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# THE WISCONSIN ENGINEER

VOL. 6 MAY, 1902 No. 4

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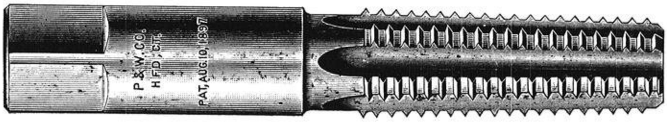
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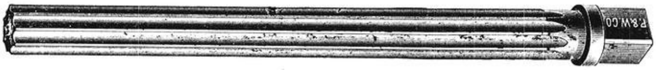
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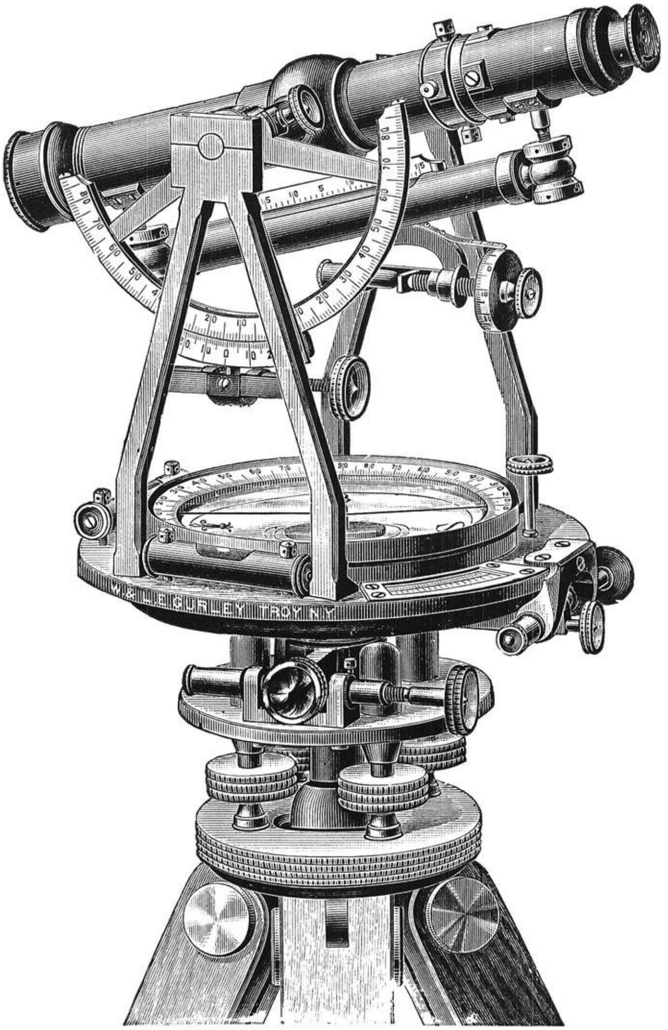
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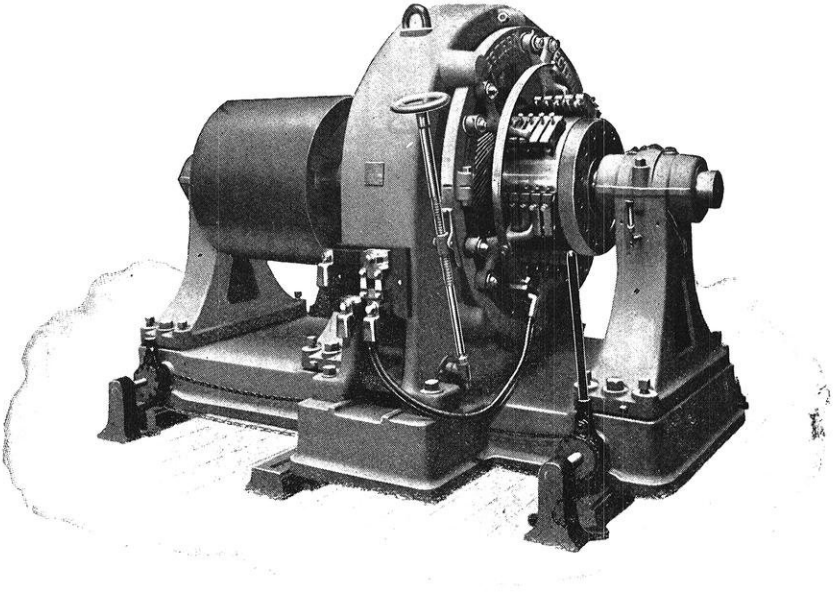

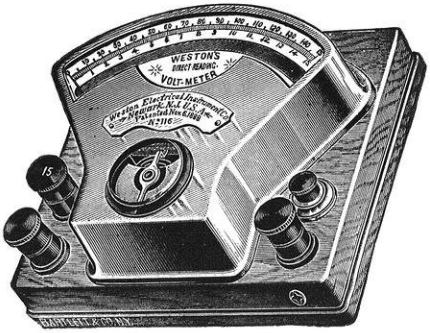
WESTON'S DIRECT-READING VOLT-METER
Weston Electrical Instrument Co Newark N.J. U.S.A. Patented Nov 6 1888 No 116
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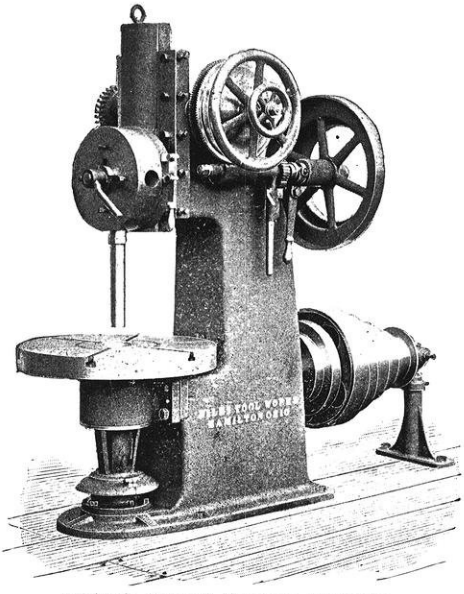

30-inch Turret Boring Machine.

# The Wisconsin Engineer,

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FROM THE UPPER CAMPUS

*Photo by O. B. Rosstead, Engr. '04.*

THE WISCONSIN ENGINEER

VOL. 6. MAY, 1902. NO. 4.

# TWELVE YEARS GROWTH OF UNIVERSITY EQUIPMENT.

PROF. JNO. G. D. MACK.

If a University of Wisconsin graduate, of the latter part of the eighties, had remained out of touch with his Alma Mater during the period since that time, he could receive without serious shock a question asked of a Wisconsin man during a recent eastern trip.

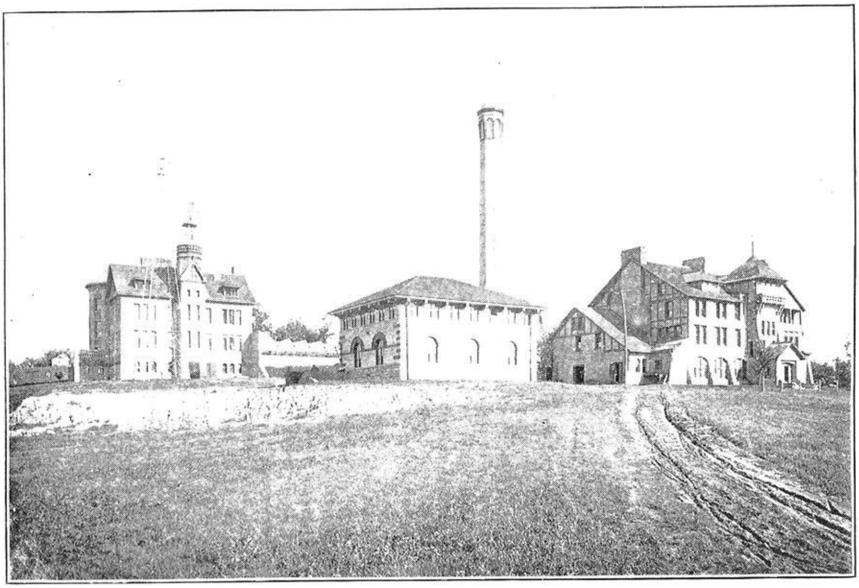
A party was being shown over the buildings of an educational institution, when one of the members of the party, a graduate of a large eastern university, asked the Wisconsin man if the University of Wisconsin could compare in building equipment with the University then undergoing inspection, the buildings of which, large and small are in number, considerably less than one dozen.

The Wisconsin man's statistical reply is not of record, but doubtless was convincing.

The first building erected for the youthful University of Wisconsin was North Hall in 1850, which was followed by South Hall, and the latter in 1859 by the construction of University Hall, known to older graduates as Main Hall. These three Halls formed the total building equipment of the University for about ten years.

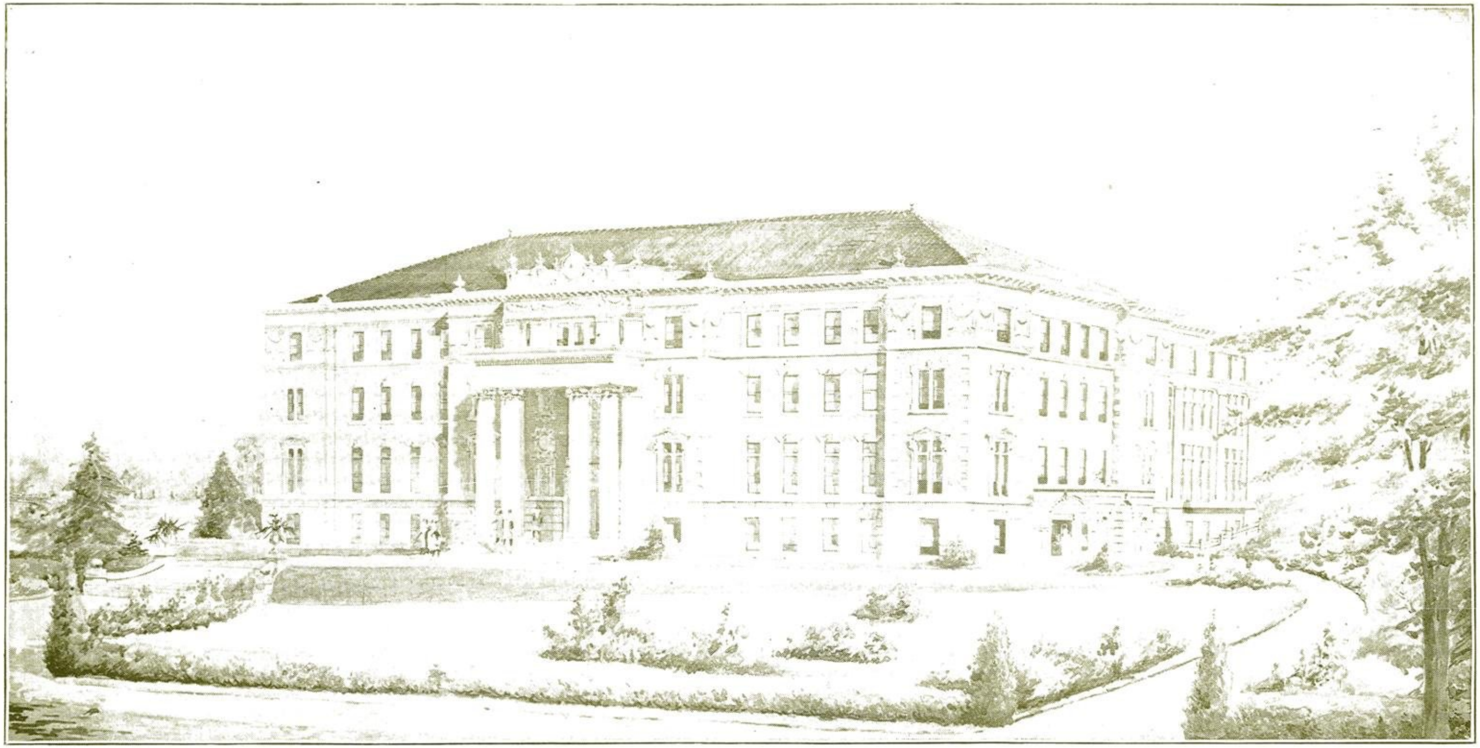
In 1890, the buildings included, in addition to the three just named, Washburn Observatory, Assembly Hall and Library, Science Hall, Chemical Building, Machine Shop, Boiler House and a so called Gymnasium. The old Science Hall which was completed in 1878 was totally destroyed by fire in 1884, and replaced as soon as possible by the present structure, which is of interest as the first building ever built in which steel construction, as distinguished from iron, was employed.

It would appear therefore, that a person having no knowledge of the University's growth since the eighties, would receive the question to which reference has been made with entire equanimity. The accompanying illustrations show the buildings and additions which have been made since 1890.



HORTICULTURAL BUILDING POWER HOUSE DAIRY BUILDING

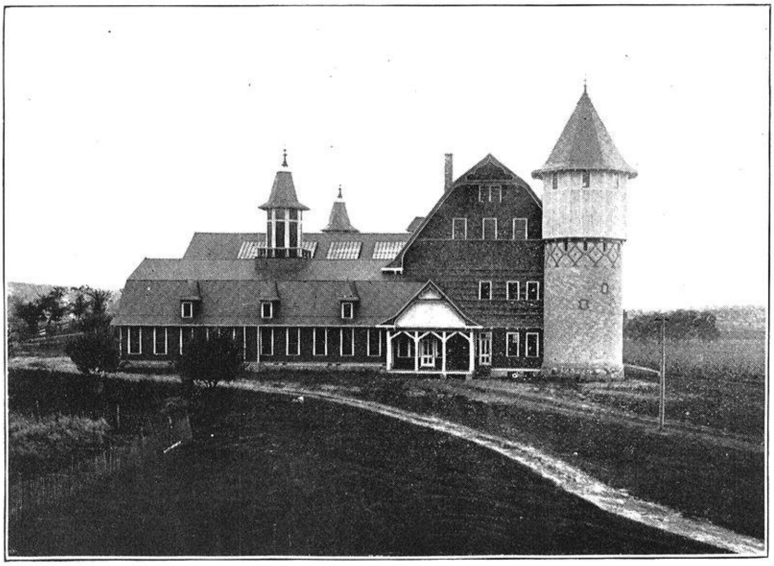
The Dairy and Horticultural Buildings, and the separate power plant for them are shown in one illustration. About two hundred yards south of this group, the foundation of the Agricultural Building is now in course of construction. It was designed by the University architect, Mr. J. T. W. Jengings, the illustration being taken from his drawings. It occupies a picturesque location on the hill side below the observatory, and when completed with its red tile roof and



NEW AGRICULTURAL BUILDING

general color scheme will form the center of one of the most charming views in this locality.

The Dairy barn belonging to the department of agriculture is shown in the illustration. It was built at a cost of $20,000 and is equipped with all the improvements necessary for scientific dairy husbandry. There is a similar structure used for the care and study of horses.



DAIRY BARN

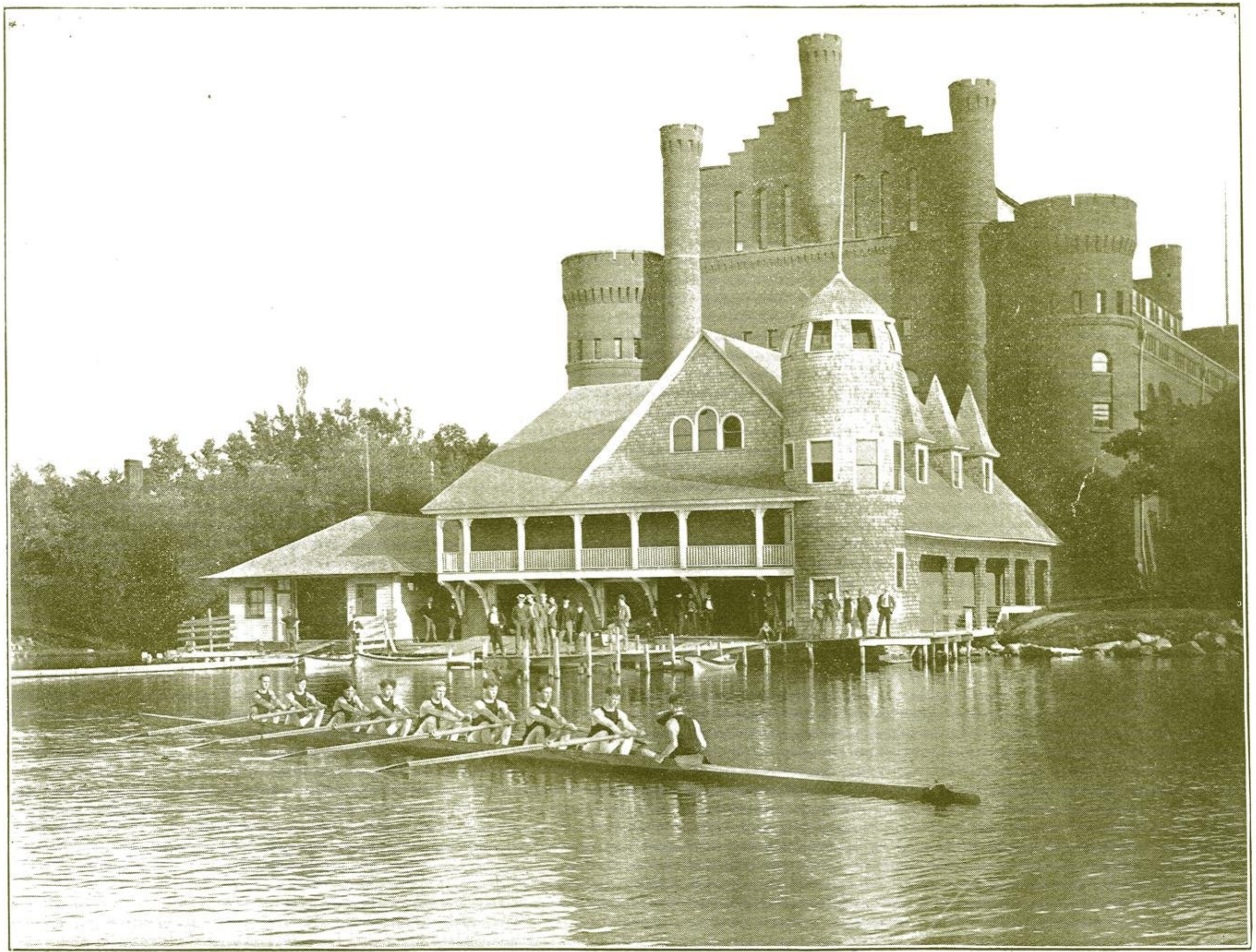
The Law Building, a brown stone building, stands on the south side of the upper campus. It was completed in 1894, previous to which time the law school was held in the capitol.

The University boat house on the shore of lake Mendota was built in 1891. Here the shells of the crews are housed as well as many pleasure boats. Adjoining the boat house is the tank in which the crews practice before the opening of the lakes in the spring.

The gymnasium, a red brick structure, was completed in 1894. Before this time there had been a gymnasium, a frame structure which stood to the west of University Hall; it was destroyed by fire in 1891, in celebration of some great event, so the tradition goes, and from '91 until '94, the facilities for athletic training were entirely absent; such as the boys had before '91 would now be considered of no consequence whatever.

