The Wisconsin engineer. Vol. 21, No. 2 November 1916

Madison, Wisconsin: Wisconsin Engineering Journal Association, [s.d.]

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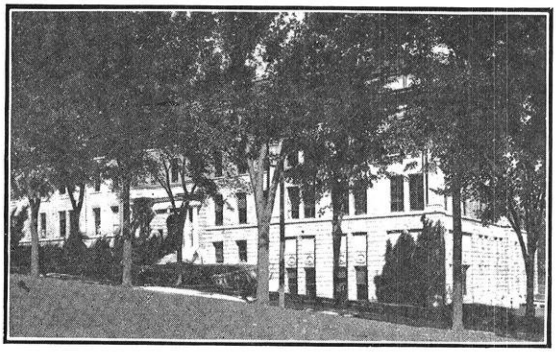
The Wisconsin Engineer

VOL. XXI NOVEMBER, 1916 NO. 2



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The Wisconsin Engineer

VOL. XXI NOVEMBER, 1916 NO. 2.

CHANCE

WARREN WEAVER

There is a popular tendency to scoff at pure mathematics. Although engineers may pride themselves upon belonging to that class of men who realize the necessity and the importance of the laborious study of the mathematician, there is a considerable number of technical graduates who fail to realize the importance of many branches of this science. It is the purpose of this article to point out in a very brief and sketchy way the most essential applications of one of these branches of analysis, namely, the theory of probabilities. By many men, who in the restricted sense of the word are not scientists, this subject is regarded as existing in an upper air of science too attenuated to support healthy and practical existence, but in accordance with M. Laisant [1] there is perhaps no branch of mathematics which is today in more constant usage.

Science has been defined as a body of human knowledge connected by constant relations which man discovers and expresses as laws. Inasmuch as scientific law is by very nature a statement of the invariable sequence of cause and effect, there is apparent as one of the fundamental characteristics of a science a regularity of phenomena,—a sure and substantiated knowledge that a given set of conditions will result in certain definite events. There is nevertheless a large class of phenomena the causes for which human knowledge will never analyze. There are two possible explanations for this unfathomable obscurity: either the cause is apparently non-existent, or it is of such extreme complexity as to elude us permanently. Under such circumstances there is no other alternative than to say that we do not know which of various possibilities will occur. It is evident that an event which at a given time falls in the above-mentioned class is

[1] *Docteur es-sciences. Examinateur a l'Ecole Polytechnique.*

at that time a chance event and forms a subject for contemplation in a way suggested by the various theories of probability. The phrase "at that time" is emphasized since it is perfectly conceivable that a later age, armed with analytical tools which we have thus far failed to secure, may be able to investigate causes which now appear far beyond us and thus elevate an event from the field of probability to that of those sciences which treat with certainty of the single case. It is, then, simply our ignorance that necessitates such study,—not the fact that there is any sort of phenomena that is actually without cause. Every event is the result of the laws of nature, the causes for some being obscure merely because we are ignorant of the ties which unite such events to the entire system of the universe. On this basis, it is evident that events depend upon causes or upon chance according as they appear with or without unchanging regularity in invariable sequence.

It is advantageous at this point to use a single illustration for the two above classes of chance events, since this will point out that the classification while apparent is not real. If one tosses a coin into the air, it is impossible to say whether it will fall heads or tails. At first sight either possibility seems an event without cause, for who can say what makes a coin turn heads one time and tails the next? This may serve therefore as an illustration of the first class of events,—those without apparent cause. We may easily examine, however, why it actually does fall heads or tails, and we see that it is a question of the height to which it is thrown; its rotational speed; the effect upon it of the wind, air resistance, and gravity; the elastic properties that it possesses upon impact with the floor; etc., etc. We can believe that if all these qualities were known and carefully studied we could predict the phenomena and make a very good living by the tossing of coins. It is then of reality the complexity of the cause that forces us to class this as a chance event.

In the light of the definition of science given above, one may question whether the knowledge we may collect concerning such events should be dignified by the name of a science. The answer to this question lies in the obvious fact concerning our illustration—that while no man can say whether a single trial will offer a head or a tail, it is certain that eventually we shall get half heads and half tails. This expresses one of the greatest laws of probabilities, Bernoulli's law of great numbers, an excellent example of which is contained in the following fact: If a million coins be tossed and the heads and tails be counted, it would be expected from this law that 500,000 of each would be found, so that the fractions

$$\frac{\text{number of heads}}{1{,}000{,}000} \text{ and } \frac{\text{number of tails}}{1{,}000{,}000}$$

would each approximately equal 0.5. In point of fact, the probability of either fraction being less than 0.443 or greater than 0.507 is so small that were every person on earth to perform this experiment ten thousand million times every second for 10^{18} centuries, only once in this time would either of these fractions exceed the bounds given.[2]

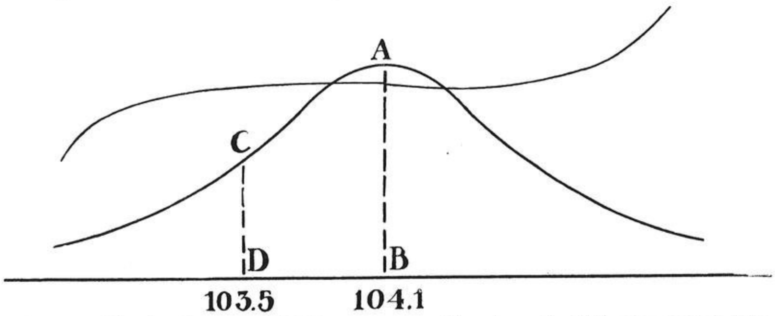
As a matter of fact, then, these events do follow certain laws, and the investigation of these laws is the object of this branch of science. Another of the great laws of probabilities, indeed the very foundation of this subject, is contained in the following statement, the theoretical basis for which is sound and the experimental justification complete: If a given distance be measured a great many times, the results will vary in such a way that if a graph be plotted in which abscissæ represent actual values of measurement and the ordinate at a given point, say, 103.5, represents the number of times we obtain this result when we measure, a curve like the following is obtained. This is the well known probability curve, the equation for which is $y = e^{-kx^2}$.

There is another curve, though not so well known, which is of immense practical value,–the curve of normal distribution. For instance, if a company of university cadets were to arrange themselves in a single line according to height the top of their heads would fall more or less closely on a curve similar to that shown in the figure, there being a few short men, the greater percentage average men, and a few tall men. If any set of physical measurements be ranked in ascending order and thus plotted, a similar curve will result. Thus man's weight, physical strength, length of reach, the diameter of the head, or the keeness of vision all are distributed according to the law exemplified in this curve.

[2] Em Borel, Le Hasard, page 35.

If a certain characteristic is being distributed among men according to chance, its distribution will follow this curve.

Every one that has studied college algebra is familiar with one of the applications of probabilities—its application to games. For instance, we may calculate the probability of throwing a certain combination with dice, of holding a certain hand at cards, or of drawing a given number of black and white balls from a box containing white and black balls in definite proportion Indeed problems of this nature, interesting to be sure but obviously



Curve CA is the probability curve. The length CD measures the frequency with which the result 103.5 was obtained.

The unlettered curve, which is not drawn to any special scale, is the curve of normal distribution.

of themselves trivial, have been studied for several centuries.[3] This is unfortunately the field of probabilities that is best known and with many people the only one known. However self-evident may be the narrow limitations of practicability of such problems, these investigations do give us the material to handle more practical things. Baye's theorem, for example, states the probability that a certain cause has produced a phenomena which has occurred, this probability being affected by the *a priori* hypothesis upon the probability of each cause in question. To illustrate, suppose that a certain urn contains white and black balls in an unknown proportion. Ten balls are drawn and all prove to be white. What are the probable contents of the urn? We see that it is impossible to answer the question without establishing an *a priori* hypothesis of some sort, such as, for example (1) that all

[3] In a commentary on Dante's Devine Comedy published in 1477, is found a reference to the probability of various throws of dice.—Todhunters' Hist. of Prob.

mixtures are equally likely, or (2) that the urn was filled from some elemental source which contained white and black balls in equal proportions, so that while any mixture is theoretically possible, we lean towards the supposition that the urn contains about half white and half black. It is readily seen in the first example that the most probable answer is that the urn contains white balls, whereas in the second case, we should certainly believe that it contained a good many more white than black, but that there were nevertheless some black balls. This theorem serves to give exactly and quantitatively the most probable contents of the urn in each case. Let us now note a practical application of this theorem.

To determine a person's reading vocabulary a scheme has been devised and is offered in one of the education departments of this university. It is as follows: Two hundred words, selected at random from the dictionary, are examined with the end in view of ascertaining familiar words—say 120—and the reading vocabularies is then calculated as $120/200 \times 104{,}000$ words (104,000 being the approximate number of words in the dictionary). The question arises as to whether we may place confidence in such a result.

This case is perfectly analogous to the former illustration of the black and white balls. We are drawing in this case from an urn containing 104,000 words, some black (which we do not know) and some white (which we do know), they being mixed in unknown proportion. Two hundred are drawn, and it is found that 120 are white and that 80 are black. What are the probable contents of the urn, or, in other words what is the probable value of the reading vocabulary. We see that the answer as given above is justified only by the *a priori* hypothesis that all values are equally likely before the experiment is performed.[4] For this reason a man who before the experiment is performed can show

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[4] As a matter of fact, this hypothesis is intenable, since it would force us to admit (in the extreme case) that before the experiment is performed, the possibility that we do not know a single word in the dictionary is as likely as any other possibility. This and thousands of other similar cases are excluded by our common sense. We see that all mixtures are not equally likely before the experiment is performed and that the results of this experiment are not correctly interpreted if the answer be taken as 62500.

in any way that a person's reading vocabulary is probably in the neighborhood of 10,000 words would be entirely incorrect in accepting the above named value, namely: $120/200 \times 104,000$ or about 62,500; but he is entitled to change his *a priori* estimate of 10,000 because of the evidence the experiment furnishes.

