The W. P. I.

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CONTENTS.

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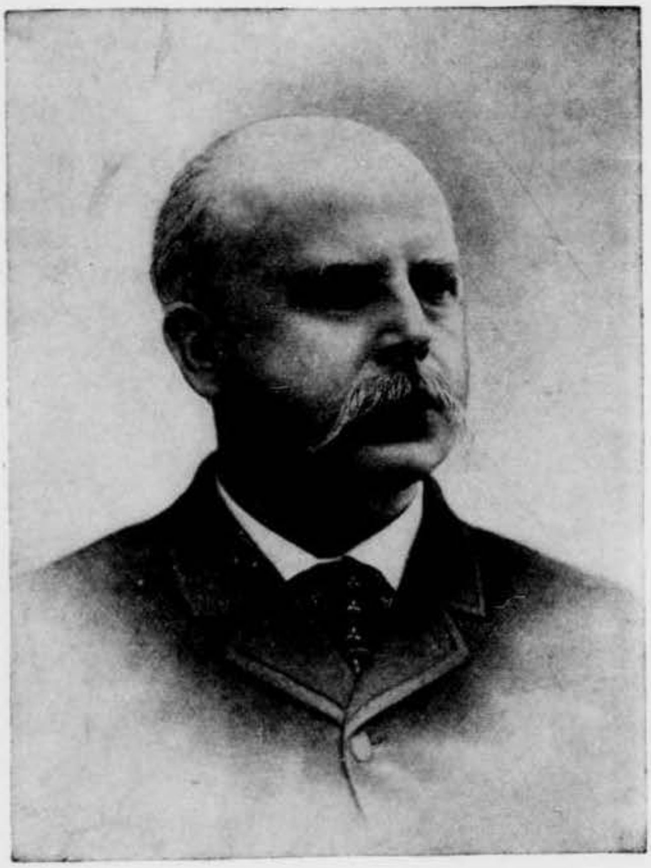
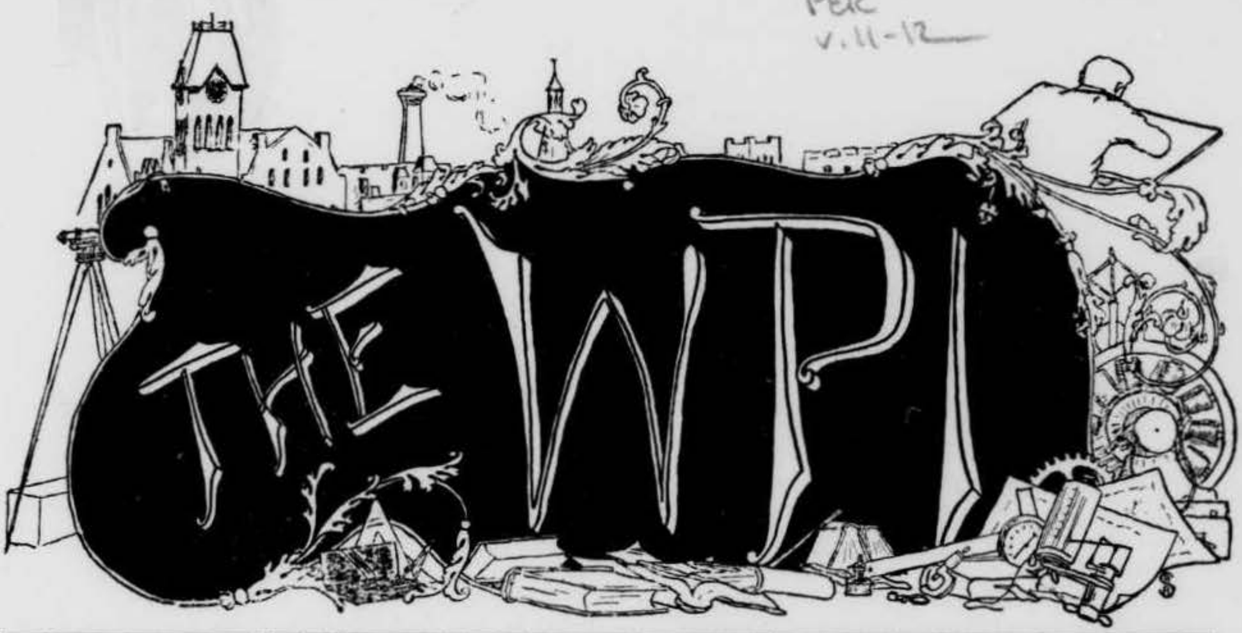


T. C. Mendenhall



Vol. XI. WORCESTER, APRIL 20, 1895. No. 1.

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In commencing its eleventh year the W P I is somewhat diffident of the result. It will be our constant aim and endeavor to make this paper a fit representative of the student and Alumni bodies. We ask aid from all, knowing how hopeless it is for us to expect to succeed without it.

The columns of this paper are open at all times to all who are, and to all who have been, in any way connected with the Institute. To them we say, show us that you feel an interest in our actions, and we shall try to be worthy of your notice. The interest taken by the Alumni in this sheet since its birth is certainly a source of gratification. We hope this interest is still a living, growing one. We earnestly petition for the same indulgence and coöperation which has hitherto always been shown by the Alumni. To the undergraduates all we can say, is that we will do our best, but that without their aid we are helpless. If each one will give us his aid we feel justified in saying that he will never regret it.

The past executive corps have had many difficulties to overcome, and ably have they conducted the conflict. To Mr. Warren and to Mr. Riley more credit belongs than ever can be published. To them we offer our sincere congratulations for their unselfish work. We thank them for upholding the standard of the paper and for fixing such a high goal for us to attain.

Through the kindness of the *Scientific American*, we publish on our opening page the likeness of the President of the Institute, Thomas Corwin Mendenhall, Ph.D., LL.D.

The baseball season which has just begun promises a decided advancement in the popularity of this sport among the colleges. Our own team has started the season under particularly favorable circumstances. All that is necessary to make the year a success from a financial, and, what is more important, from an athletic standpoint, is the hearty support of the students. At the Institute a more hopeful outlook for a successful career has never faced a nine. Why is this so? First and foremost the Faculty have recently shown a marked leniency to all branches of Athletics. Then, when the call was made early in the spring for applicants on the team, more than thirty men applied and supported their applications by constant practice. We may add, as a third reason, the fact that all athletics are now under one control, there is no jealousy between different associations, and, as President Mendenhall once quoted in this connection, "In union there is strength." We repeat, all that is needed is the enthusiasm of the students. Each student must remember, that he sets an example which others will follow. If he is indifferent, others will be indifferent. If he is zealous, others will be zealous also. Will the students do what is expected of them, or will they permit the reputation of last year to be lowered? We are confident, we feel convinced, that the first and not the last will be answered in the affirmative.

We are in receipt of a newspaper from Sydney, New South Wales, containing an address delivered in that city on January 18th by Prof. N. A. Cobb, '81, who is Pathologist to the Department of Agriculture of Australia. The subject of the lecture is "Looking Forward" or the "Final Predominance of the English Language." The article is very interesting and we regret that we are unable to publish it owing to lack of space. Anyone who so desires, may, however, obtain this paper on application to us.

The results of the Interscholastic Meet in Boston lately are certainly of interest to us all. The Tech should take a warm interest in all of the High School and Worcester Academy athletics, if for no other reason than that so many of their men are her graduates, undergraduates or future students. We wish the High School success in everything and we congratulate them on winning the highly prized Shield the second time in succession.

