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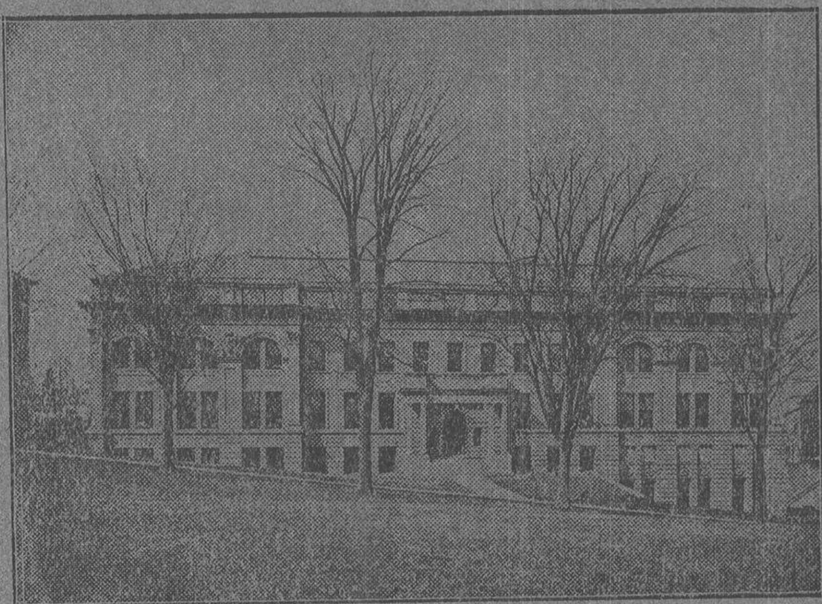
Engineer

THE WISCONSIN ENGINEER

Vol. 7 DECEMBER, 1902 No. 1



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THE LATE DEAN J. B. JOHNSON.

THE WISCONSIN ENGINEER

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JOHN BUTLER JOHNSON.

By the accidental death of Dean J. B. Johnson, on June 23d last, the University suffered a very great loss; a loss not only of a highly efficient and valuable member of the faculty, but to a peculiar extent that of a personal friend of both faculty and students. When such a man passes away it is wise and fitting for us to consider what were the elements of his character which led to his great success, and in what peculiar respect did his life influence the lives of others.

Professor Johnson was born of Quaker parentage on a farm near Marlboro, Stark Co., Ohio, June 11, 1850. In 1866 the family moved to Kokomo, Indiana, where he attended Howard College for a short time and later went to the Holbrook Normal School at Lebanon, Ind. From 1868 to 1872 he taught school in Indiana and Arkansas, and in 1872 went to Indianapolis as secretary of the School Board. He also taught one year in the Indianapolis High School, where he was required to teach Latin, although never having studied Latin himself. In 1874 he entered the University of Michigan and graduated in 1878 from the Civil Engineering course. During his college course he gained considerable professional experience in vacations, and at the same time earned considerable money to assist in paying his expenses. It has been stated by him that in carrying on this summer work he was obliged to enter late and leave early nearly every year of his course. The additional effort required to do the regular work of the course under these conditions, will be appreciated by many of our own students who are attempting to do the same thing. And yet Professor Johnson found time to do, what he so strongly advises all engineering students—attend occasional lectures in other departments, and take his part in the various college activities. Doubtless his mature age and experience, (he graduated at the age of twenty-eight), enabled him to profit much more by his college course than the average student; and the success he has achieved should be a great encouragement to those who are not able to pass at once from the high school to the college, and who are thus obliged to begin their chosen profession at what is ordinarily considered a rather late period in life.

After graduating, Professor Johnson was engaged until 1881 on the survey of the Great Lakes, and from 1881 to 1883 he was assistant engineer on the Mississipi River Commission, in which position he accomplished considerable work of public importance. During one of the greatest floods ever experienced on the lower Mississippi, he was commissioned to measure the discharge through various crevasses, a somewhat dangerous and difficult task. As a result of these measurements and studies made at that time, he recommended several improvements in the method of river control, which, although considered radical at the time, have since proved to be wise and peculiarly foresighted.

In 1883 he became Professor of Civil Engineering at Washington University, St. Louis, where he remained for sixteen years. During the years spent in this position he gained a world-wide reputation by his valuable contributions to engineering literature and his active work in connection with engineering and scientific societies. His greatest contribution to the engineering profession has probably been his four published works on engineering subjects, all of which he prepared while at St. Louis. The Index to Engineering Periodical Literature, which he originated and to which he gave a large amount of his time, is scarcely less important. It well illustrates one of his chief aims, which was the promotion of the cause of good engineering in this country. It was during the years from 1892 to 1895 that he also carried out important investigations on the strength of timber for the Forestry

Division of the U. S. Department of Agriculture, which have been of great value to builders and engineers. The results there obtained are now quoted in all handbooks of engineering data.

For some time previous to the coming of Professor Johnson to this University, the Regents had felt the need of a head for the rapidly growing College of Engineering, and finally the task of finding the right man was placed upon President Adams. During an inquiry extending over a considerable time, the suggestions received pointed clearly to Professor Johnson, of St. Louis, as the man for the place. A single interview was sufficient to demonstrate to President Adams that this was the case and the position was, therefore, offered to him, and accepted. He was appointed in January, 1899, but spent the first half-year abroad, entering actively upon his duties in September, 1899. The growth of the College during his administration is familiar to all. In attendance it has more than doubled, the new building has been erected and furnished, and the material equipment has been greatly improved. It was his desire to make the interior of the building the most attractive of any on the campus, and to him we are indebted for our handsome and homelike surroundings. This is but an instance of his thoughtful interest in the students and his belief that nothing is too good for the engineers.

It is not too much to say that Professor Johnson's real service to the University was greatest in the work he did towards improving the spirit of the College and in cultivating a proper *esprit de corps* among the student body. This desire on his part was constantly exemplified in ways such as the inauguration of the series of socials for engineering students, by his annual addresses, on which he put his most careful efforts, and by his sympathy with the students in all worthy projects. His attitude towards technical education was of the broadest and is well illustrated by his address of last year, in which he says:

"I beseech you, therefore, while yet students, to try to broaden your interests, extend your horizons now into other fields, even but for a bird's-eye view, and profit, so far as possible, by the atmosphere of universal knowledge which you can breathe here through the entire period of your college course. Try to find a chum who is in another department; go to literary societies; haunt the library; attend the available lectures in literature, science, and art; attend the meetings of the Science Club; and in every way possible, with a peep here and a word there, improve to the utmost these marvelous opportunities which will never come to you again. Think not of tasks, call no assignments by such a name. Call them opportunities, and cultivate a hunger and thirst for all kinds of humanistic knowledge outside your particular world of dead matter, for you will never again have such an opportunity, and you will be always thankful that you made good use of this, your one chance in a lifetime."

He had great faith in young men and thoroughly believed in the policy of placing upon them duties of responsibility. His influence with his students was indeed due in no small measure to this attitude of confidence in them, together with his readiness to aid them with words of encouragement and advice.

While, first of all, an inspiring teacher, Professor Johnson was also deeply interested in all that contributed to the welfare of society. He was a member of many engineering and other societies and in all these his activity and helpfulness were almost remarkable. In the church he was equally active and in all worthy enterprises of the community was always ready to lend a hand. He had many plans for the future welfare of this institution, and it seems most unfortunate that a man should be taken away in the prime of life with such great promise for future work. And yet it was, I think, in one sense, as he would have wished,—that as long as he lived he would be able to do with vigor his full part in society. His loss is felt by a very wide circle of friends and by many interests, but by none more keenly than by his own students and the younger generation of engineers to whom he was an inspiration and guide.

F. E. TURNEAURE.

THE ELECTROLYTIC RECTIFIER.

[Abstract of paper presented before the Science Club, October meeting.]

PROF. C. F. BURGESS.

There is perhaps no form of electrical apparatus the use of which is increasing more rapidly than the storage battery. Of the great variety of duties which electrical energy is called upon to perform, many of them are made possible by this device, and recent improvement as regards both product and price has greatly extended the use of the storage cell. The storage battery in the larger sizes furnishes enormous reservoirs for the storage of energy and the equalization of loads in central station work, and the uses of the smaller sizes are too numerous to detail.

The automobile is most satisfactorily operated by means of energy stored in batteries, and small boats and launches are similarly propelled. Police, fire, signal and watchman clock-service employ small storage batteries, and in telegraph and telephone systems the older forms of primary cells are being replaced by the cheaper and more serviceable secondary cells. They also furnish the power for operating automatic machines of the "nickel-in-the-slot" type. Physicians and dentists make use of them for cautery and similar purposes.

One of the serious limitations to an increase in the use of storage batteries, especially in the smaller sizes, is the difficulty in charging them from electric lighting and power circuits. Where the electric circuits are of the alternating type this problem has been such as to practically prohibit the use of storage batteries, and in view of the fact that the majority of central stations employ alternating current distribution there are many localities where storage batteries cannot be used.

The problem of changing an alternating to a unidirectional current suitable for charging has been the subject of much study and experimentation, and various devices, such as the rotary converter, rotating commutator and vibratory rectifier, have been devised, the most successful being the rotary converter. In small sizes, however, the expense, low efficiency, and trouble of operation have placed it beyond the reach of the ordinary battery user.

An ideal apparatus for rectifying the alternating current is one which has no moving parts, the analogue of the alternating current transformer, and capable of operating at high efficiency and with little detention and deterioration. For the purpose of working out such a device a great deal if experimental work had been carried out in utilizing a peculiar property of aluminum which was discovered about half a century ago. Wheatstone found that aluminum possessed the property of allowing current to flow freely in a direction from the electrolyte to the aluminum dipping into it but opposing with a high resistance the current flowing in the opposite direction. The idea in utilizing this property is that if an electrolytic cell containing an electrode of aluminum and one of some other metal not having the same property and a suitable electrolyte be connected in series with the storage cells to be charged the current in the desired direction for charging would be allowed to flow, but the impulses in the opposite direction would be shut off.

The efficiency of such a device depends upon the completeness with which the current in the wrong direction is opposed, and this in turn depends to a large extent upon the electrolyte employed. A great many solutions have been tried, such solutions consisting of various substances such as sulphuric acid, aluminum sulphate, sodium and potassium phosphate, and sodium potassium tartrate dissolved in water. Certain publications of results thus obtained would lead to the impression that the satisfactory rectification of the alternating current by this means has long since been accomplished. Efficiencies as high as 95 per cent. have been claimed, and various other statements have been made which would lead to the conclusion that we need look no further for a satisfactory solution of the problem in question. The facts show, however, that such devices have not been extensively used for commercial purposes, one reason being that under practical conditions an efficiency above 20 per cent. has not been realized.

The use of aluminum as a means of rectifying alternating currents has been the subject of study in the Laboratory of Applied Electrochemistry of the University of Wisconsin during the past two years. Attempts were made to duplicate results which had previously been published, tests were made to separate the losses and determine their amounts, and a large number of new solutions and arrangements of electrodes were tried in the hope of devising an economical apparatus.

The attempts at duplicating previous work almost always led to the conclusion that erroneous data had been published, due probably to wrong methods of measurement or to neglecting some of the factors causing loss.

The losses of energy in a rectifier of the aluminum type may be subdivided as follows:

C^2R loss, C being the current flowing toward the aluminum and R being the resistance of electrodes and electrolyte.

CE′, where C is the current flowing toward the aluminum electrodes and E′ is the counter electromotive force which is developed by the decomposition of the electrolyte.

C′E where C′ is the leakage current flowing from the aluminum to the electrolyte and E is the applied pressure.

Inasmuch as the values of current and electromotive force are variable quantities, a determination of the same make it

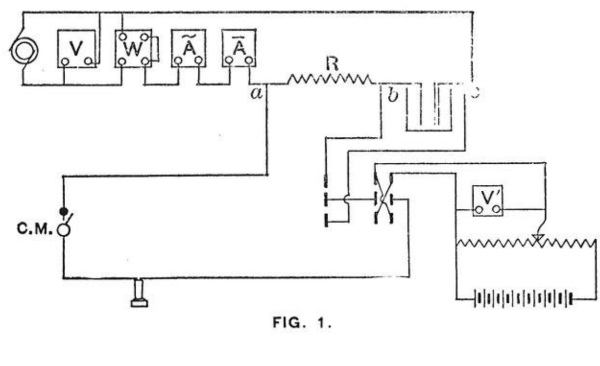


FIG. 1.

necessary to employ the instantaneous contact method, and by means of connections shown in Fig. 1, curves were taken showing action of the rectifying cell under various conditions. c. m. indicates a contact maker placed upon the shaft of an alternating current generator, R is a non-inductive resistance, and b, c are the electrodes of the cell.

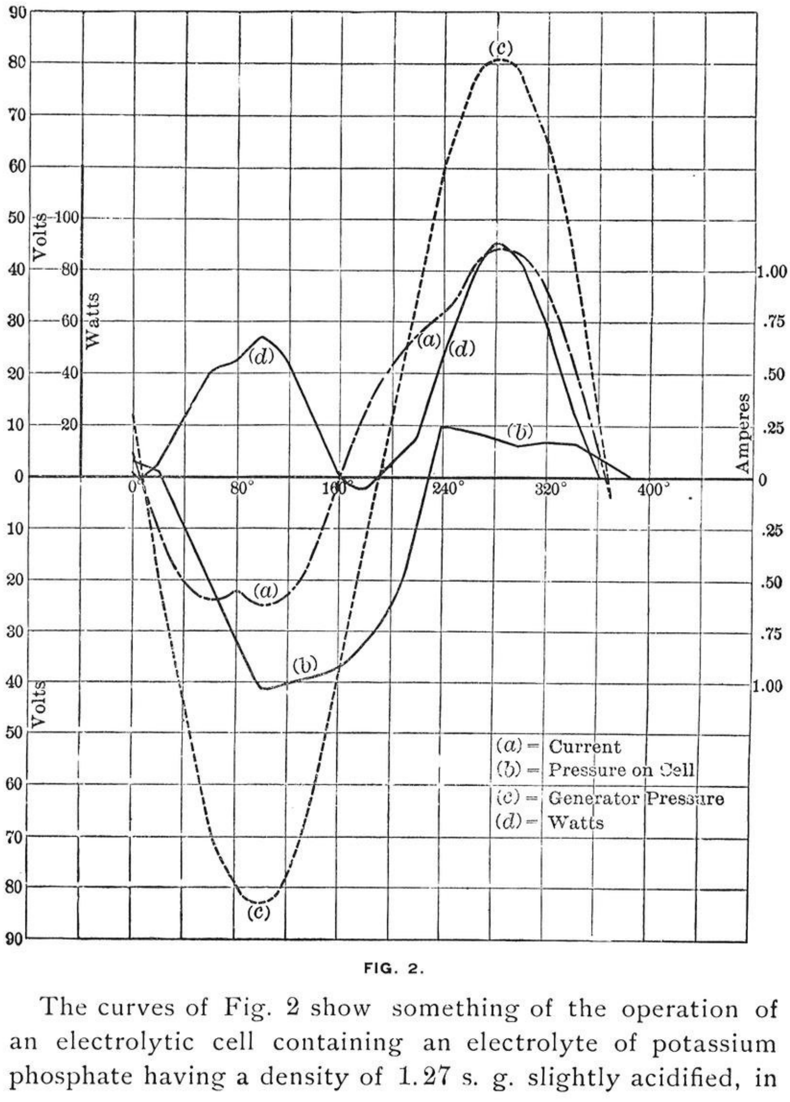


FIG. 2.

The curves of Fig. 2 show something of the operation of an electrolytic cell containing an electrolyte of potassium phosphate having a density of 1.27 s. g. slightly acidified, in which were placed an aluminum sheet electrode having an immersed area of 45.5 sq. in. and a lead electrode of similar size.

The portion of current curve (*a*) below the base line indicates the current which flows from the aluminum plate to the electrolyte, or the leakage current, and the remainder of the curve shows the current in desired direction. The pressure curve across the rectifying cell is shown by curve (*b*), the negative part being the pressure at which the leakage current flows through the cell and the positive part representing the CR + E′ in the cell where C is current flowing, R is internal resistance, and E′ is the counter electromotive force of polarization. The pressure applied to the circuit by the generator is indicated by the sine curve (*c*).

It is to be noted from these curves that there is a very considerable leakage current; the loss due to CR + E′ is seen to be much smaller than that due to leakage. The current curve being in advance of the pressure at the center of the cycle shows that there is some capacity effect.

The curve (*d*) showing the watts delivered to the circuit gives an idea as to the loss due to leakage as compared with the watts delivered during the remainder of the cycle. The average watts delivered to the circuit is 33.9. The average watts lost in leakage is 13.9.

It will be seen from these curves that the principal source of loss is the leakage current, and this seems to be the most important subject for study in bringing the electrolyte rectifier to commercial efficiency. The leakage depends upon various factors, including the following:

Electrolyte—as to composition and temperature.

Aluminum electrode—as to composition and surface exposed.

Pressure.

Frequency.

These various factors were investigated, and, for a discussion of the same, reference may be made to the Transactions of the American Electrochemical Society, Vol. I, pp. 147–163.

