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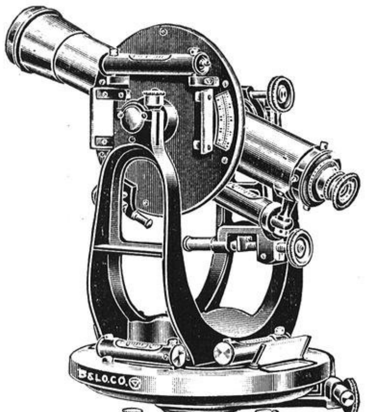
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The Wisconsin Engineer

VOL. XIX DECEMBER, 1914 NO. 3

MANUFACTURING AND TESTING OF ELECTRIC STEEL.

MERRILL E. SKINNER, '14.

The importance of raw materials in manufacturing processes is usually greatly underestimated by the majority of engineering students. It is hard to comprehend the immense quantities of the staple materials which are used in a year by the large manufacturers, and harder still to appreciate the tireless efforts of the manufacturers to keep the standard of these raw materials up to the highest level. In the electrical business, everyone realizes that very large quantities of copper and steel are used, but few have definite ideas of their magnitude. It has been the author's good fortune to have been connected with the electric sheet steel testing department of the Westinghouse Electric and Manufacturing Company, and in this article an attempt will be made to give some idea of the quantity, standards of quality, and methods of handling this important raw material.

The term electric steel is applied to the particular grade of sheet steel which, because of certain physical and electro-magnetic properties, is especially adapted to use in the magnetic circuits of transformers and dynamo-electric machines. After some thirty years of experimentation, it has been found that a silicon steel containing from 2 to 5 per cent. of silicon is the best form. Electric steel is one of the most important raw materials used in an electrical manufacturing plant. Practically all modern electrical machines are electro-magnetic in their operation, and as such must have an iron core somewhere in their make up. When the countless types and varieties of apparatus which are put out by the larger companies by the thousands are listed, the importance of this raw material becomes apparent. The Westinghouse Company uses about 1,000,-000 lb. of this steel in a normal operating month at their East

Pittsburg plant. This consumption means an expenditure of about $720,000.00 per year, the average cost of the steel being about $0.06 per lb.

The sheet steel manufacturers furnish the electric steel in standard sheets 30 by 96 in. and in three standard gauges, classified according to the kind of machine in which the steel is to be used. The thinnest sheets are used in small apparatus like fan motors, automobile ignition generators and automobile starting motors. In this class of apparatus the loss in efficiency due to iron losses is small in comparison with other losses, whereas the workmanship must be fine and accurate throughout. For this reason the magnetic properties of this grade are relatively less important than the mechanical properties. The medium gauge is the most important one for it is used in all transformers, turbo-generators, and synchronous converters, and most motors and generators of large size. At present with friction, windage, and copper losses reduced to a minimum in this class of machines, any further increase in efficiency must come in the reduction of the iron losses. The third class is the coarse steel, for use in pole cores and in the rougher types of motors and generators of medium and small sizes.

The manufacture of electric steel presents some interesting features which are due to the very peculiar characteristics of silicon steel. Some thirty years ago it was discovered that the hyteresis and eddy current losses of steel for electro-magnetic use vary considerably with the so-called impurities in the steel. These impurities consist of silicon, maganese, phosphorus, and sulphur, and it was found that only the silicon was a determining factor in the properties of the electric steel. At the time of these discoveries, the Westinghouse company induced the American Rolling Mill Company to make up several lots of these alloy steels to be tested in an endeavor to determine the best composition. The investigations which are still being conducted jointly by the research departments of both companies have resulted in the modern silicon steel used by the Westinghouse Company. The steel is made in basic open hearth furnaces in order to secure freedom from impurities. This method necessitates the addition of the silicon to the steel after it has been tapped from the furnace, since it would attack the basic lining of the furnace. The acid lined furnace can be used, and indeed must be used where scrap containing silicon is used to charge the furnace, but it makes control of the silicon content very difficult. When ferro-silicon is added to the molten steel, the ensuing reaction is exothermic; hence it is impossible to control the temperature, and very hard to guess at the right conditions for keeping it down. As the charge is being tapped from the open hearth furnace, a man stands beside the trough and shovels in the requisite amount of ferro-silicon. This must be done graually and at a uniform rate to ensure a thorough mixture and to avoid local super-heating. As soon as the charge is tapped, it must be poured into the moulds immediately. Unless this is done and the heat given a chance to radiate off, one of two things may happen: either the plug melts out of the ladle, or the charge goes through the roof. Needless to say, both of these occurences are to be avoided if possible. The next difficulty encountered is in the final rolling of the billets into sheets. Silicon steel shows a decided tendency to scale excessively, especially if it has been overheated or if it contains a high percentage of silicon and so careful attention must be given to the temperature in the reheating ovens. Billets which have been kept free from scale through the blooming and bar mills usually roll out successfully.

The uses to which this steel is to be put require certain qualities in the steel which the company demands. Silicon, if present in excessive quantities, makes steel hard and brittle, and the company reserves the right to reject any steel which is hard enough to damage the punch dies or to crack when it is punched. With regard to losses and permeability, the steel is graded into four grades with prices according to quality. A fifth grade is made of all steel which shows a watt-loss of over two watts per kg. and is rejected. When the mills are operating properly, seldom if ever is any steel rejected, for most of it falls considerably below the limit of magnetic loss. Up to a certain extent scale is desirable. Since it consists chiefly of iron oxide it acts as insulation between the laminations, thereby cutting down the eddy currents. However, as soon as it becomes loose and flaky it decreases the space factor of the steel. The space factor is the ratio percentage of the total volume of the steel occupied by active steel. The last requirement and the least important is in regard to the ohmic resistance of the steel, any unusual departure from the standard being an indication of impurities. Moreover, the ohmic resistance is an indication of the specific gravity of the steel, High resistance steel has a specific gravity of 7:5 and low resistance steel a specific gravity of 7.7. Naturally this property depends to a very large extent upon the scale, and when this is good the ohmic resistance is sure to be satisfactory.

A curious fact about this silicon steel is its behavior on annealing. This process as adapted to electric sheet steel treatment has been patented by the Westinghouse Company, and is an important enough factor to receive a separate treatment later. It is enough to say at this point that it improves every quality of the steel and has no detrimental effects whatever. All steel used by the Westinghouse Company is given one annealing at the mills of the American Rolling Mill Company. A great deal of it is subsequently annealed again at the electric shops although a portion of it is used just as it is received from the rolling mills.

Upon the receipt of a shipment of steel, the head storekeeper makes out the sample cards for each lot. These sample cards give the quality, gauge, width, date of receipt of shipment, car number, lot number, weight, and heat number. The heat number being the number by which a lot can be traced to any given charge in any furnace. The heats, which contain about 50 tons, usually get split up in the rolling so that sections arrive at different intervals. These sections are denoted by letters affixed to the heat number so that 1073—A, B, C, D, and X on the mill records may correspond to lots 3545, 3567, 3595, 3605 and 3711 on the company's records. These cards are sent to the testing laboratory along with the mill samples, which are shipped with their respective lots. The testing laboratory receipt consists of steel tags with the lot numbers punched on them, and with wires for attaching them to the proper sheets. The tags go back, and as the steel is unloaded are attached to their respective sheets, which then go to the punch shop to be cut up into the proper sized strips. The main shipment is stored in a large shed just outside the punch shop in the order of the lot numbers assigned by the testing laboratory so that any shipment can be reached easily if the results of the tests show it to be especially adapted to a certain class of work. The cards are filed at the laboratory for reference and for the recording of subsequent data. The number of samples taken from each lot depends on the size of the lot. On all lots up to 12,000 lb. one sample is taken and is designated as the "A" sample. Lots weighing from 12,000 to 25,000 lb. have two samples, "A" and "B," and lots over 25,000 lb. have three samples, "A," "B" and "C." The specifications of the American Society for testing materials require a standard sample for watt-loss tests weighing 10 kg. and composed of strips 50 cm. long and 3 cm. wide. However, for the sake of economy both in material and in time of handling, the size of the "A," "B" and "C" samples has arbitrarily been reduced to 5 kg. When the results of the tests upon the first samples are within one per cent. of the dividing values between classes, an additional and full weight sample is taken which is designated as the "L" sample. The result of the test upon the "L" sample is the determining factor in placing the lot in one class or another.

In a day or so after the receipt of the cards (the time consumed in the unloading and cutting up of the sample) the samples arrive at the laboratory. They are weighed out, the scale is estimated and recorded, and then they are done up with friction tape into four approximately equal bundles. The "A" sample is the only one which is tested as received. After the test, all the samples are bound up with wire, the steel tags are reattached, and the samples annealed. When they come back from the annealing oven, they are again taped and tested as before. It is upon the results after the first annealing that the lots are graded and released for use in the shops. At the end of each day a list of all the samples released and their grade is sent to the store room, with carbon copies to the purchasing department, the punch shop, and the director of the laboratory. The steel is then assigned to whatever order may require the particular grade of steel indicated by the test and the laminations are punched and annealed and all, except those for small motors and dynamos, are coated with shellac. The steel is then ready to be assembled and is sent to the respective assembling department.

The annealing process mentioned above is such an important feature of the treatment of electric steel, and has such an effect upon the results obtained that it is deemed advisable to devote a separate section to its discussion. Annealing consists of heating the steel to a cherry red heat out of contact with the air, so far as is possible, and allowing it to cool gradually after it has been subjected to this temperature for from 6 to 8 hours. It has long been known that such treatment affects the mechanical properties of steel, but the discovery that it also affects the magnetic properties was comparatively recent, and the use of the annealing process for improving the magnetic properties of steel has been patented by the Westinghouse Company.

