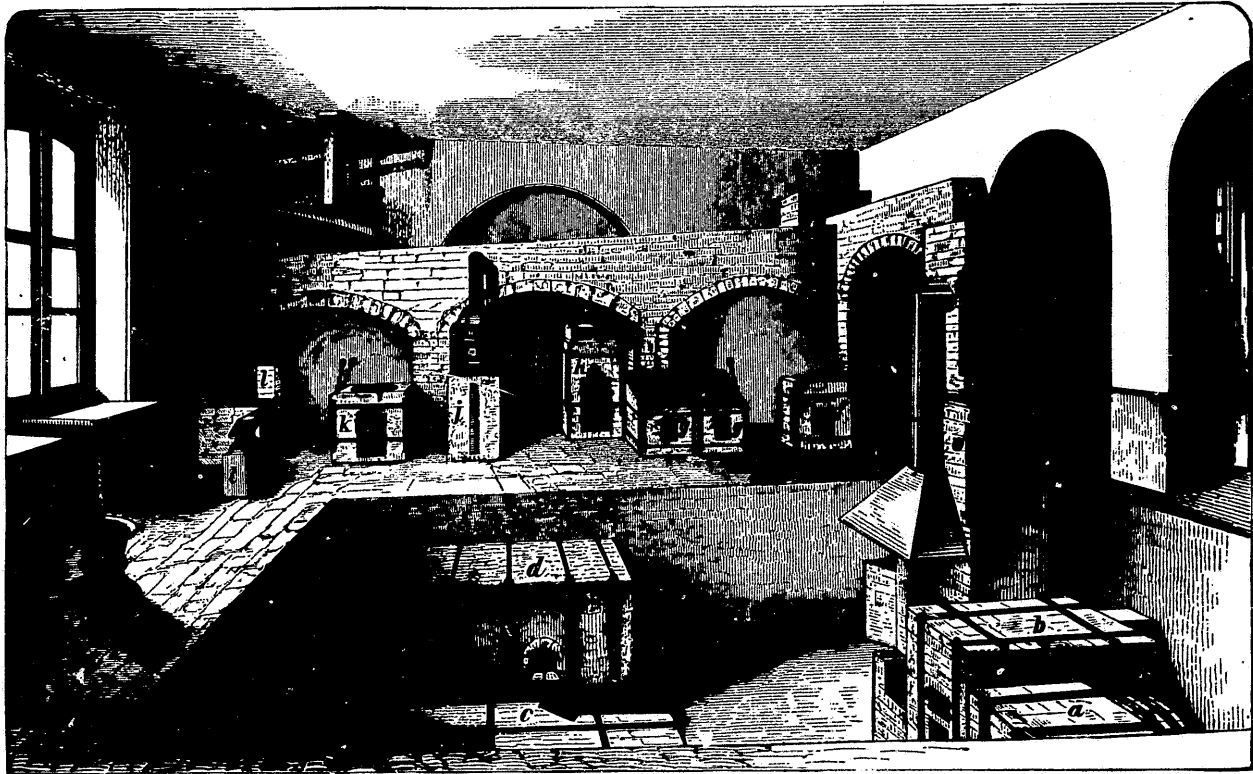
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