That leakage will depend upon the pressure applied is evident upon taking the characteristic of a cell having two aluminum electrodes, using either direct or alternating pressures. The leakage increases proportionally with the pressure to a certain point, when the rate of increase becomes

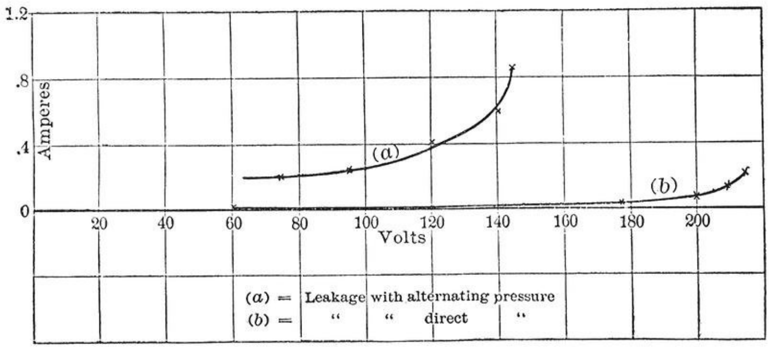


FIG. 3.

much greater. This is shown in Fig. 3, where curve (*a*) is for two aluminum electrodes in a sodium potassium tartrate solution using an alternating pressure, and curve (*b*) is for the same plates with unidirectional pressure. It will be seen from these curves that the behavior on alternating and direct current circuits is very different and that the amount of leakage in one case is not a direct indication of the amount of leakage in the other. An aluminum electrode may successfully withstand 200 volts unidirectional pressure and not operate successfully on 120 volts alternating pressure. It will also be noted that, with direct pressure up to 150 volts, the leakage was almost a negligible amount, while with an alterating pressure of 75 volts the leakage was many times greater. This difference was probably due, at least to a considerable extent, to the condenser effect which the aluminum electrode shows, allowing a capacity current to flow with the alternating pressure.

The various aqueous electrolytes tried, showed little promise of commercial success, but through a discovery made by Mr. Carl Hambuechen that a fused electrolyte would serve more advantageously, a new field of investigation was pointed out. From a great many curves taken, Fig. 4 gives some typical results, these being obtained by use of an iron and an aluminum electrode in molten sodium nitrate.

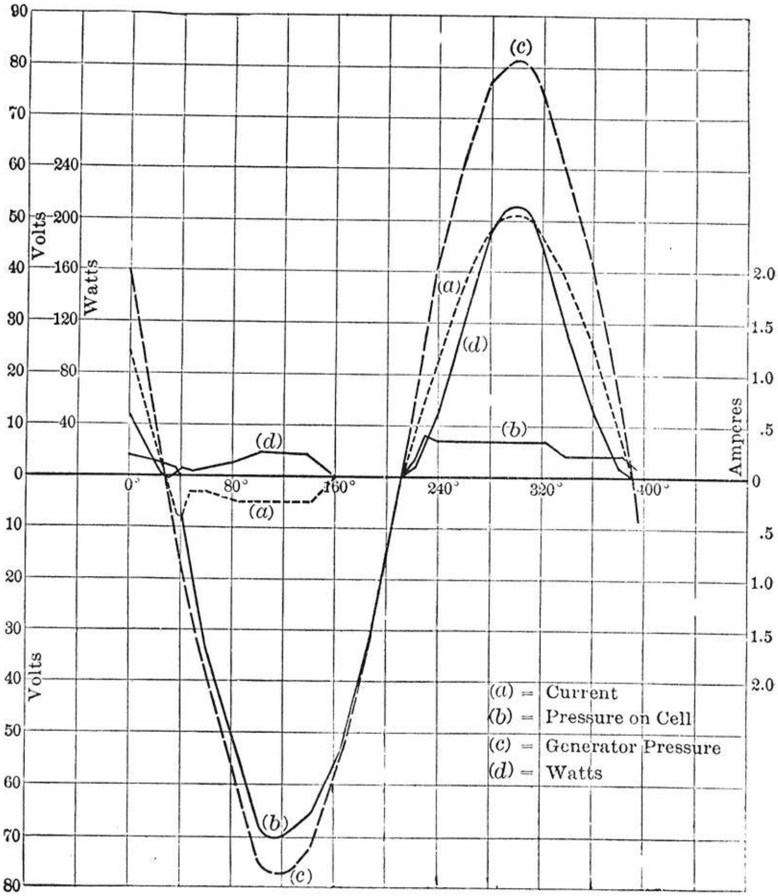


FIG. 4.

Curve (a) represents instantaneous valves of current, the negative values indicating leakage. Curve (b) gives values of pressure at terminals of rectifier and curve (c) shows form of pressure wave delivered by the alternator at a frequency of 58. These curves compared with those of Fig. 2 and obtained under similar conditions as to pressure, frequency, and output show decided differences in operation between aqueous and fused electrolytes. The leakage is seen to be a much smaller percentage of the total current flowing.

The loss due to internal resistance and counter pressure is smaller in spite of the fact that the aluminum electrode in the fused salt was about one-fortieth the area of the aluminum in the aqueous solution.

The portion of the curve (*a*) between 30° and 50° demonstrates, we believe for the first time, the interesting fact that at the instant of reversal of aluminum from cathode to anode it offers little resistance to the flow of current, but that it quickly recovers itself and closes the current valve. The rapidity with which this action takes place is seen to be somewhere in the neighborhood of $\frac{1}{1100}$ of a second at the beginning of a sine pressure wave. After applied pressure has reached its maximum negative value, the leakage current rapidly decreases to nearly zero where it remains until reversal of applied pressure again takes place.

The rapid increase, and slight elevation of curve (*b*) at the point 230° shows that the "formed" aluminum plate offers considerable resistance to the flow of current toward it but the resistance almost instantly diminishes. The portion of curve (*b*) from 340° to 400° consists mainly of the counter pressure which maintains its value even after direction of applied pressure has changed as shown by the fact that (*b*) becomes negative *after* (*a*) has reversed in direction.

A further observation is the fact that there is no evidence of capacity effect or difference of phase between pressure and current, which is so noticeable in curves in Fig. 3. This is undoubtedly due to the much smaller era of the electrode surface acting as condenser plates.

Curve (*d*) shows instantaneous values of watts delivered to the circuit, the portion from 30° to 160° representing the loss due to the leakage and from 200° to 380° the watts delivered during remainder of cycle. This curve shows an energy efficiency of over 80 per cent.

It will be observed that at a point at about 40° the value of the watts is negative to a very slight extent, indicating that energy is being restored to the circuit. This is undoubtedly caused by the aluminum plate acting in conjunction with the iron as a voltaic cell, delivering energy at the expense of corrosion of aluminum. This delivery of energy, however, at the expense of the aluminum continues only for a very short part of the cycle, or until the "valves" begin to work. While having no figures to demonstrate this fact it seems reasonable to suppose that the small amount of corrosion of aluminum which takes place when used in a rectifier is due to, and proportional to, this energy delivered to the circuit.

Among the advantages which may be claimed for the fused electrolytes in comparison with aqueous solutions in addition to sharper and more clearly defined action, higher efficiency, and low inductive capacity effect, are large output per unit weight of cell, which is attained through ability of the cell to stand a high temperature in addition to the much greater conductivity which a fused salt may show over an aqueous electrolyte.

The form of current curve obtained by use of a single pair of electrodes is not suitable for most commercial purposes. Various methods of connection have been devised for use with the fused electrolyte whereby this objection may be overcome, and a form of apparatus has been designed which seems to fulfill commercial requirements.

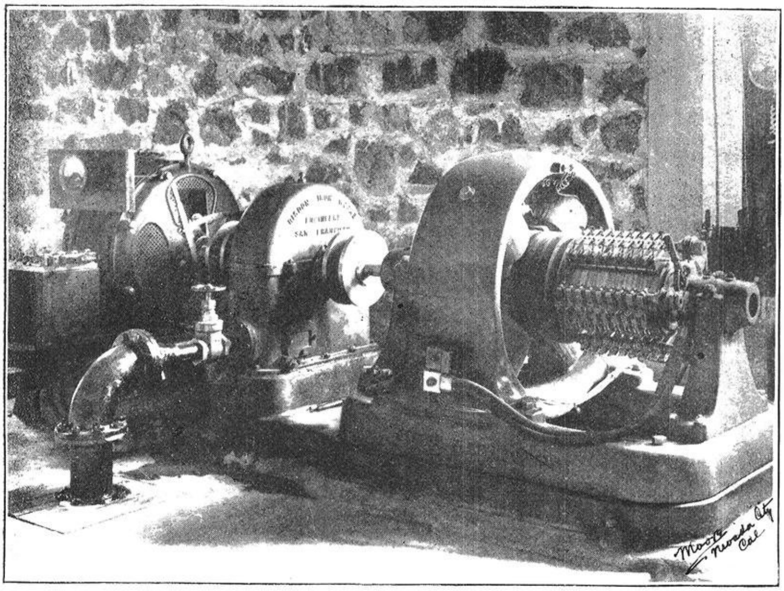
The efficiency of operation of the smaller sizes is about 60 per cent and very little attention is required during operation. The depreciation of electrodes and electroly tes is very small and can be covered by a small fraction of a cent per kilowatt hour delivered.

BAY COUNTIES POWER COMPANY EXCITER COMBINATION.

L. M. HANCOCK, '88.

The exciter water wheel induction motor combination shown in the accompanying photograph, was originated and installed by the writer at the Colgate Generating Station of Bay Counties Power Company over a year ago, and has proved beyond a question its superiority for the purpose for which it was designed. Construction of the main flume had not been completed; shut downs on account of water wheel troubles, especially on account of nozzles choking with small blocks of wood from the carpenters' saws, had become very much too numerous. The water had to be continually adjusted to suit the exciter load, which at times was changing every few minutes, and the excessive noise of the water when partly deflected from the wheel, all made it necessary to make some radical change. After careful consideration it was decided that an induction motor connected to the unit would, as a motor, take care of any disturbances on the water wheel end and in passing from the extreme as a motor to the other extreme as a generator would control the whole unit and give us what was specially lacking, a governor.

The design, as shown, is somewhat clumsy on account of adapting commercial machines to meet the conditions without making a complete new design. The operation is as follows: The unit can be started either by water or by the induction motor. If water is used, the speed of the unit is brought up to normal as indicated by a techometer; the motor switch is closed and afterwards water is put full on the wheel. If the motor is used to start the unit its switch is closed and the unit brought up to speed with the auto starter, water is then turned full on the water wheel; the induction motor, as the water strikes the wheel, changes to an induction generator, and, as the water comes full on the wheel, delivers to the station bus bars the power of the water wheel not needed by the exciter; load can now be put on or taken off the exciter without any attention to the unit; the induction generator motor acting as an almost perfect governor. The importance of this fact can be better appreciated when it is remembered that there is not on the market any suitable governor for small water wheels, and that the variation in speed of a water wheel of the Pelton type, from no load, to full load is nearly 50 per cent.



The variation of the speed of the induction motor from no load to full load does not cause any serious drop in the station voltage; even should there be a serious drop in the station voltage that is infinitely better than a shut down. In fact, under the conditions as they exist with us, water has been entirely choked from the wheel by small sticks and trash without causing our customers any inconvenience and, in fact, without the station attendants knowing it, the induction motor changing from generator to motor instantly, and going ahead with the load until the water wheel nozzle was found choked and could be cleaned.

We are so well pleased with this method of driving our exciters that we are installing, in a new 8,000 K. W. power house now building, a specially designed duplicate exciter outfit, which is to have the exciter and induction motor on the same bed plate with three bearings; the water wheel to be overhung at one end of the induction motor, which is wound for the bus bar voltage of the station, thus making a very simple, compact and complete exciter outfit.

JAPAN OF TO-DAY: SOME OBSERVATIONS MADE DURING A RECENT VISIT TO THE MIKADO'S EMPIRE.

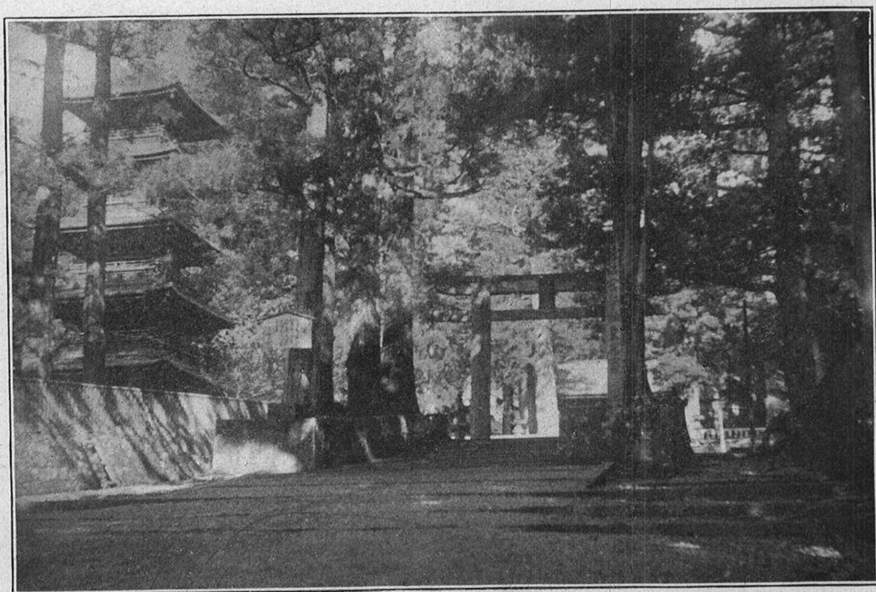
EDW. FRESCHL, '99.

After a voyage of eighteen days from San Francisco, including a stop of twenty-four hours at Honolulu, our ship steamed into the harbor of Yokohama, the first stopping place for all vessels going to the Orient.

Into this same harbor Lieut. Perry, representing the United States government, had sailed in 1853, and had demanded the abandonment of the Japanese policy of isolation. What a different Japan it must have been when Perry first saw it, and in what a comparatively short time the change had been brought about! Arrived at the landing place, one might imagine himself set down in a large European city; surely Perry, when he first gazed on this spot, had not seen stone buildings, steel light-houses and massive granite breakwaters.

Just outside of the latter, on the day of our arrival, was an aggregation of a dozen or more warships, sent hither by England, Germany, France, Russia and the United States, to fire a royal salute in honor of the Emperor's birthday, which falls on November 3d. Thus were all the great powers of the earth paying their respects to a nation which, a short time before, had not only kept itself isolated from all the world, but had for many years effectively resented any efforts on the part of other people to intrude into its privacy.

Whatever thoughts one might have had about Europe, however, on landing in this city were quickly dispelled by the tumultuous approach of a legion of brown-visaged, bare-legged, energetic little coolies, each drawing behind him his jin-riki-shaw (man-power-wagon), and begging the stranger for his august and honorable patronage. To one just come from a land where all men are supposed to be born free and equal, there was presented an opportunity for hesitation at



PAGODA AT NIKKO.

the thought of being drawn through the streets by one of these human beasts of burden; and if one had finally overcome such compunctions and had decided to undertake the journey, there still remained the problem of choosing one of the applicants; and I was forcibly reminded of Paris and the apple and could appreciate the young Grecian's perplexity. Finally, I made a choice, however, and crawled into a cart drawn by a magnificent specimen of physical perfection; I chose him on account of his muscular development, and it turned out to be the first of a long series of deceptions which

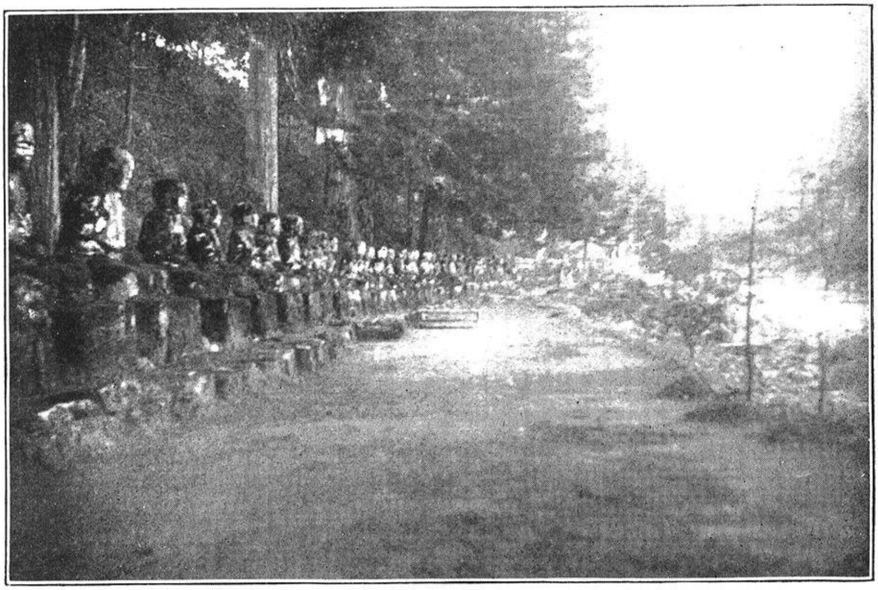
I experienced during my stay in the country. For I can say with but little hesitation that, however good my coolies performance might have been with a passenger who was not "green" in the land, he was passed on the way to the hotel by every mongrel, nondescript outfit that was on the street that day. Later on I became more adept in the matter of selecting "rickshaw-men," and as for my aversion to using this means of transportation, it vanished entirely before I left the country.