In practice the laminations are piled upon a large iron, sand-covered grid, a large cover is put on and the cracks are filled up with moist fire clay. The whole arrangement is then rolled into the furnaces on large steel balls, the doors are closed, and the fires lit. When the samples are annealed, they are put in with the regular runs to insure the same treatment which the iron itself receives and to check the efficiency of the annealing. At the present time the temperature is not measured accurately but is left to the judgment of the attendant. However, results of tests now in progress at the laboratory indicate a very definite maximum temperature and duration of time of cooling so that it will be necessary to install accurate pyrometers to insure the best results. The results are affected not only by the time of cooling and the maximum temperature but also by the time required to reach this temperature and the ratio of time of heating to time of cooling. At present a considerable number of experiments are in progress to determine the most favorable conditions. If these tests come out as the present results point, it is probable that a new type of furnace will be installed for the annealing work.

The watt-loss test is the most important one, for the final grading of the steel depends on its results. It consists of the determination of the number of watts of power consumed per kg. of steel by the hysteresis and eddy current losses. Both these losses depend on the conditions of the test and it has therefore been necessary to prescribe standard conditions. The Epstein Test, so-called from the name of the man who first outlined it, has been revised and standardized by the American Society for Testing Materials. In this test the steel to be tested is used as the core of a small transformer. The power consumed by the transformer corrected for the copper loss is measured on a watt meter, and finally reduced to watts per kg. In order to have results that are at all comparable, the flux density, voltage, frequency and wave form must be adjusted and the sample made to conform to standard specifications. It must consist of strips 50 by 3 cm. cut or punched with the grain of the steel. The sample should weigh 10 kg. but, as has been explained, this weight has been halved by the company. The current used must be a 60-cycle sine wave, the voltage depending upon the resistance of the magnetizing coils. The apparatus used consists of a standard Epstein outfit, a precision wattmeter reading to one one-hundredth of a watt, a standard voltmeter with temperature adjustment, a frequency meter, and a suitable source of power. The frequency meter is of the vibrating reed type, having both a direct and an alternating current winding.

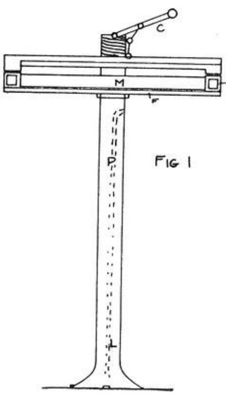

FIG I

The direct current winding is connected across the 110-volt shop circuit and subjects the reeds to a constant field in one direction. The alternating current winding is connected across the phase of the synchronous converter, which does not feed the Epstein set. The reeds vibrate in the resultant field of these two windings. The instrument is very sensitive because the field is unidirectional instead of reversing, and varies with the intensity. The reeds themselves are stiff steel strips securely clamped at one end and adjusted by weighting the ends with sealing wax.

The Epstein apparatus itself consists of a hollow iron pedestal P, Fig. 1, through which the lead wires L pass, and upon which is mounted a square, wooden, revolving frame F. The four coils M are wound on fibre cores G so that there is no iron in the magnetic path except the sample. The spring clamp C is for clamping the corners firmly in place to avoid vibration and to cut down leakage at the joints. The leads are attached to the terminals T of the primary and secondary coils by means of flexible lamp cord. The coils are wound concentrically, the secondary over the primary, to minimize the leakage.

The source of power consists of a two phase synchronous converter. The converter is fed by a 110-volt direct current generator driven by a two phase, 25-cycle, 10 horse power induction motor. By varying the field of the generator and that of the rotary, the voltage and frequency can be adjusted to any desired value. The electrical connections are shown schematically in Fig. 2. A small booster mounted on the converter acts as a

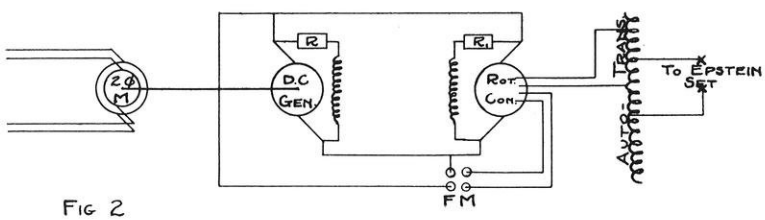

FIG 2

compensator and serves to keep the sine wave free from harmonics.

The actual testing consists of inserting the taped bundles composing the samples in the magnetizing coils. The switch S is then closed and the joints tapped lightly to minimize the leakage. After the voltage is adjusted by means of the auto-transformer, and the desired frequency is secured by means of the converter field rheostat R_1, the wattmeter is read. The Epstein equation for the voltage to be used is:

$$E = \frac{4\pi\ f\ Nn\ B\ M}{4\pi\ L\ D\ 10^{8}} \text{ volts}$$

where

f form factor of wave.................... 1.11 for sine wave
N number of secondary turns.......................... 600
n frequency .... 60 cycles per sec.
B maximum induction .... 10,000 gausses
M mass of sample in grams ....10,000 gm.
L length of strips.................................. 50cm.
D specific gravity of sample.................... 7.5 and 7.7

From this equation the proper voltages have been found to be 103.8 and 106.6 volts respectively for the two classes of steel. For the half weight sample used in the company's tests these values become 51.9 and 53.3 volts respectively. The wattmeter is so connected that the only power loss is that in the secondary winding. Then the watt loss per kg. is:

$$W^{10}_{60} = \frac{\text{wattmeter reading} \times \text{constant} - \frac{E^2}{R}}{\text{weight of sample in kg.}}$$

To facilitate the testing a set of curves has been plotted for the different wattmeter connections, between wattmeter readings and watts lost per kg. After the first annealing the test results are averaged and the steel is graded. The classes into which the steel is divided are as follows:

1.65 watts per kg. and less......................... Class 1
1.65 – 1.76 watts per kg........................... Class 2
1.76 – 1.88 watts per kg........................... Class 3
1.88 – 2.00 watts per kg........................... Class 4
2.00 watts per kg. and over...................... Rejected

The second test is the permeability test on a part of each "A" sample. The method used in this test is to balance the inductance of a coil having the sample as a core against a calibrated mutual inductance. It is a modification of the divided bar method. Two coils are wound on a hollow core, and a third compensating coil is experimentally adjusted to give a uniform density throughout the coil. The sample, consisting of about a dozen of the strips, is divided, and half of it is clamped in each coil between heavy soft iron yokes of low reluctance. The currents in the magnetizing and compensating coils are adjusted to give a uniform density of 6,000 gausses throughout the sample. The mutual inductance is then adjusted to such a value that when the current in the primary is reversed, a galvanometer in the circuit deflects equally with either the secondary or the mutual inductance connected to it. Usually these readings are taken for three different densities, the values ordinarily taken being 6,000, 10,000 and 16,000 gausses. However, special cases may require a complete permeability curve, in which case readings are taken every thousand gausses. The strips used on this test are inserted in their proper sample and tested again after they have gone through the annealing ovens in the same way in which the watt-loss samples are tested.

After the first annealing, all samples except the "A" samples are scrapped after the second testing. This sample is again annealed and tested after which they are set aside for ageing and space factor tests. In practical use, transformers, dynamos and other apparatus heat up considerably on continuous use, and so it is essential that the magnetic properties do not change under these conditions. To insure that the steel will not change under these conditions, the "A" samples are places in an electric oven and kept at a temperature of 100° Cent. for 25 days. At the end of this time they are tested again and the ageing coefficient computed. This is the ratio of the change in watt-loss during the 25 days, to the watt-loss at the beginning of the test, and should average zero per cent. for any considerable number of samples.

The final test is the space factor test. In this the thickness of 100 strips is measured under a uniform pressure of 20 lb. per sq. in. and the weight of the strips obtained. The space factor is the ratio of the active iron to the total iron, and reduces to:

$$\frac{4.34 \text{ x thickness in inches}}{\text{weight in pounds.}}$$

For ordinary iron the space factor should be about ninety per cent., although very little superfluous scale will bring this value down as low as seventy-five per cent.

At the conclusion of these tests all of the sample remaining is scrapped unless a portion is to be reserved for research work. For this purpose composite samples are made up, consisting of one strip from each of several hundred lots. These samples are supposed to be fairly representative, and are used in all research work. The results of all the tests are recorded on duplicate cards along with the results of the American Mill Rolling Company's tests, and one is filed while the other is sent to the mill. In this way the routine testing can easily be checked without serious inconvenience or delay. At the end of a test it can be predicted with a fair degree of accuracy what the core loss of a given trans-

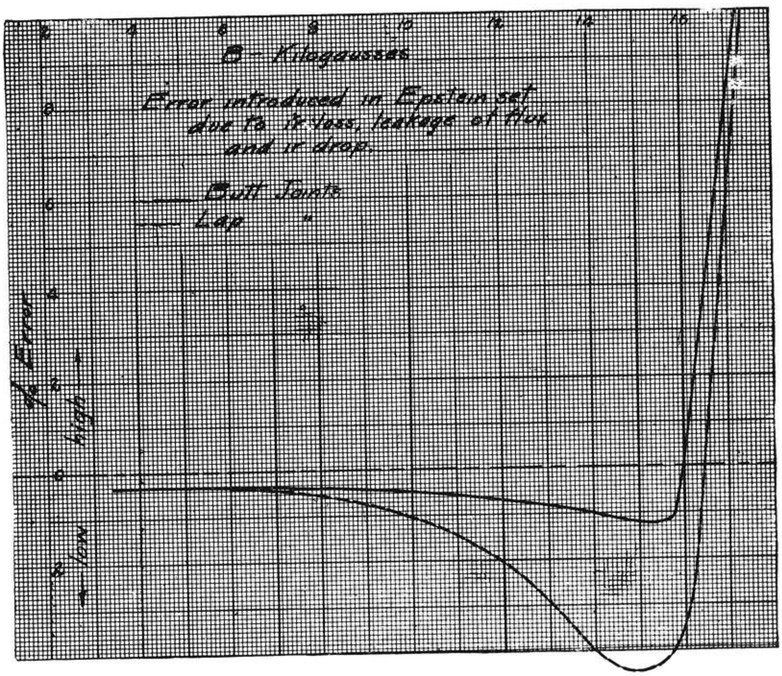

FIG. 3.

former made up of this steel will be, at just what density the core may be worked most economically, and to what pressure the laminations may be subjected.