LAW BUILDING

With the completion of the present "Gym" Wisconsin athletics took a decided "brace," and in the fall of '94 Wisconsin for the first time defeated her old rival, Minnesota on the gridiron.



VARSITY BOAT HOUSES AND GYMNASIUM

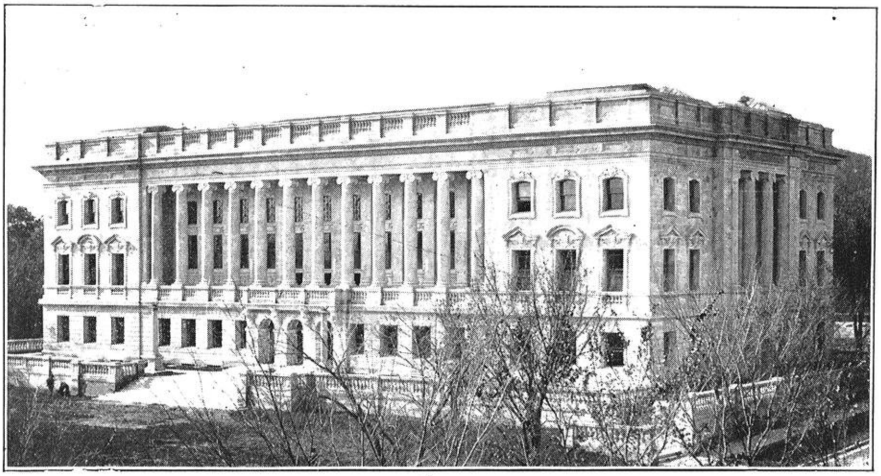
This was the greatest day Wisconsin athletes ever saw, and ranks in the chronicles as does "Trafalgar" in British naval annals. On the day of the dedication of the Gymnasium an event occurred which was not on the regular program—the greatest Freshman-Sophomore rush in our history. The battle opened with some desultory skirmishing on the lake shore. Orders were sent out, re-enforcements began to arrive, and the conflict became a general engagement on the lower campus, the line of battle and trail of wounded hats, collars and coats extending as far as Lake street and University avenue.

UNIVERSITY HALL

After the completion of the Gymnasium, the athletic field at Camp Randall was laid out and the grand stand built. Improvements have been made from time to time, and now any Wisconsin man should be proud of our facilities for physical training.

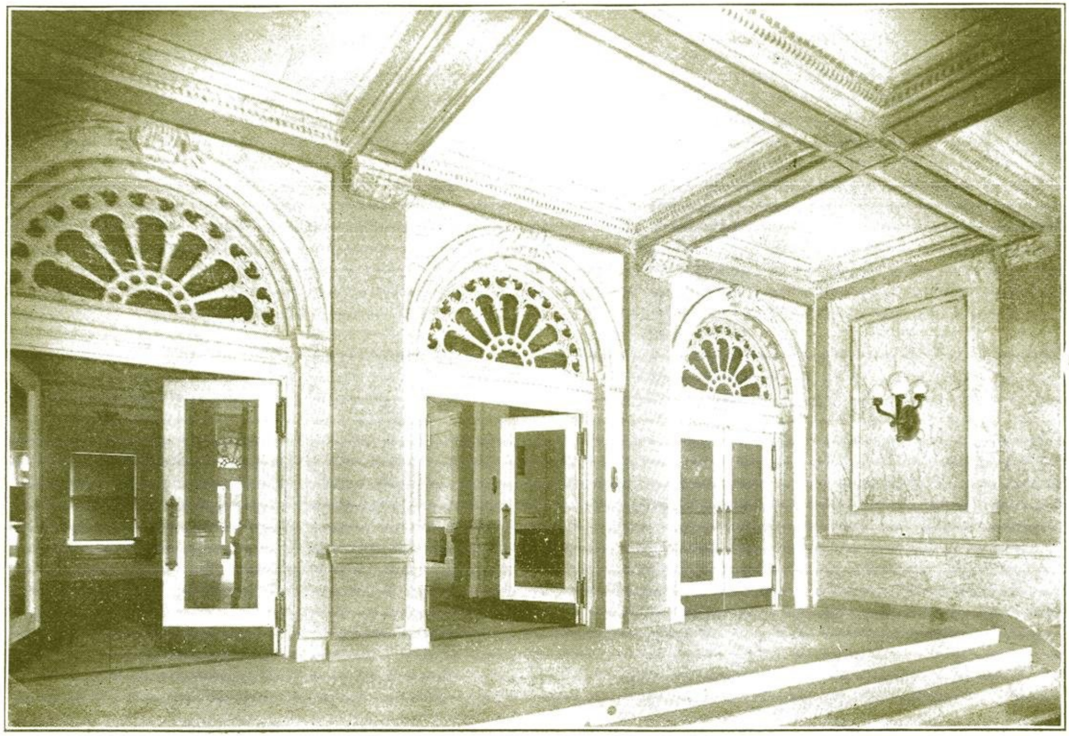
Some of the growth in University building equipment has been due to additions to older buildings or the rebuilding of them. The University Hall of today differs materially in appearance from the original structure, on account of the new dome and the large south wing added in 1899. This wing is about equal in space to the old building. At some future date a similar wing will be added to the north end of the building.

The hub of a University is its library, and in library facilities the University of Wisconsin is particularly fortunate. There are five libraries in Madison, the University, Historical, University Law, State Law, and Madison Public. The first two are in the new Historical Library Building, the third in the Law Building, the State Law Library is in the Capitol and the Madison Public Library is at present in the City Hall. The latter, however, will soon have a building of its own, $75,000 having been given by Mr. Carnegie for that purpose The site for the building has been promised by Mr. Frank A. Ogden, a University of Wisconsin student of the early days.



THE STATE HISTORICAL LIBRARY BUILDING, MADISON, WISCONSIN

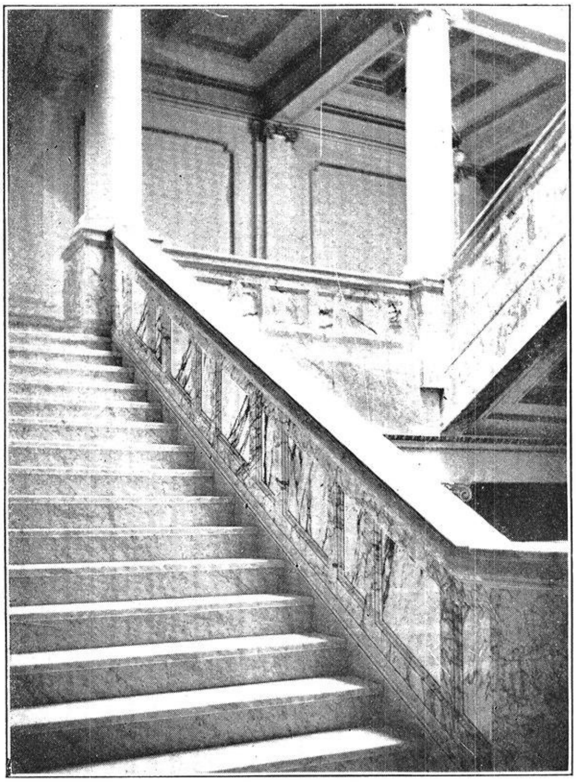
The Historical Library Building stands on the west end of the lower campus, facing east.



VIEW OF MAIN ENTRANCE—HISTORICAL LIBRARY

VIEW OF READING ROOM—HISTORICAL LIBRARY

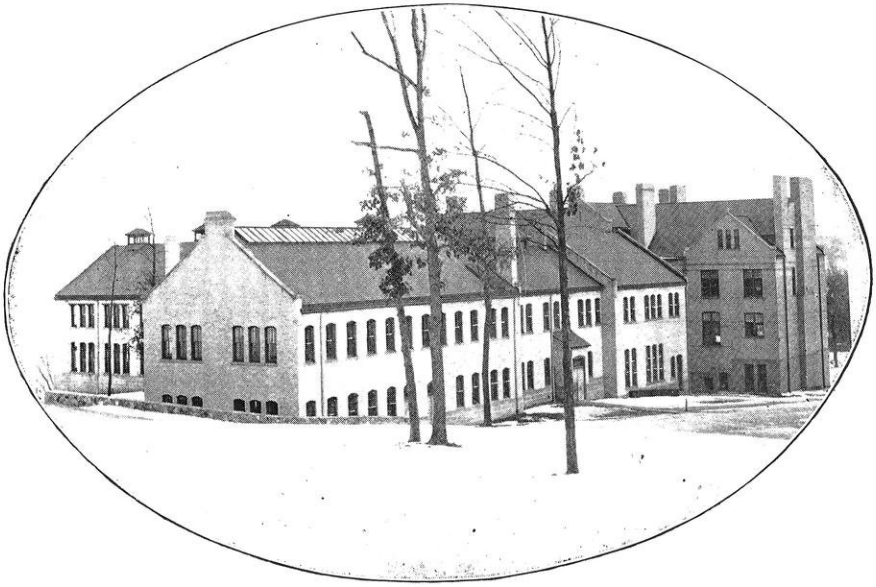
It was built and equipped by the state of Wisconsin at a cost of $650,000. One wing is not yet built, but when completed at some future time will be used for the University library, which now occupies the south wing with the Historical collection. For many years it has been known that ultimately these great collections would be in one building, and therefore the librarians have adhered to the policy of duplicating only the more common reference books, thus making the value of the combined libraries far greater than it would otherwise have been.



VIEW OF MAIN STAIRWAY—LIBRARY HALL

The Historical Library contains many works along the lines of science and engineering, among which may be noted complete sets of the Franklin Institute and Silliman's Journal, a large portion of the Proceedings of the Royal Society, some of the latter of the seventeenth century.

There are also Patent Records of great value, including the Canadian Gazette, and practically complete sets of the United States and British Reports, the latter being one of a very few complete sets in this country.

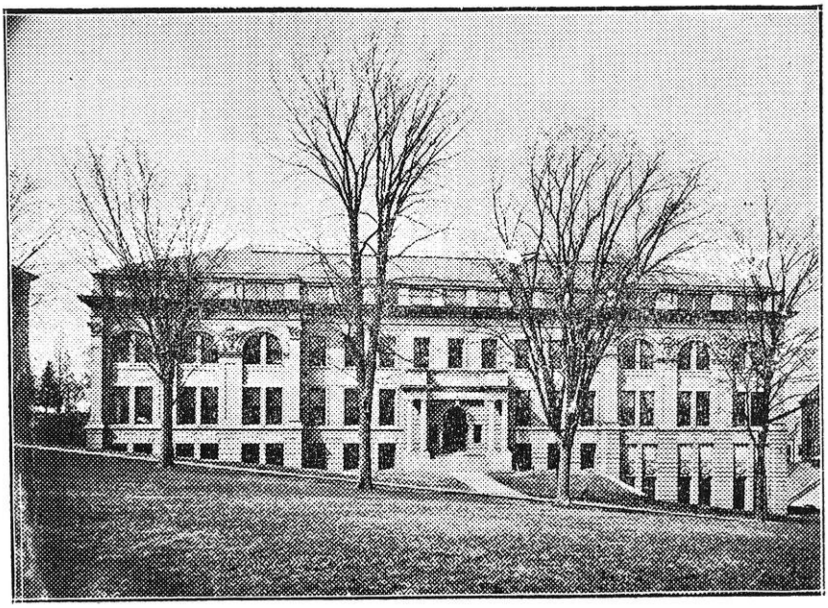


MACHINE SHOP, DYNAMO LABORATORY AND CHEMICAL LABORATORY IN DISTANCE

In 1890 the College of Engineering occupied a portion of Science Hall and the small machine shop. The writer had two of his students make a plan of the shops in the spring of '95. A blue print of this tracing was recently uncovered among a lot of old drawings, and was of particular interest from the fact that a pencil line had been drawn on it, enclosing about ten feet square to scale, which space then included the entire electrical engineering laboratory.

In '95 the machine shop was extended north, a new blacksmith shop and the foundry enlarged. On the south front a wing was added, both floors of which are now used by the electrical engineering department, the ground floor as a dynamo room, and the second floor for electro chemical work.

These laboratories are now crowded, and an extension to the space is projected among future improvements. The pride of the engineers is the new Engineering Building, which faces the law building from the north side of the upper campus. It was designed by Mr. Jennings and Dean Johnson, and is considered a model of what an engineering building should be. Blasting for the basement was begun while the ground was frozen in March, 1900, and it was ready for class work in September of the same year, less than seven months being required for its construction.



ENGINEERING BUILDING.

The first and second floors are finished in oak, the upper floors in Georgia pine. All the plaster is tinted adding greatly to the beauty of the interior. Nearly all of the available space has been covered with pictures donated to the college by manufacturers; these pictures serving both for ornament and for illustrations in class work, of types of machinery and construction. Many of them were made specially for the college, and in nearly every instance they were shipped framed and expressage prepaid.

The College of Engineering has for a number of years had a uniform increase in numbers of 20 per cent. a year. This resulted in a crowding of the old quarters in Science Hall, which hardly seems possible as we now look back on the days when classes were held in offices, in the ends of corridors, in drafting rooms, and in some instances, of which the writer remembers, out on the campus under the shade of the trees.

Dean Johnson began his duties at the opening of the college year in the fall of 1899. The "second best" recitation room, belonging to the college, was transformed into the dean's office, leaving but three which we could call our own. A lecture room in the shop, a portion of which was used for a photometry room, the old descriptive geometry room No. 22, on the northeast corner of the first floor of Science Hall, and a room in the basement with no ventilation, and which was irreverently known as the "Black Hole of Calcutta."

All of the students of that day will remember the first floor drafting room in which were over 100 desks, and on some days, four classes working at the same time. In addition it was the common assembly ground for other students between classes. Another drafting room occupied a portion of the geological laboratory, and a third was on the second floor of the shop where the electrochemical laboratory is now located.

In the final crush Philomathia's room, on the fourth floor of Science Hall, was pressed into service as a drafting room. It was the writer's duty to arrange time table and room schedules. It is not a pleasant subject to speculate on, as to what would have happened if the engineering building had been delayed a year or two in completion. In the basement of the engineering building are the laboratories for testing materials, for electrical measurements and the steam laboratory.

Future extentions to the engineering building have been provided for in the plans of the present structure, which is only about one fourth of what the building will ultimately be This plan also proposes the doubling of the steam laboratory. which even in its present form, is the best arranged laboratory of its kind.

The first floor contains the Dean's office, surveying instruments, reading room, recitation rooms and the auditorium, the latter seating about three hundred and fifty. From this floor a gallery opens which extends entirely around the steam laboratory. This gallery will be used also for a brick, stone and tile exhibit.

On the second floor are the larger portion of the offices of the professors, and a number of recitation rooms. The third and fourth floors are given up to drafting rooms, one of the fourth floor rooms being used for a museum.

A portion of the periodical fee paid each year by every student is used for the purchase of duplicates of the more common technical books, so that they may be consulted without the necessity of making a trip to the library. This duplicate technical library will be increased from year to year and is a feature of great value to the work of the college. A laboratory for hydraulic work is projected, which is to stand on the lake shore near the university pumping station.

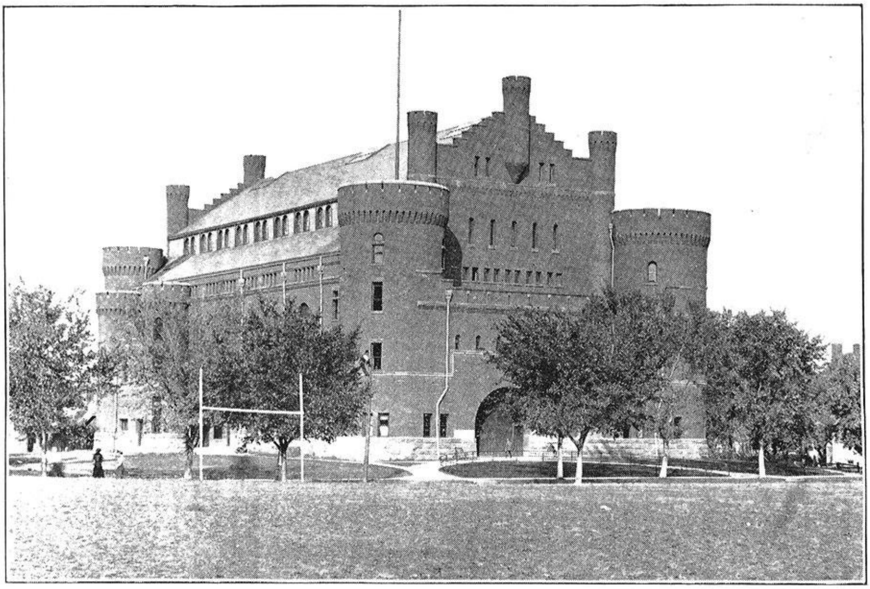
Nearly all of the former quarters of the College of Engineering, in Science Hall, have been occupied by the Department of Physics, the old drafting room having been transformed into a magnificent laboratory for the Sophomore Physics work. Under the present arrangement in the College of Engineering, there is no division into courses in the Freshman year. All Freshmen are required to take surveying and this has necessitated a large increase in the number of surveying instruments, each of which has its glass front, oak closet; making the instrument room one of the "show" places of the college, which it decidedly was not in the Science Hall days, as the students of that time well remember.

Gradual increase has been made in the equipment of all the laboratories, but it is not nearly what it should be, and what we all hope to see in time. A university which enjoys a healthy growth is always crowded for room and apparatus.

The following table shows the increase in numbers of both faculty and students during a period of fifteen years:

| Year. | Total University Faculty. | Total Students in University. | Total Students in Col. of Engineering. |
|---|---|---|---|
| '84-'85.... | 41 | 407 | 29 |
| '91-'92.... | 62 | 1,337 | 115 |
| '96-'97.... | 119 | 1,882 | 205 |
| '01-'02.... | 171 | 2,777 | 513 |

The total number of buildings now used by the University for instructional purposes is twenty-one.



U. W. GYMNASIUM

In the University of Wisconsin, great as has been the growth in buildings and equipment, the increase in the number of students has more than kept pace with it, so that some departments, notably the chemical, are as crowded as was the engineering department before the erection of its building.

# THE EFFECT OF METALLIC SALTS IN THE ELECTRIC ARC.

BY G. W. WILDER, PH. D.

Edlundt (1867) was the first to discover that the electric arc considered as an electric conductor, as a column of flame or vapor, conducting the current, does not follow the laws of ordinary electric conductors; that is, its resistance is not directly proportional to its length, nor inversely proportional to its cross-section. From his experiments it appeared that the resistance of the arc was made up of two parts, one a constant which seemed independent of the length of the arc, and the other which was directly proportional to its length. This extra or independent resistance, he thought, was due to a sort of polarization which occured in the center of the arc, or something similar to that which takes place in a secondary battery when it is being charged or in a voltameter when water is being decomposed.