To those, who received a notice through these columns regarding their back subscriptions to this paper, we beg permission to make the following announcement. Mr. Riley, the past business manager, has written to you all, and it is absolutely necessary that he receive, as soon as possible, all payments of subscriptions for the last volume of this paper.

In another column will be found the two papers read before the last meeting of the Washburn Engineering Society. We are indebted to Mr. Clinton Alvord, '86, for his article on gearing and also for his original drawings, cuts from which enable his paper to be more intelligently followed. We are also grateful to Messrs. M. C. Allen, '94, and F. W. Sawyer, '94, for their paper on the transmission of power.

It is with pleasure that we announce the election of Lawrence Powers Tolman, '97, and Howard Sprague Knowlton, '98, to the editorial staff of the W P I.

CONSTRUCTION OF ECCENTRIC AND ODD-SHAPED GEARS BY A GRAPHICAL METHOD.

By Mr. Clinton Alvord, '86.

Mr. President and Members of the Society :—

While reading this paper on gearing, the speaker wishes it understood that he is not presenting a mathematical treatise on the subject, but simply a graphic method of constructing eccentric and odd-shaped gears. He is not an expert on gearing and has studied the subject from time to time only as problems have arisen in the regular course of his work.

It is not my intention to give an engineering paper on the designing of gears to carry given loads under certain conditions. All I desire, is to illustrate a few points in the drawing of odd-shaped gears, hoping some parts may be of interest and profit to some of my hearers, if they ever have occasion to draft a gear which is out of round.

The speaker has never seen a description of a method of drawing eccentric gears, and so has constructed one for himself; but the whole subject is probably an old story to some of my hearers, who may have a better and more accurate method. I find eccentric gears are generally cast gears, and the old shop method was to cast two solid gears, bore them off centre to an equal amount, and then file flat on the sides sufficiently to allow them to rotate. To run well, these gears must always be meshed together on the sides that were filed into each other. A second shop method was to cast two gears in brass, saw away the arms and hub, and then flatten the toothed rings on the sides sufficiently to induce rotation; the hubs being replaced after the required form was found.

I may say the only help I have had in drawing eccentric gears is illustrated in Fig. 1. Here is a

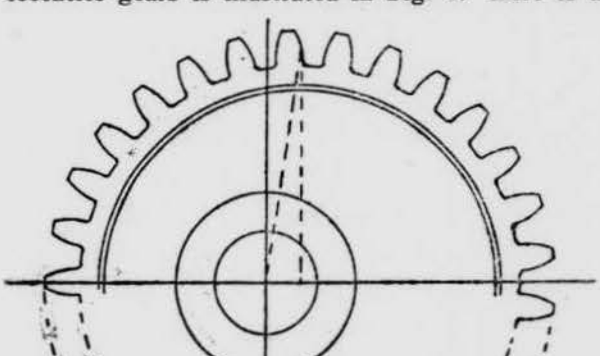

Fig. 1.

simple gear of 7″ longest p. dia. and $\frac{3}{8}$″ eccentricity. I was instructed in such cases to strike my p. circle with a $3\frac{1}{2}$″ radius, to set off the eccentricity (in this case $\frac{3}{8}$″), then to calculate the third side of the right-angled triangle when $\frac{3}{8}$″ is the base, and $3\frac{1}{2}$″, or the radius, is the hypothenuse. Two half circles were then to be struck by placing the dividers off the centre the determined amount, and the teeth erected on these lines. Let me say here, that this is a sufficiently accurate method for a cast gear of small eccentricity. If you have a good wood-pattern-maker, have him make the gear accurately to your shrink drawing, otherwise scratch the bottom lines on a prepared iron disk, and have a good workman cut to the scratched lines. An eccentric gear should have an odd number of teeth so a tooth will always come opposite a space on any diameter, then two castings off one pattern will run with each other.

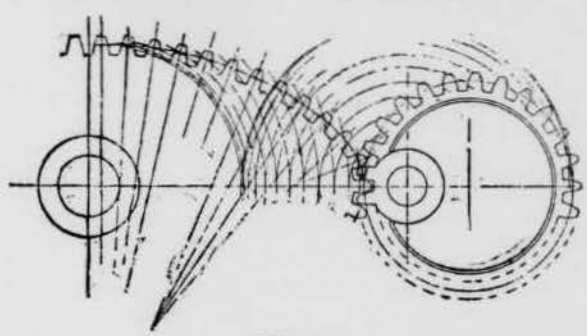

Fig. 2.

Fig. 2 illustrates the second style of problem I came across, and here the speaker had to depend upon himself. It was the solving of this problem that opened the way for all others. My employer had undertaken the problem himself, and after two days of hard work had made a drawing of two 2 to 1 gears that were supposed to run together. In spacing the teeth he was out three teeth on the small gear. After which his patternmaker had two 2 to 1 gears cast in brass and hammered them into shape so they would rotate. All this was some months prior to my advent upon the field of operations. A year later the call was for a pair of smaller gears and of greater eccentricity, and I was advised to go through the brass bending process. Being a draftsman, the speaker had the well founded belief, that a drawing was better. It seems very simple and easy now, but I worked on it for half a day, after which brain effort I told my employer I could design him 2 to 1 eccentric gears of any size, or eccentricity, in half an hour. His polite answer was, that I might be mighty smart, but he had worked two whole days and failed, and I had better hurry along those brass gears. A showing of the drawing, an eloquent description thereof, and finally a strong pleading, drew out a reluctant consent to a trial. Of course the gears ran perfectly, just as good as if cast from cut iron patterns. The speaker thinks he has never seen even a wood-cut of 2 to 1 eccentric gearing. First and always, it is the duty of the draftsman to make things as cheaply as possible. My employer had started with the elliptic gear, and striven to make an eccentric gear to run with it; thus making two expensive wood patterns. The speaker took a cut round iron pattern for the small gear and then bored it off centre as shown here in Fig. 2. That part of the pattern-making was simple and inexpensive.

Manifestly all the teeth and spaces in this small gear must revolve around the hub centre. Therefore I have drawn the lines in which they rotate and we have them here in these light lines which cross the line of centres at these points. The small gear is 6″ p. dia. and 25 teeth; a 50-tooth gear would be 12″ p. dia., and the two gears would be 9″ from centre to centre; therefore I started the centre of the elliptic gear 9″ from the hub centre of the eccentric gear.

In the drawing I have rotated the pitch point of the *spaces* of the eccentric gear. The *teeth* of the elliptic gear will mesh with these spaces. The pitch points of these meshing spaces and teeth must be common where they cross the line of centres; consequently by revolving these common pitch points around the centre of the elliptic gear, we have the lines upon which the teeth of the elliptic gear must be at all times. By setting the dividers at the same pitch as in the eccentric gear and stepping off from line to line, we find our calculations correct. We may find it necessary to correct the pitch to come out just even, for the curve is sharp at the end and flatter on the sides; but if we have been careful the result will be satisfactory. These gears will run together, but the eccentric will not run with another of its kind, nor will the elliptic run with another elliptic. In making the patterns, the eccentric is a round iron cut gear bored off centre, and a good wood pattern-maker will have no trouble in following your shrink drawing for the elliptic.

This laying out, or revolving, the lines on which the teeth rotate, and then finding their position by stepping off the pitch from line to line with the dividers was the method I discovered after a half-day of study, and I have kept to it in all forms of gears. It is simple and when intelligently used will give good results.