The results are surprisingly accurate, considering the speed at which the samples are rushed through, but of course there are numerous sources of error. These have all been investigated to see in what degree they influence the results. When possible they are neglected but where the effect is serious every effort is made to eliminate them or compensate for them. In the watt-loss test there is a chance that the instruments may be inaccurate, but with the use of the best instruments and frequent calibration this possibility is greatly minimized. In the weighing there is some chance for error in the adjustment of the scales, but the fact that the weighing can be done only to the nearest strip introduces the largest error. To this error most of the inaccurate results may be attributed. Magnetic leakage introduces another error, which is very hard to reckon. The coils are wound to include as much of the iron as possible but the corners can not be covered, and it is at these corner joints that most of the leakage occurs. In this connection the question arises as to which type of joint, lap or butt, introduces the larger error. This question has been investigated quite thoroughly and it has been found that the butt joints actually introduce less error when considered with the other errors than the lap joints. In addition it is much easier to set up the test with the butt joints. The curves shown were taken on composite samples, and both in the shape of the curves and in the magnitude of the values represent average conditions. For the flux used in the test, 10,000 gausses, the curves show an advantage on the side of the butt joints. Errors may also be introduced by incorrect values of voltage, frequency and wave form. The first two are regulated by the operator by means of the rheostat but it is difficult to get them exactly right simultaneously. The wave form is checked by means of an oscillograph and adjusted by means of the booster.

In the permeability test the errors may be in the instruments, in the compensation, or in any clamping of the sample in a strained position. The mutual inductance is hard to calibrate accurately, and hard to keep in adjustment. However, permeability is at best such a vague quantity that a measure of it is bound to be inaccurate. The apparatus described has been adopted after a careful study of present permeability testing methods, and its construction based on the best method known, in point of accuracy.

ELECTRICITY BEHIND THE SCENES

HARRY HERSH, '15.

NOTE: This article was written after an interview with Mr. E. H. Spranger, electrician of the Pabst Theatre, Milwaukee. Mr. Spranger has held this position for the last twenty years and during the last four years has been in charge of the stage illumination for the Haresfoot Club of the University.

The theatre-goer little realizes the important part that electricity takes in the production of plays he sees until he takes the trouble to investigate behind the scenes. It has been said [1] that none of our modern productions compare very favorably with the costly and elaborate pageants of medieval times. But the simplification which has come about has brought to our modern stage an excellency in the realistic representation of nature and her phenomena, a lowering of the cost of production, and a safety and ease of operation that was never thought of in those early days. This simplification has involved merely the application of engineering principles to the mechanics of the stage. Electricity has played no small part in these applications, for it now operates the back drops, flies, drop curtain, traps and bridge elevators; it works the thunder, wind and rain machines and it produces the illuminating effects. The entire subject of theatre engineering is very broad and extremely interesting, and has been brought to a high stage of perfection within the last thirty years. This article, however, will consider principally the illuminating applications of electricity, and will treat of the other applications only with respect to recent or noteworthy improvements or precautions.

A little excursion into history reveals some interesting facts. The year 1720 marks the change from dipped to molded candles for stage illumination. This was followed by the lamp with the circular wick, and in 1822, in Parisian theatres at least, by gas. This in turn gave way to the oxy-hydrogen lime-light and in 1882 the first attempt to use electric arc and incandescent

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[1] Dr. A. Neuburger, Scientific American, July 25, 1905.

lights was made in Munich. This change proved very successful, since stronger lighting effects were obtained and the fire risk was greatly minimized, and from this time on the art of stage lighting made very rapid strides. These first lights did not give a fair reproduction of nature, because the rays were unidirectional and not diffused as in natural sunlight.[2] This has been overcome in the perfection of reflectors, which now diffuse the light so as to approach actual sunlight very closely.

The electrical system of a stage must fufill three requirements: safety, efficiency, and simplicity. The first is practically controlled by the National Board of Fire Underwriters, who limit the size of wire to be used and the number of lamps to the circuit. Ordinarily twelve lamps are permitted on a house circuit, but for the stage the board permits twenty lamps where number twelve wire is used. The circuits are all 110-volt and the lamps range from fifty to sixty watts. All temporary unprotected wiring for chandeliers or similar fixtures must be made with stage cable because ordinary cord is too easily cut and does not stand the wear and tear of the stage. This stage cable is the ordinary cord protected against hard usage by an extra heavy insulation, so that even scenery can be moved over it without wearing off the insulation. The cable is usually run from floor pockets on each side of the stage, in order to facilitate the making of temporary circuits.

For most efficient operation and harmonious effects it is essential that all circuits be controlled by one man. This is accomplished at a switchboard located where the operator can have a good view of the stage and actors. Some theatres even go so far as to place the switchboard at the rear of the theatre in order that the operator can get the same effects as the audience and thereby more properly manipulate his circuits.

The switchboard is made up principally of several master switches, a great number of the auxiliary switches and the dimmers. All of these must be arranged not only for safety but for convenience, because the operator is often forced to operate switches simultaneously which are at opposite corners of the

[2] Modern Stage Illumination, Scientific American, April 16, 1910.

board; consequently the distance between switches, in the average sized theatre, must oftentimes be made less than the rules of the Board of Underwriters allow. At the Pabst Theatre in Milwaukee, for instance, such a condition arose, and to make the switchboard electrically safe the electrician placed like poles of adjacent switches in juxtaposition and crossed the bus-bars, which were well insulated, at the back of the board. Another move toward efficiency was made in putting the fuse plugs on the front of the board, in order that they might be more speedily renewed while the act is in progress.

Electric stage lights may be classified in five divisions: (1) foot lights, (2) border lights, (3) ground row lights, (4) stand or bunch lights, and (5) strip lights. The use and arrangement of the first kind is well known. The border lights are rows of lamps permanently fixed in the fly galleries, and the light from this source is directed upon the floor of the stage by suitable reflectors to accomplish certain effects which will be soon explained. The ground row and strip lights perform, to a certain extent, the same functions. The lamps are attached to long strips which can be hung up at the entrances or placed along the floor to prevent the formation of shadows there. The stand or bunch lights, which are used quite extensively, are made from a cluster of lamps which are placed at the center of a conical reflector. The combination is then mounted on an adjustable stand which can be set wherever it is needed.

Every stage, no matter how crude, has its footlights, if it is at all possible to have them. Ordinarily the sockets are on the floor of the stage and the light is deflected down by a reflector. But a much more effective method is to place the bulbs pointing down towards the floor so that the light falls directly on it. There must be, of course, a suitable shield in each case to protect the audience from the glare of the lights. It is best in the footlights not to have too many bulbs on one circuit, so that in case of a blow-out the act should not be entirely spoiled for lack of light.

The footlights and border lights are each made up with blue, white, and red bulbs. By properly blending these colors the operator can produce the various lighting effects for sunrise, sunset, daylight and moonlight. The red mixed with white produces sunrise and sunset; the white alone produces daylight; the blue alone produces moonlight and when blended with white gives the effects of dawn or dusk.

Very marked strides have been made in the reproduction of lightning. The old way of producing lightning consisted in blowing powdered resin through a flame; but the introduction of electricity permitted not only a greater accuracy in this reproduction, but also a differentiation between flash and chain lightning. The flash lightning is produced by striking together two files to which live wires have been attached. The great rush of current due to the low resistance of the files must be limited by means of a suitable resistance coil in series with them. Sometimes a file and carbon are used, but this arrangement produces a very white light which does not so closely resemble the natural flash. Chain lightning is produced with a stereopticon lantern. The light is projected through a metal slider in which are cut zig-zag slots in various positions. These slots are in turn darkened by an opaque shield which is momentarily removed and replaced whenever the flash is desired. To increase the realism of the effect the flash is made to appear at various parts of the stage by changing the position of the slider for each flash.

But the application of electricity has not been confined to illumination alone. It has extended to the electric call, signal, and ventilating systems, and to the releasing of exit doors in case of fire. In one of the Milwaukee theatres the fire risk has been further minimized by controlling the curtain motor by not one but a series of switches. While the starting box is located near the operator's usual station, switches at other parts of the stage and on the fly-floors also control the motor, thus assuring quickness in the lowering of the asbestos curtain.

From this explanation of how the electrician makes the stage both pleasing and safe, let us pass to the method of procedure while a play is in progress of preparation and production.

First of all, the electrician must read the play very carefully before he can make any plans for illumination, for it is essential that the lighting effects harmonize with the colors of the scenery and the costumes of the players. This is in accord with the principle that, if the spectacle is pleasing to the eye, the words and music will be more pleasing to the ear. Let us consider that these preliminary preparations have been made and perfected during the dress rehearsals and then let us consider the arrangement of lighting units for a general case.

The house is lit up at 7:30 and then the stage is set for the first act. Any fixtures and chandeliers needed are connected and set in their proper places. Bunch lights are always used in the entrances, and strips with bulbs on them are hung up on the sides of the wings to equalize the intensity of the light from the border lights in the fly galleries above. Other bunch lights are directed on the back drop to give depth to the scene. Finally,

The Heart of a Gypsy.

if the overhead scene consists of foliage, it is made as realistic as possible by spot lights in the fly galleries to give the effect of sunlight coming through the trees.

The illustration shown of the first act in last year's Haresfoot production gives a good idea of a successful stage illumination. Here we have the conventional forest scene of great depth, with some rocks in the back horizon, a spring among the rocks at the left, and a camp fire at the right. Some light is directed upon the water of the spring, but, as one would expect, the greater portion is in the vicinity of the camp fire. Extra spot lights and strips in that part of the stage produce the desired effect.

The camp fire was the most important part of the scene and it therefore necessarily had to be prepared very carefully. The ingenuity of the designer was well brought out here for the camp fire made a good impression wherever it was shown. The fire consisted of a few small rough tree limbs nailed to a frame resembling a pyramid with its peak removed. The inside of the frame was lined with tracing cloth, which was painted amber at the top, red in the middle, and white at the bottom, the latter to give the effect of ashes. The top of the frame was covered with a screen to which were fastened strips of red and yellow silk cloth. The back was left open so that electric lamps and a fan could be put inside. The fan produced a draft, which made the cloth strips rise and fall like the tongues of flame from a fire. One set of red lamps, visible to the audience between the limbs, appeared like glowing coals; and another set of amber colored lamps hidden from the audience by suitable shields reflected the fire upon the face of the gypsy who sat beside the fire as the curtain went up.