The applications of the theories of probabilities to the common problems of life and to our associations with other men are so varied that a mere hint of some of them is all that is possible. It has been said that what the mal-contents of this world desire is not perfect equalization of all property wealth, skill, etc. so that each man should be a machine-like counterpart of every other man, but is equality of opportunity. We may analyse this as meaning that every thing conducive to right and joyous living should be distributed not absolutely equally among men, but *normally* so that this distribution would follow a normal distribution curve. Nature, as we have noted before, actually does distribute our physical attributes in a fair way so that while some of us are tall, some short, some strong, and others weak, none of us should complain. Wealth, as the bitter experience of most of us will prove, is not so normally distributed. Set over against the millions of the earth's population who barely exist financially are a mere handful who hold the world's wealth. It is evident, then, that a possibility exists for an exact quantitative study of the unfair conditions that create economic unrest.

The institution of fire, life, or accident insurance is firmly based on this subject. By the law of great numbers, the company is assured that in the end a definite number of people will die at a specified age, and by means of those laws which show the deviations from this average result, it is able to learn the probable financial crisis that it may have to weather as the result of repeated misfortune. In this manner the reserve fund that will insure them safety may be computed. Indeed, all actuarial science is a direct but simple application of the fundamental laws of chance. Merely to suggest a course of thought concerning another matter of public concern, let us consider the following question, the investigation of which can be made only from the point of view of this science. We elect our law makers by public vote, and after considering the weight of evidence in trials, we acquit or condemn by the juries opinion. Is the probability of error in the steps here concerned—decisions of assemblies, testimonies, or judgments of tribunals—great enough to cause public concern? Although the consideration of this problem has been called the 'scandal of mathematics' by one who could not wisely apply the tools at hand, the results that have been reached by the real thinkers in this subject fully justify the process.

In the consideration of the problem of evolution, there is, apparently, a paradox concerning a theory that speaks of the evolution of species. A logical definition of species should postulate stability, whereas evolution indicates change rather than stability. We can easily imagine all the people on earth who are six feet tall within an eighth of an inch, being isolated as a certain species; but we are sure that within fifty years, the population of this colony would not consist of people six feet tall. This example may serve to suggest to us the possibility that the probable deviation from the average within a certain species will settle our doubts as to the existence of sufficient variation to furnish the steps necessary for evolution. It is obvious that a science such as biology will be served in very few cases by the result of the single example. For instance, the fact that a six foot father has a six foot son does not establish an inheritance law of height. We must concern ourselves, then, with the average result of a great many events. This expresses roughly that which may be expressed exactly by saying that we are dealing with statistical laws, and must employ, on this account, statistical methods. This is the current conservative phrase which escapes the more exciting statement that we must apply the laws of chance.

Another way in which probability can serve biology is in the interpretation of data. Of course this has application in other fields as well. For instance, in considering the race purity in certain Scottish towns, an observation was made on the girls in the city schools of Edinburgh and Glasgow. In the first of these cities, 41.1% of the girls had light hair; in the second, 44.1% had light hair. The question arises as to whether the difference of 3% between these two figures is a probable result of the errors unavoidable in such a sampling process, or, on the other hand, is significant. In this case, we may answer definitely by the laws of probability that there was not one chance in a little over a million that this discrepancy was accidental. We are thus led to seek the cause. The answer to this problem is to be found in the fact that Glasgow has drawn a pure Scottish stock from the highlands during its growth, whereas the plains about Edinburgh have been frequently overrun with British armies, and thus the stock has been mixed.

Another application of this science which is of wide application is in the quantitative analysis of correlation. When one event is the invariable result of the second, we speak of the second as the cause of the first; but when the second event has a variable influence on the production of the first, we speak of the correlation between the two events, meaning the fractional effect that the second has upon the first. If we observe and plot the heights of fathers as abscissæ against the average height of the sons of each as ordinates, the points thus found will be scattered widely. Were the points found to lie exactly on a straight line, it might be interpreted as meaning that the height of the father exactly determined the height of his sons, or as is said, that these two properties were exactly correlated. Considering the actual results, is it legitimate to say that these two quantities are correlated at all, and if so, how much? The answer to this and the entire group of similar questions is obtained by means of any of the various methods of calculating the coefficients of correlation.

One of the most beautiful and satisfactory applications of the theory of probabilities is application of this science to physics. It is well known that the greater the number of observations on chance events the more exactly will the results approximate a fixed law, or as is technically said, it is necessary to take sufficient data to make our statistics regular. The only conditions under which there is any advantage in considering average results are either those such that the phenomena of a single event is without significance or those such that the phenomena of the single event completely escapes our observations. The former is the factor that makes statistical methods so important in sociological and biological problems, the latter factor being the one that makes probabilities the keen edged tool it is for the dissection of natural phenomena. It is sensible to assume that the phenomena of the single molecule will persistently escape experimental investigation. Yet all great branches of physics are built up upon the knowledge of the average result of many millions of such events. Let us consider most briefly a phase of the classic illustration—the kinetic theory of gases.

Suppose that at a certain instant we know the direction and magnitude of the velocity of each molecule in a certain volume of gas. Within a second after this instant millions of inter-molecular collisions have occurred in such a manner that the direction of motion of each has been changed countless times,[5] and each has doubtless enjoyed every possible value of speed. We easily see that whatever may have been the original distribution of velocity, it will now be distributed purely by chance among the molecules, but with the one restriction that since the heat energy content of the gas has not changed, the average value of the sum of the squares of the velocities must be the same as before. Let us suppose then that a given molecule is represented by the point O and its velocity at a given instant by the vector OM. We are led by our former statement to consider the most probable distribution of points, such as M, requiring that the sum of the squares of the distances from O have a fixed value. If this problem can be solved, the most probable distribution of velocities among the molecules of the gas may be determined. This problem offers no serious difficulties as an exercise in continued probabilities, and its solution gives rise to Maxwell's law or to the fact that the distribution of these points M in space is proportional to $e^{-k^2v^2}$, in which v is a distance such as OM. Obviously these points are most dense about O, but it is easily proved that the most frequent value for speed is of course, not zero, but a speed in the neighborhood of 1/k. Velocities ten times as large are exceedingly rare, since they correspond to points M whose density is $e.^{-100}$ It is an interesting fact that in a given plane these points are distributed exactly as would be the bullet holes of a very large number of marksmen aiming at the point O.

In a manner similar to this, the great laws of gases have been placed upon a firm scientific basis, and it is to the theory of probabilities that the framework of all practical gas calculations—Van der Waals' equation—owes its existence. A considerable amount, indeed practically all, of the modern work on ionization, magnetic permeability of gases, the experimental work on the

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[5] This number is of the order 10^9 per second. See Jean Perrin, Les Atoms.

Brownian movement, the diffuse dispersion of light by molecules, the double magnetic and electric refraction of fluids, the thermodynamic properties of ultra-rarified gases, the equipartition of energy, and the conception of entropy as a logarithm of a probability stands as testimony of the amazing power and applicability of this branch of mathematics—a branch which is but partly developed, but whose future is perhaps more glowingly promising than that of any other of the great concepts of modern analysis.

A PHYSICAL INTERPRETATION OF POWER FACTOR

Robert C. Disque
Assistant Professor of Electrical Engineering

One of the most difficult concepts for the beginner in electrical engineering is that of the power factor. Although as an abstract process the mathematical interpretation of power factor is simple enough, the physical significance of the phenomena represented is not clear to many students of the subject. It will be the purpose of this article to explain the power factor by basing it primarily upon its purely mechanical aspects, subordinating the mathematical relations as much as possible to these aspects.

We shall begin by considering a bi-polar alternator with a single coil as represented in Figure 1. Let the armature be driven in a clockwise direction by some prime mover, and assume that both current and voltage are sine functions. Furthermore as an initial case, let the current be in phase with the voltage generated. Now if time be counted zero when the coil is horizontal as shown, the current will reach its maximum as the coil rotates to the vertical position; it will then fall to zero when the coil is again horizontal, will rise to a maximum in the opposite direction when the coil reaches the vertical position, and will fall to zero again as it becomes horizontal. The current will follow precisely the same cycle, reaching its maximum and zero values at the same time as the voltage.

Let us next consider the electromagnetic torque exerted by the conductors on the armature in this particular case. The torque is at any instant proportional to the product of the current and the strength of the field through which the conductor carrying that current is being driven. But the voltage is proportional to the strength of the field, and therefore we may say that the electromagnetic torque is at any instant proportional to the product of the current and the voltage generated at that instant. In the case at hand, in which the current is in phase with the generated voltage, the current is at every instant in the same direction as the voltage, whereas the electromagnetic torque, according to Lenz's Law, is opposed to the motion of the prime mover at every instant. When the voltage passes through its zero value and change in direction, that is, when the coil enters the field of opposite polarity, the current,

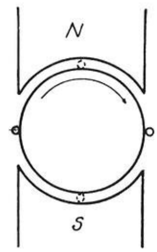


Figure 1

being in phase with the voltage, also changes in direction; hence the torque remains in the same direction as before or against the torque of the prime mover. Since the torque is proportional to the product of the two alternating values, it is obviously not constant in value. In fact it pulsates with a frequency double that of the current, as will be shown later.

The fact that the electromagnetic torque is at every instant opposed to the torque of the prime mover means of course that *power is being absorbed from the prime mover at every instant.* This is the physical criterion for unity power if sine waves of voltage and current are assumed. This criterion will be made clearer by a consideration of the case where the current is out of phase with the voltage.