I write at greater length on the matter of rickshaws than the subject would seem to merit; as an explanation, however, I would say that this institution appeals so strongly to the sense of the ludicrous, especially in an American, and is such a prominent characteristic of the land, that long after one has forgotten the temples, the groves and the images of Japan, one remembers the rides through the narrow, crowded streets of the cities and through the rice fields and tea-gardens of the country in these funny little carts, drawn by the funny little Japs, shouting all the while, in a high falsetto, "A-hee! A-hee!" to the hundreds of picturesque babies forever playing in the road.

The rickshaw, while it has been of great value to the land on account of having been the direct cause for the improvement of all roads throughout the country, has, on the other hand, been a great obstacle in the way of the progress of civilization, as far as railways are concerned. In Yokohama, I heard, the society (or "union" as we would call it in our country) of rickshaw-men is so powerful that it has been able to successfully antagonize all efforts which have so far been made to introduce street railways into that city; the reason obviously being that the operation of a street railway would necessarily take away their occupation from thousands of men. In Tokio, a city of over 1,500,000 inhabitants, there are a few miles of street railway, the cars being drawn by the diminutive Japanese horses, scarcely larger than Shetland ponies, and moving along at a pace which excites the contempt of the rickshaw-men, who take great delight in racing with them; this affords a rather one-sided contest, however, as one car after another is easily distanced and the coolie must look for other worlds to conquer. At Kiota, which has about half a million inhabitants, there are several miles of electric railway, but the maintenance is so poor that this line does not interfere with the rickshaw industry to any great extent. The only other street-railway in the country, as far as I could ascertain, and this is rather an inter-urban railway, is the electric line from Kodzu to Yumoto, covering a distance of ten miles. This line is very modern in its equipment, its rolling stock especially being quite up-to-date; each train has a first, second and third-class car, as on the steam railways, the cars being modeled after the American pattern. The first-class cars are beautifully finished, and I had expected to find an American manufacturer's mark on entering one, but was surprised to learn that they had been built in Tokio; at least so the sign in the cars proclaimed, but this must not be taken as conclusive evidence.

The development of the steam railway systems is naturally not hampered to such an extent by the rickshaw industry, as the greater distances cannot so conveniently be covered by these conveyances; besides, the commerce of Japan is becoming so extensive that the matter of the rapid transportation of large quantities of freight must be taken into consideration. Formerly, merchandise was transported from place to place, as it still is in some parts, by means of long trains of pack-animals (like the car horses that I mentioned above). With the gradual increase of commerce, however, especially the export trade, this method became insufficient, and the adoption of more modern means had to be considered; in 1870, therefore, the first railway was commenced and completed, and opened for traffic two years later; it was constructed entirely by English Engineers, and of English material.

This line, extending from Yokohoma to Tokio, a distance of eighteen miles, was built and is still owned and operated by the government and its opening was the occasion for a series of magnificent ceremonies and festivities, the Emperor and Empress themselves being present. Since then the government has built and now operates 540 miles of railway, most of which has been constructed by native engineers, in exact imitation of those first eighteen miles, so that the newest railways show very little improvement over those built thirty years ago. The narrow gauge of three feet six inches has been retained, the rails are exceedingly light, much lighter than those now being used for street railways, in our country, and the rolling stock has been improved but very little. The



IMAGES OF THE GOD AMIDA AT NIKKO.

whole affair reminds one more of a child's toy railway than anything else, and the similarity is heightened when the whistles of one of the locomotives lets out a shriek which resembles nothing so much as the blast emanating from a boy's penny whistle. So far all the locomotives, both on the government railways and those operating on the 1,400 miles of railway recently built by private interest, have been brought over from England, except a few large Brooks' freight engines which were sent over from this country; up to this time no engines have been built in Japan, although it does not seem that this should prove such a great undertaking, in view of the fact that the government and private concerns have built complete steamships; the engines in these may have been imported, although I was informed to the contrary.

The cars, both passenger and freight, for all the railways, are being built in Japan. The passenger cars are a queer combination of American and European styles; like the American they have but one compartment extending the full length of the car, the seats running lengthwise along the sides; as in the European carriages, the doors are in the sides, and a running-board extends the full length on the outside. There are two trucks, with but two wheels each, which gives the cars a very flimsy appearance. The interiors of the first class carriages are quite neatly finished, but of course do not approach our modern cars in the matter of luxuriousness. The freight cars are so small and light that two men can move them about the yards for switching purposes, a performance I often witnessed. At the stations the tracks are depressed, so that the running boards of the cars come flush with the platform, an arrangement which might be copied to good advantage in our country, as the boarding and leaving of cars is thereby greatly facilitated.

At all large stations the platforms are either stone or cement, a fact of which one is forcibly reminded by the uproar caused by the clatter and scraping of wooden clogs when a large number of people are hurrying to and from their trains, all dragging their feet in the slipshod manner peculiar to the Japanese; a habit for which one is fain to excuse them, however, when one considers the structure of these clogs, the most unnatural and, seemingly, most uncomfortable of all foot-gears. Often, when a multitude of people are leaving the cars, the noise of an approaching train is completely drowned by this unearthly clatter.

The Japanese are great travelers; this, however, it is said, is a characteristic peculiar to all uncivilized people who are given the opportunity, such as the railroad affords, of enjoying the exhilaration of rapid motion. I never saw a train in Japan in which the second and third class carriages, at least, were not filled to suffocation; the natives, men, women and children, travel up and down the country, from village to village, with no apparent object in view except that of enjoying the ride. Even the poorest classes are enabled to indulge in this luxury, as traveling is quite inexpensive, the fare for first class passengers being about a cent and a half a mile and that for the second and third class being of course, still lower.

The cost of living, in general, is low in Japan, being commensurate with the low wages labor commands. Men employed at skilled labor are seldom paid more than one yen (about 50 cents) a day; women and children earn much less. In a large paper mill at Takasago, I was told, the average wages of male employees is 22 yen per month and that of female employees 18 sen (about 9 cents) per day. Unskilled labor is so cheap that modern labor-saving devices are not much sought by manufacturers, builders and other employers. While many instances to substantiate this statement could be cited, I will mention two cases which came under my observation and were particularly interesting. At Yokohoma, in the erection of a three-story government building a novel, or possibly, very old method of conveying mortar to the top story was used. A system of inclined ways extending from the grour d to that part of the building on which work was being done at the time had been erected, and on this structure men were stationed at intervals of about ten feet; the system of conveying the mortar from the ground to the top was as follows: The lowest man would gather up a large handful of the mortar, which appeared to be simply a mixture of mud and straw, and throw it up to the next man, much as one of our athletes would put the shot; this man would catch it in one hand and propel it in the same fashion to the next above, and so the process would be repeated until the mortar reached its destination. The men showed great dexterity in passing these handfuls of mud, and the work was kept up with lightning-like rapidity from morning until night.

Another instance which came under my notice was the manner of coaling ships at the coaling ports, principally at Nagasaki. This work is invariably done by women and in much the same manner as the mortar is conveyed in the erection of buildings. Inclined ways are laid from the coal junk up to the opening in the ship's side into which the coal is to be thrown and on these ways women are stationed at small enough intervals to be able to pass to each other shallow round baskets, each containing I should judge, about five pounds of coal. In this way junk after junk is emptied as it comes up to the ship's side and a vessel is coaled in a day or a day and a half, on large steamers and war-ships, of course, three or four of these human conveyors are kept at work at different parts of the ship at once in order to hurry the operation. The women, naturally, soon became totally begrimed with the coal-dust and look more like demons than human beings but this fact does not deter them from keeping up a continual bantering, singing and general merrymaking as long as the work lasts.

The Japanese, in general, are a light-hearted, cheerful people who live a life free from care and worry and have, as individuals, but little thought for the future. Very few of them can be said to be wealthy, nor do they evidence any great desire to acquire great riches. Leading an extremely frugal life, they work at their various trades and are satisfied to earn enough to supply their families and themselves with the few pints of rice which they require for the day's sustenance and to enable them to indulge in the few innocent amusements which they appreciate so much.

Men have been known to devote months and even years to a piece of work, an intricate bit of carving or something of the sort, simply for the love of art and on its completion to part with it for a low price, out of all proportion to the real value of the work. The amount of time and labor that has been devoted to the external and internal decorations of temples and shrines and to the construction of various images of gods which are to be seen all over the country has been enormous and many artists, for centuries and centuries, have made their names famous by the works they have left behind them.

As an illustration I would mention the temple of San-ju-san-gen-do which was built at Kyoto in the year 1266. This building is 390 feet long and in it are 1000 carved wooden images of the goddess Kwannon; each image is five feet high

THE DAIBUTSU AT KAMAKURA.

and has eleven faces, that being the way this particular goddess is always pictured; the images were made by four different artists (or possibly I should say workmen) and no two of the figures are exactly alike. The interior of the building was so dark that I did not attempt to photograph this goodly array of goddesses, but at Nikko, a beautiful spot about a hundred miles north of Tokio I took a picture of a long row of stone images of the god Amida, which have stood here for

I know not how many centuries. There is a peculiar tradition connected with this aggregation of Amidas to the effect that no matter how often one attempts to count them, the result will always be different, the truth of which assertion I did not take the trouble to test.

At Kamakura, which was at one time the capital of Eastern Japan, is a monster image of the god Buddha, called the Daibutsu. While this is not the largest image of Buddha in Japan, there being a larger one both at Nara and Kyoto, it is in point of workmanship and artistic perfection by far the most valuable; and, although it has stood here for 700 years, it is in an excellent state of preservation, time and the elements having left scarcely a mark on it, which shows how carefully and thoroughly the work must have been done. The image is built up of sheets of bronze, cast separately, brazed together and finished off the outside with the chisel; the eyes are of pure gold, and the boss on the forehead is silver, weighing about thirty pounds. An idea of the immensity of the structure can be had from the following dimensions: the height is 49 ft. 7 in., the length of its face 8½ ft., and the length of the eye, ear, and nose are 4 ft., 6½ ft, and 3 ft. 9 in. respectively. The image is hollow, and I climbed up into the head on a series of rather shaky ladders, which have been put there for the benefit of the curious.

While Japan is considered by foreigners much in the light of a playground and a sort of museum of curios, and the common class of natives give but little thought to the future, the Japanese government takes itself much more seriously and is very much in earnest in its desire to make rapid progress on its way to civilization; the nation has high ambitions, and, if one may judge from present indications, will persevere in its attempt to complete the task it has set itself, until it will have attained a place among the first nations of the earth, if it has not already done so.

Thus the Japan of yesterday, with its romance and art, is changing into the Japan of tomorrow, a land of commerce, industry and education; soon the country will be Japan in name only, and the thrifty Japanese will have shown that they have merited the title, "The Yankees of the Orient," which some one has bestowed on them.

THE HOLBROOK SPIRAL CURVE.

PROF. W. D. TAYLOR.

The following account of the properties of this curve and of its use is compiled from various sources:

Let R = radius of the central circular curve.

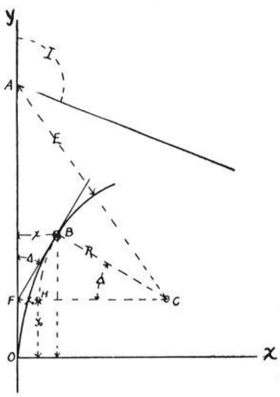
Let $\triangle$ = total angle turned on the spiral from the tangent to any point B on the curve.

Let d = deflection angle at O to turn from tangent O A to any point on O B distant L ft. from O.

Let (x, y.) = co-ordinates (cartesian) of any point on O. B.

Let (x_0, y_0) = co-ordinates of H., P. C. of the central curve.

Let L = distance from O in ft. of any point on O B.



Note: By a "60 ft. spiral" is meant a spiral that increases its rate of curvature one degree per 100 ft. for each 60 foot distance along the spiral.

The equation of the spiral can be written thus:

$$R\,L = C$$

where C is one constant for any one spiral, but a different constant for each particular spiral. Thus: For a 30 ft., 60 ft.. and 120 ft. spiral, respectively, taking the radius of a one degree curve to be 5730 ft.

R L = 5730 × 30 = 171900.

R L = 5730 × 60 = 343800.

R L = 5730 × 120 = 687600.

Now to express in minutes of arc the subtended central angle for any length L of the spiral we have:

$$\triangle = \frac{K\,L^2}{100} \quad \text{.......................................} (1)$$

where K is a constant and = the number 30 divided by the chord length of spiral: Thus for a 60 ft spiral $K = \frac{30}{60} = 0.5$. To express Δ in circular measure we have:

$$\Delta = \frac{KL^2}{100} \times \frac{1}{60} \times \frac{1}{57.2958} = 0.00000291\ K\ L.^2 \ldots\ldots\ldots\ldots\ldots (A)$$

Or if we make $c = 0.00000291$ K. we can write:

$$\Delta = c\ L^2 \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots (B)$$

Where c has the value shown in table I below for the various spirals.

Applying the calculus we have:

$$\frac{dx}{dL} = \sin \Delta = \sin cL^2 \text{ , or}$$

$$dx = \sin cL^2 dL \therefore x = {}^{*}\!\!\int_0^L \sin cL^2 dL.$$

Expanding the sine in terms of the angle by trigonometry.

$$\sin a = a - \frac{a^3}{\underline{3|}} + \frac{a^5}{\underline{5|}} - \frac{a^7}{\underline{7|}} + \text{etc.}$$

For *a* write cL^2 in value of x and we have:

$$x = {}^{*}\!\!\int_0^L \left(cL^2 - \frac{c^3L^6}{\underline{3|}} + \frac{c^5L^{10}}{\underline{5|}} - \frac{c^7L^{14}}{\underline{7|}} + \text{etc}\right) d\ L, \text{ integrating,}$$

$$x = \frac{cL^8}{3} - \frac{c^3L^7}{42} + \frac{c^5L^{11}}{1320} - \frac{c^7L^{15}}{75600} + \text{etc.}$$

$$= \frac{cL^3}{3} - 0.0238c^3L^7 + 0.00076\ c^5\ L^{11} - \text{etc} \ldots\ldots\ldots\ldots\ldots (2)$$

Similarly, $\frac{dy}{dL} = \cos \Delta = \text{cas } c\ L^2$.

$$dy = \cos c\ L^2\ d\ L, \text{ and } y = {}^{*}\!\!\int_0^L \cos c\ L^2\ d\ L.$$

$$\cos a = 1 - \frac{a^2}{\underline{2|}} + \frac{a^4}{\underline{4|}} - \frac{a^6}{\underline{6|}} + \text{etc. Hence:}$$

$$y = {}^{*}\!\!\int_0^L \left(1 - \frac{c^2L^4}{\underline{2|}} + \frac{c^4L^8}{\underline{4|}} - \frac{c^6L^{12}}{\underline{6|}} + \text{etc.}\right) d\ L\text{-}$$

$$= L - \frac{c^2L^5}{10} + \frac{c^4L^9}{216} - \frac{c^6L^{13}}{9360} + \text{etc.}$$

$$= L - 0.1c^2L^5 + 0.00463c^4L^9 - \text{etc.} \ldots\ldots\ldots\ldots\ldots (3)$$

By inspection of the figure the following formulas are easily derived:

$$x_o = x - R(1 - \cos \Delta) \ldots\ldots\ldots\ldots\ldots\ldots\ldots (4)$$

$$y_o = y - R \sin \Delta \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots (5)$$

$$d = \tan^{-1}\frac{x}{y} \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots (6)$$

$*\int$ denotes integral sign.

In most cases in steam railroad practice it will be near enough for practical purposes to take $x_o = \frac{x}{4}$, and $d = \frac{\Delta}{3}$

Since both (2) and (3) are rapidly converging series a very few terms will express the result with sufficient accuracy. For care in computation the formulae (1), (2)......(6) are arranged in order to give the elements in the tables in the (1), (2)...... and 6th column after the column giving L.

To get the distance to measure back from the point of intersection to start the spiral we have:

$A\ O = T = (R + x_o) \tan \frac{1}{2} I + y_o$ ....(C)

To take an example from practical work let $I = 36°36'$ and A fall at station 42 + 47.47. Run in the curve with 60 ft spirals, the central curve being a 6°.

$A\ O = T = (955 + 5.64)\ 0.3307 + 179.79 = 497.47$. Then O the P. S. falls at 37 + 50. To locate the stations 38, 38+50, 39, 39 + 50, 40, 40 + 50, 41, and 41 + 10, the point B, the P. C. C., turn from the tangent A O the angles 0° 0.42′, 0° 16.7′, 0° 37.5′, 1° 06.7′, 1° 44.2′, 2° 30′, 3° 24.2′ and 3° 36′, respectively, the transit setting at O. To continue the central curve from B, sight back at O with vernier set so that when the angle $O\ B\ F = \frac{2}{3}\Delta = 7°\ 12'$ (in this case) is turned the zeros of the instrument shall coincide when the telescope points along the common tangent of the spiral and central curve at B. The central curve is thus to be run in similarly to any other circular curve to the point 43 + 60 which is the P. C. C. of 2nd spiral. Note that 10° 48′ of central angle is turned on each spiral leaving 15° to be turned on the central curve.

In putting in spirals in old track it is often times best to increase the degree of the central curve so as to throw the middle point of the curve toward A and the ends of the old curve toward C, then getting in the spirals with the minimum amount of horizontal shift of the track. If the old track is to true line and located without spirals we have the external distance $E = R(\sec. \frac{1}{2} I - 1) = R$ Exter. sec. $\frac{1}{2}$ I.