For the conventional ball-room, such as that of the second act, there is no need of shadows or of bright spots, and therefore the whole room must be diffused with light of the same intensity. The only lighting fixtures necessary are the wall brackets and those on the newel posts. A calcium light can be used outside of the windows to give the effect of moonlight, and strips must be placed back of entrances and doors to prevent shadows there.

The development of the stage has been wonderful indeed, but the art might have advanced much further had there been more encouragement and more opportunities for systematic research and experiment. Because the American theatre is so highly commercialized, Europe has offered the only possible field for such experiments. The German Crown has subsidized its theatres and operated them at an actual loss in order to give the public entertaining and educational plays at popular prices. But now with the present devastating war in progress, European productions and research are no longer in existence, and the responsibility for the development of the art lies with America.

A REMARKABLE PRIMARY BATTERY.

By O. P. Watts.
Assistant Professor of Applied Electro-chemistry.

Members of the instructional force of the University are called upon to test all sorts of materials, devices and machines. In some cases information is desired in regard to their composition, value, or efficiency; in others the inventor or promoter of some new device seeks to secure the stamp of approval by the University through a favorable test made by some member of the faculty. To which of these classes the following experience of the writer belongs will be left for the reader to determine.

One evening last winter the writer received a long-distance telephone call asking him to go to a neighboring city and test a new primary battery. A rheostat was constructed suited to its quoted rating of four volts and fifty amperes, the proper instruments were selected, including an additional shunt of low range for the ammeter to be used in case the battery should prove less powerful than represented. Several days later the writer was met, as he alighted from the train, by the gentlemen who desired the test made, and escorted to the court house, where the test had been staged in the court room. The battery had previously been on exhibition, and was apparently the chief topic of interest and conversation in the town. About forty men were present besides the representatives of the battery company, and although nothing can well be more prosaic and dull than a battery test, the size of the audience was practically unchanged for most of the day.

The writer was introduced to the Engle battery and its representatives, and told that he might test the battery in any way he pleased except that the cases must not be opened. The battery consisted of four cells, each $9 \times 3\frac{1}{2} \times 7\frac{1}{2}$ in., sealed in wood cases, all encased in a larger box, so that only the terminals and the tops of the individual cases were visible. The toy motor and miniature lamps, which had been used for demonstrating the power of the battery, were disconnected and the electrical instruments put in place.

The open-circuit voltage was 3.47 volts. The measurements of resistance at 1.5 amperes gave an average of 0.112 ohms for the battery, or 0.028 ohms per cell, which is very satisfactory for a primary cell of this size. A discharge of the battery was then started for the purpose of determining its output and behavior on continuous service for five or six hours. While the test was in progress much was learned about the battery from pamphlets and from a lengthy address by one of the promoters to prospective investors who were watching the test.

It appeared that the Engle battery was the property of and was made by the American Elementary Electric Co. of Washington, D. C., a company chartered by Congress, with an authorized capital of $25,000,000. Several state companies had already been organized with exclusive rights to manufacture and lease the Engle battery to users in their territory, and the purpose of this demonstration and test was to convince people that the battery would do all that was claimed for it, and lead them to invest in the Wisconsin Elementary Electric Company. No Engle batteries were to be sold; but they were to be leased to the users for heating, lighting and cooking. Some of the oral and printed claims follow:

"The basis of the electrolyte is lime. The negative plate is entirely new. The electrolyte and the negative plate are lasting. How many years they will last remains for future generations to tell, as we have never been able to destroy either. The positive plate is an alloy of zinc. When the battery is resting it has a counter electromotive force, which we may call a chemical reaction, by which the hydrogen element deoxidizes the zinc oxide, liberates the oxygen and puts the metal back upon the plate, so that in a ten days run we lose but a fraction of an ounce of our positive plate, and since this plate is 1/8 in. thick and weighs 1 1/2 lb., we compute the lasting period of a positive plate to be from one to three years, and on the assumption that the plate be renewed at the end of each year the cost to be nine cents to each cell. If we use seventy-two cells for a house plant of twelve to eighteen 16 c. p. lamps, the annual cost of running this battery for house lighting will not exceed $7.00 per year, so that we can afford to light and heat houses (hot water circulation) at much less than one-half of the present cost of coal for heating and gas or electric current for lighting. The cost of materials is $0.98 per cell. We now have a house-lighting exhibit at our factory in Washington, to which a wattmeter is attached, recording the number of kilowatts consumed, so that the cost of production, we demonstrate, will be less than one-half cent per kilowatt, as against the present rate for the District of Columbia of 10 cents per kilowatt.

"Patents, chemical and mechanical, have been secured in all leading countries. Organization and incorporation of State Companies, subsidiary to the American Elementary Electric Company, are now being perfected for the purpose of supplying stationary power, light and heat to consumers. No batteries will be released or delivered until the State companies of the United States have been organized and incorporated and ready for business, and all other precautions taken to prevent piracy."

Many testimonials were given, some of which are quoted here, but with the omission of the names of the signers.

"Laboratories of ——— & ———, analytical and consulting chemists. Providence, R. I.

* * * The electrolyte employed, while inexpensive, is carefully compounded and lasts for a very long time; in fact the actual life of the same is at present unknown. It is true, however, that the same electrolyte has been employed for over six months and the same portion is still in actual use. The power of this battery to rapidly recuperate to its full capacity, makes the use of primary batteries for the production of great power possible and practicable.

Signed ——— ———"

"——— ———, Automatic Charging Devices and Battery Service.

Washington, D. C.
August 29, 1913.

* * * My knowledge of your battery satisfied me that it can be readily enlarged to any desired voltage or amperage. * * * The cost of manufacturing and maintenance being so low, will

easily place it in use wherever electric power, heat or light can be used * * *.

Signed ——— ——— ———."

"House of Representatives, U. S.
Washington, D. C., Nov. 28, 1913.

——— ———

My dear Sir:

It has now been my pleasure to make a personal and careful investigation of the new plan of producing electricity as discovered or invented by Gen. Engle and which now bears his name.

The day I was there I met Prof. ——— of the University of ———, who had become interested in this method of making electricity. ——— is the Prof. of Electricity of ——— State University. He brought the University electric appliances with him and made his own tests with the electrical appliances belonging to the State University. He also made tests for me. All tests were entirely conclusive and satisfactory. Engineers and college experts from many states are there daily making tests and investigations of this new method of producing electricity and they all go away singing its praise. * * *

Signed ——— ——— M. C."

"——— ———, Consulting Electrical Engineer,
Washington, D. C.

* * * The Engle Battery is in principle a primary electric cell having new elements from which its revolutionary results are obtained. It is free from polarization; holds its rated load for weeks of continuous operation; recuperates fully when permitted to rest for a period of from six to eight hours, and has a gelatine electrolyte which does not creep, slop, or freeze, and gives off no fumes in operation. There is no capillarity and its internal resistance has been reduced to a point making it commercially negligible. While all of these advantages place it far in advance of any primary cell today, the feature which makes it a factor in the power field lies in its reaction when resting, in virtue of which the destructive salts formed in operation are

broken up, reducing the loss on the positive plate to such an extent as to guarantee a year's commercial operation without attention or renewal.

Signed ——— ———," (A graduate in electrical engineering, 1896, from a well known state university, and since engaged in engineering practice, he has recently resigned his position with the U. S. government to become chief engineer of the battery company.)

A unique property of this battery is its ability to stand short circuits for hours at a time without injury, as shown in the second of the two tests of an eight cell battery which follow:

November 23, 1913.

"Load consisted of nichrome wire.

Current	Volts	Time	Current	Volts	Time
14	7	11:56	9.40	2.76	12:51
9	2.75	11:57	9.42	2.81	1:08
8.2	2.52	12:	9.51	2.82	1:22
8.48	2.70	12:06	9.59	2.86	2:55
9.0	2.70	12:12	9.40	2.81	3:58
9.2	2.74	12:35	9.29	2.75	4:53
9.21	2.75	12:31	9.29	2.75	4:56
9.38	2.75	12:41	0	4.0	4:57

In 26 minutes after the circuit was opened the battery had recovered to 6.95 volts.

November 24, 1913

"In order to further determine the durability of the battery the short-circuit test was made. Open circuit voltage 7 volts.

Current	Volts	Time	Current	Volts	Time
40	0.55	10:03:45	f1	.265	10:13:45
13	.32	10:05:45	8	.20	10:20:30
12	.30	10:07:45	10	.23	10:25:10
11.8	.27	10:10:45	....	....	....

Short circuit here discontinued. In eighteen minutes the battery had recuperated to 6.9 volts.

Signed ——— ———, Instructor in Electrical Engineering, University of ———."

The writer was told by the promoters of the battery that this young man had become so confident in the success of the Engle battery that he had just resigned his university position to join their engineering staff. After returning to Madison the writer verified the truth of this statement through a friend on the faculty of that university.

The writer's test, omitting many unessential readings, was as follows:

Time	Amperes	Volts	Time	Amperes	Volts
10:01	0	3.47	11:01	1.90	0.056
10:02	5.2	1.8	11:15	1.65	0.05
10:04	5	.81	11:25	1.55	0.05
10:15	5	.20	11:30	1.50	0.05
10:25	3.9	.125	11:31	0	2.15
10:35	3	.10	11:45	0	3.17
10:45	2.25	.07	12:05	0	3.40

It was found impossible to draw larger currents from the battery or even to maintain a current of five amperes although the rheostat was short-circuited in the endeavor to do so. The test was stopped at 11:30 when the trifling energy obtainable showed that it was useless to continue it longer. The output of the battery was 3.37 ampere-hours, or 1.22 watt-hours. Since the writer was not allowed access to the plates to weigh them it was impossible to report upon the materials used up. According to Faraday's law the consumption of zinc per kilowatt-hour based on the writer's test would be 29.8 pounds, which at 8 cents per pound would cost $2.39 for zinc alone. The inventor claims however that Faraday's law does not apply to this battery, except on 24-hour service, because it recuperates on standing. Tests by students in our chemical Engineering laboratories have shown the output of a No. 6 dry cell to be between 16 and 20 watt-hours which, at the usual retail price of 25c per cell, is at the rate of $16.60 to $12.50 per kilowatt-hour.

