6-8-1893

The WPI Volume 9 Issue 5, June 8 1893

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Vol. IX. Thursday, June 8, 1893. No. 5.

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Any shortcomings in this issue may be laid to the fact that examinations are upon us. Trying to study much in preparation for them, which is decidedly necessary for most of us, is something of a detriment, to say the least, in getting twenty-three columns ready for press. And surely vice versa.

The Ninety-three men are rejoicing that their last regular duties at the Institute are over, that their diplomas have been paid for and the only thing remaining is to get them. Two weeks and they will be out on the cold, cold world, shifting for themselves. We will not say good bye yet, however.

The Tech did not seem to be favored with good fortune in anything pertaining to general athletics this spring. The annual spring field-day was about as uninteresting as any in the recollection of the undergraduates. Having it after the intercollegiate meet of course detracted very much from the interest, for the winners in each event were named in almost every case beforehand and it was difficult to get a good field of starters in any event. The action of the Board of Directors has been severely criticized, and we think with cause. Ninety-five wanted the pennant and were going to get it in one way if not in another. To rehearse the arguments and excuses would be useless, but we will say that it seems a rather unjust way to treat a man who has worked so hard for athletics at the Institute, to say nothing of the injustice done the class.

There is no doubt but that some general rule should be passed to cover all such cases, but to make a special decision every time a doubt arises, and in this case to wait so long before making a decision is altogether wrong, because whenever a special question arises it cannot be settled without class feeling entering into the matter. Why not pass some law or come to some understanding now or the first thing next fall, before the cross-country runs bring up some question which just as surely as it comes up will be decided in favor of the class which can get the votes of a majority of the Athletic Directors?

THE TEACHING OF MATHEMATICS.

An Article Published in the School Review by Prof. L. L. Conant.

In the teaching of natural science, the past quarter of a century has brought about a reform of the most sweeping nature. Methods of instruction have been radically changed, and the whole point of view from which the study of the sciences is approached has shifted. In its work in connection with chemistry, physics, natural history, botany, etc., secondary instruction has abandoned the abstract for the concrete. The student has now to deal, not so much with formula and law as with actual experiment—or as some enthusiasts would put it, with cause and effect. Of the good which has resulted from this change we need not speak. Of the danger which attends this method of instruction, of the points wherein it is inferior to the method it has supplanted, we have here no room for discussion. All that concerns us at the
present moment is the fact that this change has taken
place. Emphasis is the watchword of to-day. "Read
nature in the language of experiment," cries the re-
former. The cry has been heard and heeded; and the
high school or academy, to say nothing of the college
and scientific school, which is not well equipped with
laboratory and apparatus, is not looked upon as "pro-
gressive," is not "up with the times."
In another department of instruction we see to-day
the beginnings of a reform no less important, and cer-
tainly no less needed than was reform in the teaching
of natural science. Ten years ago the teaching of
English in our secondary schools was the merest farce.
Latin and Greek, and in many cases French and Ger-
man, received most liberal allowances of time and most
painstaking care on the part of the teacher. But of
systematic work in English there was none. Of
comprehension on the part of the teacher that such
work was needed there was almost none. The public
apathy, yes, the possibility of re-form, matric - well, what can be said of
the subject of instruction given in English there was none. Of
the tangled mass of tangibles that have as yet been produced are insignif-
icient. The actual instruction given in English is meagre and
often very poor. The public is still apathetic, and
the great army of primary teachers is worse than
apathetic. But the college and the secondary school
have fairly begun the work of placing on a sounder
basis this most indispensable subject. Some echoes have reached us from across the water
of the agitation in Germany which has for its object
the elevation of the study of German; of the utter-
ances of the leading French educators on the study of
a nation's own language and literature; and of the
revolutionary change in Sweden which has made the
study of Swedish one of the corner stones of the national educational system of that country. These
tidings from abroad, coupled with the earnest en-
deavors of our own educational leaders, have fairly
inaugurated among us this most important reform.
The study of our own language and literature is at
last coming to receive the attention it deserves; and
not only that, but it is the certain fact that near future
will see a leading place given in our schools to this
long neglected subject, this branch of study which
lies at the root of all true culture.
Science, language, mathematics. About these three
branches may be grouped all that is most important
in the purely mental part of the school training of
children. In the teaching of science, reform has al-
ready come. In language it is at hand. In mathe-
matics-what can be said of the present status
of instruction in mathematics, and of the need and
the possibility of reform in its methods? Few will
dissent from the proposition that mathematics is one
of the essentials of education. No one whose opinion
is worthy of respect will deny that our schools, from
the first steps of the primary grade to the close of
the mathematical work in college, are in need of re-
form. But reform in the teaching of mathematics
must, from the very nature of the case, be slower of
growth and more difficult of achievement than has
been the case in the natural sciences. About the sub-
ject of mathematics there is nothing to inspire the
enthusiasm or to awaken the spontaneous interest
that may be made to accompany work in natural
science. Hence the reform, whenever or however it
may come, will come slowly, reluctantly, and with
uncertain step. But come it must, and come it will;
may, rather, come it shall.
Selecting for our consideration those branches of
mathematics which properly belong to secondary
education, i.e., algebra, geometry, and trigonometry,
let us examine briefly the reasons why mathematics
must fairly be considered a difficult subject, much
more difficult, for example, than natural science. In
connection with the latter the teacher can summon to
his assistance a multitude of external aids. A diffi-
cult point can be illustrated and explained by exper-
iment after experiment, each in itself sufficiently en-
tertaining and valuable to hold the student's attention;
each possessing at the same time the charm of being
something that can be done by his own hands, and
that can appeal directly to his mind through the
medium of the five senses. He is brought to see and
to comprehend clearly relations which in the abstract
could not be acquired only through long and difficult pro-
cesses. His quick wit detects practical applications
which may be useful to him in his future life; and he is
made to feel in various ways that he is, in the study
of science, acquiring something whose value he can
comprehend. In a word, he is entertained and inter-
sted, and he sees the practical value of what he is doing.