To find the degree of central curve D′, radius R′ with the new external distance E′, and without spirals, we have:

$R' = \frac{E'}{\text{Exter. sec.} \frac{1}{2} I.}$ From which D′ can be determined by interpolation in a table of radii or by the formula $D' = \frac{5730}{R'}$

D′′ the degree of curve with spirals and external E′ is given by

$$D'' = \frac{E' + x_o \sec. \frac{1}{2} I}{E'} D' \dots\dots\dots\dots\dots\dots\dots\dots \text{(D)}$$

The formula (D) is perfectly general and by its use E′ can be taken = E so that the central part of the present curve need not be disturbed if so desired.

It should be noticed that in the formula (D) x_o is supposed to correspond with D′′ and not with D′, but knowing x_o for (D) since x_o changes so slowly with considerable change in D, x_o can usually be estimated on the first, and always on the second, approximation with sufficient accuracy.

TABLE I.

Chord Length of Spiral Used.	6 ft.	12 ft.	18 ft.	24 ft.	30 ft.	36 ft.	48 ft.	60 ft.	84 ft.	108 ft.	120 ft.	180 ft.	240 ft.
Valve of K.	5	$\frac{5}{2}$	$\frac{5}{3}$	$\frac{5}{4}$	1	$\frac{5}{6}$	$\frac{5}{8}$	$\frac{1}{2}$	$\frac{5}{14}$	$\frac{5}{18}$	$\frac{1}{4}$	$\frac{1}{6}$	$\frac{1}{8}$
Value of c = 0.00000291 K.	0.0000145	0.00000755	0.0000048	0.00000364	0.00000291	0.00000243	0.00000182	0.00000145	0.00000104	0.00000081	0.00000073	0.00000048	0.00000036

TABLE NO. II.—18 FT. SPIRAL.

Degree of curve.		L. ft.	△		x	y	y_o	d	
0°	20	6	0°	0.6	.00	6.00	3.00	0°	0.2
	40	12		2.4	.00	12.00	6.00		0.8
1°	00	18	0°	5.4	.01	18.00	9.00	0°	1.8
	20	24		9.6	.02	24.00	12.00		3.2
	40	30		15.0	.04	30.00	15.00		5.0
2°	00	36	0°	21.6	.08	36.00	18.00	0°	7.2
	20	42		29.4	.12	42.00	21.00		9.8
	40	48		36.1	.18	48.00	24.00		12.1
3°	00	54	0°	48.6	.25	54.00	27.00	0°	16.2
	20	60	1°	00.0	.35	60.00	30.00		20.0
	40	66		12.6	.46	66.00	33.00		24.2
4°	00	72	1°	26.4	.60	72.00	36.00	0°	28.8
	20	78		41.4	.77	77.99	38.99		33.8
	40	84		57.7	.91	83.99	41.99		39.3
5°	00	90	2°	15.0	1.18	89.99	44.99	0°	45
	20	96		35.6	.43	95.98	47.98		51.2
	40	102		53.4	.71	101.97	50.97		57.8
6°	00	108	3°	14.4	2.04	107.97	53.97	1°	4.8
	20	114		36.6	.39	113.95	56.96		12.2
	40	120	4°	00.0	.79	119.94	59.95		20.0
7°	00	126	4°	24.6	3.23	125.93	62.94	1°	28.2
	20	132		50.4	.72	131.91	65.93		36.8
	40	138	5°	17.4	4.25	137.88	68.92		45.8
8°	00	144	5°	45.6	4.83	143.85	71.90	1°	55.2

TABLE NO. III. 30 FT. SPIRAL.

Degree of Curve	L. ft.	△	x	y	y_0	d
0° 20	10	0° 1.0	.00	10.00	5.00	0° 0.3
40	20	4.0	.01	20.00	10.00	1.3
1° 00	30	0° 9.0	.03	30.00	15.00	0° 3.0
20	40	16.0	.06	40.00	20.00	5.3
40	50	25.0	.12	50.00	25.00	8.3
2° 00	60	0° 36.0	.21	60.00	30.00	0° 12.0
20	70	49.0	.33	70.00	34.98	16.3
40	80	1° 4.0	.50	80.00	39.98	21.3
3° 00	90	1° 21.0	.73	90.00	44.98	0° 27.0
20	100	40.0	.97	99.99	49.97	33.3
40	110	2° 1.0	1.29	109.99	54.97	40.3
4° 00	120	2° 24.0	1.68	119.98	59.97	0° 48.0
20	130	49.0	2.14	129.97	64.96	56.3
40	140	3° 16.0	2.66	139.95	69.96	1° 5.3
5° 00	150	3° 45.0	3.27	149.93	74.95	1° 15.0
20	160	4° 16.0	3.97	159.91	79.94	25.3
40	170	49.0	4.77	169.88	84.94	36.3
6° 00	180	5° 24.0	5.65	179.84	89.93	1° 48.0
20	190	6° 1.0	6.64	189.79	94.91	2° 0.3
40	200	40.0	7.75	199.73	99.89	13.3
7° 00	210	7° 21.0	8.96	209.65	104.86	2° 27.0
20	220	8° 4.0	10.30	219.56	108.89	41.3
40	230	49.0	11.77	229.45	114.82	56.3
8° 00	240	9° 36.0	13.38	239.33	119.79	3° 12.0

TABLE IV.—60 FT. SPIRAL.

Degree of curve.	L. ft.	△	x	y	$y_\circ$	d
0° 10	10	0 00.6	0.00	10.00	5.00	0° 00.2
20	20	02.1	.00	20.00	10.00	00.7
30	30	04.5	.01	30.00	15.00	01.5
40	40	08.1	.03	40.00	20.00	02.7
50	50	12.6	.06	50.00	25.00	04.2
1° 00	60	0° 18.0	0.10	60.00	30.00	0° 06.0
10	70	24.6	.17	70.00	35.00	08.2
20	80	32.1	.25	80.00	40.00	10.7
30	90	40.5	.35	90.00	45.00	13.5
40	100	50.1	.48	100.00	50.00	16.7
50	110	1° 00.6	.66	110.00	55.00	20.2
2° 00	120	1° 12.0	0.84	120.00	60.00	0° 24.0
10	130	24.5	1.06	129.99	65.00	28.2
20	140	38.0	1.33	139.99	70.00	32.7
30	150	52.5	1.64	149.98	75.00	37.5
40	160	2° 08.0	1.99	159.98	80.00	42.7
50	170	24.5	2.38	169.97	85.00	48.2
3° 00	180	2° 42.0	2.83	179.96	90.00	54.0
10	190	3° 00.5	3.32	189.95	95.00	1° 00.1
20	200	20.1	3.88	199.93	100.00	06.7
30	210	40.5	4.49	209.91	104.99	13.5
40	220	4° 02.0	5.16	219.89	109.98	20.7
50	230	24.5	5.90	229.86	114.98	28.2
4° 00	240	4° 48.0	6.70	239.83	119.97	1° 36.0
10	250	5° 12.5	7.57	249.79	124.97	44.2
20	260	38.0	8.51	259.75	129.96	52.7
30	270	6° 04.5	9.53	269.70	134.95	2° 01.5
40	280	32.0	10.63	279.64	139.95	10.7
50	290	7° 00.5	11.81	289.57	144.93	20.1
5°	300	7° 30.0	13.07	299.49	149.91	2° 30.0
10	310	8° 00.5	14.42	309.40	154.91	40.2
20	320	32.0	15.86	319.29	159.89	50.1
30	330	9° 04.5	17.34	329.17	164.86	3° 01.5
40	340	38.0	19.02	339.04	169.85	12.7
50	350	10° 12.5	20.74	348.89	174.82	24.2
6° 00	360	10° 48.0	22.56	358.72	179.79	3° 36.0
10	370	11° 24.5	24.49	368.54	184.76	48.2
20	380	12° 02.5	26.52	378.33	189.72	4° 00.7
30	390	40.5	28.66	388.09	194.68	13.5
40	400	13° 2.0	30.91	397.84	199.64	26.7

TABLE V. 90 Ft. SPIRAL.

Degree of Curve.	L. ft.	△	x	y	y_0	d.
0° 10	15	0° 0.75	0.00	15.0	7.50	0° 0.2
0 20	30	0 3.0	0.00	30.0	15.00	0 1.0
0 30	45	0 6.75	0.02	45.0	22.50	0 3.2
0 40	60	0 12.0	0.07	60.0	30.00	0 4.0
0 50	75	0 18.75	0.13	75.0	37.50	0 6.2
1° 00	90	0° 27.0	0.23	90.0	45.00	0° 9.0
1 10	105	0 36.75	0.37	105.0	52.50	0 12.2
1 20	120	0 48.0	0.58	120.0	60.15	0 16.0
1 30	135	1 6.75	0.79	135.0	71.11	0 20.2
1 40	150	1 15.0	1.09	150.0	75.00	0 25.0
1 50	165	1 30.75	1.44	164.99	77 51	0 30.2
2° 00	180	1° 48.0	1.88	179.98	90.01	0 36.0
2 10	195	2 6.75	2.36	194.98	97.70	0 42.2
2 20	210	2 27.0	2.99	209.97	105.03	0 49.0
2 30	225	2 48.75	3.68	224.95	112.34	0 56.2
2 40	240	3 12.0	4.47	239.93	120.02	1° 4.0
2 50	255	3 36.75	5.36	254.90	127.80	1 12.2
3° 00	270	4° 3.0	6.29	269.87	134.97	1 21.0
3 10	285	4 30.75	7.40	284.83	142.43	1 30.2
3 20	300	5 .0	8.64	299.78	148.96	1 40.
3 30	315	5 30.75	10.00	314.71	157.47	1 50.2
3 40	330	6 3.0	11.50	329.64	164.91	2 1.0
3 50	345	6 36.75	13.14	344.55	172.40	2 12.2
4° 00	360	7° 12.0	14.93	359.43	179.42	2° 24 0
4 10	375	7 48.75	16.87	374.31	187.40	2 36.2
4 20	390	8 27.0	18.95	389.16	194.75	2 49.0
4 30	405	9 6.75	21.23	403.98	202.21	3 2.2
4 40	420	9 48.0	23.66	418.78	209.47	3 16.0
4 50	435	10 30.75	26.28	433.54	217.33	3 30.2
5° 00	450	11° 15.0	29.08	448.27	224.69	3° 45.0
5 10	465	12 0.75	32.07	462.96	232.15	4 0.2
5 20	480	12 48.0	35.27	477.61	39.45	4 16.0
5 30	495	13 36.75	38.66	492.21	46.64	4 32.2
5 40	510	14 27.0	41.03	506.91	54.38	4 49.0
5 50	525	15 18.75	46.08	521.27	61.69	5 6.2
6° 00	540	16° 12.0	50.10	535.69	269.26	5 24.0
6 10	555	17 6.75	54.35	550.07	76.42	5 42.2
6 20	570	18 3.0	58.76	564.46	284.05	6 1.0
6 30	585	19 0.75	63.57	578.59	291.27	6 20.2
6 40	600	20 .00	68.52	592.73	298.60	6 40.0

THE CONDUCTION OF HEAT IN LIQUIDS.

G. W. WILDER, PH. D.

It is a matter of common experience that water will expand and become less dense upon being heated. The usual process of heating a vessel of water is explained upon this basis. The layer of water next to the bottom of the vessel is heated by conduction through the vessel from the flame; expansion occurs and the consequent decrease in the density of the liquid causes the heated portions to rise to the surface, while the cooler parts sink to the bottom. This process is repeated and the currents set up by the continual streaming of warm water upwards and cold water downwards are known as convection currents.

In studying the conduction of heat in liquids it has always been difficult to eliminate these convection currents. Various methods have been tried by different investigators but the lack of harmony among the many results obtained, indicate that the complete separation of conduction from convection is still a difficult matter. Most of the earlier investigators sought to eliminate all effects of convection by heating the liquid from above instead of from below and watching the increase in temperature of the lower layers. Such has been the scheme in general with later investigators, only greatly modified.

The earliest experiments of any note were those of Depretz's (Pogg. Ann. XLVI), who used a simple method for observing the flow of heat through water. He put the water in a cylindrical wooden tank, one meter high and twenty centimeters in diameter. Along the sides of the tank he bored holes at equal intervals and inserted thermometers so that their bulbs were in the axis of the cylinder and vertically over one another. After heat had been supplied to the upper surface of the water for some time the upper thermometers were observed to show a gradual increase of temperature and the wave of heat proceeded slowly downwards until after some thirty-six hours all of the thermometers were constant in their readings. The conclusion was reached that the flow of heat through liquids followed essentially the same laws as those for solids. Also that the conductivity of copper was to that of water as 1000 : 9. There is no doubt that in this method convection currents are present, for, unless the walls of the containing vessel conduct heat at exactly the same rate that water does, then that portion of the water in contact with the walls becomes heated sooner or later than does the water in the interior, hence we have an uneven distribution of temperature horizontally as well as vertically and convection currents are produced.

In order to eliminate the effect due to the sides of the containing vessel Guthrie (Phil. Mag., vol. xxxvii) used two equal hollow metal cones placed with their bases horizontal and at a small distance apart. The liquid was placed between the bases of the cones, where it was held by the forces of capillarity. Hot water was allowed to flow in and out of the upper cone, thus heating the upper surface of the liquid between the cones.

The air in the lower cone served as an air thermometer to indicate the temperature of the lower surface of the liquid. While this arrangement would seem to be a good one, it is probable that the means used to measure the change in temperature of the layer of liquid were very inaccurate (see Chree, Phil. Mag. July, 1887), at any rate the results obtained by this method are inconsistent.

Lundquist (Upsala Universitets Arsskrift, 1867) used a method due to Angstrom (Pogg. Ann., 123, 137, 1864), in which the liquid was placed in a glass cylinder and periodically warmed and cooled from above. This method, which is a tedious one to perform, gives quite consistent results. Some of the values obtained are as follows:

Water	K = 0.0936
Salt solution, density 1.178	K = 0.0894
Zinc sulphate solution, density 1.237	k = 0.0984

In which k is the coefficient of thermal conductivity expresed in units of the gram, centimeter and minute, and is defined as being the number of calories of heat which will be conducted in one minute through a cubic centimeter of liquid between any two parallel sides differing in temperature by one degree centigrade. The calorie being the amount of heat necessary to raise a gram of water one degree centigrade.

Winkelman (Pogg. Ann. 153, 1874,) used two brass cylinders, one enclosing the other. The liquid to be examined was placed between the cylinders. The system was heated from the outside and the flow of heat through the liquid to the inner cylinder was measured by using the latter as an air thermometer. Since the inner cylinder was completely enclosed it was thought that convection currents were entirely compensated for. The results obtained by this method agree with the preceding one only in the case of water. It has been shown since, however, that the discrepancies are due to convection currents, which are not compensated for.

Beetz. (Wied. Ann. 8, 1879) used a very similar method, using glass cylinders. He discovered, however, the presence of convection currents by using lycopodium powder in the liquid and watching its movements by a microscope. He found also, that the higher the temperature the greater was the convection effect.

Prof. Weber (Wied. Ann. 10, 1870) sought to entirely eliminate convection currents by a method in which the layer of liquid was very thin. For this purpose he used two copper plates about 16 cm. in diameter, which were placed in a horizontal position, and separated a small distance by three little pieces of plate glass. The liquid to be examined was placed between the plates and the whole system was then heated to a temperature of about 40°C. The system was then placed on a plane of ice and allowed to cool. The cooling of the upper plate was observed by means of a thermojunction and galvanometer.

By means of this method, Prof Weber found the coefficient of thermal conduction of water and of numerous salt solutions.

The following table shows the values found for a few of the more common solutions, in which k is the coeff. of conduction, δ the specific gravity, and c is the specific heat. The product of δ x c gives the specific heat per cubic centimeter; η is the ratio between conductivity and specific heat per unit volume.

	δ.	c.	δ. c.	$\eta = \frac{k}{\delta . c.}$	k.
Water....................	1.000	1.000	1.000	0.0745	0.0745
Copper sulphate	1.160	0.878	0.984	0.0722	0.0711
Zinc sulphate, I..........	1.134	0.861	0.976	0.0729	0.0718
Zinc sulphate, II.........	1.272	0.765	0.973	0.0721	0.0691
Zinc sulphate, III........	1.362	0.706	0.962	0.0718	0.0690
Salt solution.............	1.178	0.800	0.942	0.0735	0.0692
Glycerine.................	1.220	0.605	0.738	0.0545	0.0402
Alcohol...................	0.795	0.566	0.450	0.0649	0.0292

The fourth column shows that the coeff. of conduction is proportional to the specific heat per unit of volume. The last column shows that water has the highest coeff. of conduction, and that in the case of a solution of zinc sulphate, the coeff. decreases with increase in specific gravity.

Prof. Weber also experimented at different temperatures and found that the coeff. of conductivity varied considerably with the temperature. The following values will give a general idea of the effect of temperature upon the coefficient:

	k	
Water	0.0745	for an average temp of 4.10°C.
Water	0.0857	for an average temp of 23.67
Salt solution	0.0692	for an average temp of 4.40
Salt solution	0.0808	for an average temp of 26.28
Zinc sulphate	0.0691	for an average temp of 4.50
Zinc sulphate	0.0776	for an average temp of 23.40
Glycerine	0.0402	for an average temp of 6.25
Glycerine	0.0433	for an average temp of 25.20

If it is assumed that the conduction coeff. of these liquids increases linearly with the temperature between 4° and 25° C or that

$$k = k_0(1 + at)$$

when k_0 and a are calculated from the data above, then we obtain the following values:

Water	$k_0 = 0.0722$	$a = 0.00786$
Salt solution	$k_0 = 0.0669$	$a = 0.00790$
Zinc sulphate	$k_0 = 0.0670$	$a = 0.00670$
Glycerine	$k_0 = 0.0391$	$a = 0.00423$

Later Prof. Weber extended his experiments and included over 50 organic liquids. In these experiments he used flowing water as the cooling agent instead of ice.