The cause of this extra resistance discovered by Edlundt is usually referred to as the counter electro-motive force of the arc, and many investigators have endeavored in various ways to explain the reason of its existence and to study its nature. No agreement has been reached as to its cause although much is known regarding its behavior and distribution. It has been found, for instance, that the total difference in potential between the two electrodes forming an arc, depends upon the current, the length of the arc, the material forming the electrodes, the distance between them and their cross-sectional area.

The various relations existing between these quantities have been carefully studied by Mrs. Ayrton (London Electrian, 1896-99) who found in addition that the potential difference, for any given set of conditions, took on a constant value only after sufficient time had elapsed for the carbons to assume a definite shape. The shape itself depending upon the set of conditions referred to. Thus, for a given length of arc and a given current, the potential difference will depend upon the size and hardness of the carbons and for any size and grade will not become constant until the carbon tips have assumed their peculiar shape due to these set conditions. When all of these quantities are constant and bear a certain relation to each other, the arc is said to be normal.

The distribution throughout the arc is quite different than one would at first expect. In order to find the distribution it is only necessary to explore the arc by means of a test pencil of some kind, and compare the fall in potential between that and either carbon to the total fall between both electrodes. Fig. 1 shows such a pencil placed between the two carbons forming an arc and connected by means of a voltmeter to the positive electrode from which the current is flowing. Another voltmeter is connected between the positive and negative carbons, measuring the total drop across the arc. This arrangement enables simultaneous readings of the two valves so that for a given value of current, a given length of arc, and a given set of carbons a check is made upon the corresponding potential differance between the carbons at the same time that the potential difference between the test pencil and the positive electrode is read.

When the test pencil touches the crater of the positive carbon, the voltmeter, between the two, reads nearly zero. The reading being merely due to the resistance offered by the connecting wires, contacts and that due to the hot carbon itself which is usually very low. Now separate the test pencil ever so little from the positive carbon and immediately a large fall of potential occurs. In the case used for illustration where the carbons are twelve millimeters in diameter and separated by a distance of four centimers, this drop amounts to thirty-six volts, while the total drop between the positive and negative carbons is fifty-two volts, the current being five amperes. If the test pencil be moved across the arc from the positive carbon to the negative, the voltmeter reading will increase from thirty-six to thirty-nine volts. Then as the test pencil touches the negative carbon another sudden change occurs and the reading goes up to fifty-two volts and both instruments give nearly the same reading. We see from this that a major portion of the total drop in potential between the electrodes occurs just at the surface of the positive in going from the carbon into the vapor and that a smaller portion oc-

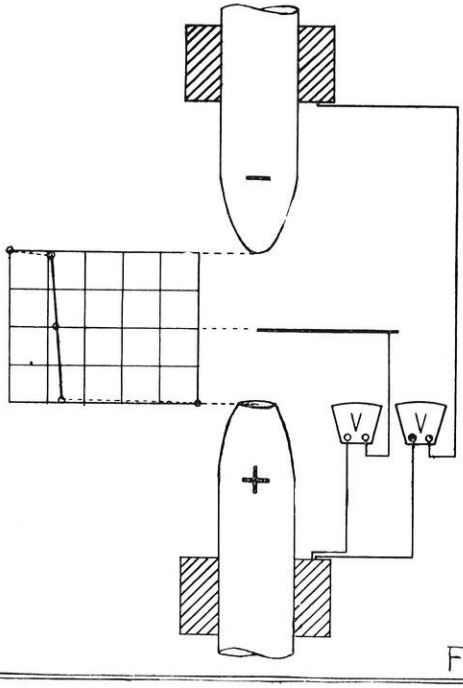


Fig. 1.

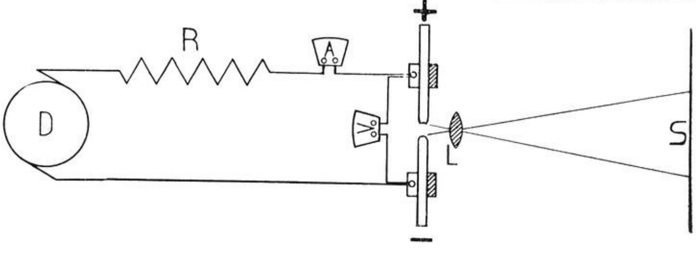


Fig. 2.

curs in like manner at the surface of the negative carbon, while a very small part, namely, three volts, is distributed uniformly throughout the arc. In order to represent this graphically a scale has been drawn at the left of the figure upon which distances are plotted to the scale of 1 cm. per square in the direction of the motion of the test pencil while at right angles to this direction are plotted the values of the difference in potential between the pencil and the positive carbon, ten volts being plotted to the square.

It has long been known that metallic salts introduced into the arc, changed the relation between the current and the potential difference between the electrodes. The object of the following work was to make a quantitative study upon the effect of putting metallic salts into the core of the positive electrode and possibly to account for the large drop in potential at the electrodes. The general scheme of connections was the following: A 110 volt Direct Current dynamo, D, Fig. 2, supplied the current at a very constant pressure. A hand rheostat, R, an ammeter, A, and a hand regulated lamp were connected up in series. The image of the arc was thrown upon a screen, S, through a lens, L, and magnified ten times. The screen being of millimeter cross-section paper, the length or arc was read off directly. The test pencil, as shown on Fig. 1, was made by grinding out a thin strip of hard carbon. This was attached to an adjustable device and placed at will at any point of the arc. The soft core of the positive electrode was removed and its place filled with the metallic salt to be examined.

In order to study the distribution of potential between carbon electrodes, arcs were first tried with different kinds and sizes of carbon, various currents and lengths of arc. The results are shown in the curves of Fig. 3, in which volts are plotted as ordinates and lengths of arc as abscissae. It should always be understood that the curve is plotted from the positive on the left to the negative on the right. As it was necessary to draw several curves on the same sheet the origin has been displaced vertically as is indicated by the beginning of the broken line at the left of each curve.

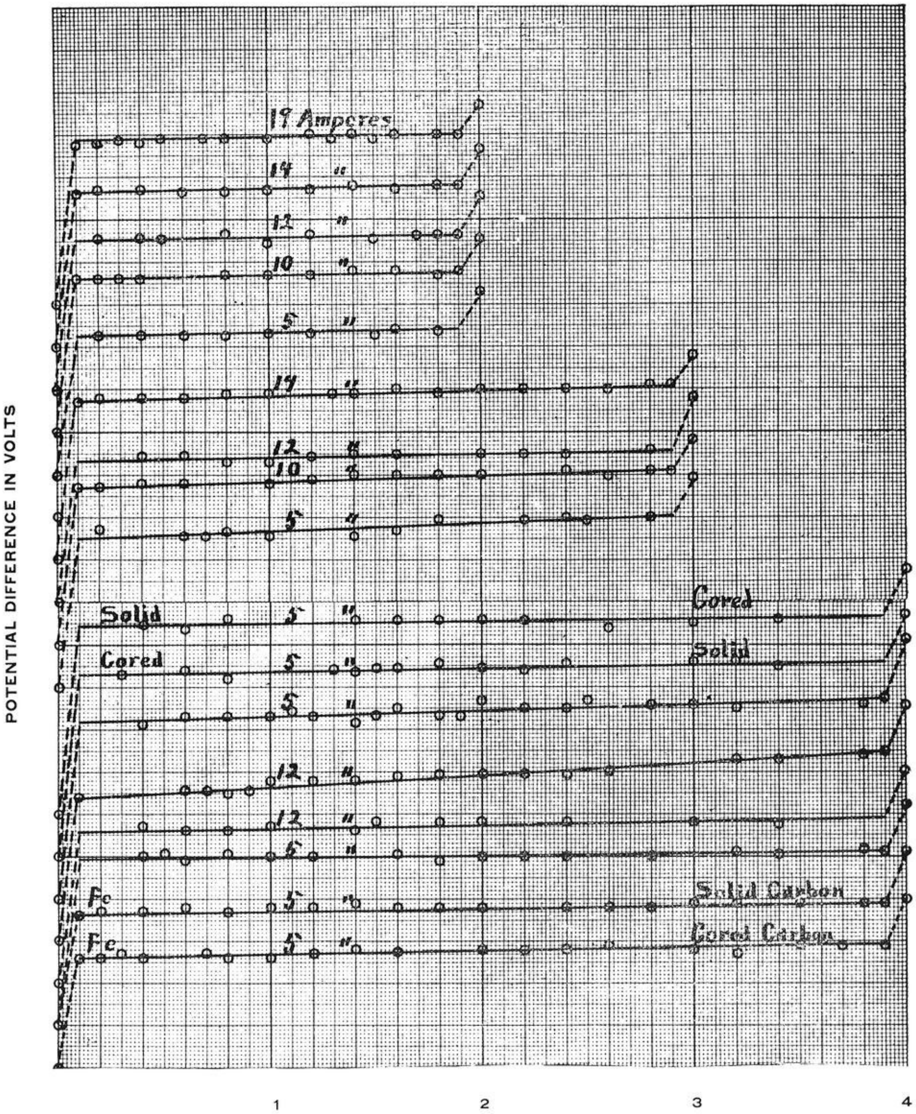


FIG. 3 — LENGTHS OF ARCS IN MILLIMETERS

A general inspection of the curves show that in all cases the distribution of potential between the electrodes is similar to the arc used as an illustration above, and consists of three distinct parts, one in the immediate neighborhood of either electrode and the third through the arc itself.

Since it was found rather difficult to measure closer than one-half of a millimeter the broken lines at either end of the curves indicate the region in which the potential difference suddenly changed. The fall of potential throughout the arc seems to be very uniform, although some of the curves are not as horizontal as others, which shows that the resistance of those arcs is greater than the latter ones. The curves are all straight lines showing that the resistance of the vapor column varies directly as the length, and in most cases those of small currents are not as horizontal as those of larger currents, hence the resistance depends upon the size of the current, or, upon the cross-section of the column of vapor. Since the resistance of the vapor column is very small, the changes due to the size of current and length of arc are consequently very small, and hence are not very prominent in the curves, but it is readily seen that in the whole drop in potential from one eletrode to the other, only a very small part of the drop is due to the resistance of the arc itself, most of the drop occurring at the electrodes. The drop in potential at surface of the negative electrode is, in general, not as great as that at the positive, especially when carbon electrodes are used, but the drop becomes nearly as great in case of iron electrodes, or certain metallic salts, or when iron is used as a positive with nearly any metal for a negative.

The curves at the top of Fig. 3 show the distribution of potential for various currents throughout an arc two millimeters in length, between electrodes of cored carbons twelve millimeters in diameter. Under these are shown the curves for an arc three millimeters in length. Curves A are for an arc four millimeters in length, while curves B are for the same arc between solid carbons nine millimeters in diameter.

Curve C is for an arc between a solid carbon positive and a cored carbon negative, and curve D is for a reverse arc or a cored carbon positive and solid carbon negative.

With the arc two millimeters long it is seen that the potentential difference between the carbons slightly increases with the current, while for arcs of three millimeters length it decreases somewhat, and for the longer arcs the decrease is very pronounced. It has been pointed out by Mrs. Ayrton that this drop is greater for large arcs for this range of current, while for very short arcs there was an actual increase in potential difference with increase of current. The potential difference at the positive carbon is seen to increase slightly in arcs of two millimeters length, while it remains about the same or perhaps decreases slightly for those of three millimeters, but drops in those of four millimeters. From this we see that it strictly follows the total drop between the carbons. Again if we compare the drop at the positive for arcs of different lengths, it is found that with equal currents the drop increases with length of arc. The drop of potential at the negative electrode seems to remain fairly constant for all currents and lengths of arc. The drop being considerably smaller at this carbon, the differences among the curves appear large, but as it is often quite difficult to measure close to the carbon, they are necessarily quite a portion of the whole drop. Measurements are quite often made difficult at this electrode by a tendency of the arc to join the carbon at some point not near the tip or extreme end; when this happens the observed values are somewhat larger than the real values.

In order to see what effect the material of the electrodes had upon the distribution of potential, an arc was formed with a cored carbon positive and a solid carbon negative and visa versa. The carbons being the same ones used in the previous arcs. Curves C and D show these arcs. In either case the potential difference between the carbons is fifty-seven volts with a current of five amperes and length of arc four millimeters. At the positive the drop is greater when a solid carbon is used than when the cored carbon is used, but in the latter case the resistance of the arc seems to be larger. The drop at the negative is larger when that electrode is a solid carbon. In order to further study the effect of material in the electrodes, arcs were formed between iron rods alone and also in conjunction with carbons. These curves show arcs between iron positive and cored carbon negative and iron positive and solid carbon negative. It is seen that in both cases the drop at the iron is the same, while at the negative it is greater for the solid carbon than for the cored carbon. From the above it is readily seen that the material composing the positive electrode is more effective than that of the negative in changing the potential difference between the carbons.

In order to study this effect further a number of arcs were used with cores composed of different metallic salts. In each case the soft core of a cored carbon was removed and the salt to be examined inserted in a finely pulverized condition and carefully packed. Since a cored carbon used as a negative keeps the arc from wandering off the sides of the electrode and hence produces a quiet arc, a cored carbon negative was always used. A few arcs were tried using cores tightly and loosely packed and with large and small cores, but in all cases the results were the same when reasonable limits were used.

When arcs are formed by inserting various substances in the core of the positive, it is found that they do not all behave alike. The general effect of most salts is to permanently change the potential difference between the carbons. With some the potential difference is raised, while with others it is lowered. In some extreme cases the change is so great that the potential difference varies from twenty-two in some to sixty-five in others.

The time required to form a normal arc is also considerably varied especially when the substance raises the potential difference above the value obtained with an arc having the same conditions, formed between carbons. In some cases the time required for a five ampere arc of four millimeters length to become normal is from three to four hours. The usual behavior of an arc of constant current and of length, when formed between carbons is to show a gradual increase in potential difference from the time the arc is struck until it becomes normal. This is the case with the majority of the arcs formed with different salts in the core of the positive. It is not unusual, however, to find arcs in which the potential difference reaches a maximum at the time the arc is struck,

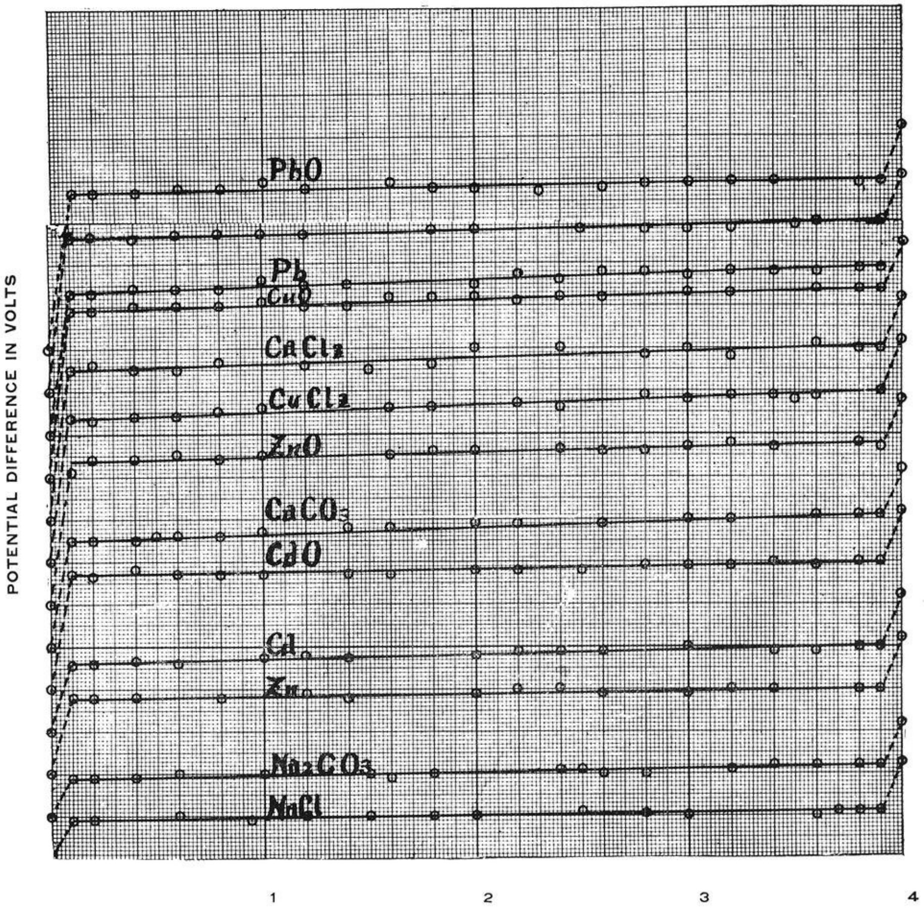


FIG. 4 — LENGTHS OF ARCS IN MILLIMETERS

and then slowly decreases as the arc becomes normal. When the normal condition has been once obtained it is found that the substance composing the core is removed to a depth of from one to five millimeters below the surface of the crater.

Fig. 4 shows a few curves selected from those obtained by using sixty different substances as cores, each one being operated with five amperes. It will be noticed from the curves that NaCl, $Na_2CO_3$ give a low potential difference and hence a small drop at the positive. The same thing is true for $LiCO_3$, $NaNO_3$, KI, KCl, KNr, $BaSO_4$, $BaO_2$, and others. In nearly all of these cases the drop at the positive is nine volts with about ten at the negative.

With the other chlorides we get a potential difference which in case of CaCl and CuCl in nearly equal although the former the potential difference drops to thirty volts when the current is increased to twelve amperes. BaCl gives thirty volts, $CrCl_3$ gives sixty volts so that there seems to be no regularity among the chlorides at all. The carbonates and oxides are found to vary widely, for while $Na_2CO_3$, also $LiCO_3$, give a potential difference of twenty-two volts. $CuCO_3$, $ZnCO_3$, $MgCO_3$, give a potential difference of fifty-two and sixty volts. It might be said that these latter carbonates decompose in the arc while the former ones volatilize. A noticeable distinction is recognized between the metals and their oxides. The latter require a higher potential difference than the former. The difference is probably due to the energy required to reduce the oxide to the metal.

A consideration of all the curves will show that the fall of potential across an arc consists of these parts as already mentioned, one at the positive electrode, one due to the arc itself and one located at the negative. It is to this latter one that I wish to call attention particularly, inasmuch as it is not generally known and seldom mentioned. The drop at the positive depends first upon the nature of that electrode, that is: upon its material and a little also upon its hardness. *[L. B. Marks, Am. Ins. Elect. Eng. vol. F, p. 175.] The drop at the positive and the total potential difference are dependent upon each other, an increase in one producing an increase in the other. The former is slightly affected by a change in the length of arc and current, but it is entirely independent of the negative electrode. For arcs of the same length having different currents, the drop at the positive increases slightly for short ones and decreases for larger ones. As already mentioned the resistance of the arc forms but a small part of the total potential difference since the curves representing that part of the arc are nearly horizontal.

The drop at the negative depends upon the material composing that electrode and is entirely independent of current, length of arc, or of the positive electrode.

## GROWTH AND DEVELOPMENT OF THE STEAM ENGINE.*

PROF. A. W. RICHTER.