What, on the other hand, is likely to be his mental
attitude toward mathematics? He finds himself here
brought face to face with, and expected to acquire,
something essentially abstract and theoretical. Now
and then his common sense does find some fact or prin-
ciple that is really practical; certain laws respecting
the solution of volumes remain to be mastered; a
factor of an elementary function may be of service
in his elementary geometry; the unknown quantities
of algebra furnish an easy method of solving many prac-
tical problems with which the future may confront
him; the sine, cosine, tangent, etc., of trigonometry
are indispensable tools in ordinary surveying. But of
what use is it, he asks, to know that the sum and the
product of two conjugate imaginary numbers are both
real numbers? Why is he bothered about the develop-
ment of a line into its extreme and mean ratio? Who
cares whether or not \( \sin x + \sin y = 2 \sin \frac{x}{2} \cos \frac{y}{2} \) ? He can imagine no possible use for these
things, and his mind instinctively rebels against them.
In a word, he is not entertained, he is not interested,
and he does not see the practical value of the work
which he is compelled to spend his time upon. The
result of all this it is easy to see. The student who has
no natural taste or aptitude for mathematics
becomes disgusted, then angry, then disheartened.
Hard work, induced by sincere love of his other
studies or by fear of the disgrace of failure, may
carry him through his prescribed course; but it is a
wearsome experience, and it leaves on his mind a
deep seated aversion for the work he has been through,
and causes him throughout his future life to look back
on his mathematics as the "worst grind" of his en-
tire school and college life.
The facts here stated are incontrovertible. They
are borne out by the experience or observation of
almost every scholar who has ever pursued a college,
or even a high school course, and they constitute one
of the greatest blots on the American educational sys-
tem of the past century. And what, meanwhile, has
been the condition of mathematical instruction? If,
as is undeniably true, mathematics is the most diffi-
cult branch in our commonly prescribed curricula,
it would certainly seem as though its instruction
should be entrusted only to those of most scholarly
attainments and ripest preparation for their work.
But the exact reverse of this always has been and is
to-day true in this country. In the early part of this
century it was almost invariably the case that instruc-
tors in mathematics were chosen from among those
who had distinguished themselves in their classical studies. Forty or fifty years ago the opinion began to obtain that, in the teaching of mathematics, scholarship was an entirely secondary matter; that, in fact, any one could teach mathematics. At the present day this same pernicious opinion is still almost universal, and it is only in a comparatively small number of our college and scientific schools, and in a still smaller number of our secondary schools that the dangerous absurdity of this proposition has been recognized, and earnest attempts have been made to place the control of this branch in the hands of those properly fitted to take charge of it. Since the beginnings of education in this country, mathematics has been weighted down by the dead load of inefficient instruction so ignorantly fastened upon it. Under that load it is still weighted down. A long, hard struggle must be passed through before the subject is emancipated from its present burden; before the reform so earnestly desired and so acutely needed can be established.

For the study of mathematics four principal reasons may be given: 1. It is in itself a pure science and, like any other pure science, is worthy of study for its own sake. 2. It is invaluable as a means of mental discipline. 3. It is capable of innumerable practical applications. 4. It is necessary for the completion of all or nearly all prescribed school curricula. Of course it need not be said that the number of those who are influenced only by the first two, or either of the first two reasons is, in this country, wholly insignificant. Now and then it is found worth while, like Rittenhouse, to suppose to have been acted only by the purest love for mathematics; or like Abraham Lincoln, who forsook his law studies for a time and devoted himself to Euclid for the sake of the mental drill and the training in rigorous accuracy of reasoning to be derived from geometry. But all such cases are to be considered merely as exceptions to the otherwise universal rule that students follow mathematics either because it is a part of their regularly prescribed course, or because it is in some way to be of direct practical benefit to them. In saying this I do not intend to say that all students dislike mathematics. On the contrary, experience shows that a fair proportion of the students of any class are selected at random as natural liking and aptitude for this work. In the preceding, reference is made to those who devote themselves to mathematics for either or both of the first two reasons to the exclusion of the last two. For such students instruction is almost unnecessary. They need not now and then a suggestion from an experienced and widely read mathematician or logician—daily recitations in the ordinary sense of the word. In fact, daily recitations as conducted by the ordinary teacher are precisely what such students do not need; for by that means errors in reasoning and loose habits of thought are inculcated which are sometimes detrimental in the highest degree to the student. From our present discussion, then, we eliminate these two classes, and proceed to consider mathematical instruction only as it affects those who are pursuing this subject with direct practical ends in view, and those who find in mathematics one element of the general education for which they are striving.

Wherein is the mathematical instruction of the present day lacking? Or, to ask the same question in a different manner, what are the particular points that will ensure good instruction in mathematics? Certain important but general truths may be stated in answer to this question, but they are truths that will apply to any other branch equally well. There are, however, a few elements of this question to be considered which are either peculiarly true of mathematics or of mathematical transitions, or of mathematics in transcendent importance in the general theory of teaching that they must not be lost sight of in our attempt to answer the question we have propounded.

At every step of our progress in mathematics, review is necessary. The truths of mathematics are, as has already been said, essentially abstract in their nature and are not easily fastened on the mind. The common processes employed are forgotten by the ordinary student with a rapidity that would be discouraging to the teacher, were it not for his recollection of the ease with which the same things slipped out of his own mind but a few years before. Nothing but repetition, practice, practice, repetition; nothing but a constant, faithful, and long continued hammering can fix the common processes of mathematics in the mind so that their use will become, as it should be, automatic. To a certain extent this matter of review will regulate itself, so constantly does each successive stage of mathematical work involve what has gone before. But to a much greater extent this does not hold. On the contrary, it requires on the part of the instructor unremitting vigilance to ensure a class against losing one week what was learned the week before. In using the word review, it must not be understood that reference is made to turning back and going over for a second time any part of a text-book. What is meant, and what is commonly understood by review, is that of any subject should be made to involve to a greater or less degree as many as possible of the subjects already mastered. Text-books are often of but little assistance in this matter, and are sometimes a direct hindrance. Our text-books in algebra, geometry, and trigonometry are often the merest compilations, differences of subject matter "whacked" together by some ignoramus, ambitious to see his own name on a title page. Even our best books are far from perfect in this respect; and the teacher who would secure the highest degree of excellence from his students must at the outset make up his mind to be, in some degree at least, independent of his text-book.