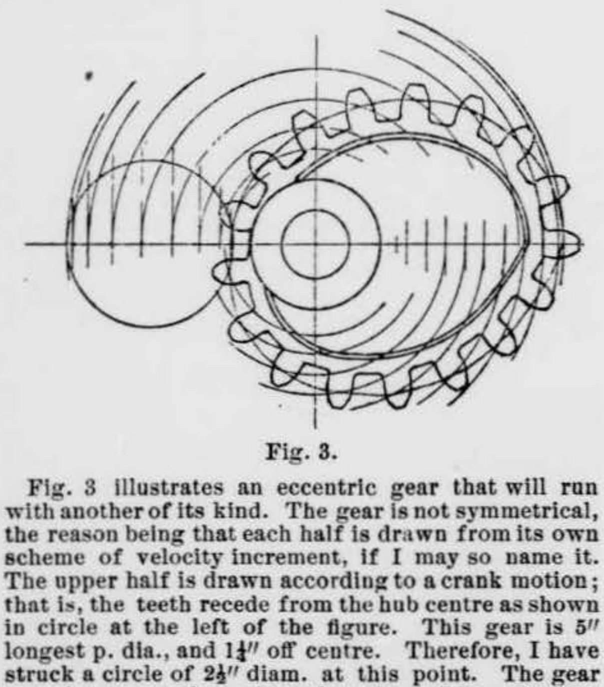

Fig. 3.

Fig. 3 illustrates an eccentric gear that will run with another of its kind. The gear is not symmetrical, the reason being that each half is drawn from its own scheme of velocity increment, if I may so name it. The upper half is drawn according to a crank motion; that is, the teeth recede from the hub centre as shown in circle at the left of the figure. This gear is 5″ longest p. dia., and 1¼″ off centre. Therefore, I have struck a circle of 2½″ diam. at this point. The gear must have an odd number of teeth, so I have divided the circle in 17 equal parts, and projected them down onto the line of centres, which arrangement gives me the desired crank motion. These pitch points are then revolved around the hub centre, as shown, and the pitch stepped off by the dividers from line to line. Two or three trials of course are necessary, as would be the case in an ordinary round gear.

I have erected the teeth perpendicular to the curve on which they are standing, and as the curvature changes they change in shape. The teeth are supposed to be involutes. The reason the lower half of the gear varies in contour from the upper half is as follows: At the right hand side I divided the 2½″ into equal parts representing the number of teeth, and revolved every other point in the manner already described. On stepping off the centres of the teeth I obtained a different curve from the upper half. Two castings from that pattern will run together. The gear could be made wholly on either plan instead of half and half, in which case it would be symmetrical. Somebody is probably saying these gears are constructed and look like cams.

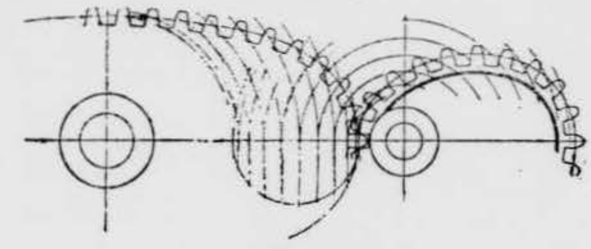

Fig. 4.

Fig. 4 introduces us to a more complex example. Here we have two to one gearing, and the gears will run together, and also each gear will run with another of its kind. I constructed the large gear on the same plan as the upper part of Fig. 3, using the crank motion for development. Having decided on the longest and shortest diameters, I struck a circle, the diameter of which is the difference in length between the major and minor radii. I divided the circle, as in the previous figure, and revolved the lines on which the various teeth must be at all times. Two or three trials with the dividers established the pitch. The pitch is the same in both gears, so with the small gear it is the hub centre which must be found. Two or three trials of centres and revolved pitch lines furnishes the centre, which will satisfy the pitch stepped off by the dividers. As already stated, each of these gears will mesh properly with another of its kind.

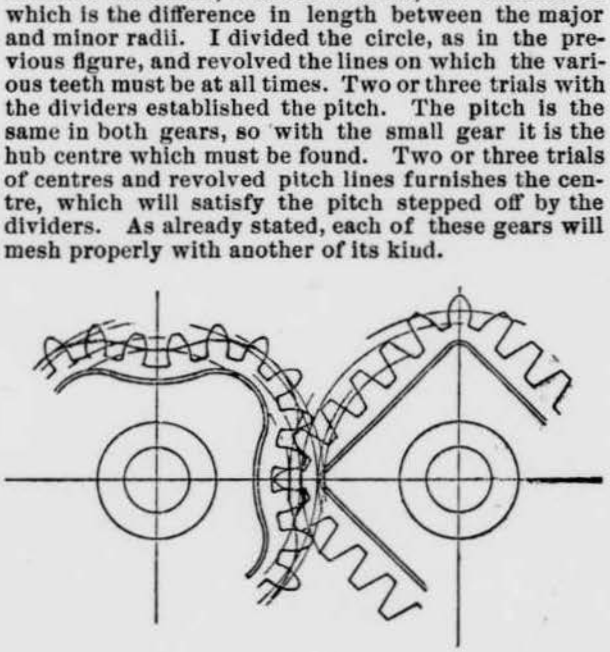

Fig. 5.

Fig. 5 is something which we have all seen in books on gearing, in a perspective wood-cut; but the speaker has never seen a description of any method for constructing such gears. However, this is almost the simplest example on these drawings. Draw the square gear first, forming the corners on a circle, revolve the pitch points of the teeth and then try for the centre of the mate to run with the square gear, exactly as we found the hub centre of the small gear in Fig. 4. I was fortunate enough in this case to find the centre at the first trial, the dividers coming out just even. A problem like that would be termed in slang "a snap."

Fig. 6 was to me the hardest of all, and required the most thought, considering that I already knew I must revolve the pitch points of the teeth. The gears look easy to construct now, but somehow or other at the time I used considerable brain effort in my drawing.

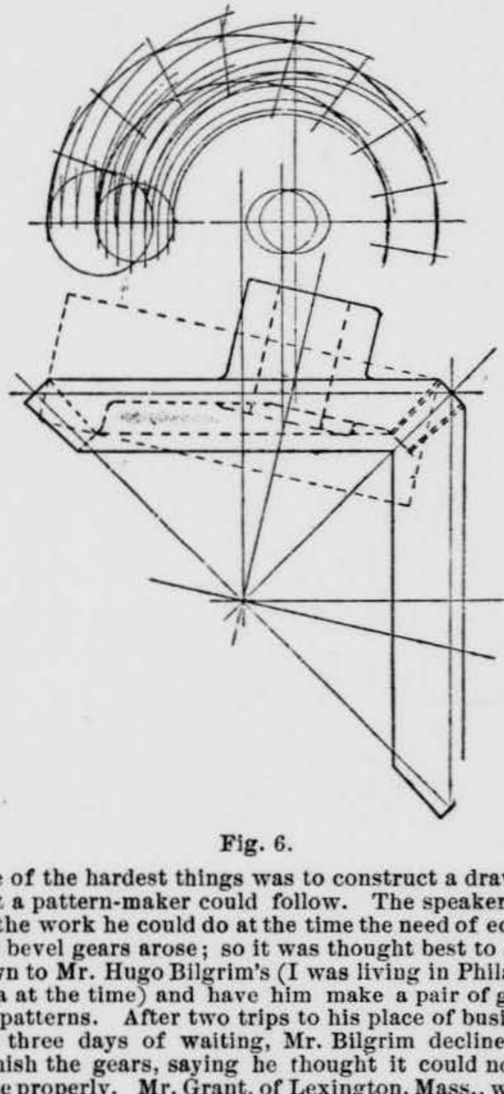

Fig. 6.