Let it be next assumed that the current lags behind the voltage by a certain amount or that it reaches its maximum value somewhat later and passes through its zero value somewhat later than the voltage. This means that when the generated voltage is passing through its zero value and the coil is therefore in its horizontal position, the current in the coil has not yet reached its zero value; therefore when the coil passes under the influence of the next pole the current remains for a fraction of a cycle in the old direction. During this interval, until the current is also ready to change direction, the torque is opposite in direction to what it was when both current and voltage were in the same direction. Now this opposite torque is in the same direction as the torque of the prime mover. In other words, the prime mover is being driven during this interval by the alternator, which is acting as a motor. This continues until the current reaches its zero value and changes in the opposite direction, whereupon the torque returns to its opposite direction and the alternator resumes operation as a generator. In general there will be two such motoring intervals in each cycle because of the fact that the voltage passes through zero twice in each half cycle, and each time is followed by the fall of the current to zero. Moreover the duration of the motor intervals is proportional to the lag of the current behind the voltage. During these intervals the prime mover absorbs energy from the alternator, and thus it follows that the total power absorbed permanently by the alternator must be less than it was when the current and voltage were in phase and there were no motor intervals, even though the sine waves of current and voltage are the same in value as before. When intervals of motor torque like those here described occur on account of a difference in phase between the current and voltage, the power factor is less than unity. It is clear that so far as the occurrence of motor intervals is concerned, the same results will occur if the current leads. In that case the voltage changes in direction after the current has passed through its zero value, and the motor interval continues until the voltage in its turn changes in direction. Fractional power factor may therefore result from either lead or lag of the current.

We pass next to the question as to the source of the power which drives the alternator as a motor during these intervals. Since the prime mover is the only source of energy in the circuit we must conclude that by some means the motor energy came originally from it. The mechanical energy of the prime mover must have been transformed into electrical energy, stored up as such in some suitable reservoir, as it were, during the generator proportion of the cycle and returned to the alternator during the motor portion of the cycle. In the case of a lagging current, this reservoir is the magnetic field, associated with the inductance, that causes the lag; with a leading current it is the dielectric associated with the capacity that causes the lead. It will be remembered that the back voltage of inductance is proportional to the rate change of current. Now as the generated voltage falls toward zero there are intervals when this back voltage is actually greater than the generated voltage and is able to maintain the current in a direction opposite to the generator voltage. This occurs until the latter rises sufficiently again to change the direction of the current, and at this point generator action is resumed. A similar situation exists in the case of a leading current.

What then actually occurs in this case is that part of the energy transformed into electrical form during the generator interval is stored up in the circuit, to be returned to the prime mover during the subsequent motor interval. The remainder of the energy is permanently absorbed in the electric circuit by being transformed into heat, chemical, or mechanical energy. That which is permanently absorbed in each case is equal to the difference between the energy of the generator interval and that of the motor interval. The ratio between the power absorbed under these conditions and that which would be permanently absorbed if the current and voltage were in phase is the power factor.

Under the conditions in which the current lags behind the voltage by ninety degrees, the current in the alternator is opposed to the voltage during exactly one-half of the cycle and is in the same direction in the other half. Every alternate quarter cycle is a motor interval, and the intervals between are generator intervals. It follows that the generator energy of one quarter cycle is completely stored in the inductance or capacity as the case may be, and is all returned during the immediate subsequent quarter cycle. This condition resembles the interchange between the kinetic and potential energy that takes place in the perfect pendulum. No power whatever is permanently absorbed by the circuit and the power factor is consequently zero. This condition, like that of the perfect pendulum, is impossible because resistance is invariably present in the electric conductors, introducing a power absorbing component.

It has been shown that a current in phase with the voltage means the continuous absorption of energy by the alternator and that a current ninety degrees out of phase means a pendulous interchange of power between the prime mover and alternator with no absorption. Since a sine wave by its mathematical properties can always be resolved into two components along any two axes it is often convenient to resolve an out of phase current into two components, one in phase with the voltage and the other ninety degrees out of phase, leading or lagging as the case may be. The component in phase is known as the power component, the one ninety degrees out of phase, the wattless component. The product of the former into the voltage measures the power absorbed and transformed by the alternator, and the product of the latter by the voltage measures the power that is alternately taken and returned by the electric circuit. The ratio between the power absorbed as here defined to the product of the voltage into the entire current is the power factor.

The question often arises in the mind of the student as to whether the wattless current can heat the conductors through which it passes. To answer this question, it must be remembered that the term wattless current is used as a mathematical abstraction to measure the amount of oscillating power. It can never exist alone; it invariably must be accompanied by the power component because of the fact that resistance is inevitable in every electric circuit. The presence of resistance reduces the relative value of the wattless component, but the product of the latter by the voltage is always the interchanged power, no part of which can possibly be absorbed. In this sense, it is evident that a heavy wattless current—that is, a large amount of oscillating power—necessarily involves the absorption of power in the resistance through which it oscillates, but no part of the oscillating power is absorbed as heat.

The relation of the phenomena herein described to the mathematical treatment of power factor can now readily be understood. If two sine waves, one of voltage and the other of current, be drawn in phase with each other, the product at any time will be

$$E\ I\ \sin^2 wt$$

in which E and I are maximum values of voltage and current, respectively, and w is the angular velocity. This product measures the power absorbed by the generator at time t. It is positive for all values of t and if it is plotted, the resulting curve will be like that shown in Figure 2. Now work is the time integral of power, but this time integral in this illustration is the area

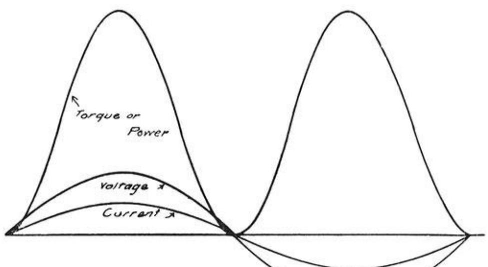


Figure 2

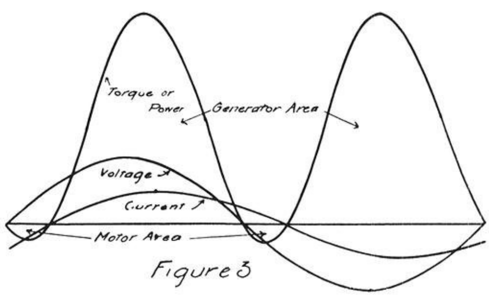


Figure 3

under the power curve. If this area be found by integrating the product over a certain time and if the result be divided by the time, the result will be $\frac{E\,I}{2}$, which is usually written

$$\frac{E\,I}{\sqrt{2}\ \sqrt{2}}$$

The term $\frac{E}{\sqrt{2}}$ is called the effective value of the voltage, and $\frac{I}{\sqrt{2}}$ the effective value of the current. The curve of power expresses the fact that at every instant power is being absorbed by the generator. This is due to the fact that no part of it is negative.

If, however, the current lags the voltage by an angle ϕ the product expressed as a function of the time is

$$E\ I\ \sin wt\ \sin\ (wt - \phi)$$

If this curve be plotted, the result will be Figure 3, in which it is seen that there are negative portions. These negative portions correspond to motor power in the alternator as already explained. Now the net energy, converted by the alternator during the cycle, the positive area of the product curve, and the part returned to the prime mover in the form of motor power, is the negative area. The net power absorbed and retained by the electric circuit is the difference between the two areas. Now when the integral of a function which has positive and negative values is taken, the result is the difference between the positive and negative areas. Consequently the time integral of the above product gives the net energy permanently absorbed by the electric circuit during the period over which the integral is taken. This net energy divided by the time of the integral gives, of course, the net rate at which power is permanently absorbed. This is found to be

$$\frac{E\ I}{2}\cos\varphi$$

which can be written as before

$$\frac{E\ I\cos\varphi}{\sqrt{2}\ \sqrt{2}}$$

It is thus seen that the product of the effective values must be multiplied by the cosine of ϕ in order to give the rate at which energy is permanently transformed and absorbed. This factor, cosine ϕ is known as the power factor.

THE EFFECT OF SURFACE CONDITIONS UPON THE RATE OF HEAT TRANSMISSION THROUGH STEAM PIPE COVERINGS. PART I

A. D. FULTON AND R. C. PARLETT

EDITOR'S NOTE: This is the first of two installments of a thesis submitted for the degree of Mechanical Engineer, June, 1916. This thesis has completed the investigations of Mr. McMillan under whose direction this thesis was developed, and it really is the concluding portion of his research reviewed in the WISCONSIN ENGINEER for November, 1914.

A consideration of the loss of heat by radiation from heated surfaces is one of the very great importance in power plants, and the necessity of minimizing such losses is well-recognized by all engineers. It is well known that the amount of this loss depends in a very large measure upon the character of the surface and such conditions of the surrounding air as, temperature, velocity, etc. Thus, uncovered steam pipes at high temperatures are not to be thought of in well-regulated plants; but the insulation against such losses of heat cannot be intelligently done until correct information concerning all factors is at hand.

In spite of the fact that a very large amount of highly valuable work has been done in connection with the determining of losses of heat through steam pipe coverings, there are three factors which have been very consistently neglected. These are:

1. Humidity of the air surrounding the pipe.
2. Velocity of the air past the pipe.
3. Nature of the surface of the pipe covering.

In some of the more thorough discussions of the subject these factors have been mentioned, but very little has been done to show their importance and the extent to which they may affect the rate of heat flow through the pipe covering. It was with the object in view of thoroughly investigating the effects of these factors that this thesis was undertaken. In the following pages is given a complete description of the methods employed and a discussion of the results obtained.