Study is not a recreation, and to be productive of good results it never can be a recreation. Study is work, and mathematical study is hard work. Any teacher who tries to persuade either himself or his class that this is not so, is unwise and dishonest. Mathematical work may be and should be made interesting, but it cannot be made play. Mental strength and mental accuracy can not be gained from algebra or geometry if the teacher insists upon making of it a mere holiday excursion with himself as conductor. Inaccuracy and the tendency to shirk, which every teacher meets, must be ruled out with the most remorseless rigor. Leniency and infinite patience are necessary in guiding the first steps of a child in its primary work, but the high school and college are not the places for them. If the student is ever to walk alone, he must learn to do it there. But, it is asked, how about those who have for mathematics no natural aptitude whatever? How can such methods be applied, in any fairness to them? I answer unhes-
Last of all, the teacher should shrink from no amount of personal labor in connection with his daily work. The preparation of problems, the correction of written work, and the many other direct and incidental demands upon his time combine into a serious burden; one which teachers would be glad to escape. But the teacher who allows himself to do this is unfaithful to his trust, and has his own case more at heart than he has the interests of his class. Not only is there no royal road to mathematics, but there is no royal road to success in mathematical instruction.

W. P. I. A. A. FIELD-DAY.

Many things combined against the annual field-day of the Institute, and whatever success was achieved, was attained only against odds. Following three days after the Intercollegiate meet on the 25th, the W. P. I. sports suffered by comparison, and only about two hundred spectators were present. Two-thirds of those present, however, were ladies, in spite of the fact that, for the first time, they were charged the regular admission. The interest shown by the classes was surprisingly slight, and none of the three upper classes had more than twenty men together on the grand-stand; '96 had the largest delegation present, about forty in all, and gave vent to a long yell at every opportunity. The Freshmen deserve great praise for the showing they made in tying the Seniors, an unusual occurrence for a new class without organization or time for training; '94 was the only other class that encouraged its athletes by cheering. Why the Sophomores, who were from the start sure of the pennant, remained silent until the last event was finished, is unknown. As they themselves assign no reason, we do not know whether to attribute their silence to shame, modesty or inability on account of lack of numbers.

The difference in points between '93, '94, and '96 was very slight, and the winning or losing of an event would have altered the standing materially. Had Parker and Baker been in the best of form, they would have undoubtedly taken enough points to have evened up the score to some extent. The fact that the health of Whipple and Chase has been such this spring that they were unable to train for either the Intercollegiate or the Tech field-day is to be regretted, as both men are capable of good work when in condition. Whipple's running in the team race against the M. I. T. will long be remembered by all who saw it, and Chase was second in the 220 yards dash last spring in faster time than that made this year. The Juniors still had hopes that they might make a strong bid for the championship, but, when the board of directors by some remarkable process of reasoning, decided that Allen...
was not a member of the Junior class, and that any points which he might score should not be counted for '94, the pennant was practically given to the Sophomores.

The day was raw and a chilly wind was blowing from the southeast which was decidedly unfavorable to record breaking. It did not entirely prevent good work, as a glance at the time made in the mile walk and the two-mile bicycle race will show. The record in the running high jump was raised by a half inch, and if Zaezer had not injured his ankle, he would probably have done better. Owing to a mistake in the announcement of the time of the games, many of the spectators and also some of the competitors did not arrive until after two o’clock, and there was a delay of nearly half an hour before the first event was started.

Four men lined up at the scratch for the 120 yards hurdle—Gallagher, '94, Stone, H. S. Davis, and Field, '95. The latter was the only one of the men who had trained and was expected to have things his own way. At the pistol shot, Stone dropped out, but the other men took the first three hurdles at nearly the same time. After this point, Field got a slight lead with Gallagher a few feet behind. At the last two hurdles the '94 man began to gain and when Field broke the tape, Gallagher was only a foot behind. Field’s time was 19 1/2 seconds. Davis was not in the best of form and contented himself with third.

The 100 yards dash was run in two heats and the first and second men were to run in the final. In the first heat the starters were Denny, O’Connor, Stone, ’95, and Derby, ’93. The men got off the mark together, but Derby and Stone soon got the lead. Derby managed to force his way to the front and won by a foot in 11 seconds. The second heat had for starters, Killam and Morse, ’93, Philpot, ’96, and Proctor, special. Killam had no trouble in winning the heat in 11 2/5 seconds. Proctor was a yard behind. All four men entitled to run in the final heat, presented themselves at the scratch. Derby was somewhat tired and did not make so fast time as he did in his trial heat. As it was, Killam just beat him out of first place in 11 2/5 seconds. Stone was a close third.

The one mile relay race between the class teams, of four men each, was, as is usually the case, the event of the day. ’95 had a team of fast runners entered who did not disappoint their classmates. The freshmen came forward with four men, whose running may be considered very creditable when it is remembered that, without time for training, they beat out the team which was second in last year’s relay race. The teams were made up and ran as follows: ’93, Farwell, Coombs, Baker, Derby; ’94, Linnell, Harris, Gordon, Gallagher; ’95, Field, O’Connor, Stone, Harrington; ’96, Cunningham, Harris, Vaughn, Whittall. At the start, Field sped into the lead with the others bunched close behind. Linnell tripped and fell opposite the club house, and, when he got on his feet, he was far behind. He pluckily resumed the race, although he was unable to regain the lost ground. Field finished the quarter nearly seventy-five yards ahead of Cunningham and Farwell. O’Connor started in to increase ’95’s lead and succeeded in making the gap wider. Coombs ran his best for ’93 and managed to finish on nearly even terms with Harris, ’96. Harris, ’94, finished last, but he had made up nearly half the distance between him and the ’96 man. Stone set a hot pace for three hundred yards, but was unable to retain all the lead given him. Baker and Vaughn were well together until the upper turn was reached when Vaughn was passed on the stretch by Baker; Gordon finished fourth by about fifteen yards. Harrington was so far ahead that he was able to take his time, but the other three men ran well in a bunch. Whittall and Gallagher both passed Derby a hundred yards from the finish; Gallagher satisfied himself with winning second place from Whittall by a yard.