One of the hardest things was to construct a drawing that a pattern-maker could follow. The speaker had all the work he could do at the time the need of eccentric bevel gears arose; so it was thought best to send down to Mr. Hugo Bilgrim's (I was living in Philadelphia at the time) and have him make a pair of gears for patterns. After two trips to his place of business and three days of waiting, Mr. Bilgrim declined to furnish the gears, saying he thought it could not be done properly. Mr. Grant, of Lexington, Mass., wrote that it was all explained in his book on gearing, but a careful reading of said publication disclosed only a small wood-cut in perspective with absolutely no description of construction. Then the problem was turned over to the speaker. It is really quite simple, and a good pattern-maker need have no difficulty in making a single pattern of an eccentric bevel gear, any two castings of which will run together nicely.

Sketch in two bevel gears. In this case I have placed them ⅜″ off centre at pitch line of large end. Parallel to the inclined pitch line, draw off and construct the bottom lines of the large and small ends of the gear, exactly as you would construct two eccentric gears of the same number of teeth, but of different pitch. Now please pay attention to the point. It is not the pitch lines that the pattern-maker wants, but the bottom lines. He should first construct the cone which is the bottom of the gear, and upon this fasten the teeth. I find the following to be the easiest method for the pattern-maker. Have him turn out a disk of wood that will just make the bottom cone. I have represented this block by the dotted lines. Cut this block on the lines of the large and small ends of the gear. This will give you a section of a cylinder, cut on an angle, which will conform nearly to your sketch of the large end of the gear. On this cut block he can lay out his hub centres from your drawing, and also the centres of the teeth for both large and small ends. The wood outside of these pitch points is cut away, leaving the bottom cone. Bore the hub centre accurately and fit on the hub, for the gear must be chucked from the hub. Cut out enough teeth for the gear from your sketch of the profile at both large and small ends, and tack them on to the cone by the centre lines already laid out. Get two castings from the pattern and you will be pleased to see how nicely they run. I prided myself a good deal on that method of having the pattern-maker form the bottom cone in that way, and attach the teeth afterwards.

You perceive I have said nothing about rolling circles for the construction of teeth, nor have I advanced any theory, or attempted a mathematical equation for any of the curves. But you can construct odd-shaped gears by this method.

LONG DISTANCE TRANSMISSION OF POWER BY ELECTRICITY.

BY M. C. ALLEN, '94, AND F. W. SAWYER, '94.

To present in as short a paper as this more than a general discussion of the subject of power transmission by electricity would be an impossibility, and we intend to give only a general outline of the different systems, state their advantages and disadvantages, and to detail as far as possible their workings.

Power transmission is advisable only where we have a cheap source of power, as in the case of waterfalls. This is especially true of mining sections in mountainous countries, where the price of fuel is fabulous, and where good streams of running water are quite numerous; but where the cost of fuel is cheap, as in New England, power transmission *in small units* cannot compete with steam generated on the spot.

The three great systems for transmitting power are by the direct current, the single phase alternating, and the polyphase alternating. In transmitting by the direct current we have the dynamo coupled directly to the turbine, the current carried direct to the line and thence to the motors at the other end. Transmission by the direct current is only profitable for short distances and in small units. This system has not been used to any extent in this country, and it has been stamped a failure, but in Europe we find several small plants transmitting a short distance and giving satisfaction. The most noteworthy being in Germany, France and Switzerland. In any power transmission the power transmitted is equal to the current times the E. M. F., and the loss on the line is equal to the current squared times the resistance of the line.

In order to transmit profitably, we can readily see that we must use a high voltage; this will make our current small, consequently our loss on the line a minimum, in fact the limit of economy of transmission is the limit to which we can raise our voltage. In direct current work we can use only small voltages on account of the sparking at the commutator parts.

With the alternating current, voltage is limited only by the perfection of insulation; for the current can be taken from comparatively low pressure machines, and by the use of transformers voltage can be raised and after being transmitted can be lowered to a suitable pressure and distributed. In all alternating current systems we have the generator coupled directly to the turbine, the current taken to transformers, pressure raised, then transmitted to the end of the line, where step-down transformers do their work of lowering the voltage, and the current is distributed to motors, etc., as required.

The three alternating current schemes are the single phase, the two phase, and the three phase systems. The single phase is transmission by a single alternating current; the two phase by two currents differing in phase by 90°, that is one current reaching its maximum value one-quarter of an alternation before the other, and requiring two separate circuits. In the three phase we have three currents differing in phase by 120°, or reaching their maxima at intervals of one-third an alternation, and requiring three separate lead wires. The value of the plants of any of these systems as a transmitting agency depends on the first cost, efficiency of transmission and adaptability of the system. The efficiencies of these three alternating systems do not *vary greatly*, and are dependent on the style of motors used.

Now let us consider the cost of the systems. In almost any system a large per cent. of the cost is with the wire on the line, and it is to this we must pay particular attention. The cost in the pole line is practically the same, and the variation must come in the cost of the wire. On first sight one would think that the single phase, having only a single lead wire and return, would be the cheapest; but such is not the case. In the two phase system there are two separate circuits, each carrying a portion of the load, and requiring two lead and two return wires, but in practice the two return wires are combined to a single wire, making a slight saving in copper. In the three phase there are three separate circuits, each carrying a portion of the current. It has been proven that if the systems are balanced, and the three return wires combined into one, there would be no flow of current through the single return, so that by interlinking the wires no return current can flow, so no return wires are necessary, and in practice we need only the three lead wires. This gives a large saving in copper and is considered by many to be the best system for transmission. It has, however, this disadvantage, that unless the three circuits are loaded equally the return wires cannot be dispensed with.

The adaptability of the systems and their general workings are next to be considered, and present, perhaps, the most interesting part of the paper. In reading of transmission installations we find that a greater difference is drawn between the styles of motors used than between the phases used to transmit. We see the terms synchronous and non-synchronous used more frequently than the term single and poly phase. The synchronous motor is a generator reversed, using electrical power rather than mechanical, and moving at the exact speed of the generator to which it is wired. The induction motor is nothing more than a transformer with an open magnetic circuit, and a revolving secondary. These two types of machines differ widely in their workings. The synchronous motor is not self-starting, but must be brought up to synchronism, that is to the exact speed of the generator, by some auxiliary means. When it is up to speed the alternating current is applied, and the machine continues to run in synchronism. This style of motor is of high efficiency, often having a maximum of 95 per cent., but on account of difficulty in starting they are only used in large units, where the load is continuous for a length of time and where there is no great change in the load. While, in these machines we are not troubled with sparking commutator parts, yet the collecting rings often give us some trouble. Another objection to this machine is that by a large overload the motor is thrown out of synchronism, when it immediately comes to a standstill and a burn-out is generally the result.

Now we have the induction motor, which contains some of the good points which are lacking in the synchronous machine. This motor is self-starting, with a starting torque or couple much larger than the running torque. It runs with less than 2.5 per cent. variation in speed, has no brushes or collecting rings, consequently no sparking; it will stand any overload without a burn-out, and can be installed in small units, is of as high efficiency as a direct current motor, and the machines are of light weight. The power in a mill or machine shop is often subdivided and run to several induction motors which are bolted to the ceiling, and the armatures are coupled directly to the shafting, and thus compensating for their slightly lower efficiency than the synchronous motor by the saving of excessive friction of long lines of shafting. The induction motor has only been on the market a few years and as yet no single phase induction motor has been made which is a commercial success, the successful induction motor being of the two and three phase types.

Considering all systems as to their advantages and disadvantages, it can be readily seen that, for long transmissions and big units, the direct current, on account of its inefficiency for transmission, cannot be used economically. Of the three alternating current systems there is a great diversity of opinion as to the relative merits, and each system has its own particular champion, who seems willing to meet all comers.