REVIEW OF FORMER INVESTIGATIONS

By far the most comprehensive treatise on the subject of Heat Insulation yet published is the paper on The Heat Insulating

Properties of Commercial Steam Pipe Coverings[1] by L. B. McMillan, instructor in Steam and Gas Engineering at the University of Wisconsin. This author conducted an extensive series of tests, covering a period of more than two years in which many valuable results were obtained. The scope of this work is best described by quoting directly from his paper:

"The effect on heat losses of varying the temperature difference between pipe surface and air between limits of 0 and 500 degrees Fahrenheit has been thoroughly investigated, and the conclusions reached will be fully explained. Different thicknesses of material up to 3 inches were tested and the laws confirmed by the results of these tests to permit of their application to any thickness whatsoever. The drop in temperature from steam in a pipe to the inner and outer surfaces of the pipe wall under various conditions has been accurately determined. Another new fact brought out was that the loss from any covered pipe is a function of the temperature difference between the surface of the covering and the surrounding air; and that this function is the same for all coverings having the same character of surface regardless of what the other properties of the covering may be, since the effects, if any, of these properties appear in the temperature difference. The value of the function has been determined for canvas covered surfaces, and a complete explanation of its significance is here included." These tests were made in still air, the character of the surface was the same for all the coverings, and the effect of humidity was not noted. No conclusion as to the effects of air currents, character of surface, or of humidity could be drawn; and it remains for this paper to explain fully the effects of those very important factors.

In a paper by Professor Norton,[2] describing his work on this problem, the subject of air currents and humidity was developed to only a small degree. To quote his words: "It was found early in the series that a variation in the amount of moisture present in the air altered the amount of heat lost from the covers, but no attempt was made to correct for this. The error introduced is not greater than one per cent." In summing up his paper he says, "The effect of air currents and the increase in the moisture

[1] Transactions of A. S. M. E. Vol. 37.

[2] Transactions of A. S. M. E. Vol. 19.

of the air have been studied and I have been unable, by means of electric fans and artificial dampening of the air, to change the heat loss from a pipe enclosed with a cover by more than 10 per cent.''

Prof. Carpenter in the discussion of this paper says ''I am fully satisfied that the amount of heat which is given off from a steam pipe may vary 200 to 300 per cent depending upon the rate of motion of the air and its hygrometric condition, and I fully believe that difference of 5 to 19% may be caused by changes in air currents which are almost imperceptible to the observer. For these various reasons I cannot help but believe that accurate information of the heat losses of steam pipes should be made under conditions which at least approximate those of actual use.''

Engineers in general seem to think that heat losses from a covered pipe are directly proportional to the humidity. The extent to which the above theories and beliefs are true is left for this paper to show.

DESCRIPTION OF APPARATUS

The apparatus used in both determinations of the effect of humidity and the effect of the surface conditions of the covering was the same as used by Mr. McMillan in his tests, because this apparatus was far superior to that used by former investigators. In describing the fundamental method of the tests Mr. McMillan says:

''It was proposed to heat a section of covered pipe by means of an electric heater made up of resistance coils immersed in oil inside the pipe, and to calculate the amount of heat lost through the covering by measuring the energy required to hold the outside metal of the pipe at a constant known temperature. Under such conditions it is evident that just enough energy is being supplied to compensate for the losses through the covering, otherwise the excess or deficiency of energy will cause the pipe to heat up or cool off as the case may be. This must be true for, according to the law of the conservation of energy all energy entering must appear as heat if none is transformed into any other form and none is lost.''

The superiority of this electrical method over all other methods previously used lies in three facts, namely:

1. Higher pipe temperature can be obtained.
2. The pipe temperature can be kept constant.

3. Measurements can be more accurately made.

The test pipe was a 16 foot section of standard five inch steel pipe closed at the ends and filled with gas engine cylinder oil. It also contained resistance coils which served as an electric heater and a stirring device to keep the oil in constant circulation. The remainder of the apparatus consisted of the necessary electrical instruments for measuring the energy input; a small electric motor for driving the circulating propellor; the thermometers for measuring room temperature and the temperature of the surface of the covering; nine copper-constantan thermo-couples and slide wire potentiometer used in determining the temperature of the pipe; a high and low voltage alarm; and lamp banks with rheostats for voltage and current regulation.

About five inches of each end of the test pipe were covered with a one-inch layer of sectional 85 per cent magnesia, leaving exactly 15 feet of the central portion of the pipe to be used as the test section for five lengths of standard pipe covering. The remaining surface of the ends was also covered with plastic 85 per cent magnesia to a depth of about one inch, and the pipe was then suspended in a horizontal position by wires from the ceiling attached to steel bands placed around the short end sections just described. These remained in place throughout the entire series of tests, and the only coverings changed were the five lengths on the 15 feet of test section.

Another device, similar to the one used by Mr. McMillan in his tests for measuring the heat losses through the permanently covered ends, consisted of an exact reproduction of the permanently covered ends of the test pipe, the data from which were used by the writers in correcting their runs in the long pipe. With this apparatus, it is evident that if the 15-foot section already mentioned were cut out and the two ends of the pipe brought together, an exact duplicate of the short pipe would result, in so far as length exposed area, and character of covering are concerned. Therefore the difference between the loss from the test pipe and that from the short pipe represented the exact loss from the 15-foot section covered with five standard lengths of commercial covering. To measure the temperature of this pipe, two of the nine thermocouples were used.

In front of this short pipe and suspended also from the ceiling was a 10-inch galvanized iron pipe, through which air was forced by a fan driven by a shunt motor. An ordinary oil barrel with a hole cut in one end was suspended from the ceiling so as to enclose the short pipe and fit over the end of the galvanized pipe. In order to keep the air which passed through the galvanized pipe from striking the short pipe on the end, a circular baffle made of tin and the same size as the end of the short pipe was placed within the barrel between the end of the galvanized pipe and the test pipe and about three inches from each. This allowed the air to pass freely all around the test pipe. To measure the temperature of air sweeping past the test pipe, thermometers were placed with their ends extending into the galvanized pipe just in front of the barrel and baffle.

To determine the effects of the condition of the covering surface on heat losses, a covering was used for which the total heat loss in B. t. u. per hour per square foot of pipe surface per degree difference of temperature between the pipe and the surrounding air was known. The coverings that were used were of 85% magnesia and were plain canvas covered. This surface was then given two coats of J. M. cold water paint, such as is used in many power plant installations, and was allowed to dry thoroughly; all measurements of thickness were taken; and the test was started.

A comparatively high current was passed through the pipe until it was heated to near the desired temperature. The current was then lowered to a value that would just hold the temperature of the outside of the pipe constant. A little experimenting was sufficient to show what power input was necessary to maintain this temperature. The current was then adjusted to such a value as would make the power input a little greater than the estimated value and was allowed to remain at this temperature for a period of several hours. If the first estimate was nearly correct, the temperature would rise slowly for a while and would become constant at some point at which the losses were exactly equal to the electrical input. This usually required from six to ten hours depending upon the correctness of the preliminary estimate. When this condition had been maintained for an hour, readings were taken of temperatures of the room and the outside of the pipe covering, the current in heater, the voltage across heater terminals, and the humidity of the air in the room. The current was immediately diminished by about half an ampere, allowing the temperature to fall until it reached a value where the losses were just equal to this smaller amount of energy supplied. At this point readings were taken as before. From the data thus obtained, the resulting losses in B. T. U.'s of watt-hours, and the values of watt-hours were transformed into B. T. U. by multiplying by 3.413. The resulting losses per hour were plotted

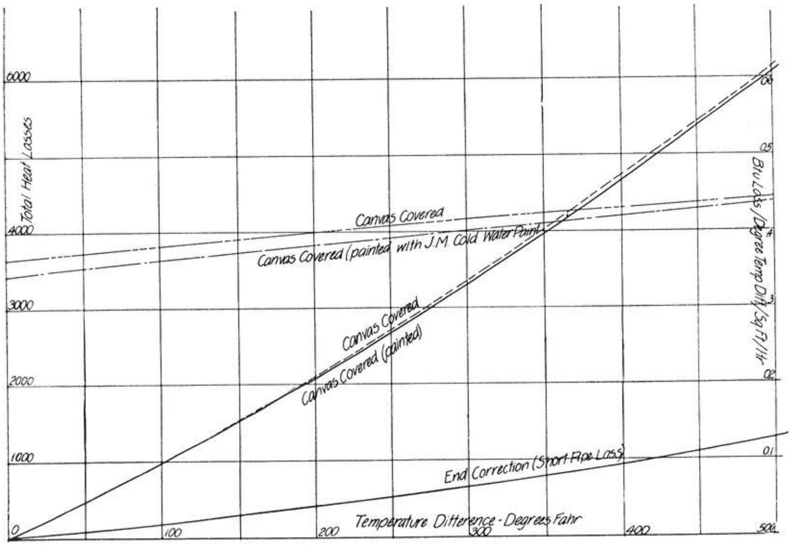


Figure 1

against the difference in temperature between the outside of the pipe and the room. This curve is shown on Figure 1.

The advantage of approaching the desired temperature from both below and above lies in the fact that the error due to failing to wait for constant conditions would cause too high a value for loss at the given temperature in the first case and too low a value in the second. In case these values checked, there was an immediate indication that conditions were constant when the readings were taken. If, on the other hand, these values did not check the correct value lay somewhere between the two. These duplicate determinations usually checked within one per cent.

The room temperature was taken as the average of the readings of five thermometers shielded from direct radiation from the pipe at different points in the room and all about equidistant from the pipe. All doors and windows were kept closed during the tests to avoid air currents other than those produced by the heated pipe itself. The temperature of the surface of the covering was taken as the average of the readings of the thermometers, two to each three-feet length of covering, the thermometers being placed on alternate sides of the pipe covering. Nine sets of readings were taken at pipe temperatures ranging from 227° to 476° Fahrenheit. The last set taken was with the apparatus under the same conditions, as near as possible, as in the eighth set, but with a greater increase of humidity of the room air. A steam radiator was opened, the steam being allowed to pour into the room and thus making the air as moist as possible. The room was kept in this condition over night, and when conditions remained constant for an hour or so the next morning the readings were taken as before. The relative humidity was 29% in the eighth run and 78% in the last. The previous experimenter ran similar tests at practically the same temperature with the same covering and at humidites of 26% and 95%.