In the writings of Hero, some 2,000 years ago, we find the first traces of the modern steam engine. In his works he describes a machine, shown in Fig. 1, which is often spoken of as the first steam engine. It consists of a lower vessel or boiler partly filled with water. A globe is supported above by a pair of tubes, which form a passage for the steam from the boiler into the globe. Two short bent pipes issue from the sphere, at points opposite each other, and are open at their extremities. Steam, being formed in the boiler by means of a fire underneath, will rush into the globe and out of the bent pipes in such direction that the reaction produces a rotary motion of the sphere.

It seems strange that, although continually confronted by evidences of the power of steam, mankind was unable to control it and put it in practical use, up to very nearly the close of the seventeenth century, now 200 years ago.

In 1601, Porta described an apparatus by which the pressure of steam might be made to raise a column of water. It

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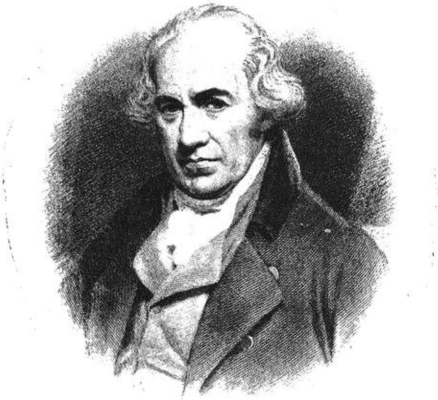
*A lecture delivered at the first annual convention of the Butter-Makers' Association.

included the application of the condensation of steam to the production of a vaccuum into which the water would flow.

In 1615, De Caus describes a machine which consisted of a metal vessel partly filled with water, in which a pipe was fitted, leading nearly to the bottom and open at the top. Fire being applied, the steam forced the water out through the vertical pipe, raising it to a height limited by either the desire of the attendant or the strength of the vessel.

In 1629, Branca described, in a work published in Rome, a steam engine in which the steam, issuing from a boiler, impigned upon the vanes of a horizontal wheel.



JAMES WATT

During the last half of the seventeenth century, the Marquis of Worcester appears to have constructed, in his home at Vauxhall, near London, a device for the raising of water by the aid of steam, and we here come to the first instance in which the force of steam is supposed to have been actually applied to do important and useful work. But Worcester was very unsuccessful in his efforts to introduce the device, and fearful, it seems, that he lose the financial benefits which must follow such introduction, we find no drawings and no minute description of his work. And as a consequence, mankind received no immediate and direct benefits from his labors. All that remained of the work of Worcester is found in the impressions which are found in the walls of his castle.

From this time on, many men were earnestly working on this problem, the raising of water by the aid of steam, and the necessities of the commercial world lent an impetus to the work. Toward the close of the seventeenth century, English miners were beginning to find the greatest difficulty in clearing their shafts of the vast quantity of accumulating water.

8

THE GRECIAN IDEA OF THE STEAM-ENGINE.

9

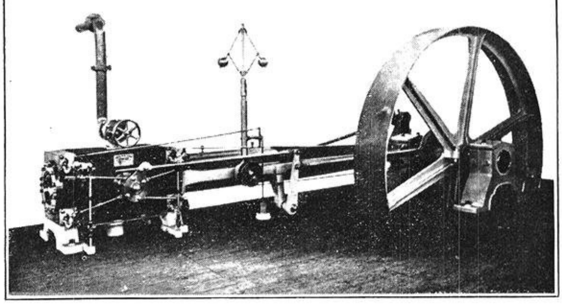


FIG. 1 — The Grecian Idea of the Steam Engine. The Steam Engine as Corliss Left It.

A more powerful aid than that of horses was absolutely necessary for their work; as a consequence, many mines were idle, and many others were threatened with a like fate.

In 1698, Thomas Savery devised a machine which partially met this want, a machine whose type is represented to-day, in an automatic form, by the well-known pulsometer and steam ram.

Savery's engine consisted of two forcing vessels and two separate boilers; the steam being admitted, the air was driven out; the steam then being condensed by means of a stream of water which was allowed to flow over the outside of the vessel, a vacuum was formed, and the water rose from the reservoir below. Steam again being admitted, the water was forced out and up through the vertical pipe. The steam being again condensed, the operation was repeated. The valves were regulated by hand. The two vessels being used alternately, a continuous stream was discharged. The large boiler was the main boiler, the smaller one being used as an auxiliary to supply feed water to the larger one.

This machine of Savery's was the first commercial success, the first device of the kind that successfully aided man in the performance of the task set before him. Whether or no Savery obtained his ideas from a knowledge of the work of Worcester, certain it is that to him must be given the credit of successfully introducing the device, and thus really first benefiting mankind commercially.

The Savery engine was used to draw water out of mines; it gave a new impetus to the mining industry. Mines previously abandoned again commenced operation, and it was probably the means of drawing much attention to the importance of the power of steam as an aid to the work of the human race. But the device of Savery was not entirely successful. Boiler making was not understood, and the device required pressures beyond those which could be safely carried by boilers then in use, and consequently several explosions resulted, followed by doubt in the minds of many as to the safety of the device. It was besides a most uneconomical machine, and was displaced in 1705 by the engine of Newcomen and Calley.

Just previous to this time, Denys Papin had devised the two-way cock, the safety valve, the digestor, and also separated the steam from the water by means of a piston or float.

The Newcomen or atmospheric engine consisted of a boiler, above which was placed a steam cylinder, connected to the boiler by means of a pipe containing a valve. Steam being admitted to the cylinder, the piston rose by means of the weight of the pump rod situated at other end of the beam. A spray of water was then admitted by means of another pipe and valve; the steam being condensed, a vacuum was formed and the piston was forced down by means of the atmospheric pressure on the outside of the piston. The engine made about eight to ten strokes a minutes. The valves, being operated by hand, required a boy attendant, until a boy, named Humphrey Potter, noting the regular motion of the beam, attached the valve handles thereto by means of cords, thus constructing the first valve gear. This increased the speed to 15 or 16 strokes per minute. This valve gear was then improved and given a more permanent form.

The Newcomen engine was a commercial success—a steam engine using steam pressures, so low as to be entirely safe, capable of pumping water from any depth or of turning the wheels of any manufacturing establishment, one meeting all requirements that could then be made upon it, and one which, by means of a train of mechanism, was capable of transmitting the power to the resistance to be overcome at the other end. Newcomen's engine is the first of an entirely new type, and he was the first to give the steam engine a form in any way resembling our modern machinery, and it is to Thomas Newcomen I would accord the honor of being the first inventor of the modern steam engine. The success of the Newcomen engine attracted the attention of the best men of the time, as for example such skillful engineers as Henry Beighton and John Smeaton, who made some improvements, but nothing of any particular importance was done until James Watt gave his attention to the work which made him famous.

James Watt was born on Jan. 19, 1736. He was a bright boy but exceedingly delicate in health, and quite unable to attend school regularly or to apply himself closely to his studies. His early education was consequently given by his parents. The use of tools borrowed from his father's carpenter bench served to give him a familiarity with their use that proved of great value to him in after life. When finally sent to school, his ill health prevented rapid progress; and it was only when 13 or 14 years old he was capable of taking the lead in his class, and showing marked ability, especially in mathematics. At 18, Watt was sent to Glasgow, to learn the trade of mathematical instrument maker; he soon removed to the city of London for the same purpose. Watt returned home at the end of a year on account of ill health and later, in 1756, he again went to Glasgow with the intention of pursuing his calling there; the trades unions, however, prevented him from opening a shop in the town. Dr. Dick, of the University of Glasgow came to his aid, and he was finally allowed the use of three rooms in the University building. In the college collection was a model of a Newcomen engine. The proposal to repair this model, together with his associations with the professors and with Dr. Robison, then a student of the University, directed his attention to the steam engine, and henceforth Watt devoted his best energies to the study of the steam engine and its improvement. Watt soon began experiments of his own and for this purpose he used, at first, apothecaries' phials and hollow canes for steam reservoirs and pipes, and later a Papin digestor and a common syringe. These experiments led to practical results. He finally took hold of the Newcomen model and made experiments with that. Watt soon determined the sources of the losses occuring in the Newcomen engine. Containing his investigations, Watt constructed a new boiler, and arranged it in such a manner that he could measure the quantity of water evaporated and the steam used. He soon independently discovered the existence of the latent heat of steam, the discovery of which was made previously by Dr. Black. The results of his many experiments, which were well devised, and scientific in character, led Watt to his correct conculsions as to the sources of loss of heat and power in the Newcomen machine and in addition he discovered many other scientific facts concerning steam and the steam engine. Watt soon saw that in order to reduce the losses of steam in the cylinder, it would be necessary to find some means, as he said, "to keep the cylinder always as hot as the steam that entered it." This finally led to the invention of the separate condenser, followed by a series of modifications, which gave to the world the modern type of steam engine. This, the separate condenser, is Watt's greatest invention, and upon it, more than any other one thing rests the undying fame of the inventor.

Watt immediately proceeded to make an experimental test of his invention, using for his steam cylinder and piston a a large brass syringe 1.75 inches in diameter and ten inches long; at each end was a pipe leading steam from the boiler and fitted with a cock to act as a steam valve. A pipe also led from the top of the cylinder to the condenser. The condenser was made of two thin pipes of thin plate 10 or 12 inches long and about $\frac{1}{6}$ inch in diameter. Another pipe about 1 inch in diameter was connected to the condenser and was fitted with a piston, with a view of using it as an air pump. This little model worked very satisfactory and raised a weight of 18 pounds. The success of this invention being confirmed, others followed in rapid succession. But even Watt's great mind was occupied for years in working out the details of the new engine. Watt now built several larger engines which were not very successful, due principally to the lack of skilled labor, and the entire lack of boring, turning and planing machines. As a consequence, several leaks were a necessary evil, and there being no financial returns, Watt was reduced to poverty.

In 1767, Dr. Roebuck, a wealthy physician, assumed Watt's liabilities to the amount of 1,000 pounds and agreed to provide capital for the continuation of the experiments and for the introduction of the engine, receiving therefor a two-thirds interest in the engine.

Several engines were again built, followed by partial failure due as before to unskilled labor and a lack of the necessary tools and machinery. During these early struggles, Watt was, at times, driven to the pursuit of his vocation as an engineer, in order to gain a livelihood for his family.

While on his way to London to procure a patent, Watt made the acquaintance of a wealthy Birmingham manufacturer, Mathew Boulton, who owned a large manufacturing plant at Soho, two miles from Birmingham. The acquaintance finally led to a partnership in the engine business, and Watt removed to Soho.

Mr. Boulton had a great business capacity, courage and health, and above all, large financial resources, which, together with Watt's wonderful mechanical ability, enabled them to overcome all difficulties.

Free from the uncertainties regarding his business relations, the next ten years, 1775 to 1785, were the most fruitful in invention in Watt's life. During this period the firm obtained five patents, covering many improvements on the steam engine, and several independent inventions. Time will not permit a description of these patents, and indeed this is probably not necessary, since most of them are well known, as they appear in our modern engines:

These patents include the following:

1. Five devices by which he obtained rotary motion without the use of the crank.
2. The expansion of steam and six methods of applying the principle and of equalizing the expansive power.
3. The double acting steam engine.
4. The use of a rack on the piston rod, thus securing a perfect rectillinear motion of the rod.
5. A rotary engine.

6. A steam hammer.
7. The Watt parallel motion.
8. The fly ball governor.
9. The mercury steam gauge.
10. The glass water gauge.
11. The steam engine indicator.

Mr. Murdock, Watt's most trusted workman patented the D or slide valve.

The earliest double acting engines of any considerable size which were built to turn a shaft, were the Albion mills engines, which were erected in London in 1786. There were a pair of engines of 50-horse power each. Financially this enterprise was a failure, as the mill was totally destroyed by fire in 1785, Boulton and Watt being the principal losers.

For the remaining years of his life Watt filled his time in studying the details of the steam engine, and in working over his earlier inventions. His health improved as he advanced in years, and the last years of his life were among his best.

James Watt died on the 19th of August, 1819, in his 83d year, and was buried in Handsworth church. The sculptor, Chantry, was engaged to erect a fitting monument above his grave, and the nation erected a statue of the great man in Westminster Abbey. Smiles says: "The visitor to Westminister Abbey will find neither monarch, nor warrior, nor statesman, nor poet honored with a nobler epitaph than that which is inscribed on the pedestal of Chantry's monument to Watt."

NOT TO PERPETUATE A NAME,
WHICH MUST ENDURE WHILE THE PEACEFUL ARTS FLOURISH,
BUT TO SHOW
THAT MANKIND HAVE LEARNT TO HONOR THOSE WHO
BEST DESERVE THEIR GRATITUDE,
THE KING,
HIS MINISTERS, AND MANY OF THE NOBLES AND COMMONERS
OF THE REALM, RAISED THIS MONUMENT TO
JAMES WATT,
WHO, DIRECTING THE FORCE OF AN ORIGINAL GENIUS,
EARLY EXERCISED IN PHILOSOPHIC RESEARCH,
TO THE IMPROVEMENT OF
THE STEAM ENGINE,
ENLARGED THE RESOURCES OF HIS COUNTRY, INCREASED
THE POWER OF MAN,
AND ROSE TO AN EMINENT PLACE
AMONG THE MOST ILLUSTRIOUS FOLLOWERS OF SCIENCE
AND THE REAL BENEFACTORS OF THE WORLD.
BORN AT GREENOCK, 1736.
DIED AT HEATHFIELD, IN STAFFORDSHIRE, 1819.

Among the foremost of Watt's contemporaries was Johnathan Hornblower, who patented the compound engine in 1781; this was followed in 1804 by the Woolf compound. It was found that the engine of Hornblower, using steam at a low tension, was no more economical than the Watt engine and in some cases did even less work with the same amount of coal. Woolf, on the other hand, used higher pressures and obtained a duty of 40,000,000 foot-pounds, as against the 30,000,000 of James Watt. For many years there was much doubt in the minds of many prominent engineers as to the value of compounding and as late even as the early 40's, we find an article in the Scientific American discrediting any advantage which might be gained by the use of the second cylinder.

In 1843 and 1845 Frederick E. Sickles of New York took out several patents on the drop cut-off as devised by him and forming the first drop cut-off applied to the steam engine.

This cut-off was not regulated automatically, but was manipulated by hand by means of a wedge or screw. Although many changes had been made in the details of the steam engine since the time of Watt, they were only details and the system established by Watt remained substantially unchanged until the middle of the past century, when, by a fortunate circumstance, the attention of George H. Corliss was called to the steam engine and its relative inefficiency.

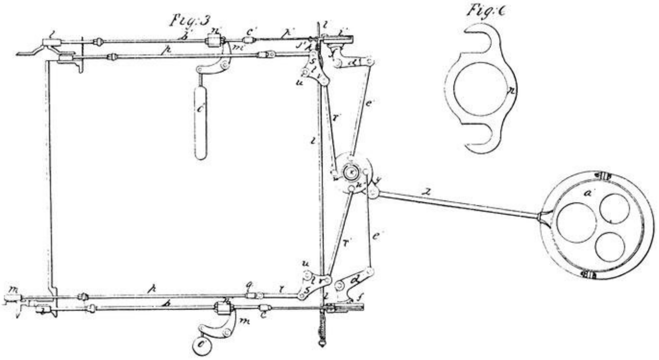


**FIG. 2**—Corliss' First Patent, 1851.

In 1843 Mr. Corliss took out a patent for a sewing machine for stitching leather. This was the first machine ever patented for stitching leather, and was brought out three years before the celebrated Howe sewing machine appeared. In 1844, Mr. Corliss went to Providence, Rhode Island, for the purpose of having his machine manufactured and placed upon the market. He sought out the firm of Fairbanks, Bancroft & Company, a Rhode Island steam engine establishment. The firm was at that time very busy with several large engine contracts and agreed to help him later if he would help them in this present exigency; and it was here, while acting as draughtsman for this firm, that Mr. Corliss' attention was called to the steam engine and its relative inefficiency. Mr. Corliss was not one to serve others in a subordinate capacity, and finally announced that he would quit unless they took him into the firm. As a consequence, the firm of Corliss, Nightingale & Company was formed, and later this firm was succeeded by the Corliss Steam Engine Company, with Mr. Corliss as sole owner.

This chance which diverted Mr. Corliss' attention from the development of the leather stitching machine to the development and improvement of the steam engine resulted in the invention of the successful attachment of the James Watt regulator to a liberating gear, which was patented on March 10, 1849.

This was accomplished in such a manner and with such a construction that the position of the point of cut-off immediately responded to a variation of load, that the pressure in the engine was almost equal to that at the boiler, that the action of the gear was almost instantaneous. This, in connection with a reduction of clearance occasioned by his use of the rotary valve and its position in the cylinder, resulted in an enormous increase in economy and regulation. This accomplished, Mr. Corliss was destined to assume his place in the steam engineering world, second only to the immortal Watt. His improvement produced so great an economy in the consumption of coal in manufacturing establishments that the Corliss engine, in time, superseded all others. In the manufacture of textile fabrics it also enabled a uniform speed to be obtained by its almost human intelligence in regulating its own power to a constantly varying load. For the first time in the history of cotton spinning could the machinery of a mill be run without jerks, and the subsequent breaking of threads throughout the mill, with the attendant vexation and loss.

In 1867, the Corliss engine was exhibited in Europe for the first time, at the Paris exposition, where it received the highest awards. At Vienna, in 1873, Mr. Corliss again received the highest award, in spite of the fact that no machinery, and not even a drawing was exhibited by him. Since then, the awards and honors conferred were numerous, and flattering in the highest degree.

In 1875, Mr. Corliss submitted plans for a single engine of 1400 horse power, to move all the machinery in the Centennial exhibit. At that time an engine of 1400 horse power or a maximum of 2000 horse power was considered enormous.

Mr. A. T. Osborn, Director General of the Exposition, in speaking of the exhibit of Mr. Corliss, says: "It worthily represents the genius and engineering ability of the producer, and the advanced progress of mechanical ingenuity and skill in the United States." The engine was proclaimed by the French commissioner in his report to the French government, as one of the greatest works of art ever produced by the hands of man.

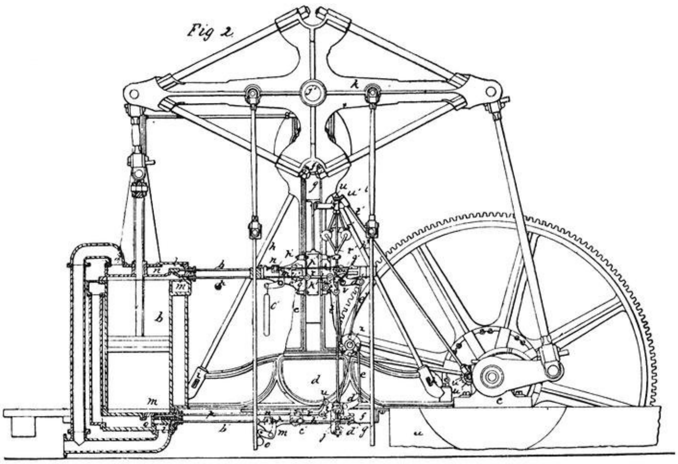


FIG. 3—Corliss' First Engine.

The success of the Corliss engine was not, however, reached in a minute. Like all great innovations, it was at first assailed with derision, and was scornfully designated as the "Come and go fetch" valve motion. Radically different in operation, appearance and theory, it was inevitable that it should not escape condemnation by those less enlightened and professing to be steam engineers.