The later experiments were carried out mostly for the purpose of testing the accuracy of the Weber method. A few used a modification due to Christiansen (Wied. Ann. 14, 323, 1881,) in which three copper plates were used, being placed vertically above one another. The temperature in this case was measured by a specially constructed thermometer. Henneberg (Wied. Ann. 36, 146, 1889,) found by this method values for water and for alcohol which were slightly smaller than those given by Weber. He found also that for a mixture of alcohol and water that the coeff. of conduction increased directly as the amount of alcohol decreased. As for temperature effects the mixture did not follow the laws given by Weber.

Jäger (Wien. Ber. 99, 245, 1890) and Graetz (Wied. Ann. 16, 79, 1883) (Wied. Ann. 25, 337, 1885) used Weber's method and found great discrepancies in the results. This led to doubts as to the reliability of the method. It was thought by many that convection currents might still be present.

Wachsmuth (Wied. Ann. 48, 158, 1893) sought to detect the presence of any convection currents which might be present by using gelatin. He first measured the coeff. of conduction of water in the ordinary way and then added one per cent. of gelatin which was sufficient to solidify the water and prevent convection currents. A second determination showed very little change in the value of the coeff., so that he concluded that with the Weber method convection currents are entirely eliminated, and is hence the most accurate for determining the conduction coeff. in liquids.

Since there was considerable doubt as to variation in the coeff. of conduction in salt solutions with regard to density, the author undertook to carry out an investigation at the suggestion of Prof. Weber with the idea of finding out if any relation existed between coeff. of conduction, specific heat, density and temperature. Prof. Weber's work had been limited to a few solutions, and no attempt had been made to carefully study these with regard to density. It had been thought that the coeff. of conduction was some linear function of the density consequently the prime object of this work was to see how the coeff. of conduction varied with the density of the solution.

The method and apparatus used in this work were essentially the same as used by Prof. Weber as outlined in the preceding discussion. The solution under examination was placed between two plane parallel copper plates. The plates were placed in a horizontal position and separated by three pieces of plane parallel plate-glass, each piece being exactly 1.005 m. m. thick. The three pieces having an aggregate area of only 22.0 sq. m. m. The lower plate was 21.0 cm. in diameter and 1.2 cm. thick and was firmly fastened to a stout metal frame which was in turn imbedded in a pile of masonry beneath the floor of the laboratory. The upper copper plate was 18 cm. in diameter and 1.3195 cm. thick. In order to place the solution between the plates a glass ring 2 cm. wide and having a diameter somewhat larger than that of the upper plate was fastened on the lower plate. The solution was then poured upon the lower plate until it rose upon the walls of the glass ring showing a depth of about 2 m. m. After the three glass pieces were carefully placed in position the upper plate was lowered into the ring until it rested upon the glass. All excess solution was then removed by a rubber tube slipped in between the plate and the walls of the ring. In this way the layer of solution was regulated and adjusted until it exactly fitted between the plates, the capillary action being sufficient to keep the liquid from escaping.

After placing the solution between the plates the system was brought to a temperature of about 45°C by heating from below with a Bunsen burner. When this temperature was attained the system was left for two or three minutes so that the heat would become uniformly distributed throughout and all parts of the system would be at the same temperature. At the expiration of a sufficient time for this to be brought about, water from the hydrant was directed against the under surface of the lower plate, thus bringing its temperature to a point far below 45° and keeping it there constant. The supply of water was obtained from a huge tank a few hundred feet away and after allowing the water to run from the two-inch hose for some minutes it was found that its temperature did not change materially during the course of an experiment.

The lower plate having been brought to a temperature lower than that of the upper one a flow of heat occurs from the upper through the intervening liquid to the lower. From the rate at which heat is conducted through any horizontal layer of the liquid the coeff. of conduction can be obtained. The upper layer or that one next to the surface of the upper plate is best chosen as the one in which to study the rate of flow, because here the temperature change is sharper and easier to observe. Since the upper plate is of copper and hence is a good conductor of heat any horizontal layer of it will experience the same change in temperature from time to time, that would be experienced by the upper layer of liquid. In order to measure this change a thermo element of iron and constantine was imbedded in the middle of the upper plate. The other junction being placed in the running water from the hydrant and the circuit being completed through an aperiodic galvanometer of the Helmoltz type. By observing the deflection of the galvanometer needle at any time a measure is obtained of the difference in temperature between the upper and lower plates. It will be observed that not all of the heat lost by the upper plate in any given time will be by conduction through the liquid. A small amount is lost by radiation from the plate out into the surrounding space. The amount of heat lost by radiation in this manner can be determined experimentally and will be described later on. In order to assure uniform results the upper plate was covered by a copper cylinder containing running water immediately after the hydrant was turned on for the purpose of cooling the lower plate. The cylinder was so constructed that water surrounded the entire system of plates, hence the upper plate lost heat by conduction and radiation to bodies having the same temperature.

By observing the rate at which the temperature of the upper plate changes by use of the galvanometer and scale, and knowing the dimensions of the different parts of the system, the mass, specific heats, etc., we are able to calculate the absolute conduction of heat through a liquid. The development of the theory for this method is long, hard and complicated, and has been worked out quite carefully by Prof. Weber (Wied. Ann. 10, 126.) The final result as used for calculating the coefficient of conduction k is:

$$k = \frac{\delta . c}{q_1^2} . \quad \frac{1}{t_{n+i} - t} \quad \log \left(\frac{x_i}{x_{n+i}} \right)$$

in which

δ = specific gravity of the liquid.

c = specific heat of the liquid.

$t_{n+} t_n$ = interval of time between the temperature observations.

x_i = scale reading at time t_i.

x_{n+i} = scale reading at time t_{n+i}.

q_1 is the smallest root of the transcendental equation.

$$q \triangle \tan q \triangle = \frac{\triangle \delta c}{\triangle_1 \delta O_1} \frac{1}{\left(1 - \frac{h_1 F_1}{k F \delta_1} . \frac{1}{(q \triangle)^2}\right)}$$

where

$\triangle$ = thicknesss of the layer of liquid.

$\triangle_1$ = thickness of the upper plate .

F = area of the upper plate.

F_1 = area of the lower plate.

δ_1 = density of copper.

c_1 = specific heat of copper.

h_1 = amount of heat radiated from the upper plate.

It will be noticed that since the value of k appears in the transcendental equation an absolute determination of the value of the least root is impossible. An approximation of k is first used and a value of q_1 determined. This is then inserted in the first equation and a very close approximation of k obtained. This new value of k is used, and the process repeated until the new values of k do not differ from each other. This method of procedure is allowable and gives an exact value of k in two trials.

To determine the value of h_1. or the radiation constant, the usual method was resorted to. The upper plate was heated to the usual temperature, and then placed in position without any liquid between it and the lower plate. The cooling of the upper plate was observed by the galvanometer and scale, the cooling in this case being entirely due to radiation and convection of air currents. Then if u is the temp. at time t and M_1, and O be the Mass and area of the surface of the plate, we have the relation between u and t expressed by the following differential equation:

$$-M_1 c_1 du = h_1 . O\, d t u$$

If u_0 is the temp. at the time when t = o, then the integral of this equation is:

$$\log\left(\frac{u_0}{u}\right)=\frac{h_1\ O}{M_1\ c_1}t$$

Now since the ratio of temperatures u_0 and u are expressed by the scale readings x of the galvanometer we have:

$$\log\left(\frac{x_0}{x}\right)=\frac{h_1\ O}{M_1\ c_1}t$$

Several trials were made in all of which the readings were taken at one minute intervals making t = 1 in the equation, the units being gram, centimeter and minute. Four trials gave as a result of $\log \frac{x_0}{x}$ the following: 0.01629, 0.01612, 0.01617, 0.01626. These give an average value of 0.01621.

Since O = 900.20 sq. cm. and M_1 = 4731.0 gms, and c_1 = 0.0932, a result for the radiation constant is obtained of h_1 = 0.00792.

After the liquid had been placed between the plates and heated to 45° C., the zero of the galvanometer was observed every thirty seconds until the water was turned on. Forty seconds later the galvanometer circuit was closed and readings taken every five seconds. As before stated the galvanometer was an aperiodic one. It had four coils and was astatic, the magnets being ring formed. The sensibility was adjusted so that 10° C. corresponded to 160 mm. on the scale at a distance of 2 meters from the mirror.

After 2.5 minutes the deflections usually became so small that the circuit was broken and in each succeeding 30 seconds the zero point determined. In general the zero point remained fairly constant. It seldom changed more than 2 or 3 scale divisions.

After the scale readings were corrected for tangents, their logarithms were found to five places and each log subtracted from the twelfth preceding one. Since the observations were taken at 5 second intervals, this would give the ratio of the temperatures per minute.

The following table gives the values of a set taken for water. The first column gives the time, the second the scale deflections, the third the corresponding temperature, the fourth the common logs. and the fifth their differences:

Time.	x	t	log x	△ log x
10 h. 23 m. 10 sec.	327.1	27.23	2.51468	....
15	306.5	19.92	.48641	....
20	287.9	18.67	.45924	....
25	270.2	17.54	.43169	....
30	253.4	16.45	.40381	....
35	238.0	15.46	.37658	....
40	224.2	14.56	.35064	....
45	210.8	17.70	.32387	....
50	198.4	12.89	.29754	....
55	187.0	12.13	.27184	....
60	176.0	11.42	.24551	....
10 — 24 — 5	165.6	10.65	.21906	....
10	155.3	10.10	.19117	0.32251
15	146.0	9.52	.16435	.32208
20	138.2	8.98	.14051	.31873
25	130.3	8.48	.11494	.31675
30	122.5	7.96	.08814	.31567
35	115.3	7.50	.06183	.31475
40	108.8	7.07	.03663	.31401
45	102.3	6.66	.00988	.31399
55	95.8	6.22	1.98137	.31617
55	90.2	5.85	.95521	.31663
60	84.7	5.52	.92891	.31660
10 — 25 — 5	79.9	5.19	.90255	.31651
10	74.6	4.85	.87274	.31843
15	70.4	4.57	.84757	.31678
20	66.9	4.28	.82543	.31508
25	63.4	4.12	.80209	.31285
30	59.4	3.86	.77397	.31417
35	55.4	3.60	.74351	.31832
40	52.4	3.40	.71933	.31730
45	49.6	3.22	.69548	0.31440
		4.84 average		0.316689

The slight decrease in the values of the last column show that the coefficient of conduction decreases a little with decrease in temperature, as was pointed out by Prof. Weber. The average value of this set gives:

$$\frac{1}{t_{n+i} - t} \log \left(\frac{x_i}{x_{n+i}} \right) = 0.316689$$

The average temperature of the layer of water was 4.84° above that of the lower plate, and since the temperature of this was the same as the hydrant water, namely, 13.46.° The average temperature of the layer of liquid was 18.30°. Eight such sets gave the following values at the corresponding temperatures:

$\triangle$ log x	t
0.316689	18.30
0.316842	18.27
0.317033	18.36
0.315020	18.40
0.314237	18.22
0.314963	18.27
0.318202	18.26
0.318030	18.32
0.316503	18.30°

If these average values be substituted with the known value of M_1, c_1, F_1, F_2, and $\triangle_1$ in the formula as described above, a value is obtained of k = 0.08127, which is the coefficient of thermal conduction of water at a temperature of 18.30°C. In order to get a value for k at other temperatures than 18.30°, it was necessary to perform the experiment at different seasons of the year when the hydrant water was at different temperatures. The above value was obtained in the summer time. In the winter, when the water was at nearly 4°C, the average temperature of the layer of liquid was about 10°C. Nine such determinations gave the following:

t	k	k_1
18.30	0.08127	0.08130
18.05	.08112	.08112
16.71	.08011	.08113
12.01	.07675	.07668
9.41	.07474	.07475
9.51	.07506	.07483
15.11	.07906	.07795
14.50	.07860	.07850
15.26	0.07916	0.07907

If the values of k and t are platted in the form of a curve we get a straight line as a result, hence their relation can be expressed by the equation:

$$k = k \ (1 + at)$$

Where k is the coefficient of conduction at the temperature t, k_o is the coeff. at temperature 0°C, and a is a constant. An average solution gives the values of $k_o = 0.0678$ and $a = 0.000738$, using these values and calculating k again gives the value in the third column above under k_1, which agree very well with the observed values.

Hence for a range of temperature from 0 to about 20°C, the coefficient of thermal conduction of water may be expressed by the equation:

$$k = 0.0678 \ (1 + 0.000738t)$$

It has long been known that adding a metallic salt to water decreases its conductivity for heat, although no relation seems to have been found between the amount of salt in solution and the coefficient of conductivity. In fact no two investigators have been able to agree on this subject. In order to completely determine if possible the relations existing between specific heat, density and coeff. of conduction, several salt solutions were made up and their conductivities measured in the manner described above. The solutions used were: $ZnSO_4$, $CuSO_4$, $CdSO_4$, $CaSO_4$, Li_2SO_4, Na_2SO_4, K_2SO_4, Fe_2SO_4, NaCl, LiCl, KCl, KBr, LiBr, KJ, NaBr, LiJ, and NaJ.

The density was measured by a carefully calibrated hydrometer, the solutions being made up at 15.0°C.

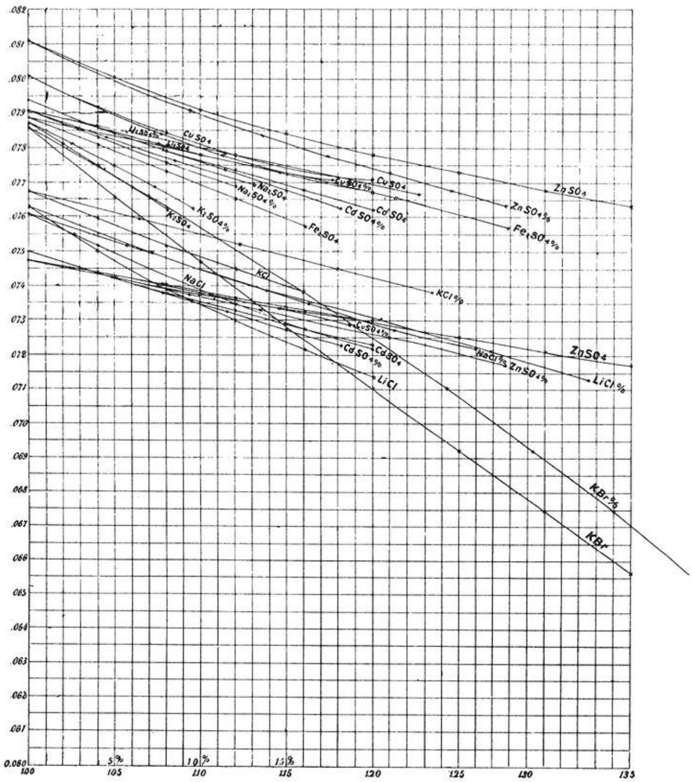
With each salt a series of solutions were made up, varying in density from 1.00 up to a saturated solution usually from eight to fourteen steps in each series. Each solution of each series was used eight times and the average value of the eight determinations used in the final results.

As it was desirable to know the specific heats of the various solutions used it was necessary in each case to make a determination of this quantity. The usual method of mixtures was resorted to. A known quantity of copper pieces whose specific heat had been carefully measured a great many times was heated in a steam bath and then poured into a weighed quantity of the solution at a known temperature a few degrees lower than the room temperature. The solution which was in a calorimeter placed in a wooden case surrounded by air was stirred and its temperature noted every four seconds by a sensitive thermometer graduated to tenths of degrees. Corrections for radiation were applied and the average of eight determinations taken as the true value of the specific heat.

The results obtained in using all these various solutions were in general very similar and it will only be necessary to give a discussion of one or two of them in order to give an idea as to the thermal conductions in any solution. The following shows the results obtained for $ZnSO_4$, at the average temperatures of 17.66° and 9.48°.

δ	k	at t	k	at t	k_0	a
1.00	0.08112	18.05	0.07474	9.41	0.06779	0.000739
1.05	.08005	18.13	.07424	9.38	.06800	.000666
1.10	.07907	17.44	.07376	9.43	.06751	.000664
1.15	.07836	17.46	.07334	9.36	.06753	.000620
1.20	.07777	17.63	.07294	9.27	.06752	.000585
1.25	.07730	17.62	.07254	9.43	.06706	.000584
1.30	.07677	17.49	.07214	9.54	.06658	.000584
1.35	0.07635	17.61	0.07180	9.39	0.06626	0.000554

This table shows that k decreases with increase in density of the solution. A curve platted for each average temperature between k and δ will not be a straight line but will be slightly curved to the axis of δ. The curve for values of k at 17.60° will be more convex than the one for k at 9.48°. Not only will the latter curve more nearly approach a straight line but its inclination to the axis of δ will be considerably less, that is, it will be more nearly parallel to this axis than the former curve. From the general straightening of the curve and the change in the position due to the lowering of the temperature it is easily seen that at from 0° to 1° C the curve would become a perfectly straight line parallel to the axis of δ which would simply mean that the coeff. of the thermal conductions for $ZnSO_4$ at this particular temperature is the same for all values of density or IS INDEPENDENT OF THE DENSITY OF THE SOLUTION AND HAS THE SAME VALUE AS THAT OF WATER AT THE SAME TEMPERATURE. This is a most remarkable thing but is plainly borne out by the results obtained by using the other salts. In some cases, however, especially those of KBr the curve becomes a straight line long before it is parallel to the δ axis and the temperature, at which calculation would indicate that it would become parallel to this axis, is below the freezing point of the solution. An inspection of the sheet of curves will show the relation between k and δ, also the relation between k and percentage of salt in solution.