In the second run with the same apparatus except for a different covering, J. M. Asbesto-Sponge Felted containing 60 laminations to the inch-pasted was substituted for the original magnesia. This covering had been previously tested by Mr. McMillan with a plain canvas-covered surface, the results of his tests are shown in Figure 2. The covering was this time painted with one coat of flat white, lead and oil paint. Readings were taken as explained in the previous tests excepting humidity readings which were this time omitted.

The next run consisted of tests on the short pipe mentioned heretofore. Three sets of runs were taken, in the first of which the short pipe (with the 85% magnesia covering) was subjected to a constant input of energy of 40.3 watt-hours. With the same constant input, readings were taken at velocities of air past the pipe corresponding to 900 and 1100 revolutions of the fan, respectively. This preliminary run, when plotted, gave an excellent idea of the manner in which the heat loss per degree temperature difference per hour, increases directly as the speed of the fan or of the velocity of air around the pipe.

With this run as a guide, readings were taken for five different speeds up to 1100 r. p. m. of the fan at a constant energy input of 98.2 watt-hours. Check runs were not made as in the other tests on the painted surfaces, but readings were taken only after the temperature of the pipe had remained constant for several hours. The second set of runs was made at two constant pipe temperatures, the first being at 353° Fahrenheit with readings at fan speeds up to 1100 r. p. m. In a like manner, readings were taken at a constant pipe temperature of about 520° Fahrenheit for fan speeds up to 1090 r. p. m. The third set of

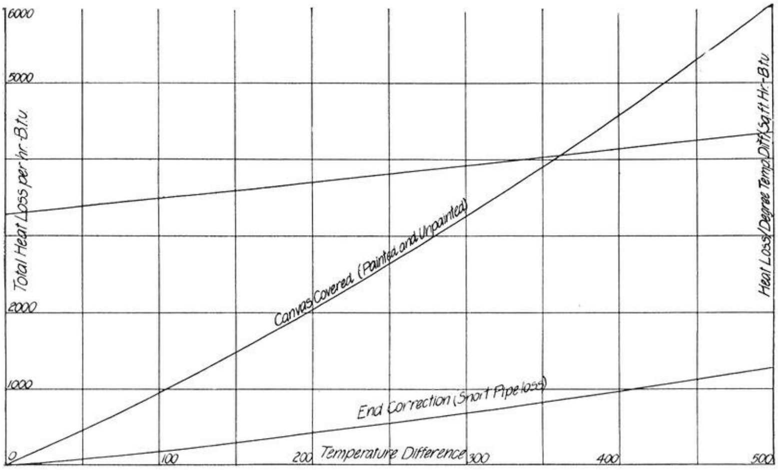


Figure 2

readings was taken on the short pipe with all the coverings removed. The bare pipe was kept at a constant temperature about 350° Fahrenheit and readings taken for fan speeds varying from 0 to 770 r. p. m. A similar run was then made on the bare pipe with a constant pipe temperature of about 207° Fahrenheit and with fan speeds ranging from 0 to 940 r. p. m.

The temperature of the outside of the pipe was read as before from the thermo-couples and potentiometer. These experiments with air were conducted in the gallery of the Steam Engineering Laboratory while those with painted surfaces were conducted in a room on the ground floor. The potentiometer was left in the room on the ground floor and connected with the thermo-couple terminals through 100 feet of electric lamp cord. The resistance of this cord did not affect the accuracy of the readings since the potentiometer is balanced when no current flows through it.

ADJECTIVAL CLASSIFICATION OF THE ENGINEERING PROFESSION

JOHN G. D. MACK
State Chief Engineer

Recently I had occasion to make reference to the large and varied classification of the engineering profession. The first statement I wrote was that "there are nearly fifty varieties of engineers." In order to check this statement I wrote forty-two with little hesitation. At this stage the matter began to take on interest, and a search through the alumni directory was made for additional titles. Several engineers were asked to go over the list to which they added other names. I then made a study of the directory to the American Society of Mechanical Engineers which lengthened the list considerably.

The titles given are only those which are sanctioned by general use, or are adopted in organizations or by individuals. In every case the designation is coupled with the word Engineer. Illustrations have not been made of the very common type of statement of professional work in directories: A. Dash, Engineer, Western Copper Company. This form is not included unless given: A. Dash, Copper Engineer, Western Copper Co. There are doubtless innumerable specialties of engineering which could be so formed. The list of 136 titles below is not offered as a complete statement of the adjectival designations of the engineering profession, for a study of directories of other engineering organizations would doubtless add many more. For example, there are only three listed belonging especially to mining engineering, namely, mining, metallurgical and smelter. Others may take up the matter at this point if they wish. By combining the titles indicating rank or position with those designating the field of work, the list may be multiplied several times.

Those marked * indicate rank or position. Practically all not so marked give some clue to the field of work.

Accountant	Factory	Process
Advisory*	Fire Protection	Production
Aeronautic	Floating Equipment	Public Service
Agricultural	Fuel	Purchasing
Apprentice*	Gas	Railway
Architectural	Gas-Power	Real Estate

Army
Assistant*
Associate*
Automobile
Aviation
Ballistic
Bridge
Cable
Cadet*
Carburetor Development
Central Station
Centrifugal Pump
Ceramic
Chemical
Chief*
City
Civil
Commercial
Concrete
Construction
Consulting*
Contracting
Counselling*
County*
Designing
Development
Directing*
District*
Division*
Drainage
Economic
Economy
Efficiency
Electrical
Electric Railway
Electro-chemical
Equipment
Erecting
Estimating
Experimental
Facility
General*
Geodetic
Heating and Ventilating
Highway
Hydraulic
Hydro-electric
Hydrographic
Illuminating
Inspecting
Installation
Insurance
Irrigation
Junior*
Landscape
Location
Maintenance of Way
Management
Managing*
Manufacturing
Marine
Mechanical
Merchant
Metallurgical
Meter
Methods
Mill
Mining
Motor
Municipal
Office*
Oil
Ordnance
Operating
Organizing
Paper Mill
Patent
Plant
Power
Power Efficiency
Power Plant
Refrigeration
Research
Resident*
Results
Safety
Sales
Sanitary
Scientific Management
Selling
Service
Sewerage
Signal
Smelter
Staff*
Standard Practice and Efficiency
State*
State Chief*
Steam
Structural
Student*
Sugar
Superintending*
Supervising*
Telephone
Testing
Textile
Topographical
Traction
Traffic
Transmission & Protection
Traveling*
Truck
Turbine
Valuation
Water Supply
Works
Zinc

The compilation of the above titles was made purely as a diversion, but as is often the case, out of a diversion something comes of more serious interest. This list clearly pictures the broad field of engineering and shows how this profession grasps so much of the activities of present day life. The inclusion of such terms as "Accountant," "Real Estate," "Commercial" and "Valuation," for example, indicates the growing demand for the engineer in fields formerly thought to be without his territory.

ALUMNI LETTERS

TEN YEARS OUT

A. U. Hoeffer, m '06

Engineer, American Telephone and Telegraph Company, New York City

SOME EPOCH MAKING TELEPHONE DEVELOPMENTS

I can scarcely realize that it has been ten years since the class of 1906 graduated and we were ushered out into the business world. About one month after graduation I went into the Engineering Department of the Chicago Telephone Company, at the head of which was Mr. J. G. Wray, '93, one of the most successful graduates of the Engineering College of the University of Wisconsin, and about the finest man I know. I enjoyed eight years of telephone engineering work under Mr. Wray and in April, 1914, accepted a position in the Engineering Department of the American Telephone and Telegraph Company in New York. This department has been engaged in some of the most interesting developments in the history of the telephone industry. Among these is the establishment of telephone communications by wire from one end of this country to the other, and the still more marvelous accomplishment of talking by wireless telephone from Arlington to Paris in one direction, and the Hawaiian Islands in the other. The transcontinental line extends 3,390 miles over mountains, under rivers, through salt marshes and waste deserts. The sun is shining on parts of the line while rain and hail are descending on other parts and sand and dirt storms are pelting it on others. There is a difference in time of three hours between the ends of the line, and because of this a message spoken over the line at New York at 3 o'clock reaches San Francisco at noon—three hours sooner. Sending the human voice by wireless over vast distances on land and sea has never before been possible, and the methods employed to accomplish this result will no doubt revolutionize wireless telephony.

The transmission of the human voice over enormous distances, however, is not the only accomplishment for which the engineers of this company are striving. As there has been an unparalleled advance in the state of the art during the forty years since the invention of the telephone, there will continue to come new and startling achievements in means of communication.

Although there is a considerable number of Wisconsin graduates here, there are not as many as I had been accustomed to meet in Chicago. The men here, however, are the same sort of good fellows that Wisconsin men generally are known to be.

NINE YEARS OUT

L. F. Reinhard, m '07
Chief Engineer, Mechanical Appliance Company, Milwaukee, Wisconsin

IMPORTANCE OF FUNDAMENTAL SUBJECTS

Your request for a letter for the Wisconsin Engineer reminds me that almost ten years have elapsed since I graduated from the College of Engineering. During this interval I have been connected with the Mechanical Appliance Co. of Milwaukee in the engineering department and the sales-engineering department. We are building electric motors for all standard power circuits in sizes especially adapted to individual motor drive and group drive.