The story of the development of our modern steam engine would not be complete without a few words on the work accomplished by our fellow citizen, Edwin P. Reynolds.

Just previous to his coming to Milwaukee Mr. Reynolds was general superintendent of the then famous Corliss works.

Entering upon his new duties as superintendent of the Allis works, Mr. Reynolds at once designed his well known and celebrated Reynolds-Corliss valve gear, consisting of the knock-off, claw and bonnet bearing which has since become the standard and universally adopted Corliss gear in America and possibly the world. The introduction of the roller flour mill soon created a demand for a more economical engine than was then used in the west. The Reynolds-Corliss engine met this demand; its success was established; its designer laid the foundation for his own increasing reputation. The Allis company was among the first to build the direct coupled type of engine and electric generator, now the acknowledged standard for economic performance, the world over. In this connection, the latest production is the 8,000 H. P. engine for the Manhattan Elevated Railroad company, New York city. These engines have a maximum capacity of 12,000 H. P., and are the largest engines ever constructed for this class of work.

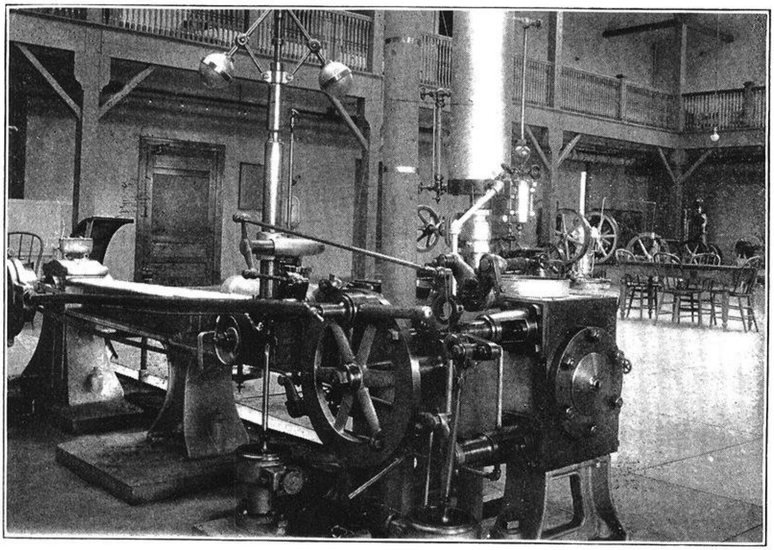
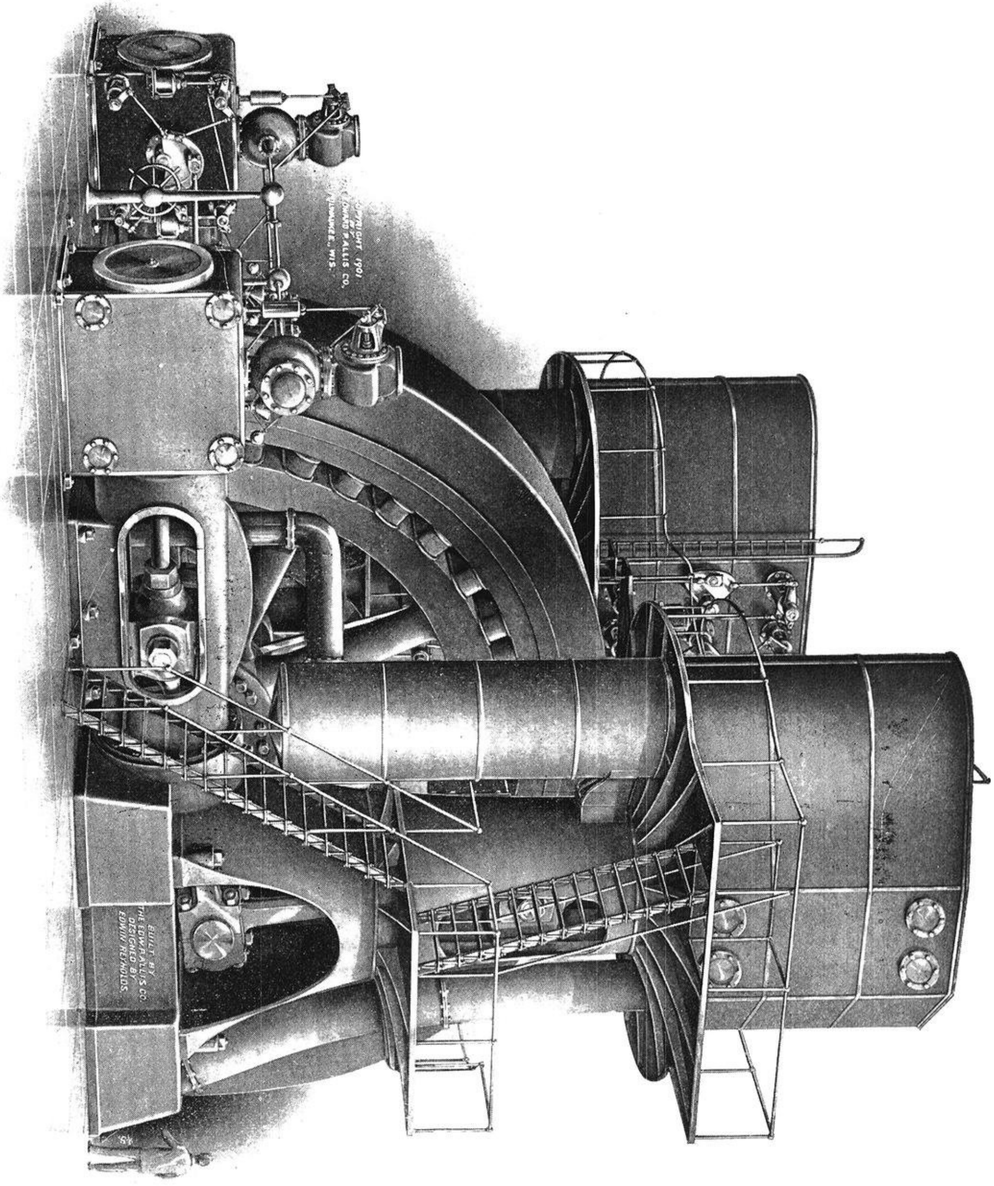


FIG. 4—Corliss Engine with Reynold's Bonnet Bearing.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MILWAUKEE, WIS.
BUILT BY
THE EDW. P. ALLIS CO.
DESIGNED BY
EDWIN REYNOLDS.

Since Mr. Reynolds' connection with the Allis shops, the Allis engines have ever been the recognized standard for efficiency and design throughout the entire civilized world. Occasionally losing their ground for a time as regards efficiency, they invariably regain it with better and surprising results. The Allis engine holds the world's record for economy for saturated steam, as shown by recent tests of the Boston type of pumping engines.

Thomas Newcomen designed and constucted the first type of the modern steam engine. James Watt found it exceeding low in economy and of a construction unable to meet the ever increasing needs of the human race. By means of his matchless genius and ingenuity he produced the modern engine embodying all the essential features of the successful engine of today.

George H. Corliss found the engine of Watt a commercial success but of economy equal perhaps to less than half of that attained at the present day. By a master-stroke he raised the economy by at least fifty per cent., and laid the foundation upon which Edwin Reynolds, by means of his skill in the thermodynamic principles involved, produced the record results of the world.

The introduction and development of the steam engine revolutionize the methods of production.

The spread of civilization, depending upon extended intercourse by means of rapid transit, the application of more forces and the consequent discovery and invention of mechanical appliances, is perhaps due more to this substitute for the brute strength of man and its necessary adjuncts, than to any other one thing.

Machinery was a necessary consequence of the power to propel it; at first, labor loudly protested. That the introduction of the power to move and propel vast numbers of machines would also in a far greater proportion increase the demand for the manufactured articles and ultimately increase the employment of labor, did not for a time dawn upon the mind of the laboring man. What supplied his place in the workshop and the mind arose before him like an evil spirit to deprive him of his power to gain a livelihood. How opposite was the effect. New enterprises sprang up on every side; the cheapening of manufactured articles by the increased facilities for production, increased the consumtion. But labor had to acquire a certain degree of skill, the application of the mind was as necessary as the application of muscle, under the improved methods of production; physical strength and animal persistence were not the only requisites of the laboring man, but intelligence and practical learning became prime movers in the industrial world.

The greatest influence exerted through the invention of mechanical appliances has been upon manufactures, traffic and commerce, means of communication, and finally upon the methods of warfare. The discovery of a new motive power was of the first importance; the wind-mill and the ancient water wheel are displaced by engines of mighty power. The discovery of this motive power was followed by the invention of numberless machines. Every branch of manufacturing was invaded; new industries were established; and all received renewed life and activity.

But without a corresponding increase in the means of transportation, all these improved methods of production would be of no avail. Time was when only a limited area of agricultural land could profitably be tilled, when the base and precious metals remained in their subterranean chambers, when vast unbroken forests cast their shadows upon a virgin soil, and a great portion of our mighty domain was the home of the savage and of wild beasts.

The advent of the railroad and steamboat revolutionized commerce and vastly increased manufactures and agriculture. The exchange of products with the overcrowded nations of the old world became a possibility, an established fact, and has created an intimacy between nations that were as strangers to one another before, made all mankind brothers. The progress made in methods of transportation and traffic are wonderful; considerably less than a century ago there was not a mile of railroad in existence; to-day there are several hundred thousands miles of track in this country alone, extending to every corner of our land, connecting ocean with ocean, traversing seemingly impassible mountain ranges and opening up to improvement the remote portions of our country. Further, this ever growing institution opens up one of the greatest avenues of employment for labor; many hundred thousand men are employed directly in the service of the railroad companies to-day; and the division of labor from the highest executive ability, from the army of clerks and the superior craft of engineers and mechanics to the common working-man upon the line of construction, is, perhaps, more marked than in any one single enterprise employing the labor of men. The extremes of mental and physical capabilities meet.

The increase of the facilities for carrying the mail is another era inaugurated by the introduction of steam. The introduction of the telegraph, flying before the locomotive with its marvelous speed, a herald of its approach, of danger, of obstruction, enables the rapid motion of that other great product of the human brain; they move hand in hand, one is a necessary accompaniment of the other, and together they have been the means of establishing our great system of trade and our immense commercial intercourse and business relations.

Warfare has become a science; discovery and invention have made it so. From the war ships of wood have been developed the first iron clads of the Monitor and Merrimac type and the magnificent steel cruisers of our modern navies. The steam engine has been an important factor in this wonderful development.

Should the ratio of increase in these improved methods of destruction continue as in the past, war between the great nations of the earth will become an impossibility, and peace will exert her gentle sway on earth.

The field of invention is practically unlimited; what has been accomplished to the present day was never dreamed of by past generations; what will be accomplished in the future is beyond the imagination of living man to conceive.

# SUGGESTIONS FOR A UNIFORM PRACTICE IN FIXING THE LENGTHS OF SPIRAL CURVES.

W. D. TAYLOR.

Though much has been said of late years on the subject of spiral curves the writer thinks that possibly the subject will bear some further treatment.

Another engineer has recently called the attention of the writer to the suggestion that on every railroad the four quantities, viz.: (1) The degree of curve, (2) The amount of superelevation, (3) The speed of prevailing fast trains, and (4) The length of the easement curve, might be with some economy connected by some uniform rule.

The folly of adhering strictly to uniform rule for the superelevation of all curves, such as 1 inch per degree of curve—whereby a 6 degree curve at the top of a grade near a station where all trains run slowly, is given the same superelevation as the same degree curve at the foot of two long grades where the trains pass at high velocity—has often been pointed out. So that now on roads where good engineering practice prevails, we will find the rate of superelevation different, as it should be, in the case of two such curves.

But since the use of spiral or easement curves is a matter of comparatively recent practice, and is even now far from being general, the principle of making an economical adjustment of the length of spiral used to the degree of curve, the amount of superelevation, and the velocity used, has possibly not been quite so well expounded. But on many, if not most roads, the rule fixed upon by which to spiral the curves on old track would make the length of spiral, or rate of transition, the same for the 6 degree curve at the top of the grade as for the one at the foot of the grade. The originator of the true spiral curve himself (See E. Holbrook, in *Engineering News*, June 13, 1901), says: "Twenty years' experience has demonstrated that a single rate of transition should be used on new work, and it is very rare that more than two are required on old work. If we use two rates, viz.: one degree in 30 feet, and one degree in 60 feet, we can relocate curves up to six degrees without getting the stakes outside the rails."

On the Tampico Branch of the Mexican Central 20 years ago, under the instructions for locating engineers, the same rate of spiraling was required for all curves. The chain was 25 meters, and the rate of transition was 1 degree in 12.5 meters, so that in spiraling a 4 degree curve the spiral was 37.5 meters, or 123 feet long, and the curve was offsetted from the tangents about a foot; while the spiral for a 12 degree curve, and there were many such, was 137.5 meters, or 452 feet long, and the curve was offsetted some 24 feet from the tangents. While it is not claimed that anyone in spiraling curves on old track would go to such an extreme as this, the example shows that Mr. Holbrook's rule is rather broad.

In figuring the cost of spiraling curves on old track the attention of engineer writers seems to be directed for the most part to the cost of the engineering work of staking out the curves, rather than to the amount of track shifting, regrading, and reballasting, necessary to get in the spirals. This last is the really costly part of the work, and it will be found in every case that the total cost of spiraling a curve varies almost in exact ratio with the amount of track shifting necessary to put in the spirals. To properly and economically adjust the two curves mentioned above to the needs of the traffic, it is certainly necessary to use a higher rate of transition or shorter chord lengths on the curve at the top of the grade.

Since the cost of spiraling a curve varies nearly with the amount of shift in the track, and the amount of shift varies as the square of the chord length of spiral used it is plain that, pre-supposing equal central angles, if a 30 foot spiral will make the same satisfactory adjustment to the traffic of the curve at the top of the grade, as a 60 foot spiral of the curve at the foot of the grade, we can spiral the former at about 25 per cent of the cost of spiraling the latter.

So far as the writer knows no engineer has attempted what might be called a scientific adjustment of the four quantities mentioned above. Mr. C. A. Morse, M. Am. Soc. C. E., Asst. to the Chief Engineer of the A. T. & S. Fe. Rwy., who first brought this subject to the writer's attention, has calculated spiral tables for use on his road for velocities between 30 and 60 miles per hour inclusive. Several writers seem to have such an adjustment in mind, as: C. A. Sundstrom in Transactions of Am. Soc. C. E., Vol. 46, Page 385, Prof. J. C. Nagle in his Manual for Railroad Engineers, Prof. Talbot, in his "Railway Transition Spiral," and F. K. Vial in *Engineering News*, Sept. 20th., 1900. It this article Mr. Vial says, "The rules to determine the length of spiral are often very crude",and then proceeds to show that the rate of transition should vary inversely as the cube of the velocity.

In the report of W. M. Camp, to the American Engineering and Maintenance of Way Association in March, 1901, on Curve Elevation, he cites replies from 58 practical Maintenance of Way men in answer to the question: "At what limit of curvature do you think speed of 60 miles an hour should not be exceeded?" The weight of the opinions given favors a limit of curvature for this speed slightly in excess of 4 degrees, and 21 of the 58 replies specifically name 4 degrees as this limit.

As to the maximum superelevation allowable, 41 replies give the weight of opinion in favor of 6¼ inches.

The same report shows that the most usual rate of running out superelevation is 1 inch in 60 feet.

The velocity in miles per hour at which the centrifugal force is just (approximately) balanced by an elevation of 6¼ inches on curves of different degrees is given in the second column of table 1 below. But the consensus of opinion agrees that 60 miles an hour is a safe velocity on a four degree curve. And the centrifugal force on a 4 degree curve at 60 miles an hour is 58 per cent. more than at 48 miles an hour, which latter is the velocity at which the centrifugal force is just balanced by the centripetal force of 6¼ inches of superelevation on a 4 degree curve.

At 60 miles an hour on a four degree curve with 6¼ inches of superelevation there is an amount of the centrifugal force unbalanced by the superelevation of the curve equal to 62 per cent. of the weight of the car body. If it is safe then to run 60 miles an hour on a 4 degree curve with 6¼ inches of superelevation it is equally as safe, at least so far as the centrifugal force is concerned, to run 120 miles an hour, instead of 95.5, on a one degree, or to run 35 miles an hour instead of 27.5 on a 12 degree curve, both curves having 6¼ inches superelevation. For the centrifugal force in each case mentioned is roughly 6.2 per cent. of the weight in excess of that balanced by the superelevation. The third column of table 1 gives, estimated on this basis, the safe velocities on curves of various degrees elevated 6¼ inches.

If a grade of 1 inch in 60 feet be found satisfactory for the outer rail to run up from a level to 6¼ inches of superelevation for the speed of 60 miles an hour on a 4 degree curve, the length of spiral for this velocity and curve would be 375 feet, or, in the usual nomenclature, a 94 foot spiral would be required. A train at 60 miles an hour would run over the length of this spiral in 4¼ seconds. And if it is found that the "curve shock" to passengers and rolling shock is removed by giving the train or car body 4¼, seconds at this velocity and on this curve, to climb the superelevation grade and adjust itself to the curve elevation the writer suggests that the most economical lengths of other spirals to be used on other curves with different velocities can best be determined by the proportional amount of *time* it takes the car body to run up the superelevation grade. For the sole object of a spiral is to ease off the *suddenness* of the changes in direction.

The fourth column in table I. gives for various degrees of curve and the various estimated safe maximum velocities on those curves, the total length of spiral, or what is the same thing, the length of grade to run up to 6¼ inches of superelevation, calculated from the requirement that the car body shall have, at the maximum allowable velocity on the curve, 4¼ seconds to pass over the spiral. And the last column gives the resulting —"foot spiral."

Tables II. and III. give the same quantities when the superelevation is 4 and 2 inches respectively, the estimated safe maximum velocity in each case being that at which the centrifugal force is 6.2 per cent. of the weight of the car body in excess of the amount balanced by the superelevation. The length of spiral is determined from the amount of *time* it takes the car at the maximum allowable velocity to run up the superelevation grade height of 4 inches and 2 inches respectively. The connection between the tables being that the ratio of the time of a car body, on the spiral, at the maximum velocity to the amount of the superelevation is constant. That is:

$$\frac{4.25}{6.25}=\frac{2.72}{4}=\frac{1.36}{2}$$

The tables are only approximately accurate, being calculated throughout with slide rule.

It is very much doubted if the limits of the estimated maximum velocities proposed will be very generally agreed to, and also as to whether or not a grade of 1 inch in 60 feet is the best that can be found for the ascent of the outer rail in the case on which the whole connection in these tables hinges; but it is suggested that if one such grade is satisfactorily established for a given traffic that the most economical lengths of other spirals on other curves with other velocities and superelovation can best be figured by some such process as is here outlined.

The writer does not believe in the theory held by many intelligent track men, and upheld by Mr. J. I. Boggs, Assoc. M. Am. Soc. C. E. Transactions, Vol. 46, P. 396, that the superelevation of curves "presents at times anomilies, refusing to be bound by printed rules or mathematical equations," nor that individual curves possess "idiosyncrasies" other than those growing out of natural laws fairly well known.