The general equation of such curves seem to be well represented by

$$k = k_0(1 - a\delta + b\delta^2)$$

where k is the coeff. for any density δ and k_0 is the coeff. for water at the particular temperature at which the solution happened to be when experimneted upon. a and b are constants, the values of a being given in the last column of the above table. b is so small that it can be neglected when the curve approaches a straight line. The values of a are different of course, for each solution.

The following table shows the relation between k and δc where δc is the product of density and specific heat or the specific heat per unit of volume. $Zn\ SO_4$ and $Cu\ SO_4$ being given as samples of the entire series of salts experimented with:

$Zn\ SO_4$

k	δ	%	c	$\delta . c$	$\frac{k}{\delta . c} = \eta$	t
0.08112	1.00	0.00	1.0000	1.0000	0.08112	18.93°
.08005	1.05	4.80	.9469	.9943	.08051	18.12
.07907	1.10	9.30	.8995	.9895	.07981	17.44
.07836	1.15	13.50	.8569	.9854	.07952	17.48
.07777	1.20	17.25	.8180	.9816	.07923	17.63
.07730	1.25	21.00	.7824	.9780	.07915	17.62
.07677	1.30	24.50	.7498	.9747	.07876	17.49
0.07635	1.35	27.70	0.7196	0.9715	.07860	17.61
						17.66°

$Cu\ SO_4$

k	δ	%	c	$\delta . c$	$\frac{k}{\delta . c} = \eta$	t
0.08011	1.00	..00	1.0000	1.0000	0.08011	16.71°
.07919	1.04	3.95	.9560	.9942	.07965	17.00
.07845	1.08	7.70	.9175	.9909	.07917	17.15
.07780	1.12	11.20	.8825	.9884	.07872	17.09
.07732	1.16	14.50	.8505	.9866	.07837	17.15
0.07706	1.20	17.70	0.8210	.9852	0.07822	17.20
						17.05°

This table shows that the ratio between the thermal conductivity and the specific heat per unit volume is fairly constant for any given temperature. This constant decreases slightly with increase in the density of the solution. A second table showing values for the same quantities k, δ, %, etc., arranged as above, but for lower temperatures, shows the following:

$ZnSO_4$

0.07404	1.00	0.00	1.0000	1.0000	0.07404	9.41 °
.07424	1.05	4.80	.9469	.9943	.07466	9.38
.07376	1.10	9.30	.8995	.9895	.07464	9.43
.07334	1.15	13.50	.8569	.9854	.07443	9.36
.07294	1.20	17.35	.8180	.9816	.07431	9.27
.07254	1.25	21.00	.7828	.9780	.07417	9.43
.07214	1.30	24.50	.7498	.9747	.07401	9.54
0.07180	1.35	27.70	0.7196	0.9715	0.07391	9.39
						9.40 °

$CuSO_4$

.07474	1.00	0.00	1.0000	1.0000	0.07474	9.41 °
.07442	1.04	3.95	.9560	.9942	.07485	9.43
.07405	1.08	7.70	.9175	.9909	.07473	9.22
.07367	1.12	11.20	.8825	.9884	.07453	9.46
.07328	1.16	14.50	.8505	.9866	.07427	9.54
00.07295	1.20	17.70	0.8210	0.9852	0.07405	9.53
						9.44 °

In this table the values of k/δ c are much less, but do not differ between such wide limits as in the former case where the temperature was much higher. It is evident that in the case of k/δ c we can reach a temperature low enough so that this constant will be the same for all values of δ. It will be noticed that the value of this constant is nearly equal to the coeff. of conduction of water for the same temperature. In the two tables given above the deviation is about $1\frac{1}{2}$ %. The deviation in all cases is not very large, usually less than 2 %. A general statement of the result may be made in the following way:

1st. The thermal conductivity of water varies linearally with the temperature.

2d. The thermal conductivity of a salt solution at any temperature is equal to the conductivity of water at that same temperature, multiplied by the specific heat per unit of volume.

THE M. E. AND E. E. INSPECTION TRIP.

Thirty mechanical and electrical engineering seniors and Professors Mack, Richter and Swenson comprised the party which went on the annual inspection trip this year. We had anticipated trouble in getting the required number to go, but at 9:10 A. M. on October 23, there were not only enough but ten to spare at the St. Paul depot.

The trip to Chicago was uneventful and at 3:00 P. M. we were aboard our train for Buffalo. The Wabash company had placed a special car at our disposal and this added greatly to our comfort and convenience. In order to make our presence more generally known, we had prepared two 50-foot banners with the words, "UNIVERSITY OF WISCONSIN ENGINEERS" painted in large black letters. These were fastened to the sides of the car, and were a source of comment and questioning to all who happened to be in the region through which we passed.

When Buffalo was reached the next morning at 9:00, there were several sleepy-looking specimens of engineers aboard, and various opinions were expressed about "Rough-housers," "Can't let a fellow sleep," and so on, which proves that Wisconsin men are not all sleepers.

No time was spent in "resting up," and before noon the busy plant of the Buffalo Forge company had been visited, and a general idea of the manufacture of blowers and ventilating apparatus gained. A mechanical feed and forced draft for the fires was in operation here, and almost complete combustion of the fuel was shown by the absence of smoke from the smoke-stacks.

In the afternoon the city water works was visited, where several immense Holly pumping engines were seen. The whole works has a capacity of 187,000,000 gallons per day of twenty-four hours, several of the pumps having a daily capacity of 20,000,000 gallons. The coal bunkers were very large, the amount of coal consumed per day being in the neighborhood of 150 tons. Strange to say, this is entirely handled by hand, not only being hauled to the boilers, but also fed.

We next went through the power plant of the Buffalo Street railway. Since the installation of the power plant at Niagara Falls, this plant has been kept up simply for emergency or times of overload. A very large storage battery of 270 cells was in operation here, developing 1,000 horse power. Extensive changes had been but recently made in these batteries by replacing the glass rods used for the purpose of separating the plates, and also of keeping them from deteriorating by basswood slabs, which have proven to do the work quite as well. Concentrated sulphuric acid was the acid used, as could be guessed by the dense fumes in the air. The party now divided, the Electricals going to the city electric lighting plant and the Mechanicals to the Great Northern grain elevator, the operations of which were seen from the belt conveyor in the grain compartments of the unloading vessel to the top of the massive building, where the grain was passed into the 40′ by 90′ steel bins, from which it was dropped into the cars. A fire tug, a large Lehigh Valley freight boat and the yards of the Union Ship company were also visited by the Mechanicals although, unfortunately, no boat was on the ways at the latter place.

The next morning we got an early start, taking a N. Y. C, & H. R. train for the Falls, and going at once to the Power Plant. This was carefully inspected and proved of great interest, as it has the distinction of being the largest plant of its kind in the world. We were given all freedom and looked over everything, from the bottom of the deep wheel pit to the rapidly-revolving generators above. The automatic governors were very sensitive in their operations, and, though complicated, raised and lowered the gates admitting the water to the turbines with every slight variation of load and speed. The machines in the new power house were in different stages of construction and gave us a good idea of the inner parts of the large turbines, etc. When finished, the 21 machines in both power houses will represent 105,000 horse power, the current being supplied mostly to Buffalo and manufacturing plants in the immediate vicinity.

The Carborundum Co.'s plant was next in order, and we watched Carborundum wheel construction from the electric furnace to the testing and shipping. After filling our pockets with Carborundum specimens, we next visited the Acheson Graphite Co., near at hand.

The Natural Food Co.'s factory was but a short distance away, and, though biscuit-making can scarcely be classed under the head of engineering, there were many things about the establishment that were of interest. The building itself was a model one in many ways, and the drudgery of working indoors all one's life was to a great extent eliminated. Every room was well lighted, there being more window than wall space. Absolute cleanliness is the rule here, and never a bit of dirt did we see; the light tinting and decorating on the walls and ceilings giving a sense of cheeriness seldom seen in any factory. The day's work was finished by munching "Excelsior" biscuits and boarding the train back to the city.

The party spent the next day, Sunday, viewing the Falls. Most of the party donned oilskins and went into the "Cave of the Winds," under the American Falls, while some daring exploits were made in reaching some rocks just above the Horseshoe Falls. In the afternoon the party went around the International Belt Line, down the Canadian and up the American side. Brock's monument and a Canadian orchard proved too tempting for two of the boys, and it is said the return was made after the sun had disappeared.

Early Monday morning we took an "Erie" train for Pittsburgh, and, after a long, tedious ride, arrived at Jamestown; N. Y., where the train stopped for an hour. Jamestown is prettily situated at one end of Lake Chautauqua, and we had just time enough to walk down to the lake and back. At 5:00 P. M., we arrived at Youngstown, O., just in time to see a newly-married couple off on their wedding trip. We filed through the car and bid the bride good-bye, much to the surprise and disgust of the groom, who couldn't imagine where his better 50 per cent. had met so many fine young men. A short ride brought us to Pittsburgh, where we made an attack on the first restaurant we could find, and we did our best to clean it out.

The next morning we left on the Penn. for the works of the Westinghouse Elect. and Mfg Co. at East Pittsburg. The Mechanicals went through the electrical department in the morning, while the Electricals were in the engine department. The large 5,500 horse power generators under construction were of great interest. These generators, 40 feet in diameter, are being built for the Manhattan Elect. R'y, of New York city, and will be driven, direct-connected, by Allis engines. The E. E.'s spent the afternoon in the electrical department, while the M. E.'s went through the engine department, and also the air brake department of the Westinghouse company. The Parsons steam turbines, driving generators at a speed of 3,600 R. P. M. were probably the source of most interest. Something in the line of a novelty was seen here. Instead of the time-honored hand work in the foundry, a traveling carrier was used. On this carrier the moulds were placed and the metal poured in by men standing on the moving table, the moulds being brought to the metal instead of the metal to the moulds as was formerly the case. At one end the moulds were thrown off and the hot castings carried away, while, further on, new moulds were being placed on the carrier. After a hasty supper most of the boys went to Jeannette where the factories of the American Window Glass company and the National Glass company were inspected. The glass-making operations are beautiful when seen at night, and the agility and skill of the glass-blowers was something to be wondered at. Quite a bit of time was spent here, and it was not till near morning that we reached Pittsburg, tired out, but yet well satisfied with our day's work.

We were up early Wednesday morning and took the street cars to Homestead where the works of the Carnegie Steel company are situated. It is one thing to read about steel manufacture and another to see it actually done, and we were surprised at the magnitude and spectacular features of the steel-making operations. The manufacture of steel by both the Bessemer and Open Hearth processes was seen, and the rolling of I beams and armor plate was very interesting and instructive.

The afternoon was very profitably spent at the National Tube Factory at McKeesport. Here the molten metal, instead of being poured into moulds to form pig iron, as has been done for so many years, is taken to what is called the pig machine. This was entirely new to us and was one of the novelties of the trip. The blast furnaces are monstrous affairs, fifty feet in diameter, and probably 100 feet in height. Some of the boys climbed to the top to see the mixture of ore and fuel dumped into the top. Though the climb was a rather dirty one, they all said it was worth the time and trouble spent.

The next day was a very busy one and was begun by a visit to the Pressed Steel Car Co., at McKee's Rocks. This company is far behind in its orders and was rushing every department to its utmost capacity, fifty-five cars a day proving inadequate to supply the demands of the railroads. Many interesting points about the application of high pressure were learned here, there being several 1,000 ton hydraulic presses at work. Just across the river was the Pittsburgh Works of the American Locomotive Co., and these were next visited. Locomotives and locomotive parts were seen in all courses of construction and were very instructive.

The rest of the afternoon was spent in the Brashear Optical Works of Alleghany and the Nerntz Lamp Co., of Pittsburgh. Mr. Brashear kindly left his work when we arrived and explained to us all the details of his business. The unit of measurement used here is .00001 of an inch, the length of a wave of yellow light. In grinding telescope lenses, hours are sometimes lost in waiting for the glass to come to its normal temperature, after having been worked for a few minutes. Even the heat of the workman's body must be guarded against as it causes a change in curvature due to internal stresses.

Hundreds of dollars and months of time are lost before a suitable mould of glass is obtained from which the best lenses for telescopes are made. Two Wisconsin graduates were on hand at the Nerntz Lamp Co., and showed us all through their factory. Some interesting time experiments were being made in their laboratories to determine the durability and efficiency of their lamps. Every piece of the lamp is thoroughly tested before it is allowed to go out on the market.

This ended our trip as far as inspecting factories was concerned and we left the following morning for Chicago which we reached at 11:00 p. m. We lost no time in announcing our presence by means of the "Varsity yell," and the next day we attended the Wisconsin-Michigan football game, in a body. The result of that game was indeed a sad end to a most enjoyable and instructive trip. Perhaps no better opportunity will be presented me than the present to thank, on behalf of the class, the professors who were with us on the trip and the alumni and others who so kindly acted as guides and made the trip much more profitable than it would otherwise have been.

A. E. ANDERSON, M. E., '03.

CIVIL ENGINEERS' INSPECTION TRIP.

The annual trip of the senior class in civil engineering was taken during the week beginning October 27. Only ten students comprised the party which met Prof. Taylor at Chicago, whither he had gone to arrange the details of the trip, the other members of the class not yet having returned from their summer field work or being detained at Madison for various reasons. What the party lacked in numbers, however, it may surely be said to have made up in enthusiasm. The entire trip was confined to the city of Chicago and its vicinity.

Monday afternoon a tug, furnished by the city engineer, carried us out into the harbor to the intake cribs. The oldest of these is about 2 miles off shore, while the others are $2\frac{1}{2}$ and 4 miles off shore. We saw the large tanks down which the water is drawn a distance of 90 ft into tunnels which lead to the pumping stations on shore. In winter the ice accumulates in great masses in these cribs, and it sometimes requires as many as 35 men to keep them cleared. A device for ringing a fog-bell immediately attracted our attention. The force of the water as it rushes into the tunnel is made to turn a vertical shaft which is thus kept in motion as long as the engines on shore continue to pump water, and in foggy weather this shaft is coupled to and made to ring a fog-bell. Upon returning to the city we went directly to the 14th St. Pumping Station which is one of the six or more stations at which water is pumped into the city mains.

Tuesday morning was spent in inspecting the intercepting sewer system. We were taken to the lake shore where a sewer is now under construction from 39th to 72nd St. This sewer when completed will catch all the sewage now flowing into Lake Michigan and turn it back through the 39th St. tunnel into the Drainage Canal. The sewer is being laid in an open cut so that the various features of the work could be easily examined. The driving of Wakefield sheet-piling, excavating, putting in cross-bracing to prevent a cave-in, pumping out the collected water, laying the masonry and filling in, was all going on at the time. Under the guidance of Mr. Wilcox, engineer in charge, we were then taken down into the 29th St. tunnel. This was to many of us the most interesting experience of the trip. We were taken down an elevator shaft and into the air-lock. While compressed air was being admitted to the lock, we held our noses, and tried to force air through our ears so as to equalize the increased pressure from outside. Once in the tunnel, the top of which is 20 ft under ground, we trudged along a distance of 1,600 ft to the point where the work of excavation was in progress. A large wooden shield of diameter equal to the outside diameter of the tunnel (24 ft) supports the cutting edges which are driven forward by means of the hydraulic jacks under a total pressure of 1,800 tons. In the pockets of the shield, men were at work cutting out the earth with semi-circular knives, this having been found the most efficient method of excavating the leathery soil. The work is carried forward at a rate of 20 to 24 ft per day, and the cost of the tunnel completed is about $118 per lineal ft. After everything had been thoroughly explained to us we retraced our steps, a truly exciting journey, as we had to continually dodge the mules, and try to avoid the pools of mud and water. As we emerged from the tunnel the contrast between the warm, moist air of the tunnel and the cold air outside was so great that we gave vent to the "Varsity Yell" in order to warm ourselves. In the small pools of water on the surface of the ground above the tunnel we could see bubbles of air escaping, which at once explained to us what becomes of the enormous amount of air which is continually supplied to the tunnel.

The next point of interest was the track elevation work on the Chicago & Alton road. Mr. Starr, division superintendent of that road, explained to us the method of raising the tracks, piece by piece, so as to keep the grades down to two or three per cent. and not delay traffic. He also explained the method of putting in temporary wooden trestles at street crossings, and showed us the massive concrete abutments and retaining walls.