Prof. S. P. Thompson says that the single phase alternating system is the coming system. Steinmetz agrees with him and claims that the self-induction of the machines and the capacity on the lines, the two great objections to this system, will eventually be obliterated and then we will hear very little about the polyphase systems. Prof. Forbes seems to be the champion of the two phase system, and he has designed the system by which power will be transmitted from Niagara to Buffalo. The General Electric Company stand by the the three phase system and are firm believers in its superiority.

In the three phase system we find that the self-induction is only 57 per cent. of what it is on the two phase four wire system. A further argument in favor of the three phase is that the cost of wiring is less. But on the other hand, the two phase system has excellent qualities to which the three phase cannot lay claim. Tests show that circuits of the three phase system generator differ in pressure if they are not equally loaded. If independent regulation of circuits is necessary, one circuit can be given a proper pressure from the dynamo and the other circuits can be raised or lowered as required. Now the two phase system can stand this unequal loading, and in the case of incandescent lighting is by far the better system. Another thing in favor of the two phase system is that the load is separated into two divisions rather than three, which makes it much simpler to work. Again, in transforming to different voltages only two transformers are necessary for the two phase, while in the three phase we must have three; and as transformers use up energy, we find a bigger loss in this respect in the three phase than in the two phase.

Now summing up the advantages and disadvantages of the two and three phase, an eminent electrician has said that the two phase was the best adapted to distribution on account of being able to load the circuits unequally, but for simple transmission he thought the three phase the better. Now it has been shown that, by the use of transformers, currents of the two phase can be transformed to currents of the three phase, and currents of the three phase can be transformed as easily to the two. So that some advocate a new system, namely, to transmit power by the three phase, then by the use of transformers convert into a two phase and distribute.

Now, let us for a few minutes look at some of the systems in operation. At El Dorado, Cal., we find a direct current plant supplying a mine with 150 H. P., transmitting the power 7 miles over No. 3 wire, and claiming a saving of 60 per cent. over the previous method, where they had to pay $3.50 a cord for wood.

Again, the General Electric Company put in a plant for the Virginius group of mines near Ouray, Colorado. These mines are in a mountainous country and are about 12,700 ft. above the level of the sea. Previous to the installation of this plant it cost the company about $40,000 per year for power. About 4 miles from the mines is Red Cañon Creek, across which a dam is put. An iron pipe runs along the side of the cañon for 4,000 ft., giving a pressure head of 485 ft., which runs two Pelton wheels of 500 and 720 H. P., respectively. To these wheels are coupled two dynamos of Edison make of 100 K. W. and 60 K. W., and giving a total out-put of 293 H. P. The length of the wire is about 19,000 ft. Electrical machinery at the mines consists of two pumps, 60 and 25 H. P., one 25 H. P. hoist, two 60 H. P. motors, running the concentrator and stamping mills, and a 15 H. P. blower. Current is transmitted from waterfalls to mine at 800 volts pressure, and the mine is very damp. As yet there has been no difficulty whatever with the working of the plant, and everything points to a big gain over the former method of furnishing power.

In Switzerland we find the direct current used for transmitting power to a great extent. On account of the mountainous country swift running streams are numerous, and we find many towns taking advantage of it. A waterwheel is put in and power transmitted to the town, a few miles distant, where it is distributed to the small shops and also used for lighting purposes. Here we find the power transmitted varying from 50 H. P. to 600 H. P., the distance varying from a quarter of a mile to 6½ miles, and the efficiencies from 70 to 80 per cent. So that for mountainous countries like Norway, Sweden, Switzerland, the western part of the United States, Mexico, etc., there is a great future for this means of obtaining power.

The first three phase plant to be installed in this country was at Redlands, Cal., where the cost of coal varies from $8 to $12 per ton. Here we have a stream of water which at its lowest flow can furnish 800 H. P. Two large Pelton wheels of 200 H. P. each are attached to two 50 K. W. three phase generators, delivering current to the line at 2,500 volts. The fields of these machines are excited by two 10 K. W. exciters, each capable of energizing the fields of both. From the power house are run two circuits, each three 00 B. & S. wires; one of these circuits to Redlands, 7½ miles distant, and another to Mentone, 4½ miles. This plant supplies power to the Union Ice Company, where synchronous motors are used, for the operation of the ice plant is continuous for 24 hours per day and, barring accident, for 365 days in the year. These motors are of 150 K. W. capacity and run at 750 revolutions. In Mentone they have 30 arc lamps, besides over 1,000 16 c. p. incandescents distributed over the three legs of the circuit. There are also in the line a number of small induction motors without commutator parts or collecting rings. This plant has been running for some time and has given the best of results, and no trouble has been experienced from unbalancing of light-lines. On account of the extremely high price of coal the financial advantage has been considerable.

One of the best examples of the two phase system that we can give to show its superiority is the proposed Niagara plant. This company, we see by the last *Electrical World*, will deliver 24-hour power in Buffalo for a price between $30 and $40 per H. P. per year. They will transmit, however, 100,000 H. P. and that will bring the cost much lower than if a smaller amount were transmitted.

One of the best examples of a single phase alternating current plant is at Portland, Oregon, where 300 H. P. is transmitted 13 miles at 4,000 volts pressure. At receiving end voltage is 3,300, where it is transformed to 1,100, distributed to ordinary transformers which reduce it again to 50 or 100 volts, as required by consumers.

We have shown where some of the plants have been installed, tried to point the advantages and disadvantages of each, as well as give you some idea of their working. We do not attempt to say which system is the best, but leave that for you to decide. That there is a great future for transmission by electricity goes without saying, and in years to come we expect to see it raised to such a degree of efficiency and profit that smoky cities will be only a thing of history.

DESCRIPTIONS OF THE NEW BUILDINGS.

The Engineering Laboratory.

This building is a substantial brick building, erected in 1894 with funds given by the Commonwealth. The building is 52 feet by 116 feet, with basement and three floors. The basement contains a hydraulic laboratory, an erecting and testing laboratory, a cement-testing laboratory, and room for testing materials of construction. On the first floor is an apparatus room; a laboratory for testing the properties of small samples of metals and other materials, such as woven fabrics, ropes and belts; and a general laboratory for experiments and research in connection with engineering problems and thesis work. On the second floor is a lecture room, 40 feet by 48 feet, two recitation rooms, a reading room and office room. On the third floor is a mechanical drawing room, 48 feet square, with blue-print room; a free-hand drawing room, 32 feet by 48 feet, with model room adjacent, and a room for machine design.

The Power Laboratory.

This is a one-story brick building, 56 feet by 70 feet, containing a boiler room, a room for the manufacture of gas for the generation of power by means of a gas engine, and an engine room, 52 feet by 56 feet, with sub-basement nine feet high for receivers, condensers and steam pipes. This building is located between the Engineering Laboratories and the Washburn Shops, to either of which it can supply heat and power.

The Hydraulic Testing Plant.

A one-story wooden building, sheltering an eighty horse-power turbine and the meters, weirs and other apparatus used in conducting hydraulic tests and experiments. This building has a tower for the location and observation of piezometers connected with the penstock, Venturi meter and the water-wheel casing.

Engineering Laboratory.

The basement floor is equipped with:

1st. A department for testing materials of construction, such as beams, pillars, and structural work, equipped with a 100,000 pound Emery Testing, Machine, and other smaller machines and accompanying apparatus.

2d. A cement-testing department, with facilities for making and testing briquets of cement and other similar material.