The eight starters in the 220 yards dash preferred to run in one heat without having the lanes designated by the strings. As a result, there was a confused rush and a struggle for the pole during the first half of the distance. Brigham fell, receiving a bad cut from the einders, and Killam claimed that he had been fouled, but the referee did not allow it. Just as the crowd reached the straight-away, Philpot emerged from the confusion and Harrington followed in a vain endeavor to pass him. Philpot won by a yard in 26 seconds; Stone was third.

Andrews, ’93, Harris, ’94, Field and Davis, ’95, were the starters in the 220 yards hurdle. Davis ran in ordinary clothes and stopped after the third hurdle. Andrews led for a short distance, but Field and Harris both passed him and finished in that order. Field’s time was 31 2/5 seconds.

The half-mile brought out five starters, Derby and Butterfield, ’93, Gallagher, ’94, O’Connor, ’95, and Whittall, ’96. Derby took the lead at the start and kept it for a lap and a half, with Gallagher, O’Connor and Whittall a short distance behind; Butterfield did not finish the first lap. On the second lap, the pace began to quicken and Derby dropped back one hundred and fifty yards from the finish. Gallagher, who had been holding back till this point, began his sprint for the tape. O’Connor made a close
race, but was unable to pass the little '94 runner, who won by a yard in 2 minutes, 16 3/4 seconds. Whittall had no trouble in taking third place.

The first record was broken by Strong, '93, in the mile walk. Butterfield, '93, Harris and McFarland, '94, and Tilden, '95, also started. Harris followed Strong for three-quarters of a lap, but sat down to tie his shoe near the 220-yard mark, and lost so much that he stopped when he reached the club house again. Tilden and Butterfield followed in that order until the third lap, when Butterfield passed into second place. His style of walking was very questionable, however, and, in the opinion of many of the spectators, he should have been ruled off and second place awarded to Tilden. Strong walked in good form and finished one hundred and fifty yards ahead of Butterfield in 7 minutes, 37 3/4 seconds.

With Allen out of the 440 yards run, the race became entirely a '95 event. Harrington took the lead at the start and was never headed. O'Connor and Field made a pretty fight for second place, which the former won by a yard. Harrington's time was 56 1/2 seconds.

The mile run brought out seven contestants, Baker, Butterfield, Derby, '93, Eastman, Fuller, Gordon, '94, and Parks, '95. Baker led from the start followed by Gordon, Eastman, and Parks at a distance of fifteen yards. Derby evidently felt the effects of the half-mile run, for on the back stretch of the first lap, he had to drop out. Fuller and Butterfield also quit early in the race. The first four men constituted a procession until the last eighth of the mile. At that point, Parks passed Eastman and Gordon began to close up the gap between him and Baker. The last hundred yards was run at top speed by Baker and Gordon, with the latter gaining, but Baker's lead was too great to be overcome and he won in 5 minutes, 9 1/2 seconds, with Gordon at his shoulder. Parks was third.

The two-mile race for safety bicycles was a race only in name, for only Putnam, '96, and Gile, special, appeared at first as starters. Fuller, '95, decided to ride for third place to score a point for his class. Putnam lead from the start and did not have to exert himself, as the other contestants were unable to make the event even interesting. Although there was no incentive to fast time, Putnam brought the record down from 7 minutes and 5 seconds to 6 minutes, 20 3/4 seconds. Had he been pushed, he would probably have finished under six minutes. Gile was two hundred yards behind and Fuller was nearly two laps in the rear of the winner. He received a good share of the applause and crossed the line in time to hear the official announcement of the race.

The last of the track events was the two mile run, which had for starters, Baker and Vaill, '93, Linnell and Fuller, '94, Parks and Wellington, '95. Baker again attempted to set the pace, but the effects of the mile run and lack of training evidently told on him. In the last part of the first lap, Parks and Baker had a sprint for the lead, which Parks secured; both men dropped out on the next lap however. Wellington then came to the front, followed by Fuller, Linnell and Vaill. The latter stuck to Linnell's heels until the sixth lap and then left the track. Wellington won as he pleased and made a little excitement at the finish by passing Linnell who was a lap behind him. Fuller was two hundred yards behind Wellington, but finished in good shape and ran over to the dressing rooms apparently fresh. The time was 11 minutes, 30 seconds.

The field events were run at the same time as the track contests and began with the pole vault. Sibley '96, dropped out first and was followed by Leland at 8 feet. Gallagher showed that he could compete on the field as well as on the track and vaulted 8 feet, 3 1/2 inches. Derby won easily at the height of 8 feet, 6 inches.

Six men competed in putting the shot, Butterfield, '93, Boyden, '94, Brigham, G. P. Davis, Leland, '95, Zaeder, '96, and Proctor, special. Brigham had to put only 33 feet to win; Leland was second with 31 feet, 10 1/2 inches and Zaeder took third place with 31 feet, 6 inches.

In the running high jump, the contestants were Gallagher, '94, Brigham and Morse, '95, Zaeder, '96, and Proctor, special. Zaeder broke the record by clearing 5 feet, 3 1/4 inches and should have competed in the Intercollegiate games, as he could have taken second place. Brigham and Proctor were tied for second place at 5 feet, 1 1/4 inches. Proctor won the badge on the toss, but the points were divided evenly.