A visit to the Pullman Car Co.'s shops in the morning, and the Illinois Steel Co.'s plant in the afternoon, proved to be the hardest day's work we were called upon to do. Both of these plants are so large that it required continual walking about to make anything like a thorough examination. At the car shops we saw how the various parts of railway coaches are manufactured and put together. Perhaps the most interesting part of the plant was the fancy wood-work department where all the decorations and designs for the interior of the coaches are made. At the Steel Co.'s plant we were first taken to the department in which microscopic analyses are made. We were shown some photographs of sections of steel bars and also the method of taking these photographs. We then visited the testing department, after which we went out into the yards. We saw the ore docks, at which, fortunately for us, a vessel happened to be unloading; the great blast furnaces, some of which have been in continual operation for ten years; the Open-hearth and Bessemer processes of manufacturing steel, and rolling of plates and T rails. The steel plates, when cold, are picked up by strong electro-magnates, and transferred from place to place wherever wanted. The pumping station at the plant has a capacity of 140,000,000 gallons in 24 hours, this enormous quantity of water being used throughout the plant.

Thursday morning the party was taken through a portion of the Illinois Telephone and Telegraph Co.'s Tunnels. About twelve miles of these tunnels have been constructed in the down-town district of the city and the work is going forward at the rate of a mile a month. The trunk conduits are 24 ft. 6 in. below the surface and are 12 ft. 9 in. wide by 14 ft. high, with 21 in. bottoms and 18 in. walls of concrete. The lateral conduits are 6 ft. by 7 ft. 6 in., with 13 in. bottoms and 10 in. walls. The excavated material is hauled through the tunnel on small tram cars, hoisted up the shafts on elevators, dumped into wagons and carted off to the lake shore. The concrete used is a mixture of five parts of broken stone and screenings (or gravel) to one part of cement, Atlas and Chicago A A being used. The work is carried on day and night by three shifts of men at each heading, as many as 850 men being engaged in the work of construction. When completed these tunnels will furnish an exchange of 100,000 telephones. All the surface surveying had to be done between the hours of 10 at night and 5 in the morning on account of the traffic on the streets at all other hours. After walking through several thousand feet of these tunnels, which, by the way are quite clean and thoroughly ventilated, we came up through a second shaft to the surface.

In the afternoon Mr. Isham Randolph, chief engineer of the Drainage Canal took charge of the party and showed us the work now being done along the Chicago river. The site of the State St. bridge was first visited. This bridge is to be of the rolling-lift type. One leaf is practically completed, standing in an upright position while on the north side of the river the caisson has been sunk and the abutment is being built. The pressure of the water against this caisson was so great that the large 14 by 14 timbers used for bracing have been compressed 3 inches. Another bridge of the Sherzer type farther up the river was then visited. This was more nearly completed and was operated for our benefit and its mechanism explained. At Halsted St. we were enabled to see a bridge of somewhat novel design. Each leaf of this bridge consists of a channel span and an approach span, the latter acting as a counter-balance to the former by dropping forward as the channel span is raised. Mr. Randolph proved to be a very efficient guide especially in that he paid the carfare for the entire party.

The Rock Island depot which is under construction at Van Buren and LaSalle Sts. was also visited. The various parts of the structure were explained and the manufacture of steel-concrete slabs for roofing purposes was shown us. Provision is made for twelve tracks entering this depot.

Friday morning was spent at the Lassig Plant of the American Bridge Co. and in the afternoon a short time was spent at the Randolph St. bridge. Mr. Balsley '02 who is at present in the employ of the Am. Bridge Co. was with us, and gave us many interesting "pointers."

Saturday morning the party visited the site of the new First National Bank building, in order to see the foundations. Wells of 10 feet diam. are sunk to a depth of over 100 feet down to solid rock, and are then filled with concrete. The diameter of the wells varies in accordance with the load which they are to sustain.

Although the morning was not yet half over, no further work was attempted, as the excitement incident to the Michigan game began to manifest itself strongly. We hurried back to head-quarters soon to scatter among the countless "rooters" who came pouring in from all sides.

ALVIN HAASE '03.

EDITORIAL.

With this issue THE WISCONSIN ENGINEER begins the seventh year of its existence. Last year the journal appeared quarterly after having existed for two years as a semi-annual. The present board again offers a quarterly and hopes not only to maintain the high standard of previous ENGINEERS in regard to engineering literature, but also to make it more and more the organ of expression for the students in engineering. We trust that our efforts will meet with encouragement from the student body. A college of over 500 students with an ever increasing number of alumni ought to get out a monthly publication, and it is to be hoped that THE ENGINEER may in the near future become a monthly, but this can hardly occur until jt receives the moral and financial support of every student in the college.

We take this opportunity to thank the members of the faculty and alumni for their kind assistance in getting out the journal.

In Dean Johnson THE ENGINEER has lost one of its best friends. He was a constant contributor to the paper, and an ever ready advisor. In fact the journal owes its very existence to him. Two years ago when interest in THE ENGINEER was at its lowest point a meeting of the students was called to consider the question of suspending publication. Many arguments were advanced in favor of dropping the journal, but Dean Johnson, almost single-handed championed its cause, and finally won out for it, with the remark, "Well, let's try it awhile longer."

Those of us who had the privilege of sitting under Dean Johnson in recitations carry with us many pleasant recollections of him. In the matter of discipline his manner was particularly felicitous. Shortly after the Minnesota game last year the class was one day spending the ten minutes between recitations in boisterous laughing, talking and singing. While the merriment was at its height the Dean stepped into the room with the remark: "I feel that way myself, boys, but I don't say it." On another occasion a question was being discussed with great ferocity in the draughting room. Every one was shouting at the top of his voice, gesticulating and stamping his feet. Suddenly the Dean appeared on the scene, and after saying, "Boys," three or four times before attracting attention, he quietly remarked: "I don't doubt but what you are getting a great deal of good out of this, but please get it a little more quietly." The effect of such remarks as these was to effectually quiet any disorder, at the same time leaving the boys in a happy frame of mind.

The engineers' sociables which were such a success last year are to be continued this year. Several new features are being planned which will add greatly to the attractiveness of these affairs. The seniors are making arrangements to give a minstrel show some time in February, and while this is rather a novel field for engineers, we are sure that there is enough talent among our students to insure success to the venture. The performance is being looked forward to with great interest.

A rumor has it that one of the sociables is to be transferred to the gymnasium, and converted into an Engineer's Ball. It is certainly true that the floor space in the engineering building is hardly large enough to accommodate the large number of dancers which may be expected at the sociables this winter, and if the dancing feature is to be given due prominence, it would be well to hold one of the sociables in the gymnasium. However, the original character of these sociables should not be lost sight of, and every one should turn out to sing the college songs and imbibe the college spirit.

The present board would like to add an athletic column to the features of this journal. At present the material available for such a column is quite limited in amount, but there is every reason why there should be more in the future. We should like to see a series of class contests in football, base ball and track athletics arranged between the four classes in the college. Where teams are picked from each of the three courses of one class as heretofore, the chances will always be strongly in favor of the course having the largest number of students, while with one team representing each class, we would not only have more evenly matched teams, but there would be a large number of students left to "root" for their respective sides. Such a series of contests would certainly stir up a great deal of enthusiasm and create strong college spirit.

FACULTY CHANGES.

Prof. F. E. Turneaure has been chosen acting dean to fill the vacancy caused by the death of Dean Johnson. Besides discharging all the duties connected with his new position and retaining most of the classes he formerly had, he gives instruction in all the subjects formerly taught by Dean Johnson.

Prof. O. B. Zimmerman has been promoted from the position of instructor to that of Assistant Professor of Machine Design.

Mr. Wm. G. Kirchoffer, '97, city engineer of Baraboo, Wis., gives the course in Public Water Supplies, formerly given by Prof. Turneaure.

Mr. H. J. B. Thorkelson, '98, has been elected instructor in steam engineering. He has been with the J. I. Case Plow Works, at Racine, as sssistant superintendent.

Mr. G. J. Davis, '02, a graduate of Cornell, is instructor in civil engineering, taking the place of Mr. E. E. Sands.

Mr. Budd Frankenfield, instructor in electrical engineering last year, is now in the engineering department of the Milwaukee Electric Company.

Mr. A. B. Marvin, '00, who had charge of the electrochemical laboratory last year, is now in the office of the patent examiner, Washington, D. C.

Mr. E. E. Sands, '00, has an excellent position on the United States Geological Survey in Colorado.

Dr. G. W. Wilder now has entire charge of physics in the engineering courses.

Prof. Trowbridge fills the position left vacant by Prof. Snow, who is in Europe on leave of absence.

PERSONALS.

Walter Alexander, '97, visited the University on November 9th and 10th. After leaving his work as professor of steam engineering in the Missouri State University, he was in the employ of the C. M. & St. Paul Ry. at Minneapolis as assistant master mechanic. After about six weeks work he was taken down with typhoid fever and for ten weeks lay dangerously ill in a Milwaukee hospital. He returned to Minneapolis, November 15, though still only a shadow of his former self.

L. G. Van Ess, '96, late in the engineering department of the Mac Millan Co., Denver, Col., is now general manager of the Gas & Electric Co., of Lincoln, Neb.

C. M. Kurtz, '97, has resigned his position as assistant engineer on the Santa Fe Railroad at Stockton, Cal., to accept a position with the Southern Pacific. He is now located at Ogden, Utah.

The following U. W. men were met by the seniors on their eastern trip: H. B. Alverson, '93, at Buffalo; M. C. Beebe, '97, at Pittsburg; J. M. Barr, '99, at Pittsburg; W. Hanks, ex-'98, at East Pittsburg; A. B. Rosstead, ex-'04, at East Pittsburg.

L. D. Rowell, '01, who took graduate work in the University last year, is now with the Arnold Magnetic Clutch Co., of Milwaukee, as designer.

F. Boldenweck, '02, after spending the summer in Germany, is now in the Dynamo Testing Department of the Western Elect. Co., Chicago.

C. F. Stillman, G. E. Diehl, '02, and L. Salsich, '01, are with the Minnesota Iron Co., at Hibbing, Minnesota.

L. E. Moore, '00, has a position in the engineering department of the Phoenix Bridge Co. His address is 152 Church St., Phoenixville, Pa. He spent last year at the Boston "Tech."

Alvin Meyers, '01, and Miss Susie Thompson were married July 30, 1902. Meyers is with the Telluride Power Co. at Provo, Utah.

L. R. Stockman, '02, is at present in northern Wisconsin on the U. S. G. S.

The marriage of V. W. Bergenthal, '97, to Miss Alice Beatrice Dacy took place Wednesday, October 29, 1902, at Woodstock, Ill. They reside at 5808 S. Park Av., Chicago.

F. E. Washburn, '01, is at present engaged in bridge construction at Thebes, Ill. He is assistant to Mr. Ralph Mojeski, bridge engineer.

L. H. Barkhausen, '01, is no longer with the Merrimac Croq. Mfg. Co., of Lowell, Mass., but is with the J. I Case Co., of Racine.

Willis E. Crandell, E. E. '03, will leave shortly for the south to recuperate from the effects of a bad cold taken while on the recent eastern trip.

NOTES.

The convocation of Friday, Oct. 17, was devoted to a memorial service for the late Dean Johnson. Acting President Birge spoke on Dean Johnson's services to the University, not only in bringing about an enormous growth in attendance and equipment in the college of engineering but also in securing the addition of the school of commerce to the departments of the University. He spoke of his activity in fields outside of his particular field—engineering, and of his love for poetry, it being his custom to have a volume of some favorite poet at hand with which to spend his leisure moments.

Rev. F. A. Gilmore, pastor of the Unitarian church which the late dean attended, read an extract from an address given by Dean Johnson in St. Louis six years ago. The subject of the address was "Death" and after writing at some length about death in general, how it should be regarded, the writer gives us his view of just such a death as came to him a few years later. "An untimely death," writes he, "is an unexpected visit of a friend." Further on he says: "The real benefit of a life comes only when it has ceased to exist, for then it may affect a thousand lives that take up its unfinished work."

Prof. C. M. Woodward, dean of the college of engineering of Washington University at St. Louis, a close friend of Dean Johnson's paid a fitting tribute to the late dean. He spoke with pride, of having discovered J. B. Johnson about twenty years ago while he was engaged on the Mississippi River Survey, and of having secured him for Washington University. In closing, he summed up Dean Johnson's character as follows: "He was a tireless worker, an enthusiastic student, a magnetic teacher, a brilliant engineer, a lover of art and all that is good, beautiful and true, a faithful friend, a model husband and father, a loyal citizen without fear and without reproach."

Minutes of a Hill-freshman class meeting, (exact reproduction of a slip of paper found on the Hill.)

Meeting called to order by chairman of meeting, Mr. ———. Chairman states purposes of meeting, namely to nominate canidates for class officers in Freshman class, to oppose the canidates of the Enginers. Secratary of meeting, Mr. ———. A motion was carried to elect a committee to make a slate for the nominees. This committee to report to a caucus to be held Monday at 2 P. M. in room 16 U. H.

Committee:

1. ———
2. ———
3. ———
4. ———
5. ———

Sincerely,

——— ———.

And thus they brought about the downfall of the Freshman Engineers.

On Oct. 8, a committee composed of three members each from the Senior, Junior and Sophomore classes was appointed to consider the matter of a memorial to Dean Johnson. At a mass-meeting of the students held Nov. 12, this committee reported in favor of securing a valuable painting of Dean Johnson for the engineering building, and also to petition the Regents to name the building Johnson Hall in honor of the late dean. Steps were immediately taken to secure funds, and up to date satisfactory progress has been made. H. P. Howland is chairman, and S. J. Lisberger, treasurer of the committee.

A Civil Engineering Society was recently formed by the Seniors and Juniors in the civil engineering course. The society is patterned after the Cornell Society of Civil Engineers. All Junior and Senior civil engineers, all faculty members of the civil engineering department, and all alumni engineers in the city are eligible to membership. Meetings will be held every other Friday throughout the school year. Current topics of interest will be assigned to and worked up by members of the society; and whenever possible outside speakers will be secured to talk on subjects of interest to civil engineers. A file will be kept of all the proceedings and discussions of the society, and from time to time this will be published. The following are the officers: Geo. R. Keachie, president; Henry Warner, vice-president; H. J. Cowie, treasurer; Hugo Brandt, recording secretary; Prof. L. S. Smith. corresponding secretary.

At the October meeting of Tau Beta Pi, the following new members were elected: A. E. Anderson, M. E., Janesville; H. E. C. Brandt, C. E., Watertown; W. E. Crandell, E. E., Plainfield; E. A. Ekern, E. E., West Superior; C. F. Goodenough, G. E., West Depere; Alvin Haase, C. E. Milwaukee; R. H. Hadfield, M. E., Madison; S. J. Lisberger,

E. E., Danville, Va.; J. L. Savage, C. E., Madison; F. C. Weber, E. E., Fond du Lac; Wm. Bradford, E. E., Stevens Point.

All are seniors except the last named who is a junior. The initiation spread was held Saturday, Oct. 18.

Jr. (just after the eastern trip.): Why did so many Seniors spend Sunday at home?

Sr.: Been on an eastern trip and haven't anything else to spend.

Recent Fiction: "K-a-h-e's Dream" or "The Senior Civils Play Ping-Pong." Thrilling tale of how the Seminary Room narrowly escaped being converted into a Ping-Pong court.

In electrochemistry:

(Prof. B.:) Mr. Fr-e-d, does the human body conduct electricity metallically or electrolytically?

(Fr-e-d:) Metallically.

(Prof. B.:) You must be thinking of a man with an iron constitution.

Reports from draughting room indicate that some of the Seniors are getting their "bumps" regularly.

The ignorance of the student who wanted to know how many gallons there are in a square foot of water is only comparable with that of the student who thought the ratio of the diameters was equal to the ratio of the areas.

Some time ago we received a letter from Mr. J. Thomas Hurd, Provincial Supervisor, Ilagan, Isabela, Philippine Islands, U. S. A. Besides containing good American paper money to pay for a subscription to the present volume, the letter brought Mr. Hurd's hearty good wishes for the continued success of our paper. We are pleased to say that Mr. Hurd is a Wisconsin engineer.

In appearance the letter differed very little from ordinary letters, except that it had a considerably greater number of postmarks on it. In our leisure moments we studied these marks and found that they gave a pretty complete description of the course of the letter from the time of mailing it to the time of its reaching Madison.

We have been able to trace the letter as follows: It was written Sept. 4, 1902, and was mailed at Ilagan, at 4 P. M. that day. Next, it went to Appari, Cagayan, arriving there at 5 P. M. on Sept. 10. From here the letter went to Manila, reaching this point at 10:30 A. M., Sept. 17. And from Manila the letter went on its final journey, arriving at Madison at 4 A. M., Oct. 9.

It will be noticed that it took the letter thirteen days to get out of the Philippine Islands, and one month to go from the Islands to Madison.

From our observations, we are able to learn several things, among which are the following:

1. Wisconsin engineering graduates are filling responsible positions both at home and abroad.

2. Our magazine is known and appreciated in far distant corners of the earth.

3. While business in the Philippine Islands is rapidly being reduced to American methods, there are still brilliant opportunities for Wisconsin engineers to develop transportation facilities over there.

F. W. H.

OBITUARY.

SIDNEY OLSON.

On July 11, 1902, occurred the death of Sidney Olson, a member of last year's senior class. He had just accepted a position in northern Minnesota, near Hibbing. While bathing in Snow-ball Lake, about twenty-four miles north of Hibbing, he got into deep water, and being unable to swim, drowned before help could reach him. He was 26 years old and of a quiet nature, well liked by all who knew him.