But there must be a uniform economic principle connecting the degree of curve, the allowable superelevation, the maximum allowable velocity, and the length of spiral, for a given traffic, which when properly worked out will in all cases remove the "curve shock."

The writer very well understands that in making this suggestion he is flying in the face of most of the practice, if not the theory, in regard to spiral curves. Engineers, in the light of present practice, will need to look askance at an economic theory that suggests that for the purpose for which a spiral is used one of shorter length is required for a 12 degree than for a 4 degree curve.

However it cannot be denied that this suggestion is in accord with the fact that the necessity for spiraled curves decreases very rapidly with the velocity. And this is true to such an extent that very many roads having curvature, so sharp as to form a considerable check on train velocity, have not found it necessary to use them.

# TABLES CONNECTING THE DEGREE OF CURVE, AMOUNT OF SUPERELEVATION, THE MAXIMUM VELOCITY AND LENGTHS OF SPIRAL.

## TABLE I.

Superelevation 6¼ inches. Time to run over Spiral at maximum allowable velocity 4.25 seconds.

| Degree of Curve. | Miles per Hour. | | Total lengths of spiral feet. | Feet per degree increase of spiral. |
|---|---|---|---|---|
| | Velocity balanced by 6¼ in. elevation | Estimated maximum safe velocity. | | |
| 1–00 | 95.5 | 120 | 750 | 750 |
| 1–30 | 78. | 98 | 612 | 407 |
| 2–00 | 67.5 | 85 | 532 | 266 |
| 2–30 | 60.5 | 76 | 475 | 190 |
| 3–00 | 55.0 | 70 | 438 | 146 |
| 3–30 | 51.0 | 64.5 | 403 | 122 |
| 4–00 | 48.0 | 60 | 375 | 94 |
| 4–30 | 45.0 | 57 | 356 | 79 |
| 5–00 | 42.5 | 54 | 338 | 67.5 |
| 5–30 | 41.0 | 51.5 | 322 | 58.5 |
| 6–00 | 39.0 | 49 | 306 | 51 |
| 6–30 | 37.5 | 47 | 294 | 45 |
| 7–00 | 36.0 | 45.5 | 284 | 40.5 |
| 7–30 | 35.0 | 44.0 | 275 | 36.75 |
| 8–00 | 34.0 | 42.5 | 268 | 33.5 |
| 8–30 | 33.0 | 41.5 | 259 | 30.5 |
| 9–00 | 32.0 | 40.0 | 250 | 28 |
| 9–30 | 31.0 | 39.0 | 244 | 25.75 |
| 10–00 | 30.0 | 38.0 | 238 | 23.75 |
| 10–30 | 29.5 | 37.0 | 231 | 22 |
| 11–00 | 29.0 | 36.5 | 228 | 20.75 |
| 11–30 | 28.0 | 35.5 | 222 | 19.5 |
| 12–00 | 27.5 | 35.0 | 219 | 18.25 |

# TABLES CONNECTING THE DEGREE OF CURVE, AMOUNT OF SUPERELEVATION, THE MAXIMUM VELOCITY AND LENGTHS OF SPIRAL.

## TABLE II.

Superelevation 4 in. Time to run over Spiral and Maximum allowable velocity 2.72 seconds.

| Degree of Curve. | Miles per Hour. | | Total lengths of spiral feet. | Feet per degree increase of spiral. |
|---|---|---|---|---|
| | Velocity balanced by 4 in. elevation. | Estimated maximum safe velocity. | | |
| 1-00 | 76.4 | 105.5 | 424 | 424 |
| 1-30 | 62.4 | 86.0 | 344 | 230 |
| 2-00 | 54.0 | 74.5 | 298 | 149 |
| 2-30 | 48.2 | 67.0 | 268 | 107 |
| 3-00 | 44.0 | 51.0 | 244 | 81.5 |
| 3-30 | 40.8 | 56.4 | 226 | 65.0 |
| 4-00 | 38.2 | 52.7 | 211 | 53.0 |
| 4-30 | 36.0 | 49.8 | 199 | 44.0 |
| 5-00 | 34.0 | 47.1 | 188 | 37.5 |
| 5-30 | 32.5 | 45.0 | 180 | 33.0 |
| 6-00 | 31.1 | 43.1 | 172 | 28.5 |
| 6-30 | 29.9 | 41.4 | 166 | 25.5 |
| 7-00 | 28.9 | 40.0 | 160 | 23.0 |
| 7-30 | 27.9 | 38.5 | 154 | 20.5 |
| 8-00 | 27.0 | 37.3 | 149 | 18.5 |
| 8-00 | 26.2 | 36.2 | 145 | 17.0 |
| 9-00 | 25.5 | 35.2 | 141 | 15.5 |
| 9-30 | 24.8 | 34.3 | 137 | 14.5 |
| 10-00 | 24.2 | 33.4 | 134 | 13.5 |
| 10-30 | 23.6 | 32.6 | 130 | 12.5 |
| 11-00 | 23.0 | 31.8 | 127 | 11.5 |
| 11-30 | 22.5 | 31.0 | 124 | 11.0 |
| 12-00 | 22.0 | 30.4 | 122 | 10.0 |

# TABLES CONNECTING THE DEGREE OF CURVE, AMOUNT OF SUPERELEVATION, THE MAXIMUM VELOCITY AND LENGTHS OF SPIRAL.

## TABLE III.

Superelevation 2 in. Time to run over Spiral at Maximum allowable velocity 1.36 seconds.

| Degree of Curve. | MILES PER HOUR | | Total lengths of spiral feet. | Feet per degree increase of spiral. |
|---|---|---|---|---|
| | Velocity balanced by 2 in. elevation. | Estimated maximum safe velocity. | | |
| 1–00 | 54.0 | 90.7 | 181 | 181 |
| 1–30 | 44.0 | 74.0 | 148 | 99 |
| 2–00 | 38.2 | 64.0 | 128 | 64 |
| 2–30 | 34.2 | 57.4 | 115 | 46 |
| 3–00 | 31.3 | 52.5 | 105 | 35 |
| 3–30 | 28.9 | 48.5 | 97 | 28 |
| 4–00 | 27.0 | 45.3 | 91 | 23 |
| 4–30 | 25.5 | 42.8 | 86 | 19 |
| 5–00 | 24.1 | 40.5 | 81 | 16 |
| 5–30 | 23.1 | 38.6 | 77 | 14.5 |
| 6–00 | 22.0 | 37.0 | 74 | 12.5 |
| 6–30 | 21.2 | 35.4 | 71 | 11.0 |
| 7–00 | 20.4 | 34.2 | 68 | 9.9 |
| 7–30 | 19.7 | 33.1 | 66 | 8.8 |
| 8–00 | 19.1 | 32.1 | 64 | 8.0 |
| 8–30 | 18.5 | 31.1 | 62 | 7.3 |
| 9–00 | 18.0 | 30.2 | 60 | 6.7 |
| 9–30 | 17.5 | 29.4 | 59 | 6.2 |
| 10–00 | 17.1 | 28.7 | 57 | 5.7 |
| 10–30 | 16.7 | 28.0 | 56 | 5.3 |
| 11–00 | 16.3 | 27.4 | 56 | 5.1 |
| 11–30 | 16.0 | 26.8 | 54 | 4.7 |
| 12–00 | 15.7 | 26.2 | 52 | 4.3 |

# EFFECT OF FREQUENCY ON THE LIGHT OF AN INCANDESCENT LAMP.

[An Extract of a Thesis.]

BY H. SEAMAN, '00.

The effect of frequency in alternating current circuits on the steadiness of light emitted from incandescent lamps has not as yet been thoroughly investigated.

Many different frequencies are at present in use all over the world, varying from 20 to 133 cycles per second. Efforts have been made at times to standardize frequencies, but apparently with little if any results.

With the introduction of long distance transmission lines, the matter of frequency is a question whose importance is daily becoming more apparent. Power furnished by these lines is used for a variety of purposes, such as rotary converters for electric railways, lighting, heating, motors, etc. Different frequencies are preferable for these different uses to which the power is put and it is desirable to use that frequency which will be most satisfactory for the majority of power transmitted.

It is an important matter to ascertain the limits of frequency that will give good service on these different circuits.

In this thesis one branch of this subject—namely, that of incandescent lighting—has been investigated.

The object is to ascertain what the variation in light from a 110 volt incandescent filament is, for various frequencies, and to derive curves showing, to a certain extent, what is the lower limit of frequency for good incandescent lighting. The ingenious method used, together with the curves and data, is soon to be published as a bulletin.

Various schemes are found for determining the effect of frequency on arc lamps, but the methods used in these are to a large degree original, for experiments of this character. In this method a slotted disc is made to rotate in such a manner that the rays of light from the lamp under test are intercepted at different points on the current or light wave. The intensities of light are noticed for these various points, and a curve is plotted corresponding to each of the different frequencies used in the tests.

Points were obtained from 0 to 360 electrical degrees, and curves plotted, showing the amount and rate of variations for different frequencies. Some ideas may be obtained from these curves, as regards the limit for good service in incandescent lighting.

As the photometer used was not a direct measuring instrument it was necessary to standardize it for each reading and this was done by means of a direct current of the same voltage as the alternating current which was passed through the lamp, and the disc rotated at the chosen speed of the the experiment, the intensity of light being recorded by a photometer.

Some form of photometer was desired that would record the intensity of light accurately and quickly. The usual form was neither sensitive nor quick enough, and of the light cells, the selenium cell only was made sensitive enough to measure the variations of the light of the lamp, and was consequently used as the photometor. (A full description of this cell is given in the bulletin.) In using this cell as a photometer, use is made of the perculiar property which it has of offering different resistence to an electric current when in the light than it has when in the dark. As temperature effected the resistance, it was calibrated for different temperatures. The amounts of light emitted at different points in the curve were compared by means of the different resistances offered by the selenium cell to the passage of an electric current, when the cell was placed in these lights.

Frequencies of 17½, 20, 22½, 25, 27½, 30, 35, 40, 55 and 60 were used.

The experiments show exactly what the effect of frequency in an incandescent lamp is. The temperature of the filament varies periodically, the range and number of these variations depending upon the frequency. It was found that the maximum change in resistance to these variations was 1760 ohm., which corresponds to a change of 5.5 volts. This occurred at a frequency of 17½. At 80 frequency, the change was only 2 volts. The fact that light come to a maximum and minimum twice in 360 electrical degrees, or twice that of the alternating current, was demonstrated very clearly.

The following facts were demonstrated:

I. The radiation from an incandescent lamp varies with the variation of the alternating electric current; and this variation is shown by means of a silenium cell for the curves' freqencies, but becomes materially less noticeable when the frequency is raised.

II. Since the photographic plate is more particularly affected by the radiation of waves of shorter wave length than those affecting the eye as light, and as this is also probably true of the silenium cell, the facts demonstrated perhaps apply more specifically to the radiation of waves of shorter wave length which belong to the upper spectrum.

III. As the current intensity increases, the proportion, which the waves of short wave lengths bear to the total, increases; therefore the diminution of the range of variation in the intensity of radiation will be more marked in case of the visible spectrum.

IV. It is reasonable to conclude from the results of the experiments that the *light* (that is the physiological effect of the radiation) from an incandescent lamp operated on a current frequency of 60 cycles per second, will be very nearly, if not quite, uniform, but at a frequency as low as 25, the light emitted from an incandescent lamp certainly cannot be considered other than as varying between comparatively wide limits and with a frequency equal to double that of the alternating current.

The form of the pressure wave affects the amount of light. Peaked waves cause a maximum variation, and flat topped waves a minimum, consequently the sinusoidal wave, used in this thesis, would give nearly average results. The higher the temperature of the filament and the smaller its diameter, the greater will be the change in the amount of light, for a certain change ofenergy.

## THE N. O. WHITNEY ENGINEERING ASSOCIATION.

The following are the programs given at the meetings of the Association.

April 4.

Inauguration of officers.

Presidents' Address.

Periodical Review—F. H. Murphy.

Discussion—"Merchant Marine and Subsidy," led by E. G. Hoefer, R. E. Haganah and P. W. Morrissey.

Critic—H. S. Cole.

April 11.

Critic—William Bradford.

Periodical Review—E. W. Galloway.

Paper—"High Speed Railway", A. F. Krippner.

April 18.

Critic—F. A. Naramore.

Review of Periodicals—M. G. Hall.

Paper—H. A. Schwendener, "Electric Switches".

Paper—G. G. Post.

Discussion—"Irrigation of the Arid Regions of the West," led by R. L. Hankinson and Paul Zinke.

April 25.

Critic—W. R. Heidemann.

Periodical Review—L. G. Rosenstock.

Talk by Mr. O. B. Zimmerman on his observations of Armour Institute of Chicago.

Periodical Review—Sydney Olson.

Paper—"Reclaiming Lands under the Zuyder Zee," L. B. Moorehouse.

Paper—"Steam Turbines", C. H. Hoefer.

Discussion—"Should all cities of 10,000 population and over have surveys made and all property lines be designated by monuments," led by E. A. Bilsley, D. P. Falconer, and E. A. Mority.

May 2.

Critic—A. F. Krippner.

Paper—"The Mississippi River", F. B. Jenkins.

Paper—"Some Thoughts on Aerial Navigation", Wm. Ungrodt.

Discussion—"Beet Sugar Industry"—Led by E. A. Goetz, M. W. King, C. L. Eustis and F. V. Larkin.

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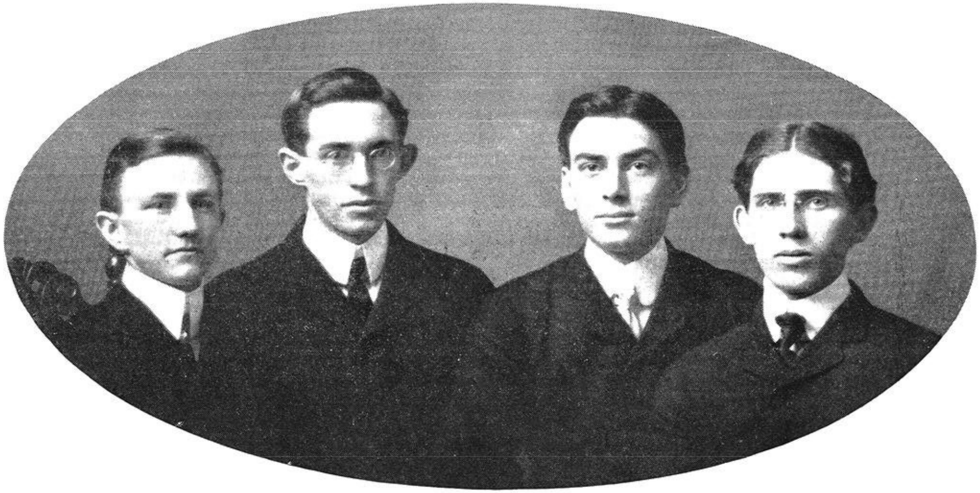
The joint debate which was scheduled for this spring had to be postponed until next fall, due to complications which arose in regard to the question chosen. The following question has been picked by the N. O. Whitney Ass'n team, and the U. W. Engineer's Club team will choose their side.

"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 to make agreements as prescribed by the premium system and thereby control and eventually abolish piece work in any form."

We present herewith pictures of the two teams who will represent their respective societies next fall. The exact date for the debate has not yet been settled, but it will probably be shortly before the Christmas vacation.

N. O. WHITNEY JOINT DEBATE TEAM



E. A. GOETZ W. A. ROWE F. V. LARKIN W. BRADFORD

U. W. ENGINEERS' CLUB—JOINT DEBATE TEAM

E. A. Ekern G. W. Garvens F. W. Huels

## THE U. W. ENGINEERS' CLUB.

Below is given a list of the programs given at the meetings of the U. W. Engineers' Club.

April 4.

At this meeting the inauguration of the following officers took place.

President—J. G. Hammerschlag.

Vice-President—W. R. Mott.

Secretary and Treasurer—G. C. Dean.

Censor—F. C. Stieler.

Assistant Censor—W. E. Crandall.

Music—H. E. Bailey and L. H. Lathrop.

Debate—"*Resolved*, That voting be made compulsory for those allowed to vote under the present laws."

Affirmative, L. H. Lathrop, E. A. Olin, W. E. Brown. Negative, J. G. Zimmermann, L. F. Schoelkopf, G. C. Dean.

Paper—J. G. Hammerschlag.

Paper—Aluminum, J. A. Walker.

April 11.

President's Address—J. G. Hammerschlag.

Current Events—P. G. West.

Paper—"Transformation of the Manhattan Railway from Steam to Electricity," F. C. Stieler.

Paper—"Conductivity of Metals and their Alloys," J. G. Zimmermann.

Paper—Proper Methods of Firing," D. Mac Arthur.

Paper—"Drop Forgings," L. W. Cheney.

Paper—"Combination Motor and Rudder," H. H. Hunner.

April 18.

Mr. S. J. Lisberger announced that he was on the market for an engine which was to drive a generator. Certain specifications were read which the engine was required to satisfy. Three engine companies entered the competition. Each representative of the company set forth the advantages of his machine, being allowed five minutes to show the superiority of the engine he wished to sell.

C. I. Zimmermann, represented the Ball engine, J. C. Potter for McIntosh & Seymour, and W. H. Inbush for the E. P. Allis engine!

A general vote of the club gave the Allis engine a majority of thirteen, but Mr. Lisberger and his adviser decided in favor of Mr. Potter.

Paper—P. S. Biegler.

Review of Periodicals—B. F. Auger.

Paper—F. J. Petura.

April 25.

Music—H. E. Bailey and B. F. Lathrop.

Paper—"Mining of Lead and Zinc Ores in Southwestern Wisconsin," V. McMullen.

Discussion—"Under Present Conditions should the University Install an Electric Lighting Plant for Lighting Buildings?"

Discussed by F. J. Petura, J. N. Cadby, H. B. Kirkland, H. S. Inbush, and R. R. Henry.

Paper—R. Jones.

Review of Periodicals—R. R. Caskey.

May 2. No meeting on account of Minnesota-Wisconsin debate.

May 9.

This was the last regular meeting of the club for the present school year. The program committee decided that the last meeting should be a banner one, and so called upon Prof. V. Lenher to give a paper. Prof. Lenher gave a very interesting and instructive talk on "The Manufacture of Baking Powders."

The balanee of the program was:

Paper—"The Paul System of Steam Heating," A. J. Quigley.

Paper—"A Central Stajion," S. J. Lisberger.

Review of Periodicals—A. W. Helmholtz.

The regular election of officers took place at this meeting.

The following were elected:

President—S. J. Lisberger.

Vice-President—J. N. Cadby.

Secretary and Treasurer—F. J. Petura.

Censor—V. McMullen.

May 16—Banquet at Guild Hall.

The Fourth Annual Banquet of the U. W. Engineers' Club was held at Guild Hall on the evening of May 16.

Mr. Kelley, as toastmaster, was the speaker of the evening.