THE BELL TELEPHONE COMPANY

A HISTORY OF ITS ORGANIZATION AND PATENT LITIGATION.

THESIS OF IVAN ADAIR BICKLEHAUPT, B. S. (MECHANICAL ENGINEERING) 1914. *Reviewed by* JOHN G. D. MACK, *Professor of Machine Design.*

This thesis presents rather unusual and contradictory difficulties due on the one hand to its length of 79 pages, with numerous illustrations and tables, and on the other hand to its brevity, for the author has condensed the history, growth and patent litigations of one of the world's largest enterprises in so admirable a manner that further compression seems impossible. The author has a special interest in the subject, having had much practical experience in the telephone work, in which several members of his family are engaged.

The objects and scope of the thesis may best be stated from the preamble and objects of the thesis as follows:

"Thirty-five short years and the art of telephony has grown up into a world-wide activity. Who could have been with Bell in that dingy workshop in Boston, thirty-five years ago, and after hearing the clang of a clock-spring come over an electric wire, would have dared to prophesy the massive structure of the Bell system, built up by half the telephones of the world, and by the investment of more actual capital than has gone to the making of any other industrial association? The very magic of this phenomenal development, the romance of the struggle against public opinion, the science of its inventions, the value of its policies make it a history well worth knowing and interesting in the extreme.

"It would seem that the general history of the telephone system naturally divides itself up into four great parts: invention, patents and litigations, organizations, and accomplishments. It is with these points in view that I have written the following chapters.

"My references were taken wherever I could find them—technical magazines, popular magazines, current newspapers, and books.

"My object in this thesis is not to give a technical description of the telephone instrument or its equipages, nor to run any service tests. It is merely an attempted delving into the past history of the BELL TELEPHONE COMPANY, with the idea of getting a faithful and understandable account of its growth, policies, patents, combinations, and service to civilization."

The subject is discussed under the following heads:

Introduction.
Statement of Purpose of Thesis.
A General History of the Telephone.
A History of the Bell Telephone Company.
A Brief Review of Bell Patents and Litigations.
The Telephone World of To-day.
Summary.

Chapter 1. A General History of the Telephone.

The first suggestion discovered of the possibility of transmitting speech electrically was given in a paper by the French scientist, Charles Bourseul, in 1854. This describes a possible make and break transmitter, which was not confirmed experimentally. The Reis telephone of 1860 which was never advanced beyond the scientific toy stage is described in detail, as is also the House "electro-phonetic-telegraph" of 1868. Gray's experiments in telephony are briefly noted. The curious early invention of the Drawbaugh telephone in 1866 is described in some detail. Although vouched for by many witnesses the Drawbaugh claims were not upheld by the courts. Apparently these early inventors did not recognize the commercial possibilities of electric speech transmission.

The telephone was changed from a laboratory toy to a utilitarian device by the issue of patent No. 174,465, on March 7, 1876, to Alexander Graham Bell. The fifth claim of this patent is probably the most famous single patent claim ever drawn. Several pages are devoted to Bell's early training and preparation for the invention. Following the profession of his father and grandfather, in his earlier years Bell was a teacher of the methods of visible speech to deaf mutes and in this profession he rose to great eminence before he was thirty years of age.

The statement is often made that this led him naturally to the study of electrical transmission of speech. While this was true in his case it was because he was gifted with the scientific vision, and in addition was possessed of the energy and staying qualities necessary to carry on untiring research for many years in the face of constantly repeated failures that he was able to achieve success. This is the lesson that one learns from a study of Bell's invention of the telephone. The invention was not the type which catches popular fancy, a flash of genius due to a sleepless night, but the result of long and arduous scientific study.

The American public did not show in this case its usual quickness to grasp the possibilities of a spectacular invention. Besides being shown at many public exhibitions in New England the telephone was exhibited in working order at the Philadelphia Centennial Exposition of 1876, receiving a statement of eighteen words in the official catalogue. It was unnoticed by the public for six weeks at the centennial when it suddenly burst into uncontrollable scientific fame.

Chapter 2. The History of the Bell Telephone Company.

The author has summarized this chapter as follows in four epochs:

"1. Epoch of Experiment, 1876 to 1886. This was the period of invention in which there were no experts and no authorities. Telephonic apparatus consisted of makeshifts and adaptions. It was the period of iron wire, imperfect transmitters, grounded circuits, boy operators, peg switchboards, local batteries, and overhead lines.

"2. Epoch of Development, 1886 to 1896. In this period amateurs became engineers. The proper type of apparatus was discovered, and was improved to a high point of efficiency. In this period came the multiple switchboard, copper wire, girl operators, underground cables, metallic circuits, common battery, and long distance lines.

"3. Epoch of Expansion, 1896 to 1906. This was the era of big business. It was the autumn period when the telephone men and the public commenced to reap the benefits and fruits of twenty years of investment and hard work. It was the period of the message-rate, the pay station, the farm-line and the private branch exchange.

"4. Epoch of Organization, 1906 to date. With the success of the Pupin coil, there came a larger life for the telephone. It became less local and more national. It began to link together the parts that had previously been scattered. It discouraged the waste and confusion of duplication. It taught its older but smaller brother, the telegraph, to co-operate. It put itself more closely in touch with the will of the public. The keyword of the telephone business today is organization, made necessary by a critical public and strict legislation."

Although the telephone finally aroused great scientific interest at the Centennial, it was not immediately taken up by the public. Sixteen months after the issue of Bell's first patent there were but seven hundred and seventy-eight telephones in use. Shortly after this the patents were offered to the Western Union for $100,000. About this time the affairs of the company were falling into bad condition, in part due to the fact that Edison had invented a more satisfactory transmitter than that of Bell and the Bell lessees were clamoring for a better transmitter. This difficulty was solved by Francis Blake, who invented the Blake transmitter which he sold to the Bell Company for stock.

During this early period the growth of the Bell business is shown by the following table which shows the number of telephones in use:

July 31, 1877	778
Dec. 30, 1877	5,491
July 31, 1878	12,000
March 13, 1879	22,000

In this chapter the development of the manufacture of the telephone and auxiliary apparatus such as cables, signals and switch-boards is discussed and brief sketches are given of the men who led in these lines. The last nine pages of the chapter present a statement of the physical and financial growth of the company, a portion of which is summarized by the author as follows:

"*Subscriber's Stations.*—At the end of the year 1913, the number of stations which constituted the Bell Telephone System in the United States was 8,133,017. Of these 2,717,808 were operated by local, co-operative and rural independent companies or associations having sub-license or connection contracts.

"*Telephone Toll Stations.*—The Bell Telephone toll lines of the United States now reach 70,000 places, from many of which telegrams can be sent.

"*Wire Mileage.*—The total mileage of wire in use for exchange and toll service was 16,111,011 miles of which 1,500,198 miles were added during the year of 1913. Of the total mileage nearly 13,800,000 were exchange wires, and over 2,300,000 toll wires. These figures do not include the wire used by connecting companies. Of this total wire nearly ninety-two per cent. is copper. 8,817,815 miles are underground including 543,923 miles of underground toll wires. The underground conduits represent a cost of $85,700,000 and the cables in the conduits $95,800,000, a total in underground plant of $181,500,000.

"*Traffic.*—Including the traffic over long-distance lines, but not including connecting companies, the daily average of toll connections was about 806,000, and of exchange connection about 26,431,000 for the year 1913. This means a yearly average of about 8,770,300,000.

"*Plant Additions.*—The amount added to plant and real estate by all companies, excluding connecting companies, constituting the Bell system in the United States during the year 1913, was $54,871,856, distributed as follows:

Real Estate	$ 6,109,675
Equipment	16,419,143
Exchange Lines	23,461,226
Toll Lines	8,803,441
Construction work in progress and undistributed Plant	78,371
	$54,871,856

"*Construction for 1914.*—It is estimated that about $56,000,000 will be required for current additions to plant in 1914, of which amount some $25,000,000 will be supplied by existing and current resources of the company.

"*Maintenance and Reconstruction.*—During the year 1913, $70,183,000 was applied to maintenance and reconstruction purposes; of this over $13,000,000 was unexpended for those purposes. The total provision for maintenance and reconstruction charged against revenue for the last ten years was over $457,000,000.

"*Operating Results.*—The gross revenue in 1913 of the Bell System, not including the connecting companies, was $215,600,000. Of this, operation consumed $75,400,000; taxes $11,300,000; current maintenance $32,500,000; and depreciation $37,700,000. The surplus available for charges, etc., was $58,700,000 of which $16,700,000 was paid in interest and over $30,300,000 was paid in dividends.

"The total capitalization of the companies of the Bell System is $1,390,242,470. Of this $620,127,086 is owned and in the treasury of the companies of the Bell System. The capital stock, bonds, and notes payable outstanding in the hands of the public at the close of the year of 1913 were $770,115,384. The net permanent capital obligations of the whole system outstanding in the hands of the public is $724,349,180."

Chapter 3. Bell Patent Litigation.

An enormous amount of patent litigation has centered about the Bell Telephone Company. A portion of the author's summary of this chapter is as follows:

"Since the development and present status of the Bell Telephone Company is due to a great extent to the validity and strength of its patents, it seems fitting that the patent litigation and situation be reviewed. It would be impossible to review completely the enormous amount of litigation that has transpired during the history of this company, or to touch the patent situation more than in a general manner. The Bell Company has spent millions of dollars in legal patent fights and the records of these cases would fill a good sized library. To review the patents would be almost a life's work.