Butterfield, '93, Boyden, '94, Brigham, Kilham, Leland, '95, Zaeder, '96, and Proctor, special, competed in the hammer throwing. Brigham won another first prize and broke the Institute record of last year by a throw of 81 feet, 5 inches, although he did not reach his Intercollegiate distance. Zaeder threw the hammer 68 feet, 1 inch, and won second, while Leland was third at 65 feet, 8 1/4 inches.

The last event on the program was the running broad jump. Five men competed, Derby, '93, Brigham and Stone, '95, Whittall, '96, and Proctor, special, but it was soon evident that the contest would be close between Stone, Brigham and Proctor. Zaeder's ankle prevented him from competing. Stone was first with a
jump of 18 feet, 4 inches; Proctor and Brigham jumped 18 feet, 1\(\frac{1}{2}\) inches and 18 feet, respectively, and took second and third places.

**Summary.**

120 yards hurdle—First, Field, '95; second, Gallagher, '94; third, Davis, '95. Time, 19\(\frac{1}{2}\) seconds.

100 yards dash—First, Killam, '95; second, Derby, '93; third, Stone, '95. Time 11\(\frac{1}{2}\) seconds.

One mile relay race—First, '95; second, '94; third, '96. Time, 3 minutes, 50 seconds.

220 yards dash—First, Philpot, '96; second, Harrington, '95; third, Stone, '95. Time, 26 seconds.

220 yards hurdle—First, Field, '95; second, Harris, '94; third, Andrews, '93. Time, 31\(\frac{1}{2}\) seconds.

Half mile run—First, Gallagher, '94; second, O'Connor, '95; third, Whittall, '96. Time 2 minutes, 16\(\frac{1}{2}\) seconds.

Mile walk—First, Strong, '93; second, But­terfield, '93; third, Tilden, '95. Time, 7 minutes, 37\(\frac{1}{2}\) seconds.

440 yards run—First, Harrington, '95; second, O'Connor, '95; third, Field, '95. Time, 56\(\frac{1}{4}\) seconds.

Mile run—First, Baker, '93; second, Gordon, '94; third, Parks, '95. Time, 5 minutes, 9\(\frac{1}{2}\) seconds.

Two-mile safety bicycle—First, Putnam, '96; second, Gile, special; third, Fuller, '95. Time, 6 minutes, 20\(\frac{1}{2}\) seconds.

Two-mile run—First, Wellington, '95; second, Fuller, '94; third, Linnell, '94. Time, 11 minutes, 30 seconds.

Pole vault—First, Derby, '93; second, Gallagher, '94; third, Leland, '95. Height, 8 feet, 6 inches.

Putting shot—First, Brigham, '95; second, Leland, '95; third, Zaeder, '96. Distance 33 feet.

Throwing hammer—First, Brigham, '95; second, Zaeder, '96; third, Leland, '95. Distance, 81 feet, 5 inches.

Running high jump—First, Zaeder, '96; second, Proctor, special; third, Brigham, '95. Height, 5 feet, 3\(\frac{1}{2}\) inches.

Running broad jump—First, Stone, '95; second, Proctor, special; third, Brigham, '95. Distance, 18 feet, 4 inches.

The points were distributed among the classes as follows:

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**NOTES BY THE WAY.**

**Metallurgical.**

At Thurlow, Pa., on the Delaware River, just below Chester, we pass the works of the Wellman Iron and Steel Co., where are two graduates of the Institute, H. C. Babbitt of '78, who is the chief chemist of the works, and C. F. Treadway of '90, who after having spent a year in Sweden, is learning the whole business of smelting and steel-making. This company uses chiefly Spanish, African and Cuban ores, has blast furnaces, two Bessemer converters and four open-hearth or Siemens-heater steel furnaces. Mr. Babbitt, who was recently in Worce­ester, promises specimens of foreign ores for the Institute collection.

Near Clifton Forge, Va., is seen an abandoned Catalan furnace of an old pattern. It is built of stone, lined with brick, is seven feet wide, ten feet high and five feet deep in exterior dimension, while the fire-place or reducing hearth is about one-half as large. A few miles below, on the Jackson River, is the celebrated Princess blast furnace which produces a very superior quality of pig-iron. Lowmoor, near the western boundary of Virginia, has prosperous iron and steel manufactures and single blast furnaces of old form—very like those shown on the French charts at the Institute—dot the landscape, as seen from the Chesapeake and Ohio railway, all the way from Lynchburg to the Ohio River. Owing to slow sales of products only about one-half of these are now in blast.

Ironton, O., is one of the few places south of Pittsburg where wrought iron is now manufactured. Richmond, Va., Chattanooga, Tenn., and Roanoke, Va., where Marden of '88 and Hammond of '92 make plans for bridges are, I believe, also to be counted for this industry. Generally the Southern ores do not make good forge iron on account of the phosphorus they contain.

Birmingham, Ala., is the largest producer of pig-iron south of Pittsburg. Its output increased ten-fold from 1880 to 1890, and its
population swelled in that decade from 4000 to 40,000. Its coal is burned and coked in the Warrior district only ten to fifteen miles north, its hematite ore from the Clinton beds of the low Silurian hills to the southwest is almost inexhaustible, while it picks up the little flux it needs anywhere in the fields about the city. The blast furnaces here are of the newest patterns, and have the Gordon-Stroebel hot blast stoves. The chimneys of these are higher than the smelters, and in some yards we find four stoves for each furnace. But the pressure of work for which these were originally designed has not been found profitable, and at present one-half of the plants in the city are idle. Foundries abound here, and cooking stoves and railway iron castings are extensively turned out.