3d. A hydraulic department, equipped with pressure tank, pumps, weighing tanks, nozzles of various shapes for experiments with flow of water, weirs, water meters and gauges, and all apparatus required in the experimental study of the principles of hydrostatics and hydraulics.

4th. A department for testing lubricants, provided with oil-testing machines, and means for comparing all the mechanical qualities of lubricants and alloys, as well as of self-lubricating materials for bearings of journals, etc.

5th. A department for temporarily setting up and testing machines and motors for the purpose of measuring either the power required to do certain work, the mechanical perfection of the machine, or its efficiency. Facilities are provided here for the student to dissect, re-assemble, and adjust machines before operating and testing them.

On the first floor is located:

1st. A department equipped for testing the various properties of small samples of materials; such as iron, brass, steel, woven fabrics, ropes, belting, etc.

2d. An apparatus room, in which all the portable and delicate pieces of apparatus are kept, repaired, and tested.

3d. A general laboratory for experiment and research in connection with such problems in Applied Mechanics and Engineering as may be taken up in connection with the regular courses of instruction in the various branches of Engineering, and in thesis work.

Other floors of this building furnish ample space for lecture and recitation rooms, and for extension of laboratory facilities.

Power Laboratory.

In the Power Laboratory the boiler room contains two 80 H. P. upright boilers of the Manning type, built for Tech's special use, and adapted to high steam pressures. Also a steam pump, feed heater, calorimeters, and facilities for weighing coal and feed water, securing flue gases and temperature of same, etc.

The Engine Room contains—

1st. Three highly organized steam engines, so installed that they may be combined to form either a triple or compound engine, and provided with jackets, receivers, condensers, brakes, and all appliances for the economic production and careful measurement of power and of all the quantities required for computing the various efficiencies of the engines under widely varying conditions.

2d. An upright triple engine with cranks set at 120°, and provided with heaters between the cylinders.

A gas producer plant and a gas engine of not less than fifty horse-power will probably be added at an early date, so that either steam or gas as a prmiary source of power will be conveniently available, and comparisions of efficiency and economy readily made.

An electric lighting and power plant will also be installed in the same building.

A shaft runs through the Power Laboratory three feet from the basement floor. One end of this shaft runs underneath the floor of the Washburn Shops, and from this end power is taken for running the Shops. The other end of the shaft enters the Engineering Laboratory. Two travelling cranes in the engine room enable heavy work in any part to be handled with ease in case of changes or repairs, or the setting up of new machines.

The Power Laboratory thus combines three important functions, and in an economical manner. It provides power for the Shops and Laboratory. It supplies light to all the Institute buildings that need it, and it forms a laboratory where students may make tests of boilers and engines on a practical scale and under the usual commercial conditions. At the same time the two sources of power, either of which is sufficient to run the Shops, make it easy to control either source at pleasure (*i. e.* the steam plant or the gas plant) for special experimentation and research.

The Hydraulic Testing Plant or Laboratory is located about four and a half miles from the Institute, near a way station on the Fitchburg railroad (Chaffins), and enables the Institute to offer Engineering students actual practice in testing a turbine water-wheel in a thorough manner, including the handling and measurement of large quantities of water by the most approved methods.

It also furnishes opportunity for the practical illustration of the transmission of power by electricity on a commercial scale, and for this purpose it is planned to install large dynamos at the Hydraulic Laboratory, with motors at the Power Laboratory, so that the various problems relating to insulation, weight of conductors, etc., etc., can be thoroughly studied.

The plant is located on a water privilege with thirty feet head, which furnishes about 80 H. P. for most of the year.

ENGINEERING IN TROPICAL CLIMES.

If one wishes to spend a winter away from snow storms and blizzards, and among orange groves, roses, and lilies, he will find Southern California one of the most delightful spots on earth to pass such a winter, and of all Southern California, Pasadena is demonstratably the most beautiful.

A New Englander can hardly realize what it is to pick oranges from the trees, gather roses, and to enjoy the shade of the spreading branches of the palm in the dead of winter. These one would not expect to see on NewYear's day, a coach parade in which the horses and carriages were lavishly decorated with calla lilies, roses and vines, while the participants were dressed in summer clothing. Yet these are only suggestions of the beauties and pleasures with which the tourist may delight his eyes and heart in this, "Our Italy."

But in this land of eternal summer not only wonders of nature are to be enjoyed; there is a wonder in the field of engineering of which Pasadena has a right to be proud. It is the Mt. Lowe Railway. It has been pronounced by eminent engineers "The Modern Miracle of Railroad Engineering."

From here one may reach this road via the Los Angeles Terminal Ry., the street cars, or the Mt. Lowe tally-ho coaches. After a ride of three miles Altedena station is reached, where connection is made with the trolley line of the Mt. Lowe Ry.

The power is supplied by two sixty horse-power Otto gas engines, and transmitted through Edison generators to the motors by means of the ordinary trolley.

The road rising with a grade of not more that 7% winds around the foothills of the Sierra Madre Mts. into Rubio Cañon. In order to make its ingress possible, shelves had to be hewn out of the precipitous sides of the cañon for the roadbed. To accomplish this in many places, men were let down by ropes from the top of the precipices, and while hanging in mid-air they drilled and blasted away the rock.

Along here the scenery is grand. On one side of the track the mountain rises hundreds of feet perpendicularly upwards, while on the other it is as many more down to the bottom of the cañon. Beyond the gorge are again the mountains, with all their majesty, and far below in the distance lies the peaceful San Gabriel Valley covered with orange groves and vineyards.

At the end of this road, at Rubio Pavilion, the greatest wonder of the railway is seen, "The Great Cable Incline". The incline begins with a grade of only 58%, then increasing to 62% goes on to Echo Mt. with a grade of 48%, which is the least on the road. The grading was very difficult. The rock blasted out of the cuts had to be carried by hand and thrown into the cañon on one side, while much of the material used in construction and the driving machinery at the head of the incline had to be carried to their places on the backs of burros. One of the trestles, which is scarcely 200 feet long, has one of its ends 100 feet higher than the other. This will give an idea of the steepness of the incline.

The track is a three-rail, the inside rail being used with each of the outside ones. There is a four-rail turnout exactly half way up. Here the two cars, which are permanently attached to an endless cable, pass, the one going up as the other comes down.

Power is not only furnished from the station for the trolley system, but a current is also delivered to a Keith motor which is connected by a train of gears to the driving drum of the cable machinery situated at Echo Mt. This is a singular combination of the electric and cable roads.

The cars, placed on ordinary trucks, are divided into three apartments, and built so that the floor is horizontal while it ascends this steep grade. This places the apartments one above another, like stair steps, so that, the cars having no tops, the grand view, which appears before one's eyes, is unobstructed.

A grand view indeed it is. Around you is the grandeur of the mountains; beneath you 3500 feet lies the beautiful San Gabriel and Los Angeles Valleys; and far in the distance is the great Pacific shining like a sea of gold as it is tinted in the rays of the setting sun. It is a great panorama of mountains and valleys, orange groves and vineyards, cities and towns, ocean and islands.

This road has "married the May of the verdure of the valleys to the frosts and storms of the December mountains". "It is literally true that you can play at snowball in the morning, gather roses and oranges at noon, and seek refreshment before sunset by an ocean dip at the beach thirty miles distant."

It was through the efforts of Professor P. S. C. Lowe that this great enterprise was accomplished.

CHAS. N. CHAMBERS, '94.

"SHYLOCK, JR." OR "THE MERCHANT UP TO DATE."