The toasts were as follows:

Welcome—Pres. Hammerschlag.
The University—Dean Johnson.
The Freshman Class—Harry Kirkland.
Multiple Jacks—Prof. Jackson.
The Sophomore Class—V. McMullen.
Lost Heads—Prof. Bull.
The Junior Class—E. Ekern.
Dam-Constructions—Prof. Turneaure.
The Senior Class—F. C. Stieler.
The Ladies—F. W. Huels.
The U. W. Engineers' Club—Prof. Mack.
The Future—W. Thorkelson.

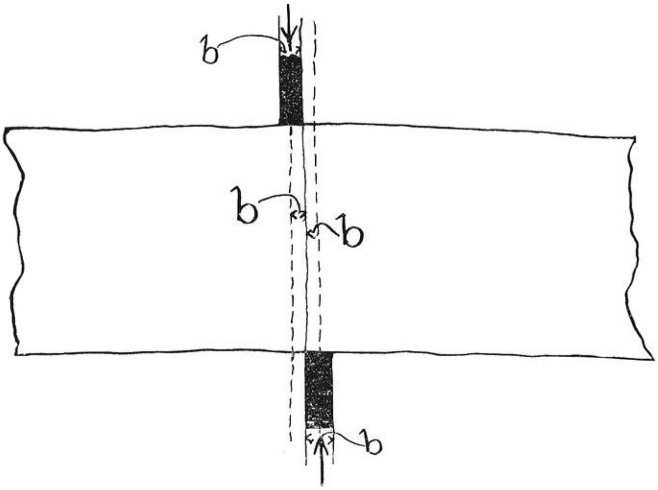
The banquet was a fitting close to a most properous year.

## NOTES.

We are indebted to Mr. O. B. Rosstead, Engr. '04, for the excellent view of the campus, which appears in this issue as a frontispiece. Mr. Rosstead expects to place on sale at an early date the originals from which our copy was made. We were forced to reduce the picture in order to accommodate it to our pages, but the pictures which he will place on sale will be full size, about 5 x 13.

We have reprinted the alumni directory again in this number, and it is now, to the best of our knowledge, correct or very nearly so. It is to be hoped however, that if any of our alumni have accepted other positions recently, or intend to do so, that they will let one of the professors or some member of the board know of it. One of our prominent alumni recently said that he often had or knew of excellent positions which he could have offered to our graduates, if he had only known where to find them. So it is in the interest of both alumni and undergraduates to keep the directory strictly up to date.

A new Ingersoll air compresser, to be used for experimental purposes has been installed in the steam laboratory. The compressor was made by the Ingersoll-Sergeant Drill Co., of New York.



TWO BE OR NOT TO BE

A 100 K. W. generator has been ordered for the electrical laboratory, to supply power for experimental work. The machine will be a compound wound 120 volt D. C. machine, built by the Bullock Elec. Co., of Cincinnati, and will be belted to the 150 H. P. Ide engine recently installed. The machine will be of great value to the electrochemical department for electric furnace work, as it will be capable of furnishing 1,000 amperes to the furnaces, and so make possible a systematic study of the curious reactions which take place in the intense heat of the electric arc. This is undoubtedly a very promising field for research work, as very few laboratories are provided with proper facilities for the work, and hence little has been done along this line.

An automatic telephone system has been installed in the Engineering Building, with connections to all the offices. When the machine shop is connected, their will be eighteen phones in all.

The last engineering social of the college year was held at the engineering building Saturday April 19th. This being the last social, it was made public, and a large number of students in other departments of the University availed themselves of the opportunity of seeing the building and its laboratory with the machines in operation. The program was similar to those preceeding, consisting of solos, the singing of college songs, etc.

Wisconsin Alpha chapter of Tau Beta Pi, is not an organization existing merely in a name. Active interest is taken in all its meetings and affairs. A dance was held April 25th at Kehls, which was pronounced a complete success by all. Twenty five couples took part. A picnic and dance across Lake Monona is planned for in the latter part of May. The fourth annual banquet was held April 30th, at Keeley's. Stories and jokes, together with the fine menu made the occasion a memorable one.

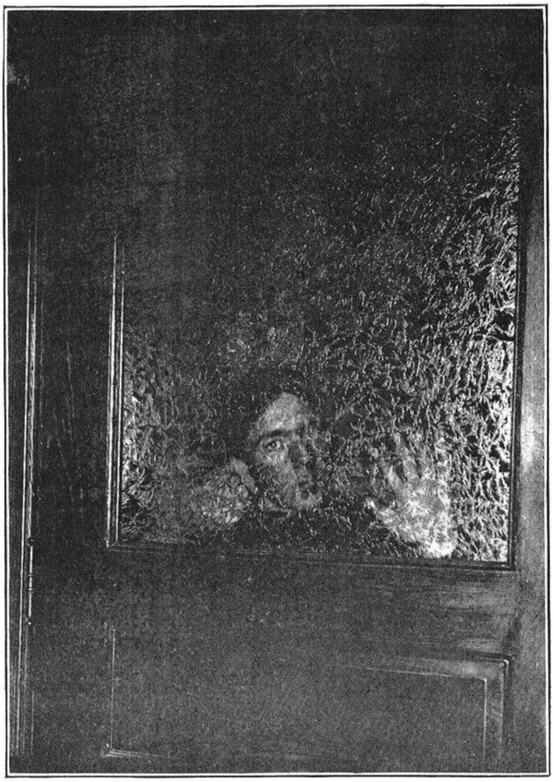
The toasts, with Prof. Jackson acting as toastmaster, were as follows.

"Our Chapter"—Milan R. Bump.
"Our New Goat"—Carl Hambuechen.
"Our Infants"—W. O. Hotchkiss.
"Stress and Strains"—Prof. E. R. Maurer.
"The Young Engineer"—Prof. C. F. Burgess.
"The Engineer Abroad"—Prof. Storm Bull.
"Our University"—Dean J. B. Johnson.

Covers were laid for 33 persons among whom were F. J. Vea, '01, and H. H. Wood, '01, of Stoughton.

On Wednesday May 7, at the fraternity rooms on State St., Prof. Clements of the Geology department gave a very interesting and instructive talk on "Coal."

The national organization of Tau Beta Pi has recently been strengthened by new chapters at Columbia and at Kentucky. Hylon T. Plumb, '01 and Nathaniel Hurd represented the local chapter at the Columbia installation. Steps are now being taken at Missouri University for the organization of a chapter by Prof. W. A. Alexander, '98.



Caught in the Act, or Seeing Yourself as Others See You

# PERSONALS.

M. C. Beebe, E. E. '97 who has been working with Mr. Wertz, upon the development of the Nerust Lamp, since his graduation, is now lecturing upon the lamp and its development. Mr. Wertz, himself, has been giving these lectures, but has turned the work over to Mr. Beebe.

Fred. J. Newman, '98, who has been with the Westinghouse M'f'g Co., is now located in the Lewis B'l'd'g, Pittsburg, Pa., as consulting engineer and automobile expert.

Prof. Taylor was granted a leave of absence, and went to Tennessee, where he will remain a couple of months as chief engineer in charge of the construction of a branch of the Louisville and Tennessee Railroad. The following students have left and will work under Mr. Taylor there; J. T. Schroeder, '02, Louis Stockman, '02, C. T. Watson, '03, G. W. Garvens, '03, O. H. Frick, '03, M. W. Torkelsion, '03.

Edward E. Terrell is at present engaged in locating bridge piers for the Marrietta Bridge Co., at Marrietta, Ohio.

Chester H. Stevens, C. E., '02 left on April 20 for Chicago, where he has accepted a position with the Chicago and Alton Ry. At the present time the company is extensivly engaged in track elevation in Chicago.

Herbert Whitemore, M. E.,'02 has resigned his position with the steam pipe covering works at Milwaukee, and is now with the Sullivan Machine Co., with headquarters at Claremont, New Hampshire. Clarence Taylor who is with the same company is now at work reconstructing the motor power and lighting of the companies' shops.

Three prominent engineers of the E. P. Allis company spent May 5, visiting the engineering school.

Guy Diehl, C. E., '02, has accepted a position with a branch of the U. S. steel corporation, at Hibbing, Minn.

W. J. Parson, '00 is resident engineer in the erecting department of the American Bridge Co., at Pittsburg.

Professor Clifford of the Massachusetts Institute of Technology, spent a week at Madison, as a guest of Prof. Jackson. He has been on a tour of inspection of the large engineering schools in anticipation of the establishment of a model course in electrical engineering at the "Tech." He pronounced our electrical laboratories the best equipt of any that he had seen.

Stephen Gardner, '02 has accepted a position with the Chicago Edison Co.

Gustav Ehreke and Roy Earle will enter the testing department of the General Electric Co. at Schenectady.

A. C. Grieves, '02 is assistant city engineer at Madison.

P. J. Kelley will go with the J. G. White Co., (Limited) of New York.

A. H. Hargrave, who has been employed as an engineer in the machine shop, for the last few years has resigned his position.

Mr. Victor Bergenthal, E. E., '97, is western salesman for the Stanley Electric Co., with headquarters in the Monadnock building, Chicago.

Sherman Moore, '02, and Clarence Sunderland, '02, are at work for the U. S. Lake survey at Sue St. Marie.

At a recent meeting of the board of regents, Ass't Professor A. W. Richter was appointed professor of experimental engineering. Jas. D. Philips, now Ass't Professor at the University of Illinois, was appointed Ass't Professor in descriptive geometry and drawing.

Governor LaFollette has authorized Professors Storm Bull, and B. V. Swenson to prepare plans for an electric lighting plant and a heat regulating and ventilating system for the State Capitol.

Mr. Earnest F. Legg, E. E., '01 of the General Electric Co. is expected home soon on a short visit. Mr. Legg and his classmate, Mr. A. A. Nicholous, have been very fortunate in their work at Schenectady. The former is now on the "floor" test, as expert on machines of the largest types, and the latter holds a responsible position in the transformer department.

Mr. Charles A. Rhine, E. E., '00, is business manager of the Union Electric Manufacturing Company, 615 Clybourn street, Milwaukee, Wis. This company manufactures an extensive line of rheostats and motor starting apparatus.

Prof. Chas. R. Van Hise has been elected to membership in the National Academy of Science. He is one of three members from the west who belong to that society.

George A. Polley, '02, is with the C. & N. W. R'y, with headquarters at Milwaukee.

Dr. Louis Kahlenberg was elected one of the vice-presidents of the American Electro-Chemical Society, which was recently organized in Philadelphia.

Mr. Louis Barkhausen, '01, is with the Merrimac Croquet Company. His address is 67 Chelmsford street, Lowell, Mass.

The wedding of Mr. W. J. Buckley, '99, and Miss Eastman, of Ocean Grove, N. J., has been announced.

John L. Savage, '03, will spend the summer in Ohio with the U. S. geological survey. He was engaged in the same work last summer.

R. V. Holt has obtained a position with the master mechanic of the C. M. & St. P. R'y, at Dubuque, and will probably not return next year.

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## BOOK REVIEWS.

*Mechanical Drawing and Machine Design*, by J. G. A. Meyer.

The second volume of the above work by the late J. G. A. Meyer, has recently been issued.

Mr. Meyer had a national reputation as a draftsman, and was the author of a number of books and papers on subjects relating to his profession, his best known work being "Modern Locomotive Construction," which just appeared in the *American Machinist.*

"Mechanical Drawing and Machine Design" is the most comprehensive treatise on the subject which has been written. It is of special value to the student who takes up the study of Mechanical Drawing without the help of an instructor.

A chapter in the beginning is devoted to the selection, use and care of drawing instruments.

Other chapters deal with the elements of Descriptive Geometry, Algebra, Trigonometry, Mechanics, etc.

The paper and typographical work are of the best; the figures, of which there are over six hundred, being clear, and the reference letters of large size.

Interspersed throughout the work are numbers of illustrative examples and practical data which show the application of the theoretical portions of the text.

*Armature Windings of Direct Current Dynamos*, by E. Arnold. Translated from the original German by Francis B. De Gress, M. E. New York, D. Van Nostrand Company, 1902. 124 pages, octavo. 146 illustrations. Price $2.00.

This is a translation of the 1891 edition of Arnold's treatise which was then entitled "Die Ankerwicklungen der Gleichstrom Dynamomaschinen." Dr. Arnold has an international reputation, both as a writer and as a practicing engineer. His book on armature winding, which first appeared in 1891, was revised and enlarged in 1896 when it was given the title "Die Ankerwicklungen und Ankerkonstruktionen der Gleichstrom Dynamomaschinen." It was again thoroughly revised and enlarged in 1899, the present original German being a magnificent work of nearly 400 pages octavo, with over 400 illustrations and twelve large folding plates.

The present translation was first announced several years ago, and the publication has been impatiently awaited by those interested in the theory and design of direct current dynamos. The long delay was thought to be due to the work necessary in translating the large amount of new material in the 1899 edition. The appearance of a translation of the 1891 edition is indeed disappointing when it is considered that the 1899 revision has more than three times the material contained in the 1891 edition. Much of this most recent material is of considerably greater value than are portions of the 1891 edition.

On the title page of the translation Dr. Arnold is spoken of as "Engineer, Assistant Professor in Electrotechnics and Machine Design at the Riga Polytechnic School." This is in accordance with the title page of the 1891 German edition, but for several years past he has been Professor and Director of the Electrotechnical Institute at Karlsruhe, and is so spoken of on the title page of the 1899 German edition.

In a footnote to the preface of the second German edition (1896), Dr. Arnold says: "I do not wish to let pass unmentioned, that the first edition of this book was translated into English without the author being informed of it, under the heading 'Armature Windings, E. Arnold, translanted by Francis B. De Gress, M. E., D. Van Van Nostrand, New York.'" This may account to some extent for the tardy appearance and the incompleteness of the translation.

As far as it goes, the translation appears to be well done, and the cuts are exactly the same as those appearing in the 1891 German edition. The general appearance of the book is in accordance with the characteristic attractive style of the publishers.

*Theory of Steel-Concrete Arches and Vaulted Structures*, by Wm. Cain, Mem. Am. Soc. C. E. Second edition. 1902. Van Nostrand Science Series. Price 50c. This edition of Professor Cain's work on arches is a revision of his former work entitled "Voussoir Arches Applied to Stone Bridges," etc. About one-half of this edition is new reading matter relating to the analysis of steel-concrete arches and arches of variable cross-section; the remainder is substantially as it appeared in the first edition. The elastic theory of the arch is employed, as in the treatment of metallic arches, so that the work becomes a useful aid in the analysis of metallic as well as stone and combination structures. The groined arch and the dome are fully treated.

We have received from Bement Miles & Co. their latest catalogue on Steam Hammers. The catalogue covers its field weil, being divided into five section as follows:

1. Single frame steam hammers.
2. Double frame steam hammers.
3. Open frame steam hammers.
4. Double frame steel tilting hammers.
5. Drop hammers.

Bement Miles & Co.'s interests are controlled by the same company who are now running the Pratt & Whitney Co. An ad. from the latter company appears elsewhere in this issue, and any enquiries sent to addresses given under the Pratt & Whitney ad. will receive prompt attention.

## ALUMNI DIRECTORY.

The Alumni directory given below is as near perfect as we can make it with the information at hand. A complete and authentic directory is indispensible in a college like ours, and to keep it correct, we need the support and encouragement of both undergraduates and alumni. The names of alumni, whose addresses we are not certain of, are indicated by asterisks (*). Any body possessing information, as to any change of address, or correction in the directory, will do the *Engineer* a favor by imparting such information to our alumni editor.

Abbott, Clarence E., B. S. M. E., '01. Student of Civil Engr. U. W.

Adamson, Wm. H., B. S. C. E., '86. 494 23d St. E., Portland, Ore.

*Ahara, Edwin H., B. S. C. B., '92; M. E., 96. Supt. of plant of Dodge Mfg Co., Mishawaka, Ind.

Ahara, Geo. V., B. S. M. E., '95. With Fairbanks, Morse & Co., Beloit, Wis.

Ahara, Theo. H., B. S. M. E., '00. With Fairbanks, Morse & Co., Beloit, Wis.

*Albers, John F., B. S. C. E., '77; C. E., '78. Druggist, Antigo, Wis.

Alexander, Walter B., B. S. M. E., '97. Prof. of Steam Engineering, University of Missouri, Columbus, Mo.

Allen, Andrews B., B. S. C. E., '91. Wisconsin Bridge Co., 1022 Monadnock Bldg., Chicago, Ill.

Allen, John S., B. S. E. E., '97. Mg'r Beloit Electric Light Co., Beloit, Wis.

Alverson, Harry B., B. S. E. E., '93. Cataract Bower & Conduit Co., 40 Court St., Buffalo, N. Y.

*Arms, Richard M., B. S. E. E., '94. Seattle, Wash.

Aston, Jas. B., B. S. E. E., '98. Care of Thomas Aston & Son, Milwaukee, Wis.

Austin, W. A., B. S. M. E., '99. 1011–149 Broadway, N. Y.

Baehr, Wm. A., B. S. B. E., '94. Mgr. Denver Gas Works, Denver, Colo.

*Baldwin, Geo. W., B. S. C. E., '85. Lumber Dealer, Crete, Neb.

Bamford, F. E., B. S. M. E., '87. Lieut. U. S. A., Atlanta, Ga.

Barnes, Chas. B., B. S. M. E., '00. C. M. & St. P. R'y Shops, Milwaukee, Wis.

Barr, J. M., B. S. M. E., '99. Westinghouse Elec. & Mfg Co., Pittsburg, Pa.

Baus, Richard E., B. S. M. E., '00. Western Elec. Co.. Chicago, Ill.

Bachelder, Clare H., B. S. M. E., '01. Chicago Telephone Co., Chicago, Ill.

Barkhausen, Louis H., B. S. M. E., '01. Merrimac Machinery Co., Lowell, Mass.

Bebb, Edward C., B. S. C. E., '96, U. S. Geol. Survey, Washington, D. C.

Beebe, Murray C., B. S. E. E., '97, Care of Amber Club, Pittsburg, Pa.

Bennett, Chas W., B. S. M. E., '92. American Tin Plate Co., Elwood, Ind.

Benson, F. H., B. S. C. E., '91. Life Insurance, New Insurance Bldg, Milwaukee, Wis.

Bentley, F. W., B. S. M. E., '98. Muskegan, Mich.

Bergenthal, V. W., B. S. E. E., '97. Stanley Elec. Mfg. Co., Monadnock Bldg., Chicago, Ill.

Bertrand, Phil. A., B. S. E. E., '95. People's Gas & Elec. Co., Peoria, Ill.

*Berry, Claude, B. S. C. E., '01. Great Northern R'y, St. Paul.

Biefeld, Paul A., B. S. E. E., '94. Prof. Elec. Eng., School of Heilperghausen, Ger.

*Bird, Henry, B. S. C. E., '94. Died Dec. 22, '91. Citronelle, Ala.

Bird, Hobart S., B. S. C. E., '94; LL. B., '96. San Juan, Porto Rico.

*Bliss, Wm. S., B. S. M. E., '80. J. M. Dennis Lumber Co., Williams, Arizona.

Boardman, Harry B., B. S. E. E., '93. Wisconsin Lime & Cement Co., Chicago, Ill.

Boardman, Horace P., B. S. C. E., '94. Ass't Eng'r. B. & B. Dep't. C., M. & St. P. Ry., 1100 Old Colony Bldg., Chicago, Ill.