**Geological. The Natural Bridge.**

On Tuesday, May 9, we visited the famous Natural Bridge. This is situated in Rockbridge County, Va., about 125 miles west of Richmond, and is accessible from either the Piedmont or the James River division of the Chesapeake and Ohio Railway. A carriage awaits the arrival of every train on either of these roads, at their intersection, at Natural Bridge Station and conveys passengers over the hilly and winding turnpike to the hotel very near the end of the bridge. The stream spanned by the arch is far below. We descended* to it by a winding path, over ledges made slippery by recent rains, and after a sharp turn find ourselves at the margin of a shallow stream six or eight yards in breadth. Beyond and above, at a distance of less than a hundred yards, are the perpendicular walls of the stream-chasm, surmounted and connected by an arch of natural rock of ninety feet span, sixty feet wide and fifty feet in vertical depth at its center. The water babbles below at a distance of one hundred and fifty-five feet from the middle of the arch, and it is two hundred and ten feet from the roadway which traverses the top of the bridge to the surface of the stream beneath. The whole formation is of a compact, half-crystalline limestone, distinctly stratified and almost as distinctly jointed. We looked in vain for fossils, but such masses of calcareous rock belong only to one age, the Silurian.

The interesting problem here is, of course, the cause of the arch. After viewing it from up stream and from down stream, from above and from beneath it, one reaches but a single conclusion. The arch was once the part of the roof of a long and narrow cave. The cave, like all those in limestone regions, was made by dissolving waters, which began their disintegrating work upon a softer stratum about fifty feet from the surface, then wore away deeply as now do the streams in Mammoth and other caves. Finally the thinner and perhaps wider portions of the roof fell in, while this narrower and thicker part was sufficiently strong, not only for self-support but also to bear up growing trees and a rampart of stone. Jefferson once owned this spot, and delighted to bring his guests hither from Monticello, especially if they were foreigners and Frenchmen.

The scenery of West Virginia, especially the region traversed by the C. & O. railway, is very interesting. The mountains are not so high, or grand or awe-inspiring as those of New Hampshire or North Carolina, but they are nevertheless wilder and more rugged. Nowhere else are there so many different geological formations traversed in a short distance, and nowhere else east of the Rockies are the outerops so numerous and easily studied. From Covington to Charleston we have the Archean granites and mica schists, then the limestones of the Silurian, the sandstones and shales of the Devonian, and later the thicker sandstones of the Carboniferous with alternating seams of coal and iron.

The vista of the valley of the Greenbrier River which opens at White Sulphur Springs, and the precipitous and castellated flanks of the deep canyon-like cuttings of the Great Kanawha extending for fifty miles are not easily forgotten. — H. T. F.

**HOW PHOTOGRAPHS ARE MADE.**

In order to speak intelligently on the subject of photography, we must first know what a photograph is. The word photograph, from its derivation, means an engraving by light. Webster says, "It is a picture obtained by photography, especially a picture produced or printed on chemically prepared paper by the action of sunlight, from a negative or reversed image, taken by the camera." Though there are a great variety of photographs as, silver prints, "aristos," bromides, platinitypes, and solios, yet in the general acceptance of the term, when we speak of a photograph we refer to a silver or albumen print. And it is this to which I shall confine myself.

Making a photograph involves two principal operations:—obtaining the negative, and making the print. To obtain the negative we must first prepare a sensitized plate. By the term sensitive we understand, able to secure an impression from a very feeble ray of light, or to receive it quickly from a bright ray. There are
certain chemicals which are sensitive to the light, that is, they either decompose or change color when exposed to the action of light. Certain salts of silver are affected in this way. This phenomenon is used to advantage by the manufacturer of photographic plates. After preparing an emulsion of gelatin, and sensitizing it with some salt of silver he coats his glass or celluloid with this film, in a room that has only red or orange light to which the emulsion is not sensitive. Now we have a sensitive plate and are ready to make a negative.

If a hole is made in a box, from which all other light has been excluded, there is formed at the back of the box an image of everything within its range. This image is inverted, diminished and real. A lens acts in a similar way only more accurately, and requires less focal distance. We might use this box as a camera, placing the sensitized plate at the back and obtain a negative, but the result would not be as satisfactory as if we had used a lens. I take it for granted that my readers understand the construction of a camera. So we set up our camera, focus the image on the ground glass, insert the plate in its place and expose the plate. When the light acts through the lens on the plate, the salts of silver undergo a change, the nature of which is not known. Some advance the theory, that a molecular change occurs, that the molecules are set in a state of rapid vibration by the action of the light. The image however is latent and can only be seen by development and reduction. The appearance of the plate after exposure as far as we can see, is not different from that before but by the aid of certain chemical manipulations we see that there has been a change of some kind. Certain chemicals will reduce this silver which has been acted on by the light, to metallic silver. The process is too long to be included in this article.

Among the agents used for such reduction may be mentioned as the most important, pyrogallie acid, so called, though not an acid, and hydrochinone and eikonogen, which are products of coal tar. This reduction is called developing, and a developer in its simplest form consists of a reducer and an alkali in solution, one to bring out the density and the other for the detail of the picture. The developed plate is called a negative, in it the image is reversed and whatever is light in the finished picture is dark in the negative. When the plate is developed it is still sensitive to light, and to render it permanent it must be subjected to a bath of hypo sulphite of soda, called a fixing bath, which dissolves all the free silver which has not been acted on by the light. As soon as the plate is fixed it must be washed thoroughly to eliminate all traces of hypo. If this is not done the negative will turn yellow. As soon as this is dry we are ready to print unless we wish the negative retouched, that is, to remove any defects in the film or blemishes in the faces or figures in the picture. We may print on glass, porcelain, paper, wood, silk, and in fact on almost anything, but we will confine ourselves to the silver or albumen prints. To make such a print, we must coat some good smooth paper with the white of eggs (we may and generally do buy paper already albumenized, which obviates the necessity of a very dirty, as well as disagreeable, process), then silver it by allowing it to float on a bath of silver nitrate. Next, dry in a dark closet and we are ready to print.