RICHARD ARTHUR NOMMENSEN.

R. A. Nommensen, member of the class of '99, died July 12, 1902. He had gone west a few months before in the hope of improving his health, but it was not to be. The local chapter of Tau Beta Pi of which Nommensen was a member, adopted the following resolutions on his death:

WHEREAS, God, in His infinite wisdom and goodness, has seen fit to call away our dear and beloved brother, Richard Arthur Nommenson, of the class of 1899; and

WHEREAS, By his death on July 12, 1902, we lose a dear and faithful friend and loyal and honored brother; be it

Resolved, That we the members of Alpha of Wisconsin, charge of Tau Beta Pi, hereby declare our deep sorrow at the loss of our beloved brother; and be it

Resolved, That we hereby express our heartfelt sympathy with the family and friends of the deceased; and be it

Resolved, That a copy of these resolutions be sent to the family of the deceased.

(Signed) ARTHUR C. KING.
CARL HAMBUECHEN.
H. P. HOWLAND.

EDGAR A. OLIN.

While in the employ of the J. I. Case Co., of Racine, this summer, Edgar A. Olin, of the class of 1904, met death by accident. He was a member of the U. W. Engineers' Club, which organization has adopted resolutions on his death.

CARL G. ALMQUIST.

Carl Almquist, a member of the freshman class, died on November 18, from the effects of bullet wounds received at the hands of John J. Davenport, who also took his own life. The murderer and suicide had been under the influence of liquor for days previous to the affair and was of an ugly disposition.

Memorial services were held at Library Hall for Almquist, Sunday, Nov. 23. Prof. Turneaure said of him: "As a student, he was one of those the University can hardly afford to lose. He was a conscientious man, hard to find and hard to lose. It was his ardent desire to lose nothing beneficial in the college course, and his desire to do things thoroughly led him to take less work than was required in order that he might do it more thoroughly." Secretary L. B. Smith, of the Y. M. C. A., of which organization Almquist was a member, said: "We always knew where to find him when it came to a question of right or wrong. He was extremely particular in little things, for principle's sake, as he often said. Those who knew him best loved him most."

JOHN R. HEGG.

Further particulars as to the death of J. R. Hegg, who lost his life in the Philippines last January, have reached us. It seems that Mr. Hegg started out on a journey from Bohol to Ubay, in company with a native policeman, who either proved treacherous or was afraid to interfere when Mr. Hegg was attacked. Careful examination has brought out the fact that Mr. Hegg was murdered in the house of one Thomas Reges, near Batuanen, and the deed is accredited to Pedro de Jesus, who has made good his escape. The house was burned to the ground, and it is feared that the body of Mr. Hegg will never be recovered.

FIRST SEMI-ANNUAL JOINT DEBATE.

U. W. ENGINEERS' CLUB VS. N. O. WHITNEY ASSOCIATION, AUDITORIUM, ENGINEERING BUILDING, FRIDAY EVENING, NOV. 21, 1902.

PROGRAM.

President—Acting Dean F. E. Turneaure.
Vfolin Solo—
First Air with Variations— - - - - *DeBeust*
W. E. Brown.

Debate—

Question: Is the International Association of Machinists justified in taking the following attitude in regard to the introduction or use of piece work systems in shops where such introduction or use is practical?

"That our judicial officers be given discretionary power to treat with employers where piece work now exists with I. A. M. members and make agreements as prescribed by the premium systems and thereby control and eventually abolish piece work in any form."

AFFIRMATIVE—	NEGATIVE—
N. O. Whitney Assoc.—	*U. W. Engineers' Club*—
F. V. Larkin,	F. J. Petura,
E. A. Goetz,	E. A. Ekern,
W. A. Rowe,	F. W. Huels.

Piano Solo— - - - - - - - - *Selected*

A. Lee.

JUDGES.

Judge J. B. Winslow, Prof. A. W. Richter,
Prof. H. B. Meyers.

The recent first semi-annual joint debate between the U. W. Engineers' Club and the N. O. Whitney Association again shows the attitude of the engineering students toward a broadening of the facilities offered by a college course. The power of debate is as necessary for engineers in the performance of their daily work as it is in any other profession or vocation.

Although there is room for improvement the debate of November 21st was evidence of the fact that engineers, as well as other students have all the necessary requisites that make a good debater and that they recognize the fact that one who is proficient in his profession, must be more than an engineer.

Your ideas once formed, it is necessary to have proof, which, when presented to others, frequently requires considerable argument in the presentation. Whether the case is presented in person or in writing, one must acquire the habit of presenting the matter in a clear and concise manner.

Any opportunities, offering improvement in this direction, should be taken advantage of by all the student body, and are welcomed by the faculty as well as students. The writer would urge every engineering student to become a member of one of the three engineering societies now in existence, or, if necessary, to organize additional societies in this college; by doing this you will assist the faculty as well as yourselves.

The question debated was as stated above.

The judges of this debate were instructed to base their decision on the arguments presented, and to disregard any oratorical ability shown by the debaters.

As stated at the close of the debate, the judges were unanimous in the opinion that the program was of an excellent character. that the arguments were in most cases well presented, and to the credit of the college, and that all participants should be commended for their work.

The final decision of the judges was not unanimous, being two in favor of the negative and one for the affirmative. As stated by the judges this decision was based on the fact that the burden of proof rested with the affirmative, and that sufficient proof had not been presented to uphold their arguments.

Among other things this was probably due to the position in which the affirmative found itself when presenting the argument that the last clause in the question was not intended by the I. A. M. members as written, but that the words "and eventually abolish piece-work in any form" were simply introduced by the Association of Machinists in order to pacify some of its members, and that it was not the intention of the association to carry this into effect. The negative, on the other hand, contended that the question should stand, and that it was intended as written.

Both sides presented evidence to substantiate their claims.

THE U. W. ENGINEERS' CLUB.

A. J. QUIGLEY, '03.

The club entered upon its ninth year of progress on Sept. 26, of this Fall. Never before have the prospects for a successful year been so bright. The club has long ago ceased to be an experiment and now with the stimulating influence of the other engineering societies has become an important factor in the activities of the engineering college. The spirit and number of members, and the conditions of the treasury were all most satisfactory, and thus equipped the club was able this year to look only forward.

The following is a record of the programmes and items of importance of the meetings for this year.

September 26.

Business meeting,

Resignation of G. W. Garvens from Joint Debate Team, due to absence from University, accepted.

F. J. Petura elected to fill Mr. Garvens' place.

October 3.

Inauguration of officers.

Ninth Annual Address—Prof. J. G. D. Mack.

Violin Solo—W. E. Brown.

Talks about summer experiences by Ziegeweid, Geerlings, Dean, Bailey, Douglass.

October 10.

Singing—Club.

Paper and Talk—H. J. Thorkelson.

Paper—Whyman.

Paper—C. I. Zimmermann.

October 17.

Singing—Club.

Adjourned on account of mass meeting.

October 24.

President's Address—S. J. Lisberger.

Paper: Manufacture of Carborundum—H. S. Imbush.

Debate.

Resolved, That a compulsory arbitration law for the settlement of labor disputes be enacted by the United States government.

Affirmative.	*Negative.*
Potter.	J. G. Zimmerman.
Henry.	McArthur.

Won by negative.

October 31.

Singing—Club.

Paper—Nedeleff.

At this meeting only seventeen members were present on account of the absence of the Seniors on the Annual Senior

Inspection trip. The short program was necessary since most of those on the program absented themselves.

November 7.

Joint meeting of the three clubs to install officers of the Joint Debate League as follows:

President—L R. Brown. J. B. Johnson Club.

Vice-President—A. F. Krippner, N. O. Whitney Asso.

Secretary and Treasurer—A. J. Quigley, U. W. Engineers' Club.

After this the regular program was carried out.

Singing—Club.

Debate:

Resolved, That the manufacture of articles of commercial value in the U. W. shops would be more beneficial than the present system is to the student.

Affirmative.	*Negative.*
Brown.	Peters.
Helmholz.	Lyons.
W. H. Imbush.	Hunner.

Won by negative.

Paper—Colburn.

Review of Periodicals—Libby.

November 14, 1902.

Singing—Club.

A Review of the Senior Inspection Trips as follows:

Milwaukee Shops—S. J. Lisberger.

Western Elec. Co.; Chicago Tel. Co.—Lathrop.

Chicago Edison Co.; Illinois Steel Co.; Chicago Shipbuilding Yards—Crandell.

General Survey of Eastern Trip—Quigley.

Buffalo Forge Works; American Locomotive Works—Douglass.

Niagara Power Co.; Buffalo Power Co.—C. I. Zimmerman.

Nearnst Lamp Co.; Brashear Optical Works—Mott.

Westinghouse Co., Pressed Steel Car Co.—Ekern.

Westinghouse Air Brake—Geerlings.

Carborundum Co.; Shredded Wheat Biscuit Co.; Incidents of Trip—Cadby.

At this meeting the following resolutions were adopted:

IN MEMORIAM.

WHEREAS, The sad death of Prof. John Butler Johnson has removed from our college our beloved Dean; and

WHEREAS, Dean Johnson took a lively interest in all organizations and activities of our college, and by his splendid achievements was ever one whose earnest life is worthy of our emulation; and

WHEREAS, The U. W. Engineers' Club has, in his sad and sudden death, lost one who was a staunch friend at all times, and who was always ready to help and encourge by word or deed; be it

Resolved, That while we mourn our loss, we as an organization extend our deepest and most heartfelt sympathy to the bereaved family; and be it

Resolved, That copies of these resolutions be sent to the family of Dean Johnson, and that they be entered npon the records of this society.

FOR THE U. W. ENGINEERS' CLUB,
BY COMMITTEE.

WHEREAS, Mr. Edgar A. Olin, a junior in the College of Engineering and a member of the University of Wisconsin Engineers' Club, met death through an accident, this summer, while in the employ of the J. I. Case Co., of Racine; and

WHEREAS, The death of Mr. Olin, as he was in the midst of his college career, is felt deeply by his fellow friends and classmates in the Engineers' Club; be it

Resolved, That we, as an organization, extend our deepest and most heartfelt sympathy to the bereaved parents; and be it

Resolved, That copies of this resolution be sent to the parents of our deceased fellow student, and that it be entered upon the records of this society.

FOR THE U. W. ENGINEERS' CLUB,
BY COMMITTEE.

November 21.

Joint Bebate between U. W. Engineers' Club and N. O. Whitney Association.

The meeting was held in the auditorium of the Engineering building, about 200 people being present. More extended mention is made of the debate itself elsewhere. The club is proud of the fact that our men won this first joint deate, the decision being two to one in our favor.

N. O. WHITNEY ENGINEERING ASSOCIATION.

The following officers were elected at the beginning of the year:

President—R. L. Hankinson.

Vice-President—F. V. Larkin.

Secretary and Treasurer—Ray Owen.

Censor—W. H. Hauser.

The personnel of the standing committees is as follows.

Membership Committee--C. A. Hoefer, R. F. Ewald, W. A. Rowe.

Program Commttee—F. H. Murphy, E. A. Moritz, L. B. Morehouse.

Music Committee—E. A. Moritz, E. G. Hoefer, Wm. Ungrodt.

The following is a synopsis of the programs held thus far this year:

October 24.

Periodicals—W. H. Hauser, E. W. Galloway.

Paper: "Glimpses of the West"—A. T. Stewart.

Debate: "*Resolved*, That free labor should not be compelled to compete with convict labor."

Affirmative.	Negative.
M. R. Whiting,	F. H. Murphy,
H. S. Cole,	M. W. King,
F. A. Naramore.	G. G. Post.

Critic—D. P. Falconer.

PROGRAM FOR OCTOBER 31, 1902.

Critic appointed.

Song.

Periodicals—M. G. Hall, C. A. Hoefer.

Paper—A. F. Krippner.

Debate: *Resolved*, That asphalt street would be preferable to brick street around the state capitol.

Affirmative.	Negative.
E. G. Hoefer,	W. H. Hauser,
A. H. Miller,	M. E. Wharry,
F. A. Naramore.	P. F. Zinke.

Decision.

Critic's report.

Nov. 14, 1902.

Song.

Periodicals—E. L. Barber.

Paper: M. W. King.

Discussion: In how far has the President power to act in a case like the present coal strike.

Affirmative.	Negative.
Griswold,	Hagenah,
Potts.	Heideman.

Critic's report.

J. B. JOHNSON ENGINEERING ASSOCIATION.

With the reassembling of the engineering students at the commencement of the college year, all were impressed more strongly with the great loss suffered by the University and particularly the College of Mechanics and Engineering, in the death of their beloved dean, J. B. Johnson.

At the first meeting of the J. B. Johnson Engineering Association, in view of the fact that this association bore the name of our late dean, and that he was an honorary member, it seemed fitting and proper that we should hold memorial services.

A memorial meeting was held on Thursday, October 9th, in the auditorium. Acting Dean Turneaure spoke in high, yet most deserving praise of the life and work of our late dean. He emphasized particularly the enthusiastic, positive, untiring action and great versatility always manifest in anything undertaken by him.

At the close of the meeting appropriate resolutions were presented and adopted.

Believing that college graduate engineers should be distinctly above craftsmen and broader than any specialists, that they should be men who tell not, how to do, but what to do, we have endeavored and shall continue more strongly to study the *commercial phases* of all our topics.

With the exception of the weeks when the Seniors were absent on their trip, and at the time of the Engineering Joint Debate, regular meetings have been held Friday evenings in the Dean's Lecture Room.

A limiting membership of forty necessitates frequent participation in the programs, and this is quite desirable. An outline of the programmes is not at present available.

BOOK REVIEW.

The Slide Valve and its Functions, by Julius Begtrup, M. E.; D. Van Nostrand Co.; 150 pages. Price, $2.00.

This book is written "with special reference to modern practice in the United States," and contains about ninety illustrations of various valves and valve diagrams.

About one-third of the book is devoted to a discussion of the common slide valve and its forms and dimensions. The various improvements that have been made to adapt it for use on the locomotive and such high-speed engines as the "Straight Line," "Westinghouse," etc., are reviewed and illustrated very clearly.

One chapter, covering thirty pages, treats of the various four-valve systems in use today. Corliss valve dimensions, the limitations of the Corliss Gear, directions for setting the valves, the single eccentric valve diagram, the advantage of two eccentrics, and a description of various gridiron valves form the major portion of this chapter.

The next chapter consists of a discussion of the results that may be obtained by having one valve control admission and exhaust, while a second valve controls the cut-off only. The author here describes very clearly: the Meyer valve, Rider valve, gridiron valves with independent cut-off, the Buckeye valve gear, different methods of varying the cut-off and the independent cut-off of such four-valve engines as are made by McIntosh & Seymour and other well-known engine manufacturers.

In another chapter the author describes the different valves used on such steam pumps as: the "Blake," "Dean Brothers," "Knowles," "Davidson," "Cameron" and "Worthington." These valves are all very clearly illustrated and described.

The last chapter contains a discussion of the peculiar effects caused by the angularity of connecting rod and eccentric rod, and includes different methods of overcoming this effect so as to equalize both lead and cut-off.

The author has succeeded admirably in presenting his subject in a very clear and condensed form, with a special object, as expressed in his preface, of meeting the requirements of practical men.

Worm and Spiral Gearing by Frederick A. Halsey, D. Van Nostrand Co., 50 cents. This little book certainly contains much valuable information in regard to the two forms of gears of which it treats. The subject matter is given in a way to be easily understandable to those not acquainted with the theoretical conditions.

When one knows that even many of the large firms who use these styles of gearing, frequently find that their designs have to be changed due to excessive heating or wear, the compilation of information on this point, as given in the book deserves especial notice.

The graphical solutions are good and as these styles of gearing are finding increased use in practice we believe this book deserves a place on the shelves of every machine designer. O. B. Z.

A Graphical Method for Solving Questions in Arithmetic and Algebra, by Geo. L. Vose, D. Van Nostrand (2d Ed.), 50 cents.

The method here developed was first suggested to the author by the common mode of representing train movements. From this Mr. Vose has developed a simple method of solving rather complicated problems.

There is no special claim made as to its taking the place of more precise methods of analysis, but it seems to us as precise, simple, rapid and suggestive of still further useful extension. The book should be of special use to those who are anxious to handle problems involving rates, but who have not the necessary mathematical preparation; we should also advise every engineer to run through the little book, since it is of such suggestive value. O. B. Z.

NOTICE TO SUBSCRIBERS.

The attention of our readers is called to the advertisement of the Eureka Mfg. Co., St. Paul, Minn., elsewhere in this magazine. This company supplies all the parts necessary to build motor cycles and automobiles. Our engineers who are doing shop work will be interested in this announcement and should send for a catalogue. The company will mail full information to all interested parties and will tell you how you can make a motor cycle during your spare hours.

The Standard Tool Co., of Cleveland, Ohio., has sent us a catalogue of their goods. Besides showing a complete list of drills, reamers, taps, dies, etc., this catalogue has a great many tables which are especially valuable to Mechanical Engineers. Our readers are advised to send for a sample copy. You may not get one, but write anyhow, mentioning THE ENGINEER.

We have received copies of two booklets of the J. A. Roebling and Sons Co., of Trenton. N. J., entitled "How to Order Wire Rope and Wire," and "Transmission of Power by Wire Rope." These booklets are full of good information and our readers will do well to send for sample copies. Mention THE ENGINEER when you write.

7–Eng.