The burlesque of this year will be given at the Worcester Theatre, April 26th and 27th, and the sale of the exchange checks has been far beyond the expectations of the Show Committee. At this writing it is understood to be impossible to obtain exchange checks for the orchestra for either of the evening performances, all the lower boxes have been sold, and but few checks for the orchestra for the matinee can be obtained.

During the spring vacation work on the chorus, ballet and cast has made rapid progress. Rehearsals for the chorus and ballet were of frequent occurrence, and the cast rehearsed daily. The men all take a lively interest in their work and each one is resolved to make the show a success.

As is generally known, the title of the burlesque is "Shylock, Jr." or "The Merchant up to Date." In the primary points the plot follows closely that of Shakespeare's "Merchant of Venice," but most of the characters, however, are made slightly different from the ones portrayed by Shakespeare. There will be numerous specialties woven into the plot and much is expected from these. The ballet has been under the constant supervision of A. W. Doe of the Senior class and he has introduced many entirely new figures, which will surely receive much applause. Special mention should be made of the Blizzard Ballet, on which much time has been spent, and which will close the first act. The chorus is being trained by C. I. Rice, whose work with the show of '93 is so well known and is a guarantee of a good chorus, to say the least.

There is a large number of songs and a great variety of music. Mr. W. S. B. Dana, '97, has composed the music entirely, which is said to be exceedingly bright and catchy, and in spite of the precautions of the committee, some of the airs are now whistled about college to the exclusion of the so-called popular songs of the day. The words to Mr. Dana's music have all been written by the author of the libretto, Mr. Henry W. Doe, and rumor says that they fully uphold the reputation of this clever writer.

Everything seems to point to a decidedly successful production and it is generally believed, that unless all signs fail, the show of '95 will surpass in every respect the burlesque given two years ago, which received such universal commendation.

W. E. S. MEETING.

The regular meeting of the Society was held Monday evening, March 25th, in the Mechanical Model Room of the Salisbury Laboratories.

The meeting was called to order shortly after eight o'clock with President Clement in the chair. The minutes of the last meeting were read by the Secretary and approved by the chair. The amendment to the Constitution regarding dues, notice of which was given at the last meeting, was adopted. Mr. J. P. Murphy, '95, was then admitted to membership according to form.

The first paper to be presented was by Messrs. M. C. Allen and F. W. Sawyer, graduate students in Electrical Engineering, on "Long Distance Transmission of Power by Electricity." This was read by Mr. Allen, and brought forth a large number of important questions from the members. These questions were ably answered by Mr. Sawyer. Dr. Kimball also gave a short talk on some of the practical features of electricity.

Mr. Clinton Alvord, '86, then read a very interesting paper on "The Construction of Eccentric and Odd-Shaped Gears by a Graphical Method." Mr. Alvord accompanied his remarks with frequent references to some small drawings and also with crayon sketches of some of the more intricate steps. At the conclusion of this paper an animated discussion followed, in which Messrs. Tolman, '71, Chase, '77, Parker, '79, and Prof. Alden were the principal speakers.

Mr. Parker, in his remarks on the last paper, suggested that a large amount of data, embodying the essential elements of mechanical engineering, could be collected by the members of the Society. This data, he said, drawn from experimental and research work, would be invaluable as a source of reference, and much material worth would be found in it which could not be obtained from books alone. Such a collection, he thought, would give a more pointed value to the work of the Society.

The meeting, which was largely attended, adjourned at ten o'clock.

BASEBALL.

The first two games in this year's schedule, namely, those with Wesleyan and Trinity, were cancelled on account of wet weather. This was quite unfortunate for Tech, as there were good chances for winning both games. The game for the 20th with the Academy has also been cancelled, but this date will undoubtedly be filled in with a good game.

In the meantime practice is going on steadily. The men are fast getting the kinks out of their arms and most of the players have their "eye on the ball." The first outdoor work was obtained during the early part of the vacation, and the candidates have been out every suitable day since. The men, as a whole, are showing up much better than at this time last year, although they are by no means in perfect condition as yet.

The most likely candidates for the vacant positions are Warren, '95 and Sibley, '96. Both are working hard and putting up a stiff game. Quite a little attention has been directed to Ferry, '98. He is a good hitter and base runner, but is a trifle weak in the field.

The second nine would have played the High School last Saturday if it had been fair weather. They had a very good chance of winning. Chambers is doing their twirling and Leland their catching. They played a practice game with the first team April 6th, and showed that they were good rivals. Several games have already been arranged for them, and they will try hard to have as good a record as the 'Varsity nine.

THE NEW CATALOGUE.

The annual catalogue, which has just made its appearance, is the first one to be issued by our new president, and the common verdict is that it reflects much credit upon him.

The general appearance of the book is different from the old one in that it is larger and of a different color. In the first part of the book there are, besides the list of Trustees, Faculty and Instructors, as formerly, the course of weekly lectures and the special lectures for the current year. The main portion of the catalogue is taken up by a description of the different courses of instruction. The details of each course are given somewhat more fully than in previous catalogues, this being especially true of the mechanical department, of which a very thorough description is given. The list of undergraduate students is transferred to the latter part of the catalogue, coming just before the list of graduates. There is also an alphabetical list of graduates, which is very convenient for anyone who wishes to look up a certain graduate whose class is not known.

At the very end, instead of the pages devoted to advertisements of the Washburn Shops, is a page given up to Alumni associations, giving the officers of each one.

It is understood that Dr. Mendenhall wishes all students who know of persons who are interested in the Tech, to leave the names and addresses of such persons at the office. Catalogues will then be mailed to them, and, if the student so desires, his card will be enclosed with it.

THE NEW SOUTH.

An Interesting Meeting of the C. T. S.

The Current Topics Society met Tuesday Evening, March 19th, and discussed the subject "The New South." The different phases of the situation were taken up as follows: "The work of the Atlanta University in the education of negroes," A. H. Bumstead, '98. "The present condition of the Negro," F. W. Crawshaw, '96. "The future of the race," H. C. Smith, '98. "Politics in the South," F. M. Martin, '95.

Dr. Haynes also spoke of the work of several southern educational institutions, and Prof. Cutler briefly discussed the literature of that section of the country.

A general discussion then followed touching upon the preceding topics as well as upon the manufacturing interests of the Southern States.

Y. M. C. A. MEETING.

The Y. M. C. A. held its annual meeting in Prof. Conant's room, Tuesday noon, March 28, and, after the reading of several reports, the following officers were elected for the ensuing year: President, J. W. Higgins, '96; Vice-President, E. H. Willmarth, '97; Corresponding Secretary, E. G. Beckwith, '97; Recording Secretary, W. B. Bingham, '98; Treasurer, A. T. Fuller, '98.

MAJOR LIVERMORE'S LECTURE.

The regular Monday morning lecture was delivered on March 25th, by Major Livermore of the U. S. Engineering Corps, on the subject, "Lighthouses." The lecturer traced the history of the lighthouse from the ancient ones on the Mediterranean, which were temples dedicated to the gods and having wood fires burned upon their tops at night, to the modern "first class light." He also gave many interesting points concerning lighthouse construction, fog signals, and the modern lighthouse lantern. The lecture was illustrated by many stereopticon views.

A TRAGEDY.

Mr. H. Bender is a nice young man. Tall and stately, with a clean-cut countenance which denotes both character and intelligence. Mr.

Bender combines with a lofty personality a suave, engaging manner and all the qualities of good fellowship so characteristic of the up-to-date youth. When he steps into a fashionable café, orders a welsh rarebit, together with ice water and cigars for himself and friends, then shakes and sticks the house for the layout, he does it in such a deucedly entrancing way that the proprietor smiles, bows, and almost begs his pardon for being allowed to live. When he walks down town with trousers turned up, pipe in mouth, hands in pockets, and shoulders thrown forward, he cuts such a swath that the inhabitants stand aside and gaze after him in open-mouthed wonder. His versatility is only surpassed by his equanimity. In a word, Mr. Bender is a man of parts.