This sensitized paper is cut to size and placed in a printing frame, film side down on the film side of the negative, then put in the sunlight, and examined from time to time until the print is somewhat darker than the finished picture is desired. This allows for bleaching in the final bath. Then they are placed in water to wash out all the free silver and the washing is continued until the water ceases to be milky. Now we are ready to tone, and a bath of gold in the form of a chloride, and an alkali is used. For the gold is more stable than silver, which it replaces, and also gives tone or color to the picture, while the alkali aids the action of the gold. After the desired tone has been reached, the prints are transferred to water and washed, then to a fixing bath composed of a hypo sulphate of soda, which has the property of bleaching the print and at the same time making it permanent. Then the prints are mounted with any good paste that will not injure them and burnished and they are ready for exhibit.

The prints may be spoiled at any stage, so great care should be exercised. The face or film side of the paper should not be touched by the fingers, as the moisture of the hand will leave its marks, and, too, the prints must be thoroughly washed before they are toned, and after they are fixed, or else they are liable to fade. In order to successfully make prints one must be neat, attend strictly to detail, and above all, avoid too much haste, for nothing will cause failure so surely as hurried and consequently careless work.

Edw. H. Keith.

COMMENCEMENT WEEK.

Although there has never been so much made of commencement week here at the Institute as at most colleges, there promises to be considerable this year to occupy the time and minds of
those interested in the Tech. The first event of interest is at 2 o'clock Monday, June 19th, on the campus. At this time occur the class-day exercises which will consist of the following:

Planting of the class tree; Tree Oration by Everett E. Kent; Address by the President of the Class, William H. Parker; Reading of the Class History, by Charles O. Rogers; Banner Oration, by Henry L. Phillips; Class Oration, by Nathan Heard; Address to Undergraduates, by William H. Larkin, Jr. The exercises will as usual take place on a temporary platform erected near the Magnetic Laboratory. In the evening, at Horticultural Hall, will occur the Senior reception. The committee having this in charge have omitted nothing that would help in making the affair a success in every way. An orchestra under the direction of Mr. J. J. Herron will furnish music. The three floors at Horticultural Hall will be used by the class and their friends.

Probably on Tuesday afternoon will occur the annual Senior ball game on Bliss field. Wednesday afternoon at 4.30 the June meeting of the Washburn Mechanical Engineering Society will be held in the Board of Trade rooms on Foster street. Directly following this meeting the meeting and supper of the Alumni Association.

Thursday forenoon in the Chapel at Boynton Hall the examining committee, trustees and friends of the members of the class will listen to extracts from some of the theses.

This is the day that all the buildings are open for inspection and when all the unfortunates who are making up time are expected to be on exhibition in clean overalls and jumpers. The graduation exercises are to be at Association Hall, Thursday evening. Charles Baker, Jr., will give the valedictory address and the commencement speaker, Professor Robert E. Thompson of the University of Pennsylvania, will speak, after which the lucky ones will receive their long sought and hard worked for diplomas. The last event of the week, although not by any means the least interesting to members of the class, will be the class supper, which is to be held directly after the coveted "sheepskins" have been received. Here the "Tale of the Goat" will be brought to a close and the class of ninety-three will cease to be members of the W. P. I.

BANJO AND GUITAR CLUB.

The Tech Banjo and Guitar Club made its first trip to an outside town Decoration day and assisted in giving a concert for the benefit of the Worcester Relief Corps. They took the 4.25 train, arriving in Brookfield an hour later. And there they immediately commenced to paint the town and continued to paint until they left for Worcester the next morning. Amongst others who assisted from Worcester was Louis Brennen, who gave some of his Chinese specialties with great effect, being encored until every body in the house had memorized the tune thoroughly. After the concert the boys danced until twelve and then to wind up the affair in good style they proceeded to serenade the "attractions" until the dampness ruined their banjo strings. The boys played remarkably well, being favored by circumstances, i.e., a good place to tune up in and a good hall to play in. They were royally entertained by the inhabitants of the town, and that they enjoyed themselves is assured by the fact that some of them did not turn up for a couple of days. The arrangements were made for the concert by Mr. Herbert J. Chambers, '95, for which the club extends its thanks.

The quartet, composed of Boyden '94, Chambers '95, Harris '94 and Lamson, '96, played three selections at the "Tea of the Seasons" at Old South, given by the young ladies of that church. The boys were treated to an elegant repast before and after the entertainment. Owing to the heat of the hall the strings kept snapping, but these little accidents did not disturb the composure of the club, but afforded amusement to the audience. The supper tables were tastefully arranged, each table representing a season of the year; the dresses of the young ladies officiating as waitresses corresponded to the colors of the table, making a very pleasing effect.

This practically closes the season for the banjo club. They have been most successful financially, and in point of improvement. They will reorganize next fall and with a number of new members and selections will endeavor to do their share in upholding the name of the Tech in the future, even more successfully than in the past.

W. P. I. S. MILLBURY 2.

On Memorial Day the Tech team went to Millbury, and surprised the natives by easily defeating their crack team. The baseball field however was not especially adapted for skillful playing, as the infield was very uneven and a miniature river ran through right field. Millbury scored in the first inning—Wheelock was hit by pitched ball, stole second and scored on two singles. Their other run was made in the seventh on a
hit, a sacrifice and an excusable error by Howe. For Tech, in the first inning, Howe made a hit, reached third on two wild pitches and scored on Gordon's scratch hit. Two runs were made in the fourth on three hits and a sacrifice. In the seventh, four hits, a base on balls and several errors contributed five more runs. It was an easy victory but Tech would have scored more runs if the base running had been better. In the field, however, the playing was excellent, the three errors all being excusable. Perkins especially played a fine game, while Waite and Philpot kept up their reputation for good battery work.

W. P. I.

A.B. R. B. T.B. S.H. P.O. A. E.
Gallagher, r.f., 3 0 0 0 0 1 0 0
Philpot, c., 5 1 2 2 0 6 1 0
Howe, l.f., 2 2 2 0 1 1 1
Gordon, c.f., 5 0 2 2 0 3 1 0
Cullen, 3b., 5 1 1 1 0 1 2 0
Perkins, 1b., 3 2 2 3 0 10 0 0
Knowles, 2b., 4 1 1 1 1 4 1 0
Warren, s.s., 8 1 2 2 1 1 4 1
Waite, p., 4 0 2 2 1 0 4 0

Totals, 35 8 14 15 3 27 14 3

MILLBURY.