There is one point of which I have become fully convinced in my first ten years out of Engineering School. While I was at college I was under the impression that the courses which dealt with specific subjects were of the greatest importance; I sometimes became rather impatient with the courses that dealt with general subjects. I have however found, that of all the courses that I took at college, those that dealt with general and fundamental subjects were the ones that after graduation aided me the most in solving the problems that daily arose in my engineering work.

EIGHT YEARS OUT

G. W. VAN DERZEE, e '08
Assistant to Vice President
The Milwaukee Electric Railway and Light Co., Milwaukee, Wisconsin

IMPORTANCE OF POWERS OF ANALYSIS AND EXPRESSION

"Eight Years Out" might be a badge of real distinction, signifying the survival of the toughest, if seen at a poultry show, but applied to an engineering graduate, it indicates only a "spring chicken." Nevertheless, eight years are not without their moments of reflection and things one might have done or ought to have done may be of some interest to those still "pecking at the shell."

To an employer, it is not a matter of prime importance what specific studies you undertake in college. It is a matter of prime importance whether or not you take advantage of the training and development of processes of logical thinking and imagination which result from a proper study of those subjects. It is of little value, except as a memory training, to commit to memory. Get the rudiments and then reason! Why attempt to carry a library around in your mind when the room is needed for basic principles? Your employer will not need a college graduate to recite to him from a text book. What he wants and will pay for are the things, as yet unwritten. You can not produce them from memory; they depend upon your constructive imagination, powers of reasoning and ability to develop an idea.

Too little thought is given to the study of the English language, literature and expression by word of mouth and pen. Without hesitation, it may be stated that a serious obstacle in the path of advancement to positions of importance will accompany a lack of appreciation of these facts and failure to elect studies of general educational value.

Money is often a means of sidetracking ambitions. It is a mistake to accept a position upon graduation outside of your chosen line or even in a branch of it that offers small chance of advancement or recognition, simply because you are offered an increase over other positions which seems alluring at the time. You may pay for it later by reaching a blank wall and being obliged to turn back and secure the foundation necessary for steady advancement which you missed. The return road is rough.

Choose your goal and analyze impartially the roads that lead to it. Choose it because you really like it, not because you think you ought to. No work will be as successfully done if there is lacking a feeling of contentment and enjoyment in performing it. Having chosen it and the path by which you will proceed, allow no obstacles which can be honorably overcome to stand in the way.

SEVEN YEARS OUT

F. H. CENFIELD, c '09
Efficiency Engineer, City of Chicago, Illinois

VALUE OF TRAINING IN PUBLIC SPEAKING

There is probably nothing in the whole engineering course which assists an engineer more in his professional work than a thorough mastery of courses in pure and applied mathematics. These are the fundamentals in which the engineer must be well grounded in order to be able to attack the larger problems which he is to solve.

But there is another course which I believe should be taken by every engineer, and that is public speaking. He should become a member of either one of the "hill" debating societies or one of the engineering clubs. He should prepare himself to be able not only to plan and execute, but to appear before any public body and present his propositions as well as the members of the legal or any other profession.

I want to call the engineer's attention to a class of employment which is not overcrowded with technical men but which involves some of the largest and most diversified engineering problems. This is municipal and government work. Under modern civil service employment control, engineers can be induced to enter this field, not only in designing, supervision, and direction of the engineering construction work, but also in the maintenance and operation of the same.

SIX YEARS OUT

CLIFFORD FULLER, m '10
Engineer, Ideal Tool and Specialty Co., Cleveland, Ohio

LEARNING TO HANDLE MEN

I am going to confine my attention to the mechanicals, particularly those taking up machine design or manufacturing.

First, I would suggest more attention than we gave in my time to the course in contracts and specifications. Patents and patent law are great helps, as are also cost accounting, bookkeeping and even shorthand.

And when one gets out, he should remember that the beautiful shops he sees on inspection trips are in the minority. There are any number of shops where the machinery and methods are old; some shops and foundries are everything they should not be. The young graduate should not be discouraged because no one seems to appreciate the fact that he comes from a technical school. A man is expected to jump in and get results by merit only; and a good one will stick till he has proved his quality and made that place better. There are supposed to be no quitters in Wisconsin.

I wonder if the fellows understand the necessity of being able to handle men. I often wish that I had not had to pick up my sociology and psychology from experience. Experience is a good finisher; but it is a hard teacher at first.

I am looking forward with pleasure to seeing the boys on the inspection trip in Cleveland.

FIVE YEARS OUT

A. G. OEHLER, e '11
Engineer, Wisconsin-Minnesota Light and Power Co., Eau Claire, Wis.

ELECTRICAL ENGINEERING DEMANDS VERSATILITY

A man only five years out is hardly in a position to offer advice to anyone. He has not acquired a sufficiently large perspective nor has he attained sufficient experience; he is only beginning to learn how many things he does not know. However, I am glad to comply with your request for a letter and leave my future experience to test my present opinions.

I believe that the well known saying, "this is an age of specialties" is false so far as it has to do with the electrical engineering field. Electrical work demands a degree of versatility which is amazing to the recent graduate, and gratifying to the old alumnus. In my own opinion it is entirely wrong therefore to attempt to acquire a great amount of concrete facts in University courses. I have found that the field grows rapidly, and that facts other than those most fundamental are subject to constant change. In college one should learn how to acquire facts quickly when the circumstance demands, and how to apply fundamental principles to a variety of problems

FOUR YEARS OUT

S. H. Ankeney, c '12
Advertising Manager, Davis Sewing Machine Co., Dayton, Ohio

GOOD TO BE A WISCONSIN ENGINEER

It is difficult for me to start an alumni letter for the class of 1912 without an apology. I could write reams and reams about myself and my family (yes, I have one now), but I don't believe anyone has been more out of touch with the comings and the goings of the class than I.

About the only fellow of our day at Wisconsin that I have met accidentally more than once in my wanderings is "Beany" Woffenden, first in a depot restaurant out in Montana, next in a Chicago barber shop. When I was out in Havre, Montana, the only Badger in town was the city attorney, "Vic" Griggs. It's strange how chummy you can feel toward a man from Wisconsin—even if he is a Law School grad—if there are no engineers about. Then, in New York, I used to meet some of the "old boys" every day or two. "Jimmie" Thompson, editor of the 1910 Badger and now advertising Manager for the McGraw-Hill Book Co., was located in the same building. At his home one evening I met "Cob" Bickelhaupt, '11, and at another time "Dave" Hanchett. "Herb" Stothart, who directed our ne'er-to-be-forgotten Engineer's Minstrels, happened to sit down beside me in a Broadway restaurant one noon and told me something of his efforts to break into the theatrical ring.

I must mention that John C. Beebe, '10, who roomed across the hall from me one year over on Johnson St., while here with the Conservancy District, lived across the street. On many pleasant afternoons, Mrs. B. and Mrs. A. might frequently be seen trundling along little Master B. and still younger Miss A. in their respective baby cabs. You fellows now in Madison take notice and remember that you can't predict today who of those about you will be your most intimate friend five years from now.

As I mentioned before, I could go on this way for a week telling you about "Tommie" Reynolds, '12 who saw that I was properly married, and how I caught a glimpse of Algeo, '13, ducking out of a Chicago theater one Saturday afternoon, and of the surprise that came over both Ralph Birchard, '10, and "Bob" Hughes, '13, when they called at this office on business and found me here. Let me say that it is good to be a Wisconsin Engineer, even if Professor "Lenny" Smith's direful prediction has come true and one has let the journalism bug lead him into the advertising profession. However, I am as satisfied as I ought to be for my own good and I am always glad that I spent those four years at the Engineering Building instead of "on the hill."

Now listen. We of 1912 must all go back next June to celebrate our Fifth Commencement Anniversary. And to the end that we get a good crowd there, I suggest that we form a committee to plan our reunion, execute the plans and advertise the proposition to all. Therefore, all of you who think you will be there write today to R. C. Disque, care College of Engineering, and with these letters in his hands he will be able to correlate our efforts with those of the general alumni organization and to help us start the ball rolling for the biggest gathering of engineers that ever paraded down State Street.

THREE YEARS OUT

M. W. George, m '13
Real Estate Broker, Chicago, Illinois

AN ENGINEER IN THE REAL ESTATE BUSINESS

By the time I left Madison, after four years of good times and hard work, I had decided that I was not born to be an engineer and that the real estate business would be far more to my liking. By dint of much argument I succeeded in persuading my brother-in-law, who, by the way, was not a college man and did not have much faith in those who were, that I could be of some benefit to him in his growing business. He conducted a general real estate, renting and insurance business on the South Side of Chicago. I was started at the bottom and had to labor hard to learn the thousand and one things that a successful real estate broker must know and can learn only by experience and by mixing with those who have already passed the rudimentary stage. Calculus and Hydraulics did not help me to any extent, and about the only part of my engineering course which was of any direct benefit was my old slide rule which I have used to figure a good many deals.

When I left college, I arranged to live with Stanley Harrison, e '13, who was coming to Chicago to work with the Chicago Telephone Company in his chosen profession—electrical engineering. We kept bachelor quarters with four other young fellows and are all still living together, none of us having been fortunate—or unfortunate—enough to get married as yet. Stan, however, is now looking for a wife. Stan had worked for the telephone company for a year and a half until, after listening to my glowing stories of the money to be made in the real estate business, he decided that he was not cut out for an engineer and that he would join us in our business. His judgment has proved very good for he has done remarkably well. A year ago we opened a second office in another part of the South Side and we are now attempting to make it exceed the main office in the amount of business. Neither one of us regrets having taken the engineering course at college as we feel the training we received to be invaluable to us. We are always glad to meet any Wisconsin men who happen into the city and trust that when some of the *real* engineers make their "first million," they will let us invest it for them in Chicago real estate.