Bohan, Wm. J., B. S. E. E., '95. E. E. N. P. Ry., Tacoma, Wash.

*Boley, C. U., B. S. C. E., '83; C. E., '99. City Engineer, Sheboygan, Wis.

Boorse, Jesse M., B. S. E. E., '95. Monroe Division of Chicago Telephone Co., Chicago, Ill.

Bossert, Chas. P., B. S. M. E., '88. Pfister & Vogel Leather Co., 555 9th St. Milwaukee, Wis.

Boynton, C. W., B. S. M. E., '98. Ledro-Wolley, Wash.

*Brace, Jas. H., B. S. C. E., '92. Albany, N. Y.

Bradish, Geo. B., B. S. C. E., '76; C. E., '78. Civil Engineer, La Crosse, Wis.

*Bradley, Wm. H., B. S. C. E., '78. Junction Iron & Steel Co., Mingo Junction, Ohio.

*Brennan, Wm. M., B. S. C. E., '94. Civil Eng. Office Colby and Abbot Bldg., Milwaukee.

Broenniman, Arnold E., B. S. C. E., '97. 443 Finance Exchange, New York City.

Brown, Geo. W., B. S. C. E., '86; C. E., '90. Gov. Works, Dry Tortugas, Fla. Via Key West.

*Brown, Perry F., B. S. C. E., '97. Kurtz & Brown, Mills Bldg., San Francisco, Cal.

Brown, Samuel L.; B. S. M. E., '89. Smelting & Refining Co., Station S. Chicago, Ill.

*Brown, Thane R., B. S. C. E., '95. Wis. Bridge & Iron Co., Milwaukee Wis.

Burdick, Wm. C., B. S. C. E.' '01. St. Paul Depot, Milwaukee, 1015, Sycamore St.

Buerstatte, F. W., B. S. M. E., '01. Mech. Dep't, C. & N. W. Ry., Chicago, Ill.

Bucey, John H., B. S. C. E., '95. Died Dec. 4, 1896.

Buckley, W. J., B. S. E. E., '99. United Gas & Elec. Co., Long Branch N. J.

Burgess, Chas. F., B. S. E. E., '95. Ass't Prof. of Elec. Eng., University of Wisconsin.

Burgess, Geo., H., B. S. C. E. '95. Penn. Lines Chief Engineer's Office, Pittsbdrg, Pa.

Burkholder, Chas. I., B. S. E. E., '96. General Elec. Co., Schenectady, N. Y.

Burton, Wm. C., B. S. E. E., '93. J. S. White & Co., Limited, 22 A. College Hill, London, Eng.

Buttles, Ben E., B. S. E. E., '00 Akron, Ohio.

*Campbell, Bert, B. S. C. E., '98. Chicago, Ill.

Carey, Jas. L., B. S. M. E., '88. 306 Baird Ave., Austin Station, Chicago, Ill.

Carlson, Chas. J., B. S. M. E., '96. Chicago Telephone Co., Chicago, Ill.

Carpenter, Chas. G., B. S. C. E., '82. 123 N. 40th St., Omaha, Neb.

Carter, B. B., B. S. M. E., '88. 1644 Monadnock Bldg., Chicago, Ill.

Caverno, Xenophon, B. S. M. E., '90. Kewaunee Gas Light & Coke Co., Kewaunee, Ill.

Clausen, Leon R., B. S. E. E., '97. 422 W. Jackson Bldg., Chicago, Ill.

*Cochran, Robt. B., B. S. M. E., '97. Teacher at Springfield Inst., Springfield, Mass.

Comstock, Nathan, B. S. M. E., '97. Attorney, Arcadia, Wis.

Connolly, Pat. H., B. S. C. E.,' 85. City Eng. Racine, Wis.

Conover, Allen D., Ph. B. C. E., '75. 151 W. Gilman St., Madison, Wis.

Conradson, C. M., B. S. M. E., '83. M. E. American Turret Lathe Co Warren, Pa.

*Cook, Thomas R., B. S. M. E., '00. 105 Barr St., Fort Wayne, Ind.

*Coombs, Ed. C., B. S. C. E., '97. C. M. & St. P. Ry., Chicago, Ill.

Cooper, A. S., B. S. C. E., '81; C. E., '83. U. S. Ass't Eng. Savannah, Ga.
Cornish, Ross C., B. S. C. E., '97. Racine Gas Co., Racine, Wis.
*Crandall, H., B. S. M. E., '98. 23d St., between Grand Ave. and Wells St., Milwaukee, Wis.
*Crane, Edgar W., B. S. E. E., '95. San Gabriel Elec. Co., Azusa, Cal.
Crenshaw, Thos. P., B. S. E. E., '95. Died.
Crowell, Robinson, E. E., '96. Mount Low Ry., Los Angeles, Cal.
Curtis, Norman P., B. S. C. E., '01. Madison, Wis.
Dean, Chas. L., B. S. M. E. '01. Jewish Mt. school, 1224 Mich. Ave. Chicago.
*Dixon, Fred B., B. S. C. E., '97. New London, Wis,
Dixon, John E., B. S. M. E., '00. Brooks Locomotive Works, Dunkirk, N. Y.
*Dodge, Jos., B. S. M. E., '84. Allis-Chalmers Co., Milwaukee, Wis.
Dodge McClellan, B. S. C. E., '84. City Eng., Eau Claire, Wis.
Dousman, Jas. H., B. S. C. E., '84. Milwaukee Automobile Co., 73 31st St. Milwaukee, Wis.
*Duffy, Wm. F., B. S. C. E., '84. Cannot be located.
Durand, Samuel B., B. S. C. E., '91.
Dutcher, John E., B. S. E. E., '97. Died in Colorado.
Earll, C. I., B. S. M. E., '85, 76 Williams St., New York City.
*Egan, R. A,, B. S. C. E., '99. Brooklyn, N. Y.
*Ela, Edwin S., B. S. C. E., '96. Recorder Gov. Survey, Rochester, Wis.
Ellis, John F., B. S. C. E., '87. Died Evansville, Wis., Dec. 9, '90.
Elser, R. C., B. S. C. E., '98. Died May 17, 1900.
Emerson, Fred M., B. S. C. E., '00. Milwaukee Bridge Co., Milwaukee Wis.
*Erbach, Wm. Z., B. S. M. E., '93. Lumber Business, Athens, Wis.
*Eriksen, Erik T., B. S. C. E., '98; C. E., '90. 2991 N. Winchester Ave., Chicago, Ill.
*Evans, Ed. M., B. S. C. E., 94. Insp. for Amer. Bridge Co., 2277 N. Paulina Ave., Chicago.
Evans, Geo. B., B. S. C. E., '94. 348 Atlantic Ave., Pittsburg, Pa.
Fairchild, David L., B. S. C. E., '90. 17 Columbia Block, Duluth, Minn.
Falconer, Robt. C., B. S. C. E. American Bridge Co., Empire Bldg., Pittsburg, Pa.
Farris, Jas. A., B. S. M. E., '00. Cutler Hammer Mfg. Co., Milwaukee, Wis.
Fehr, H., B. S. M. E., '84; LL. B., '86. Lawyer, Empire Bldg., Milwaukee, Wis.
Fisher, John J., B. S. C. E., '76. U. S. Dep't, Mineral Survey, Prescott, Ariz.
*Fisher, John R., B. S. C. E., '74; C. E., '80. Lumber Dealer, Beaver Dam., Wis.
Ford, Arthur H., B. S. E. E., '95. Prof. Elec. Eng., Georgia School of Tech., Atlanta, Ga.
Ford, Fred H., B. S. E. E., '93. Northern Electric Co., Milwaukee, Wis.
*Fowle, Fred F., B. S. C. E., '93. 1st Asst. Physician, Milwaukee Hospital for Insane.

*Fowle, Harry H., B. S. E. E., '95. Electrician (Fowle & Fowle), South Milwaukee, Wis.

Fowler, Myron M., B. S. E. E., '01. Western Elec. Co., Chicago, Engr. Dep't.

Fox, Henry, B. S. M. E., '92. Box 311, Hartshorn, Indian Territory.

Frankenfleld, Budd D., B. S. E. E., '95; E. E., '96. Inst. in Elec. Eng., University of Wisconsin.

*Fratt, Fred W., B. S. C. E., '82. Texas Midland Ry., Terrell, Texas.

Freschl, E., B. S. M. E., '99. 3405 Wells St., Milwaukee, Wis.

*Fugina, A. R., B. S. C. E., '98. U. S. Geol. Survey, Cincinnati, Ohio.

Fuldner, Henry C., B. S. C. E., '97. 366 Greenbush St., Milwaukee, Wis.

Funk, Wm. F., B. S. M. E., '91. M. Funk Boiler Works, 1407 Main St., La Crosse, Wis.

Gerdtzen, G. A., B. S. M. E., '93. Asss't Prof. of Machine Design, University of Illinois.

Gerlach, T. A., B. S. C. E., '98. 15124 Turlington Ave., Harvey, Ill.

Goddard, A. L., B. S. M. E., '96. Hadden Heights, N. J.

Golder, Lloyd W., B. S. M. E., '95; B. S. E. E., '96. Sullivan Machine Co., Chicago, Ill.

*Gooding, Wm. H., B. S. C. E., '73, Independence, Iowa.

Granke, Leo E., B. S. C. E., '00. Slater, Mo.

Gregerson, Louis T., B. S. C. E., '95. C. N. W. R. R., Boone, Iowa.

Gregg, H. B., B. S. M. E., '92. Eng'r of Tests, Santa Fe Ry., San Bernardino, Cal.

Griffith, John H., B. S. C. E., '93. 31 Chestnut St., Potsdam, N. Y.

*Grover, A. J., B. S. C. E., '81; C. E., 83. 1137 Park Ave., Omaha, Neb.

Grover, Allison S., B. S. M. E., '95. Draughtsman, Allis-Chalmers Co., Milwaukee, Wis.

Hackney, Robert. H., B. S. M. E., '93. Mgr. Seamless Structural Co., Milwaukee.

Hain, Jas, C., B. S. C. E. '93. 1100 Old Colony Bldg., Chicago, Ill.

Hambuechen, C., B. S. E. E. '99; E. E. '00. Investigator, University of Wisconsin.

Hamilton, Harvey F., B. S. C. E., '92. G. N. R. R., Great Northern Bldg., St. Paul, Minn.

Hancock, L. M., B. S. M. E., '88. Gen. Supt. of Bay Counties Power Co., Coe Ave. and Broadway, San Jose, Cal.

Hansen, Oscar, B. S. E. E., '94. Western Electric Co., Chicago, Ill.

*Hanson, A., B. S. C. E., '99.

*Hanson, Walter S., B. S. M. E., '95. Walburn-Swenson Co., Shawnee. Okla.

Hanson, H. O., '99. 92 W. Jersey St., Elizabeth, N. J.

Hargrave, R. W., B. S. M. E., '98. Zion City Headquarters, Chicago, Ill.

Harrison, C. N., B. S. C. E., '82. Madison, Wis.

*Harriman, F. J., B. S. C. E., '89. Appleton, Wis.

Hart, Chas. W., B. S. M. E.' '96. Hart, Parr & Co., Charles City, Ia.

Hartwell, Frank I., B. S. M. E., '95. Died 1897.
Harvey, John L., B. S. M. E. '00. Prescott Pump Works, Milwaukee.
Hawn, Russell, J., B. S. C. E., '01. Portland Cement Works, Craigsville, Va.
Hayden, Chas. B., B. S. E. E., '96. Sun Prairie, Wis.
Heald, Eugene H., B. S. C. E., '00. Schager Br. Co., Chicago.
*Hegg, John R., B. S. C. E., '00. Dead.
Hedke, Chas. R., B. S. C. E., '00. Holland Beet Sugar Mfg. Co., Loveland, Cal.
Heine, R. E., B. S. E. E., '98. Ass't Prof. of Elec. Eng. University of Washington.
Hile, Chas. H., M. E., '94. Boston Elevated Ry., 552 Harrison Ave., Boston, Mass.
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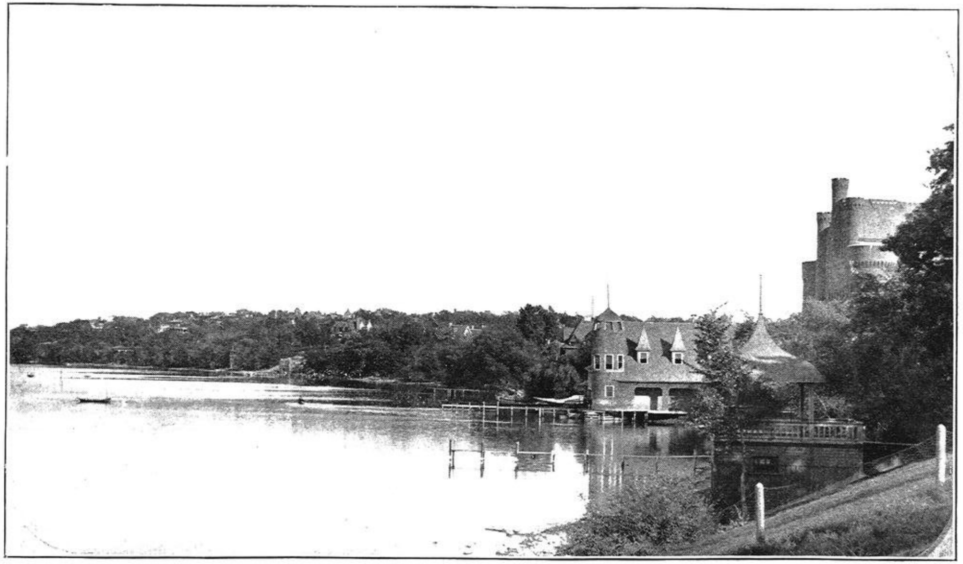

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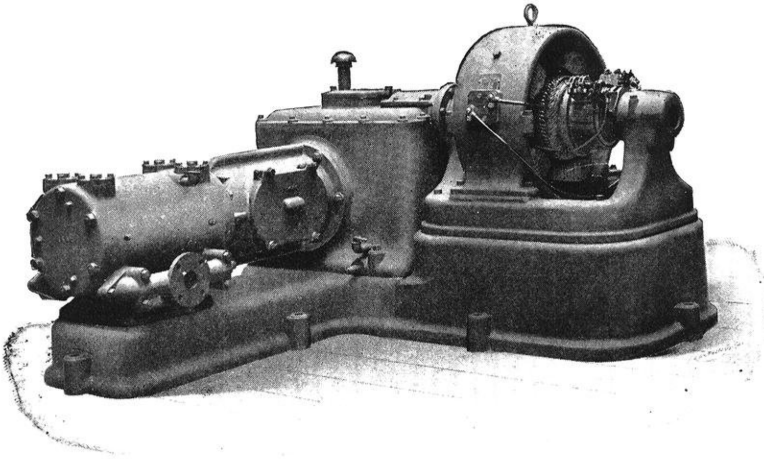

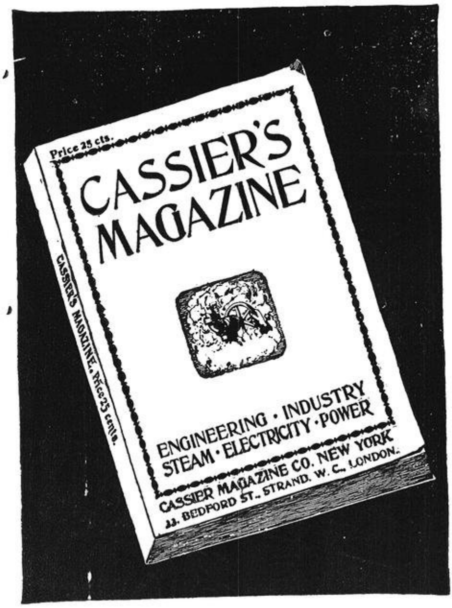
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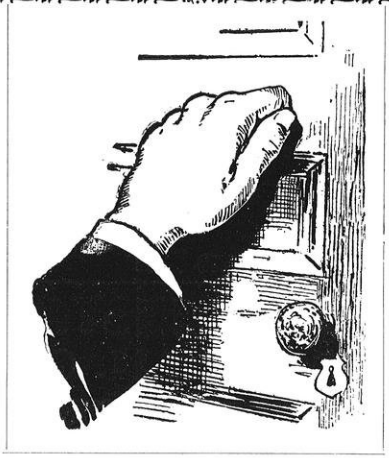

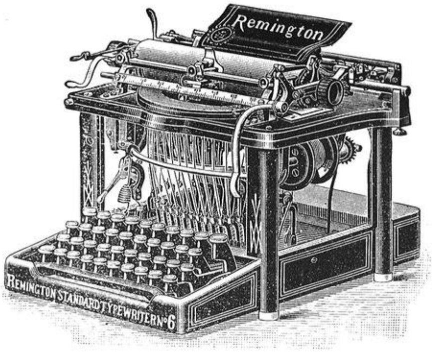
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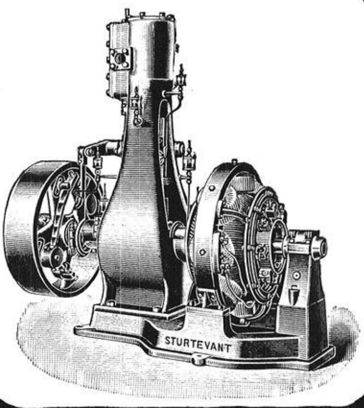
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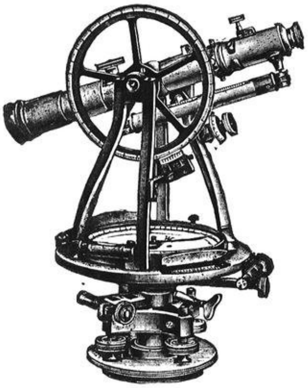
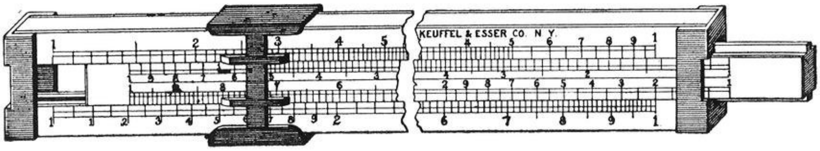
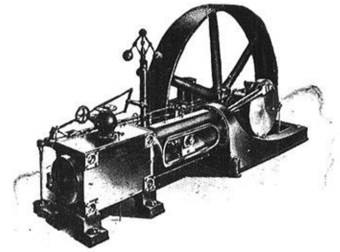
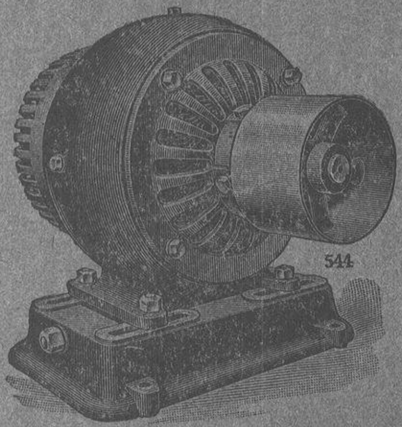



KEUFFEL & ESSER CO. N.Y.

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