A.B. R. B. T.B. S.H. P.O. A. E.
Wheelock, p., 3b., 4 1 1 1 0 1 2 1
Boyle, c., 4 0 1 1 0 6 1 3
D. Bebo, 2b., 3 0 2 2 0 3 1 0
Chase, c.f., 4 0 1 1 1 1 1 0
A. Bebo, 1b., 3 1 1 1 0 7 0 0
Wright, r.f., 4 0 1 1 1 1 2 0
McAvoy, 3b., 3 0 0 0 0 1 2 1
Crossman, s.s., 4 0 0 0 1 2 1
Frazier, 1.b., 4 0 0 0 0 2 0 0

Totals, 33 2 7 7 2 24 8 6


JUNE MEETING OF THE W. M. E. S.

The following notice has been sent to all members of the Alumni with the notice of the meeting of the Alumni Association:

Worcester Polytechnic Institute, Department of Mechanical Engineering.


MY DEAR SIR:

You are cordially invited to attend the June Meeting of the Washburn Mechanical Engineering Society, to be held in the rooms of the Board of Trade, No. 11 Foster Street, Worcester, Mass., on Wednesday, June 21st, 1893, at 4.30 o'clock, P. M.

The meeting will be addressed by Mr. William R. Billings of '71, and by Mr. John M. Goodell of '88. Mr. Billings' subject is "The Commercial Side of Engineering." Mr. Goodell will speak on "Recent Advances in Municipal Engineering."

The time for this gathering has been selected with reference to the convenience of those who may attend the Alumni Meeting, and the Society Meeting will adjourn just before the hour for the Alumni Meeting. Members of the Society will receive no further notice of the June Meeting. The rooms of the Board of Trade will be open at 3.30 o'clock, to give opportunity for a social hour before listening to the addresses.

Yours sincerely,

Geo. I. Alden, Secretary.

A NEW MEMBER OF THE FACULTY.

With the beginning of the next term Prof. Arthur Kendrick, a graduate of Amherst College, will commence his labors at the Tech. Mr. Kendrick graduated from Amherst in the class of '87, and in the three years following he taught physics and chemistry at the Leicester Academy. Concluding his labors in Leicester in 1890 he entered Harvard for an advanced course. For the past year he has been assistant instructor in the physical laboratory at Harvard. Prof. Kendrick will have charge of general physics, delivering lectures and conducting recitations.

A CANING.

When Instructor George B. Viles came into the room for his last recitation of the term with Division A of the Sophomore Class, he was somewhat surprised to find a silver-headed cane on his desk. On investigating the matter, it was found to be no joke, as the Instructor at first suspected, for a silver plate on the cane bore the inscription:

George B. Viles,
From Division A,
W. P. I., '95.

As soon as he had fairly recovered from his surprise, Mr. Viles spoke a few words expressive of his pleasure at the gift and also of the good feeling which had existed between him and the class.

BIGELOW-RHEUTAN.

Fred Andrew Bigelow, class of '91, and Miss Alice Maribel Rheutan were united in marriage on the evening of June 1st at the home of the bride's parents, 41 Providence St. Rev. Calvin Stebbins of the Church of the Unity performed the ceremony in the library, which was elaborate-
ly decorated with a profusion of white lilacs, lilies of the valley, palms, ferns, and smilax.

Henry J. Ketelle was the best man, and Miss Ellie S. Rheutan, sister of the bride, was the bridesmaid. The ushers were Isaac L. Rheutan, Arthur J. Bassett, Willard B. Walworth, and G. Fred Davis of Boston.

During the ceremony, Sedgwick’s Orchestra of Natick played the wedding march from “Lohengrin.” The numerous presents of silverware, china, etchings, etc., were shown in a room on the second floor. After an informal reception, Mr. and Mrs. Bigelow left for New York. They will reside a short distance from Jersey City in West Bergen, where Mr. Bigelow is employed in the West Bergen Steel Works.

CROSBY-CUMMINGS.

Harry P. Crosby, class of ’90, was married to Miss Nettie G. Cummings, at four o’clock on the afternoon of June 1st. The ceremony was performed by Rev. A. E. Winship at the bride’s home, 10 Bedford St., Lynn. Fifty relatives and friends were present, among whom were Louis E. Booth and Elmer C. Rice, W. P. I. ’90.

After a short trip in New Hampshire, Mr. and Mrs. Crosby will reside in Lynn, where Mr. Crosby is connected with the Thompson-Houston Electric Company.

TECHNICALITIES.

A strawberry supper at Park church, May 31st, was well patronized by Techs.

Members of the Tech Banjo Club recently sat for their pictures at Scherwee’s.

The engagement of Mr. Roswell J. Clapp to Miss Mabel R. Lawrence is announced.

Mr. Paull has arranged a game with the Worcester Academy nine at the Oval for next Monday, June 12.

As there will be no examination in Mechanical Drawing, the Junior Chemists will begin summer practice on Saturday, June 10th.

Mr. Joseph Beals has recovered his bicycle which was stolen from his house two weeks ago. The two thieves and two stolen wheels were found in Albany and brought to this city.

It is known to be a fact that K-O-L-m was alone at the Y. M. C. A. rooms one afternoon last week and, when asked, was obliged to confess that he did not know where G-L-a-h-r was.

Scherwee took a picture of the Sophomore class in the rear of the Salisbury Laboratories last Friday noon. A slight shower, which originated at the third story windows, delayed the proceedings a few minutes.

Chas. P. Goddard, for the last nine years with the Seth Thomas Clock Co. of Thomaston, Conn., has resigned his position with that Co. to take charge of a machine shop in Washington, D. C., connected with the Hollerith Electric Tabulating System.
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