TWO YEARS OUT

W. L. BRANDEL, e '14
Engineer, National Lamp Works, Cleveland, Ohio

WISCONSIN ENGINEERS MAKING GOOD IN CLEVELAND

Unless alumni are actively engaged in some phase of school work, or are closely associated with fellow alumni, they lose only too soon the old interest in their alma mater. This is undoubtedly due to the fact that when a man finishes his school career, he becomes so engrossed in his new work, particularly is this true of a profession like engineering, in his endeavor to become successful, all his time and energy are devoted to his new life and the old school days are temporarily at least, forgotten.

Fortunately in Cleveland there is a fair representation of Wisconsin alumni and in our own organization, the National Lamp Works, there are about a dozen former Wisconsin students. By occasional meetings and interviews we may thus compare notes and learn of current happenings at Madison.

I am proud to state that all the old Wisconsin boys at the National are making good to a conspicuous degree; I have heard that the higher authorities are always confident of the caliber of the men secured from Wisconsin. I am certain that we younger alumni will do all in our power to uphold this standard.

As far as my personal work is concerned, it deals fundamentally with the commercial rather than the technical aspects of engineering. In development work, however, the technical knowledge is necessarily required, especially in our dealings with central stations, for it enables one to get into closer touch with actual conditions, and to gain the needed confidence and respect of our customers.

During the two years I have been connected with the National Lamp Works, I have traveled over twenty states. This in itself has been an excellent broadening experience. Besides general sales development and educational campaigning with central stations, jobbers, and consumers, I have spent considerable time on special illuminating engineering work, especially in commercial, industrial and street lighting. In this work a technical training is likewise not only beneficial but absolutely essential.

ONE YEAR OUT

K. B. Bragg, c '15
Engineer, Miami Conservancy District, Dayton, Ohio

FLOOD PREVENTION IN OHIO

Of the seventy-five engineers in Dayton working for the Miami Conservancy District, nine are Wisconsin graduates, more than from any other University. This immense project on which we are now working, is designed to give flood protection to the cities and farm lands of the Miami Valley, and involves the construction of five large earth dams and extensive channel improvements at eleven different cities. Four or five years will be necessary for its completion, and the total cost is estimated at twenty-four million dollars.

The aforementioned nine Wisconsin graduates are looking forward to getting valuable experience on construction work when the dirt starts to fly some time next spring. Six of them are from the class of 1915, and we feel that on a job of this magnitude a graduate just one year from Commencement Day is still in the transition stage between the student and the practicing engineer. He is kept busy adjusting himself to new conditions, and acquiring the ability of applying his training of the past to the problems of the present.

We are looking forward now to seeing Professor Mead here in October as one of the consulting engineers who will testify at the hearing before the court when the plan for flood prevention will be officially approved.

JUST OUT

O. H. Loynes, e '16
Engineer American Telephone and Telegraph Co., New York

ONE PROFITS IN PROPORTION TO HIS EFFORTS

On July 31, 1916, the American Telephone and Telegraph Company took on twenty new men in the engineering department. The men are from fifteen different colleges and universities, twelve of which are eastern institutions. This method of selecting the men not only gives the company the advantage of the engineering knowledge obtained by the men at several different schools, but also gives the men a good chance to meet men from other institutions. From the talks that I have had with the other men, I think that the engineering courses given at Wisconsin are as complete, if not more so, than the courses given in the East.

We are being put through an observational course which consists of about four and one-half months of purely observational work, and by that I mean, we stand back and look on. Hence, it is up to the man himself to get as much as possible from such a course. One can make it as easy or as hard as he chooses. Or as we are often told at school, one profits in direct proportion to the amount he puts into it. Undoubtedly, all men who are "Just Out" have found this to be true no matter what profession they have gone into. The observational course covers practically every branch of the telephone business, including traffic and four branches of the engineering department. When the course is completed we will be put in that branch of the engineering department which we like best; while those who have no choice will be placed where the company thinks best. In the telephone business a man has every opportunity of fitting in somewhere.

Volume 21 Founded 1890 Number 2

The Wisconsin Engineer

$1.00 a Year 15c a Copy

Articles printed herein may be reproduced but due credit must be given. Entered as second class matter at the post-office at Madison, Wisconsin under the act of March 3, 1897.

Published monthly from October to May by
THE WISCONSIN ENGINEERING JOURNAL ASSOCIATION
Engineering Building, Madison, Wisconsin.

Address all communications to THE WISCONSIN ENGINEER.
Subscription price $1.00 a year if paid before February 1.
$1.25 a year after that date. Canadian Subscription $1.25.
Foreign subscription, $1.50.

ACTIVITIES

That which is the cause of more regret to the average graduate as he looks back over his college career is the feeling that he did not take a real part in outside activities. This awakening to one's deficiencies or this realization of lost opportunities advances probably as the mind becomes broader and more able to see the faults and inadequacies of his life as an underclassman. Consider the average freshman, doubtful of his ability, inexperienced, and decidedly willing to spend all his leisure time in idle conversation, at the movies, or to any purpose other than more advantageous outside work. True the argument is often advanced—and especially in the engineering college—that one's regular work is so confining that activities are out of the question. In almost every case this is merely a matter of efficiency.

We will grant however that ability is dependent to a degree on the individual, but it is almost axiomatic that the general student underrates his working capacity and works at a remarkably low efficiency. Were the time spent in complaining of the difficulties of the engineering course to be spent in learning how efficiently time may be spent, there is little doubt but that there would be sufficient time to take advantage of the opportunities offered outside of the university curriculum.

It is not to the seniors that we direct this; it is the freshman just beginning their engineering work that we urge to enter some department of this or other magazines; to join one of the numerous engineering societies; or to do *something* to realize the greater possibilities and advantages of a university education.

* * *

OUTSIDE READING

Because many of our graduates have gone out into industrial practice knowing but very little of engineering beyond that contained in their texts, considerable criticism of Wisconsin and her engineers is often heard. Have you ever considered the way that the majority of students read the technical publications of our library? How often do you find the electrical engineer reading about recent developments in aeronautics or of modern skyscraper construction? It is exceptionally rare, indeed, that you will find the engineer that is interested in subjects in which he is not specializing, and it is upon this narrowness, this early specialization, this failure to read a *variety* of subjects that these objections are well grounded. The efficacy of broader viewpoints in engineering can not be overemphasized.

* * *

In the October issue of the ENGINEER, a step was taken to develop greater alumni interest in this publication and to establish a greater bond between the alumni and the student. It is with this end in view that we are running this series of alumni letters in this and the successive issues. Read this section through. The letters are from the engineers who are in service and who are able to give to you an insight into your future work.

* * *

Scarcely a month goes by without having a notice called to our attention of the death of one of our alumni. Leo Richard Wheeler, c '15, died August thirtieth following an operation for appendicitis. Wheeler was born in Chicago in 1893. He graduated from the high school at Geneva, Illinois in 1910 and from our civil engineering course in 1915. Immediately after graduation, he secured a position with the Illinois Highway Commisson and remained in this service until his death. He was stricken on August 26 and died four days later at his home in Geneva.

* * *

Errata: In the advertisement of the Madison Blue Print Company in the October issue of the Engineer, the word Rectigraph should be substituted for Pedigraph.

WILLIAM NELSON MERRIAM, '81

Three most eminent virtues—fidelity, loyalty and devotion—are indeed attributes or traits of character most worthy of emulation. To possess these, as well as to be self-sacrificing, affable and fearless, is certainly to have gained true distinction.

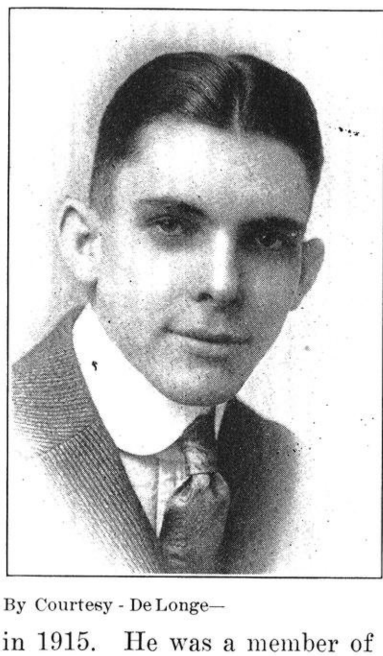
Mr. Merriam, as geologist for the Oliver Iron Mining Company of Duluth, has been known to the mining engineering world for years as one of its most distinguished members, as a profound student of geology and kindred subjects, and as an international authority on iron ores and minerological survey. Mr. Merriman had a most enviable record for, as has so often been said of him, he was the "man who never went wrong." Mr. Merriam followed his desired profession—metallurgical engineering, in which he received his degree in 1881.

After graduating, he worked for a time in the United States geological survey under Professor Irving, who was one of his former instructors. It was in this capacity that he assisted in the first survey of the Vermilion Iron Range, and it was here that he gained the distinction of being one of the first white men to cover the land along the international divide in Northern Minnesota. Following this work, Mr. Merriam went to South Africa. Later, he secured employment with the Chicago, Milwaukee & St. Paul Railway in geological work in Northern Michigan. In 1898 the Minnesota Iron Company entered the Vermilion district and employed him as their geologist. He continued in this work until 1901, when the Minnesota Iron Company was affiliated with the United States Steel Corporation. When this larger company took over the interests of the Minnesota Company, Mr. Merriam was sent on a survey of the state of Guerrero in Southern Mexico. Three years later he began his extensive South American work and for about ten months visited mining properties in practically every country in South America. In recent years he made his headquarters in Duluth as the head of the Oliver Iron Company's geological survey and continued as such until his death last June.