"The appendix of this thesis contains a letter from the United States Patent Office, March 25, 1914, which states that 'approximately 5,976 patents have been issued in class No. 179, Telephony.' This gives one an idea of the number of telephone patents. Perhaps few of these patents have been contested, but on the other hand some of them have instigated great and expensive legal fights, especially the earlier ones.

"In reviewing the patent litigation of the Bell Telephone Company it was very evident that a great many of the legal proceedings occurred either before 1880 or after 1891. This seems logical when it is considered that the original Bell patent was impregnable. This patent was issued in 1876 and immediately drew on a host of claimants who tried vainly to prove that they were the original inventors. By 1881 the decisions of the United States court made it fairly evident that Bell was the original inventor and that all others' claims had been anticipated. This undoubtedly tended to discourage ambitious inventors who thought they were entitled to the credit of the first telephone, and consequently there was very little litigation until about the time that the Bell patents expired.

"During this period of seventeen years Bell maintained an absolute monopoly by means of his original patents. After these expired the Bell Company, organized and powerful, tried to suppress competition by means of smaller and less important patents relative to telephony. They were not especially successful in this litigation, and their success in competition is due more to their power and wealth than to any patent protection which they were able to maintain.

"A thorough study of the patent records during the years of 1876, 1877, and 1879 did not reveal much of importance. The telephone patents were so intermingled and mixed up with the telegraph patents that it was almost impossible to separate one from the other. Bell's first two patents stand out from the others and convey the idea that Bell had actually conceived the idea of transmitting speech by wire whereas the others seemed to follow the idea of the musical telegraph to a greater extent. For instance, most of Gray's early patents expressed the object of transmission of musical sounds rather than the human voice."

The remainder of this chapter gives the essential details of the various great telephone patent litigations.

CHAPTER 4. THE TELEPHONE WORLD TODAY.

This chapter presents a most interesting statement of the place of the telephone in the social and business world of today, rates in various countries and a discussion of government ownership of telephones as applied to the United States. The author gives the following summary of the thesis:

"Telephony is now a recognized industry of the world, comparatively new and yet well developed and organized. This organization is not due to Alexander Graham Bell, or to Theodore N. Vail, or any other man whose name stands for 'Telephony.' It is the outgrowth of many minds and the work of many hands. It is by no means a finished story. The demands of society and civilization are constantly increasing and the telephone business must meet them like all other great public utilities. Telephony can never stand still. It is service for the people and must advance with the people. Twenty years from now the present practice and policies will undoubtedly seem as obsolete as those of 1894 appear to us now."

We are pleased to announce that Professor Mead will write an article for our January issue on his "Trip and Experiences in China." Reservations for copies should be made with the Circulation Managers.

THE EASTERN TRIP OF THE SENIOR MECHANICAL AND ELECTRICAL ENGINEERS.

On Saturday morning, the seventh of November, the party of about thirty-five Seniors, accompanied by three members of the engineering faculty, left Madison for Chicago. The long looked for eastern trip had at last become a reality and the fellows were all feeling fine even though some of them had not slept much the night before.

After arriving at Chicago we were first shown around the new Chicago and North Western Terminal on Madison street. This is claimed to be the most modern railway station in the world and after we had seen some parts of the plant we were satisfied that it really fulfilled the claims. The most interesting thing we saw was the electric interlocking system by means of which all signals, switches, and derails in the yards are operated from one interlocking tower. Next we visited one of the exchanges of the Chicago Telephone Company and, while the operators received perhaps more than their share of the inspection, we found the workings of a large telephone exchange a revelation. In the afternoon we saw the Fisk and Quarry Street stations of the Commonwealth Edison Company. These two steam power plants have a total capacity of 200,000 k. w.

Saturday evening we left on the Michigan Central for Niagara Falls. This trip was not as eventful as it might have been because most of the fellows went to bed early and tried to sleep. Still everyone seemed to be awake when a couple of girls came through our car; even one of the faculty men stuck his head out between the curtains. Anyway, we were all able to get some sleep.

At Niagara Falls we stopped at the Imperial and we surely appreciated the way they feasted us there. After breakfast Sunday we all went down to see the Falls and spent most of the morning in that vicinity. A few saw the Cave of the Winds under the Central fall and some others crossed over to Canada. It was a cloudy and rainy day and the fellows with cameras were sadly disappointed. Sunday noon we had dinner with the Pennsylvania football team and a hundred or more rooters. They were on their way home from Ann Arbor where Michigan had thoroughly beaten them the day before; as a result they could not help feeling blue. Under the leadership of "Bill" Zachow and Harry Stearns we entertained the Pennsylvania party with a few choice selections and they responded with enthusiasm. They were a crowd of good fellows and we felt sorry for them. In the afternoon we took the gorge trip and saw the lower rapids and the whirlpool. On the Canadian side we stopped at Brock's monument on the site of the battle of Queenstown Heights in the War of 1812. It surely is a picturesque place for a battle. On our way back we met "Shorty" with his dollar bill necktie, who makes a business of selling pictures to tourists. That night some of the fellows went to a skating rink, for the sake of amusement we presume, and the rest went to bed.

Monday morning we began the real work of the trip. We were called before daylight and while we then thought that was rather early, in a few days we had become accustomed to such hours. After "Pat" had bought a duster we proceeded to the International Acheson Graphite Company. This is the place where artificial graphite and Carborundum are made in the electric furnace. Next we saw two power plants of the Niagara Falls Power Company. These are the oldest plants at the Falls and their equipment now is not strictly up to date, but it does the work just the same. Our next stop was the International Paper Company, and although we were nearly asphyxiated by sulphurous acid fumes, we learned very much about the process of paper making. We also visited the Shredded Wheat Biscuit Company and spent a pleasant half hour in their modern factory. Their plant is supplied with an abundance of light and everything is as clean and sanitary as it is possible to make it. The packing department seemed to be especially interesting for the fellows and there's a reason.

On Monday afternoon we visited two of the most modern plants at Niagara, namely, the Niagara Falls Hydraulic Power Company and the Ontario Power Company. The former is situated in the gorge some distance below the Falls and has an intake canal through the city of Niagara Falls to a point a mile or more above the Falls. A head of 212 feet is obtained. We cannot help saying a word of appreciation for the entertaining guide at this plant. He was a wonder, for he not only knew his business but also knew how to describe the impressive facts concerning the plant. The Ontario Power Company on the Canadian side has its generating station near the foot of the Horseshoe Fall. The intake is through two underground conduits each 18 feet in diameter. A long tunnel connects the power plant with the distributing station on the bluff overlooking the gorge.

That evening we went to Buffalo and the mere sight of the town seemed to put new spirit into the boys. We stopped at the Statler.

Tuesday morning after the mechanicals had departed for the Buffalo Forge Company the electricals were given an automobile ride around the city by courtesy of Mr. Rich of the Federal Telephone and Telegraph Company. We assume that there are no speed limits in Buffalo judging from our speed. We stopped at two offices to study the operation of the automatic telephone exchange. There surely is no other piece of electrical apparatus that apparently shows as nearly human intelligence as the automatic telephone. Next we went to the substation of the Cataract Power and Conduit Company and found this to be an instructive place. This company gets power from Niagara Falls at 22,000 volts and distributes it to commercial plants in Buffalo. Both groups also visited Wheat's Ice Cream Factory, the largest ice cream plant in the world. The Pierce Arrow Motor Car Company occupied our attention Tuesday afternoon. We were surprised that such a large factory could build only ten cars per day, but it builds for quality rather than for quantity. Among the interesting things we saw were a large number of motor trucks made for use in the European war, and a beautiful limousine being built for President Wilson. That night most of the boys went out—some to see the town, some to go to a show, and the rest to a dance. At eleven thirty we left for Pittsburgh.

Our first impression of the place was a good one but before the day was over we found that it was by no means at its best for the general business depression has had serious effects. We were at the three Westinghouse plants at East Pittsburgh and Wilmerding on Wednesday. It would take a week to see all that there was to be seen here. The Westinghouse Electric and Manufacturing Company is building a number of alternating current electric locomotives equipped with transformers and phase converters, so that with single phase line current three phase induction motors can be used for traction. In the shop of the Westinghouse Machine Company a 30,000 k. w. steam turbine, one of the largest ever built, was under construction. The Westinghouse Air Brake Company has a very ingenious system of test racks by means of which they can test different types of air brakes even better than if the apparatus was actually installed on a train.

Wednesday night a score of Alumni congregated with us at the Fort Pitt hotel for a smoker. There are some loyal alumni at Pittsburgh and we certainly appreciated the way they entertained us that night. After we had heard all the Wisconsin yells from '08 up to date, and had listened to some interesting speeches, the party broke up. We would gladly have seen more of these alumni if we had the chance. It was at this smoker that we made the acquantance of the famous Pittsburgh stogies which later became such a great favorite with "Pat" Hyland.

The next morning we surely hated to get up but there was no help for it. We went through the plant of the National Tube Company at McKeesport, one of the best places we saw on the trip. Here we could follow the entire process of manufacture of steel pipe from the unloading of the ore to the welding of the finished product. According to the official pedometer we walked about six miles on our way through the plant but some of us felt that this figure was much too low. In the afternoon we visited the Mesta Machine Company, manufacturers of large steam and gas engines, and factory and steel mill machinery. Thursday night we took the Erie for Cleveland, where we arrived Friday morning.

The first plant we saw at Cleveland was the National Lamp Works at Nela Park. Three Wisconsin men, M. D. Cooper, '08, A. E. Anderson, '13, and W. L. Brandel, '14, helped to show us around. Mr. Cooper had charge of our entire visit in Cleveland and he made it extremely enjoyable. The plant of the lamp works is nearer the ideal than any other we saw on the trip. The company calls it a University of Industry and there never was a college campus more attractive than the surroundings at Nela Park. At lunch we were guests of the company and they surely treated us well. The mechanicals went to the Brown Hoisting Machinery Company that afternoon and the electricals visited the Willard Storage Battery Company. The latter plant makes nearly all of the storage batteries used in automobiles for starting and lighting systems. Both groups of men next went to the Standard Welding Company, manufacturers of automobile parts. At Weber's cafe that evening we had dinner with some of the Cleveland alumni. Even if they were few in number they still had the Wisconsin spirit and we all had a good time. Friday night we left for Gary, tired as ever but happy because we were on the way home. And that night we really slept.