Not long ago, fate decreed that he should accompany a young lady to the theatre. Another, who considered she had a mortgage on his time and talents, resented it. No explanation on his part could mend matters. Revenge she wanted, and revenge she would have. Bender usually had his laundry left on the table in the hall outside his apartments. Accordingly, one morning when she knew him to be at recitations, she went up cautiously, took the bundle and departed. Some copies of the more popular magazines which were lying on the table, were also included in the haul.

Presently it come to be noised about among Bender's classmates, that presents were being received. A young lady would come to the door, ask if Mr. Blank was in, and on being informed that he was not, would leave a small bundle, requesting that it be given to him. Quite a number of the fellows received them, and under precisely the same circumstances as related above. One received a pair of socks, another a necktie and a magazine, a third a collar and a pair of cuffs, still another an athletic shirt used by runners, and so on, till quite a cabinet might have been formed if they were brought together. "Who is she? Where did she get them? Pretty mysterious, old man!" Such were some of the questions and comments passed. Finally one of the fellows, Varsty, received a copy of a periodical with H. Bender written on the cover. That was the first clue. They resolved to test it.

A group of athletes were in one of the dressing-rooms preparing for the tournament. Varsty was taking off his necktie. Suddenly an involuntary exclamation from Bender: "That 's my necktie!" "Those are my stockings and that 's my collar. I can tell by the wagon tongue flaps," followed in quick succession. Then he paused; he had given himself away. Roars of laughter followed. Word was passed to the fellows outside. When he appeared on the track he was guyed unmercifully. "Go it there, stockings! Go it!" "Good work, neckties!" "Keep it up, collars and cuffs! Keep it up!" After the races Bender saw his friends. The favors were neckties, stockings, &c. The menu cards had a cut of a young lady ringing a door-bell just as the moon was beginning its eclipse. '96.

RAMBLER.

Why should not Tech have a track near the Institute grounds? It takes two hours to get twenty minutes' exercise, when a man goes to the Oval. It would not take one-third of that time if a track were located nearby, with the result, that more men would come out, come out oftener, than when they are in the habit of going to the Oval, and, what ought to have weight with the Faculty, it would give a man more time for studies. The field at the bottom of the hill would make an ideal spot. Bliss' field, with a little levelling, would do. A cinder track along the wall, and, a short-distance track, would look good on the lawn tennis courts, though likely to raise opposition. Nothing elaborate is needed. A 100-yards straight-a-way, a small oval track with a level spot inside for jumping and putting shot is all that is wanted. The catalogue recently issued says, "It is difficult to estimate the evil effect of the habit of daily riding to and fro in the cars, upon a student's enthusiasm and singleness of purpose." Here's an opportunity to give the statement a practical indorsement.

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Our classical brethren are way ahead of their Tech brothers in the matter of vacations. To be sure we have the vacations; we need not perform unless we wish to do so, but—it is this very fact wherein the rub comes. A man would rather work in the early days of spring than in the heat of summer, and, while he kicks himself because he cannot have his vacation, he is somewhat reconciled by the thought, that the grime and sweat does not stand an inch thick on his face at this period of the year. The chemists, civils, and mechanics alike, must endure this, yet there is no help for it.

* * * * * *

The remarks made by a gentlemen at the last W. E. S. meeting furnished good food for thought. The Alumni of the Institute, almost all being engaged in practical pursuits and connected with every phase of engineering life, would, by the interchange of opinions and experiences, be of great benefit to each other, to the students now at the Institute, and to the scientific reputation of the Tech. This would mean the establishment of a scientific paper, to be issued under the auspices of the W. E. S. at stated periods, and no doubt it would flourish.

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In a short time the show, everybody with his sister, cousin, and somebody else, will be there. What a night! What fun! Rambler opines that it will be superior to any of the professional shows which have been here in a long while, if rumors which are floating about are to be credited. Everybody looks forward to it with the pleasantest anticipations.

NOTES.

'89. Lieut. Rogers F. Gardner, U. S. A., recently of 16th Infantry, on duty at Fort Douglas, Utah, has been transferred to the 3rd Artillery and is stationed at Key West, Fla.

'90. Herbert E. Austin is at present Professor of Natural Science in the Maryland State Normal School at Baltimore. He was married last August to Miss Lillian E. Denny of Worcester.

'90. W. L. Smith is now located at R. F. Hawkins' Iron Works, Springfield, Mass.

'92. William Nelson has recently received an excellent promotion from the Westinghouse Electric Company, of Pittsburg, Penn. His salary has been doubled and his name placed on the first list for promotion.

'92. William F. Burleigh is now in the chemical department of the West Bergen Steel Works at Jersey City, New Jersey.

'94. Announcement has been made of the engagement of Geo. M. Eaton, '94, to Miss Alice Paine of Redlands, Cal.

'94. Chas. G. Harris is naphtha inspector for the District of Columbia.

'96. R. Sanford Riley has been elected editor-in-chief of Ninety-six's Aftermath, and F. E. Knowles, assistant.

Manager Crawshaw has appointed H. D. Carpenter assistant football manager.

COLLEGE NOTES.

The Cornell musical clubs have given up their proposed trip to England on account of the expense. They will take two short trips in this country instead.

Visitors may witness the practice of crews at Harvard on Mondays only.

Mrs. Leland Stanford proposes to enlarge Stanford University to three times its present size.

M. I. T. has no Easter recess.

The Freshmen of Stevens' Tech have been informed that the Sophs are pleased to allow them to carry canes henceforth.

The Russian language has been added to the curriculum of Cornell University.

The University of Michigan has secured the great World's Fair organ for its chapel services.

An "Alumni Weekly," of eight pages will soon be published by the Harvard *Crimson*.

At Brown each class is compelled to take four hours a week of gymnasium work, marks being given as in other studies.

Football has been prohibited at Georgetown College.

The subject of a gymnasium is being agitated at the Rose P. I., the faculty and trustees guaranteeing that when $1,500 has been raised a building costing between $2,000 and $2,500 shall be erected.

TAKE MOMENTS.

THE shades of night were falling fast,
As through the drawing-room there passed
A crowd of Seniors: each one bore
Bowser's Mechanics, saying o'er
    Take moments!

Their brows were sad; their eyes beneath
Flashed like the "Witch of Agnesi's" teeth,
And like a "cart wheel dollar" rung
The accents of the song they sung,
    Take moments!

Is there no earthly way to do
Those little sums of crank and screw?
Around the spectral problems shone,
And from their lips escaped a groan,
    Take moments!

"Now try this one," the old man said,
And down it came on the Senior's head.
"I can not do it," he replied.
The "Prof." in tones of thunder cried,
    Take moments!!!

"O stay," the maiden said, "and rest
Your o'er wrought brain upon my breast."
"I will," the Senior cried with haste,
"And with my arm around your waist
    Take moments."

Beware of ΣX and Y,
When you around the fulcrum pry.
This was the "Prof's." last warning word,
And from the Seniors 'round was heard,
    Take moments!

At break of day, as heavenward,
The pious Techs the stairway trod,
A sound came on the startled air,
And then they heard a Senior swear,
    Take moments!

And in the twilight cold and gray,
A rigid body there he lay,
While in a trajectory line,
A voice slid from the plane incline,
    Take moments!

θ. λ.