It is recognized that Mr. Merriam was one of the greatest authorities of the world on the geology of iron ores and the allied minerals. His painstaking research was so thorough and extensive that it certainly is to be regretted that one who has accumulated such vast knowledge with the practical experience so valuable to the metallurgical industry should have passed away while still in the prime of life.

ARCHIBALD WILLISTON CASE

On August twenty third, A. W. Case '15, while at work on the new Hell Gate bridge over the East River, New York, was fatally injured. He died twenty-six hours later without having regained consciousness.



By Courtesy - De Longe—

Archibald Williston Case was born at Portland, Oregon, November 17th., 1893. His father, Major James Frank Case, a distinguished civil engineer, is an alumnus of Wisconsin, class of 1890. His mother, who was Helen M. Smith, of Janesville, also is a graduate of Wisconsin, class of 1889. Case received his preparatory education in the high school at Washington, D. C. and at Phillips Exeter Academy. He received his degree of Bachelor of Science in the civil engineering course in 1915. He was a member of Phi Kappa Psi fraternity. His work as a student was excellent and he left behind an enviable record of mental alertness, accuracy, and judgment. Those who had contributed to his education and development felt justified in believing that in him Wisconsin had raised up one more brilliant son to bear her name proudly in the world. He did not stop, however, at being merely the student; the appeal of his generosity, humor and attractive personality won for him the many and loyal friends that he now leaves behind.

When he had finished school he entered upon his career with courage and enthusiasm. Although many of those rough spots that most beginners must traverse might have been smoothed for him, he refused to accept such advantages and struck out for himself. Through his own efforts he secured work with the contractors that were putting in the concrete for the Hell Gate bridge and took up his duties with a born builder's love for the thing he was helping to create. He adopted the bridge as his own; it became "Archie's bridge" to his friends. His energy and enthusiasm won the commendations of his superiors, and his kindliness of spirit won the affection of those under him. It was his thoughtfulness for others that, in a measure, led to his death. There had been a bad storm and a heavy wind was blowing. From a sheltered spot, two hundred feet above the water, he saw two men picking their way toward him He left his shelter and went to meet them saying, "Hello, boys, glad to see you. Wait till I come to help you; there is a terrible gale up here." He reached them and walking between them he put an arm across the shoulders of each. As he did so, a box, used for hoisting stone, was torn loose by the wind and fell, striking him down between his friends who remained uninjured. He was removed to a hospital where every possible effort was made to save his life; but he died the following evening, August twenty-fourth.

L. F. V. H.

ALUMNI NOTES

Harold K. Weld g '05 has recently been appointed as District Representative of the Standard Underground Cable Company, with offices at 717 Plymouth Building, Minneapolis.

C. J. Carlsen m '96, whose address was missing from the Alumni directory, now lives at 501 Washington avenue, Wilmette, Illinois. He is employed by the Commonwealth Edison Company of Chicago.

The address of E. M. Evans c '94 was also missing from this list. Mr. J. G. Wray informs us that Mr. Evans now lives at 4045 N. Hermitage avenue, Chicago, Illinois, and that he is employed by the International Harvester Company.

R. J. Coughlin e '15 is in the sales department of the Sturtevant Company of Chicago and reports that Sipp, Kruger, Hardin, and Standish, all electricals of '15, are with this company and are thoroughly interested in their work.

L. A. Terven e '02, who has been located in Mexico for a number of years, now has charge of the Terven-Childs Electric Company of Columbia, South Carolina.

D. Y. Swaty c '98, who we will recall was formerly engineer for the Great Lakes Dredge & Dock Company, is now the Vice-President of the Cleveland Engineering Company, Cleveland, Ohio.

Although the name of Edward Schildauer did not appear in the directory for some reason, we have been advised that Mr. Schildauer is at present engaged as President of the Artillery Fuse Company, with headquarters at Wilmington, Delaware. Box 516 is his mailing address.

W. H. Inbusch recently has changed his address from Box 11 Darby, Minnesota, to Kenilworth, Illinois.

C. A. R. Distelhorst c '12, who has been for some time with the U. S. Engineers at Rock Island, Illinois, has just resigned and is now with the Wisconsin Highway Commission at Milwaukee.

It is to be noted that Walter J. Parsons c '00, is now Assistant to the Pittsburg Manager of the Foundation Company, Fulton Building, Pittsburg, Pa.

Friends of Harry Hersh e '15, will be interested to learn of his marriage to Miss Rose Lynn Arnovitz of Marinette, Wisconisn. The marriage took place at the home of the bride's parents, August 15. The couple will reside in Milwaukee.

And this is not the only marriage of our engineering alumni. John R. Livingston e '13, our Tau Beta, H K N, Iron Cross, etc., man who was probably one of the most popular men in the University, was married to Miss Marjory Davis of Madison last June.

APPLIED ELECTROFUSSING (7 Fifths)

When a woman is sulky and will not speak—Exciter.
If she gets too excited—Controller.
If she talks too long—Interrupter.
If her way of thinking is not yours—Converter.
If she is willing to come half way—Meter.
If she will come all the way—Receiver.
If she wants to go further—Conductor.
If she would go still further—Dispatcher.
If you think she's unfaithful—Detector.
And if she is unfaithful—Lever.
If she proves your fears were wrong—Compensator.
If she goes up in the air—Condenser.
And if she wants chocolates—Feeder.

CAMPUS NOTES

Dr. Charles Hecker, who succeeds Dr. Charles A. Mann in the Department of Chemical Engineering, is a graduate of the University of Cincinnati, where he received his degree of Chemical Engineer in 1909 and that of Doctor of Philosophy in 1913. During the interval between 1908 and 1913, Dr. Hecker held a position as an instructor in the University of Cincinnati. In 1913 he resigned and accepted a position at the University of Illinois in a similar capacity. While he was there, he was a member of the editorial staff of *Chemical Abstracts.* Dr. Hecker has given much attention to the Catalysis of Organic Reactions, particularly in reference to the processes employed in the hydrogenation and the chlorination of oils. He has contributed a number of papers to chemical literature, and an account of his most recent research appears in Volume 50 of the Journal of the American Chemical Society under the title of "a Study of Some Hydroxylamines."

Mr. C. R. Weidner, who has been an instructor in the Hydraulics Department of this university for the past seven years, has accepted the position of Chief Engineer of the Prairie Pipe Line Company, with headquarters at Independence, Kansas. This company has over two thousand miles of main pipe line radiating from the great oil fields of Oklahoma. The enormous extent of this system may be realized from the fact that the capacity of the line from Whiting, Indiana is 100,000 barrels a day. Similar lines lead to St. Louis and to Baton Rouge, but these are of smaller capacity.

During the summer, Mr. Weidner and Dean Davis of the University of Alabama did a large amount of appraisal work for the Prairie Pipe Line Company. Dean Davis, it will be remembered, was Assistant Professor of Hydraulics at Wisconsin from 1904 to 1912. Associated with Mr. Weidner and Dean Davis in this work were the following Wisconsin men: W. J. Camlin, W. W. Cargill, F. A. Carlson, W. Evans, K. S. McHugh, M. A. Powers, H. F. Searight, F. G. Shufflebarger, T. Utegaard.

Believing that it will be a very short time before every broad gauge engineer will need to possess a knowledge of at least the rudiments of the aeroplane design and construction, Professors Maurer and Callan are now giving a course in Aeronautics. At present the fundamental principles of wing form, stability, control, and propeller design are being studied but as the art becomes more important, it is the intention to enlarge gradually the scope of the work.

Mr. Bradley Stoughton, Secretary of the American Institute of Mining Engineers, delivered an address on the "Structure of Steel" before the Wisconsin Section of the American Chemical Society on October 18. He emphasized the necessity of cooperation between metallurgists and chemists, and pointed out the fact that any notable increase in the metallurgy of steel would be dependent upon the discovery of convenient and rapid methods for the determination of the harmful impurities in steel, particularly oxygen and nitrogen, and methods for determining the distribution of impurities like sulphur and phosphorus, that are likely to segregate. Mr. Stoughton also spoke of the importance of the physical chemist in the analysis of the complex physico-chemical changes that occur during the solidification of cast iron and steel.

Mr. Ernest Lange, e '15, has accepted a position as instructor in the Department of Electrical Engineering. Since graduation "Ernie" has been with the Westinghouse Electric Company.

The U. W. Engineer's Club held its first meeting of the year on Friday evening, October 7. Although several of the active members of the club graduated with the class of '16, the meeting was very snappy, and judging by the list of the new men on the list presented there are indications that the club is to maintain its reputation as one of the leading organizations of the Engineering school. Two committees have been appointed by President Goldammer to arrange the more important events of the schedule of the club for the coming year.

The statistics given out by Professor Phillips show that there are 232 freshman enrolled in the engineering school. This is a slight decrease from the total enrollment at this time last year.

According to the plans arranged by Professors Black and Disque, the senior engineer's Eastern trip is to start November 10. Detroit will be the first stop, and it is planned that the plants of Ford, Hudson and Detroit Edison Companies are to be visited. On Sunday the party will go sight-seeing in Niagara Falls, leaving the formal inspection of the power plants, etc. until Monday. In Pittsburg, the Westinghouse Electric & Manufacturing Co. and the National Tube Company will be visited on Tuesday and Wednesday, while on Thursday the trip will be extended to Cleveland. On Friday, the Gary steel mills, the Buffington Cement plant, and the Whiting refineries of the Standard Oil Company will be visited, leaving the usual visit to Commonwealth Edison company in Chicago until Saturday. There will be three smokers—at Cleveland, Detroit and Pittsburg.

It may be of interest to note that during the early years of aviation, the mortality was one death for every fifty miles of travel, and that during the present war, it has dropped to one death for every 15,000 miles, this being inclusive of those injured by shell fire. Excluding those wounded in this way, the rate drops to one death per 60,000 miles.