Gary was better than we expected, but if the sand dunes along Broadway could be covered up it would be still better. Saturday morning we first saw the town and then the Indiana Steel Company. Their plant there covers a few square miles of ground but since they were not working to any extent we did not stop long. Probably the best thing we saw there was the power plant which consists of a large number of 3,000 h. p. Allis-Chalmers, tandem, double acting, gas engines using blast furnace gas as fuel. Some of the power generated here is sent to the cement mills at Buffington. Before we went through the steel plant we nearly got into a bull fight at the entrance gate. It so happened that a big red bull was loitering near the office; when we appeared he naturally came down our way and the manner in which some of the fellows traveled around the corners of the building was remarkable. But under the circumstances there was nothing else to do.

At eleven o'clock we left Gary for Chicago but were forced with reluctance to stop at Buffington and see the Universal Portland Cement Company. For a good dusty place we recommend a cement mill, but as this plant was the last number on our schedule nobody minded a little dust. At any rate, the cement came off without much trouble. We surely did feel good as we left Buffington and we also know that "Bob" felt about one hundred per cent. better for he had been working under high tension during the week.

At Chicago, on Saturday afternoon, the party broke up and most of us left with a feeling of real regret because the big trip was over. We surely got things out of that trip that we could get nowhere else. In the first place, it gave us a much better idea of what we are going to face next June. We saw the practical side of engineering, both good and bad, and every plant we visited made a lasting impression on us. Some of the shops were clean, sanitary, and well lighted with the best of working conditions; others were so dark and dirty that it seemed a crime to make a man work there. Things like this opened our eyes to the actual conditions existing in the industrial field. Then too, the trip made the fellows acquainted with each other and we cannot help emphasizing this fact. We never before knew that there was such a congenial crowd of good fellows among the seniors in the engineering school, but we have found them out. Anyhow, we are not going to forget the big trip—its lessons and and its associations—for a long, long time. It is one of the bright spots in our life at old Wisconsin.

R. H. GRAMBSCH.

Editors' Note: The other trips will be reviewed in the next issue because of lack of space in this one.

MACHINE DESIGN

Mr. J. D. McLean has been appointed to the position of Instructor in this department.

The Madison Kipp Co. has furnished the department a model of one of their lubricators. The Gamewell Fire Alarm and Telegraph Co. has also furnished one of their latest model fire alarm boxes. A small model in aluminum of an automobile chassis has been made by the mechanician's department. The design is by Glenway Maxon, m '14, and shows especially the action of the steering mechanism and the differential.

* * *

It has been hinted at in faculty circles that the only acceptable way to square up your cuts this year will be to show your receipt for the year's subscription to THE WISCONSIN ENGINEER!

The Wisconsin Engineer.

EDITORIALS.

Out in Kansas City they are building a $610,000 viaduct. It is a mile and a half long and is in one place 110 feet high. And yet it is merely an ordinary viaduct that has assumed rather large proportions; it is the method of construction that is striking rather than the size. A Wisconsin man is superintending the work—a man just six years out of the University. And this is the way Harold E. Ketchum is going about it.

At the end of every week he makes out a typewritten schedule covering the work for the coming week, day by day. Every day before the work starts a little red flag is set where the schedule demands the work should stand at the close of that day. And every day that flag is reached, usually by 5:30, sometimes not until 8 or 9 o'clock, and sometimes even as late as 2 or 3 in the morning. But the day's work does not stop until that flag is reached! Each of the flags bears the simple legend "On Time." And so every day as the work is brought even with the flag the long line grows steadily, and every flag in that line is a reminder that the work is "On Time."

Schedules! There is no surer satisfaction than to have left behind an unvarying procession of daily "On Time" flags. There is no surer formula for efficient work than this. The average student procedure is to take a long chance at finding time, and when we do not find it we wonder where it went. We think that we are accomplishing most if we work like madmen the whole day through without definite plan or purpose; we do not realize that we are playing a continuous game of self-deception. Busyness does not always mean accomplishment.

Excuses! We all expect to have to follow a schedule when we get out into our professional life. We expect to because we want to be well prepared to meet competition. But as for the present—well, we are managing to get through our work and that is all we need to graduate. The future will not take care of itself; it depends on the here and now. If we work by guess now we will be apt to use the same rule, to some extent, when we build our viaducts ten years from now. If we work by schedule now, it will by that time be second nature with us, not only to make a schedule but to follow it.

This is leaving out of consideration the immediate results. Do we know at the close of the day whether we dare put up an "On Time" flag? There is no way to tell save to have it down in black and white. Do we knew where we wasted time during the day? There is no check save a definite time schedule. Do we know whether we are doing too much or too little? Do we know whether we are putting a disproportionate amount of time on minor matters? Do we know whether we are sacrificing the physical to the mental or the mental to the physical? These are pertinent questions to every one of us. Can you answer any one of them accurately? We believe a definite schedule worked out in advance of the week's work will answer them.

CHARLES CLARK THWING

DIED JULY 26, 1914.

Charles Clark Thwing was born at Eau Claire, Wisconsin, March 15, 1882. He attended the Western Reserve University at Cleveland, Ohio, during 1903 and 1904, and then entered the University of Wisconsin. He graduated from the University of Wisconsin, College of Engineering (Electrical) in 1906. He was a member of the Delta Upsilon Fraternity and Secretary of the Wisconsin Twin City Alumni Association. Soon after graduation Mr. Thwing entered the employ of the Chicago Telephone Company in the capacity of Superintendent of Construction of Suburban Lines. He remained in the employ of this company for several years. In January 1912, he was appointed to the responsible position of Northwest Manager of the Federal Sign System (Electric) of Chicago, with headquarters at Minneapolis and he held this position up to the time of his death. Mr. Thwing was unmarried and leaves his mother and father and a brother and sister.

CAMPUS NOTES

The first general lecture for engineers was on Wednesday afternoon, October 7. Dr. Horton of the American Steel and Wire Co. presented fifteen stereopticon slides and six thousand feet of moving pictures portraying the manufacture of wire fence, from the ore in the ground to the fence on the farm. The pictures covered practically every phase of the whole process in a very complete manner, and Mr. Horton's explanations made everything clear. The operations around the blast furnaces, the Bessemer and Open Hearth processes, and the final weaving of the fences were especially detailed and aroused very favorable comment.

ALUMNI

We believe we are running an up-to-date alumni section. We are striving for accuracy, absolute and unvarying, in our news, first of all. We are trying to get this section out of the woods and into the light so that it may serve a better purpose than space filling. We wonder if you that are reading this section have noticed any improvement either in accuracy or in freshness of news. We call for the question.

* * *

Mr. Clark Osterheld, e '14, who edited these pages last year, is already distinguishing himself as an engineer. Immediately after graduation he took the position of superintendent of the Municipal Lighting Plant at Stoughton. Since then he has been giving that city a few exhibitions of power plant thrift that have saved the city treasury enough to pay his salary for nine years to come, and his salary is a nice round little sum at that. Osterheld is credited by a Milwaukee paper as being the youngest city plant manager in the state. Some of these days he will be getting directly under our caption "Successful Wisconsin Engineers."

* * *

C. H. Ramien, m '96, is now in the Engineering Department of the City of Cleveland.

B. K. Read, m '06, is General Superintendent of the Valecia Condensed Milk Co., Madison, Wis.

Bryan S. Reid, min '13, is Chief Engineer of the Ironwood & Bessemer Ry. & Lt. Co., Ashland, Wis.

Harry W. Reilly, e '97, has been made Construction Superintendent for the H. M. Byllesby & Co., Chicago, with temporary offices at San Diego, Cal.

B. S. Reynolds, g '09, is now Sales Engineer in the Small Motor Dept. of the General Electric Co., Philadelphia, Pa.

E. A. Richardson, e '10, is chemist for the Niles Glass Works of the General Electric Co., Niles, Ohio.

L. B. Robertson, m '06, is now Superintendent of the Coke Department, Maryland Steel Co., Sparrows Point, Md.

H. H. Rogers, ch '12, has been promoted to Chemist and Assistant Superintendent of Tannery, Hess & Hopkins Leather Co., Rockford Illinois.

H. H. Ross, c '97, e '97, is now Chief Engineer of the Toledo Railway & Light Co., Toledo, Ohio.

W. A. Rowe, e '04, has been made Construction Superintendent for the Midland Construction Co., Ltd., Edmonton, Ala., Can.

W. L. Rowe, g '07, is now Assistant Engineer, U. S. R. S., Meadow Creek Sta., Easton, Wash.

F. B. Rowley, m '05, m e '06, has been made Assistant Professor in Drawing and Descriptive Geometry, University of Minnesota, Minneapolis.

G. G. Ryder, g '07, is now Electrical Contractor with the Twin City Electric Co., Minneapolis, Minn.

W. B. Schulte, ch '10, Ch. E. '11, has been made Treasurer of the Northern Chemical Engineering Laboratories, Madison, Wis.

F. B. Sheriff, m '12, is now Examiner for the Banking Corporations of Montana, Helena, Mont.

A. H. Simon, c '13, is now Instrument man for the C. M. & St. P. R. R., Chicago, Ill.

Allard Smith, e '98, has been made General Manager of the Cleveland Telephone Co., Cleveland, Ohio.

J. E. Smith, c '02, has been made Assistant Professor in Civil Engineering, University of Illinois, Urbana, Illinois.

H. N. Starkey, c '13, is now Civil Engineer for the Grand Trunk Pacific Railroad, Canada.

W. H. Steinberg, ch '13, is Assistant in Chemical Research for the Cutler-Hammer Co., Milwaukee.

E. D. Steinhagen, c '11, is now Civil Engineer and Secretary and Treasurer, Steinhagen & Klinger, Inc., Construction Engrs.

C. P. Stivers, Jr., c '13, is now Associate Editor, "The Contractor," Rand-McNally Bldg., Chicago, Ill.

G. P. Stocker, c '09, has been made Associate Professor of Civil Engineering, State Agricultural College, New Mexico.

M. B. Stone, c '00, is a Consulting Engineer, Minneapolis, Minn.

E. N. Stait, e '06, E. E. '12, is Public Utility Expert for the Wisconsin Railroad Commission, Madison, Wis.

G. D. Swan, e '05, is Secretary of the International Committee of Y. M. C. A., Kobe, Japan.

C. E. Terry, e '11, is now Commercial Engineer for the National Lamp Works of the General Electric Co., Cleveland, Ohio.

W. F. Teschan, m '07, has been made General Manager, Milwaukee Concrete Mixer & Machinery Co., Milwaukee.

F. A. Torkelson, c '11, is now City Engineer, Wauwautosa, Wis.

G. W. Trayer, c '12, is now General Contractor, Secretary and Manager of the La Crosse Steel & Construction Co., La Crosse.

H. A. True, Jr., c '09, as been made Chief Engineer, Carey Act Dept., Office of Comm. of Public Lands, Cheyenne, Wyo.

C. F. Urbutt, c' 09, is Assistant Engineer, C. M. & St. P. Ry., Chicago, Ill.

G. V. Van Derzee, e '08, is now Assistant to the Vice-President, T. M. E. R. & L. Co., Milwaukee, Wis.

A. E. Van Hagen, e '06, E. E. '10, is Traffic Engineer, Central Group of Bell Telephone Co's., Chicago, Ill.

W. A. Van Hook, c '06, is Assistant Engineer, Public Utilities Commission of Illinois.

W. O. Van Loon, c '10, is temporarily farm manager at Midway, Wis.

G. F. Vivian, c '13, is now Road Advisor for the Portland Cement Co., Chicago, Ill.

V. H. Volquarts, m '13, is Assistant Superintendent, National Zinc Co., Kansas City, Kan.

L. E. Voyer, e '11, has been made illuminating Engineer, Edison Lamp Works of the General Electric Co., San Francisco, Cal.

O. O. Wagley, e '05, has been promoted to the position of Manager of the Wells Power Co., Milwaukee.

M. A. Waldo, m '84, is now General Manager and Secretary of the Dominion Phosphate Co., Bartow, Fla.

J. H. Wasson, c '12, has been appointed Junior Civil Engineer, Division of Valuation, Interstate Commerce Comm., Chicago, Ill.

H. K. Weld, g '05, is Salesman for the Chamberlin Co., Chicago, Ill.

SUCCESSFUL WISCONSIN ENGINEERS.

R. F. Schuchardt, E. '97—E. E. '11.

Electrical Engineer, Commonwealth Edison Co., Chicago, Ill.

During the year subsequent to his graduation in 1897, Mr. R. F. Schuchardt worked for short periods in the central station at Janesville, Wis., and in the offices of the F. B. Badt & Company, Consulting engineers, of Chicago.

From June, 1898, to date, Mr. Schuchardt has been constantly in the service of the Commonwealth Edison Company of Chicago. He entered the service of the company as night operator in a storage battery sub-station and was shortly afterwards sent to Omaha to take charge of the company's exhibit at the Trans-Mississippi Exposition. His next position was in the statistical department; within a year he was transferred to the testing laboratories. In 1906, when the first large power units in the Fiske Street Station were started he was given charge of the electrical operating force.

In 1906 Mr. Schuchardt was promoted to the position of engineer of electrical construction and three years later he was made electrical engineer of the company. In the latter position he has had charge of the company's engineering construction, the most important of which has been that of the great Northwest Station, together with the accompanying extentions of the company's immense distributing system.

Besides attending to his duties as electrical engineer of one of the largest and most complete central station systems in the world, Mr. Schuchardt has been active as a member of the American Institute of Electrical Engineers, the Illuminating Engineering Society and the Western Society of Engineers. He is a graduate member of the Wisconsin Chapter of Tau Beta Pi, and is president of the U. W. Class of 1897.

DEPARTMENTAL NOTES

HYDRAULIC ENGINEERING.

Mr. William H. Fowler, a graduate of the University of Texas, was recently elected to the scholarship made vacant by the resignation of A. L. Jacobsen. Since graduation Mr. Fowler has been doing instructional work in the departments of Mathematics and Physics at the University of Texas. He will spend two years completing the work for the degree of Civil Engineer, specializing in Hydraulics.

* * *

The plans for thesis work for this year are already well under way, the greater portion of this work being of an experimental or test nature.

Mr. C. P. Conrad and Mr. L. H. Doolittle will assist Mr. Clement and Mr. Fowler, scholars, in the experimental study of the flow of water over submerged weirs. This is a continuation of the work done by Mr. C. T. Wiskocil, their special problem being to define a region where the downstream head may be measured correctly when the obstruction causing the submergence of the weir is placed at varying distances below it.

Mr. Kendall Bragg, Mr. A. W. Case, Mr. Myron Cornish, and Mr. Lester C. Rogers will test a water turbine of thirty inch diameter under various conditions to determine the energy losses in its gearing and other parts.

Mr. B. E. Anderson, Mr. E. R. Stivers, and Mr. F. E. Witlerding will make comparative tests of three types of low lift pumps used in the drainage of cranberry marshes. Complete determination of the characteristics of the pumps will be made for the ordinary range of operation.

Mr. R. A. Anderson and Mr. H. W. Wesle are experimenting with the Pitot tube. They will compare coefficients for pipes of different sizes to determine the error made when a tube is rated in a small pipe and then used to determine the flow in a large one.

Mr. T. O. Reyes will assist Mr. G. E. Whitman and Mr. E. A. Hewit in a test of a six inch centrifugal pump to determine its characteristics.

* * *

Mr. Byron Bird, graduate student and Research Assistant in Hydraulics, will make a study of gauges used for the determination of small differences of head. A special type of gauge is being devised which will be compared with the fluid differential gauge and with other forms.

* * *

Mr. Clement T. Wiskocil, Research Assistant in Hydraulic Engineering for the past two years, has gone to the University of California as an instructor in Civil Engineering. He writes that he is well pleased with his work and impressed with the cordial reception given to new members of the etaff. Mr. Wiskocil is entitled to additional congratulaticns in that he is to be married next month to Miss Olga Reiner of Madison.

* * *

CHEMICAL ENGINEERING.

Two new instructors have become associated with the department this year. Mr. W. B. Pritz, a graduate in chemical engineering, of the Ohio State University, will give instruction in gas and fuel testing. Since graduation, Mr. Pritz has been connected with the dry battery department of the National Carbon Co., Cleveland, O., where he conducted researches on the manufacture of dry batteries and standard methods of testing their efficiency. While so engaged he also served as a member on the Committee on Dry Batteries of the American Electrochemical Society which has standardized dry battery testing.

Mr. G. W. Armstrong, a graduate in Chemical Engineering, of the University of Michigan, will give instruction in metallography and pyrometry. Since graduation Mr. Armstrong has been associated for some time with the Midvale Steel Co. in the metallographic and heat treatment work. During the past year he has been engaged in Industrial Research at Iowa State College at Ames.

* * *

Mr. R. E. Baker, M. S. University of Illinois, has been appointed Fellow in Chemical Engineering. He is specializing in Applied Electrochemistry.

* * *

Professor O. P. Watts has just published a Laboratory Manual for his work in Applied Electrochemistry.

* * *

The rooms and equipments in the laboratories for pyrometry, metallography, and industrial chemistry have been enlarged and improved during the past summer.

* * *

DRAWING.

Mr. L. J. Markwardt, c '12, comes to this department as instructor in Descriptive Geometry. Mr. Markwardt was with Mr. E. E. Parker, City Engineer of Madison, Wis., for a short time after graduation and now leaves the position of Assistant Engineer, U. S. Forest Products Laboratory, Madison, Wis., to take up his duties at the University.

* * *

UNIVERSITY SHOPS

Succeeding Mr. P. Sladky, who has resigned as instructor in Mechanical Practice to take a position with the National Enamelling and Stamping Co. of Milwaukee, Wis., comes Mr. Wm. K. Sansom, who has held positions as Department Foreman and Assistant Superintendent in several Shops in the Middle West. Mr. Sansom was last with the Capital Heating Station, Madison, Wis. Mr. Sladky resigns after seven years' service in this department.

Mr. H. A. Brunsell takes up the duties of instructor in Carpentry. He has had extensive experience in carpentry and contracting, as well as in architectural drafting. Mr. Brunsell is a resident of Madison.

* * *

MECHANICS

The Materials Testing Laboratory has recently acquired a Dorry abrasion machine for testing the attrition resistance of materials used for floors and pavements.

A small increase in the available space for storage of sand and gravel has been afforded by the erection of a wooden building at the rear of the concrete mixer-house. This building will be equipped with a large number of small bins into which the samples of concrete aggregate secured from various parts of the state may be placed. The additional space will relieve the congestion in the main laboratory and permit a more effective program for carrying on research.

* * *

At the September meeting of the Western Society of Engineers, a partial repart on Permeability Tests of Gravel Concrete was made by Asst. Professor M. O. Withey. In the paper are recorded the results of experiments on about 300 specimens of concrete. The variables reported on include the effects of age, thickness and consistency of concrete, time of mixing, gradation of the aggregate, the use of wet and dry sand, fineness of cement, and the effect of rapid drying in curing.

* * *

The Materials Testing Laboratory besides continuing the program of permeability tests on concrete and the work on concrete aggregates of Wisconsin, is also furnishing assistance in the work of two committees of the American Society for Testing Materials. The tests for standardizing the methods of determining the durability of drain tile, which were begun last year, are still in progress. This work is being done in co-operation with Committee C—6 of the above society. In a similar manner Committee C—9 of the same society will be aided in establishing standard methods of testing aggregates, mortars, and concretes.

We take this opportunity to wish you all a Merry Christmas and a Happy New Year.

Our advertising section is ready to help you make the New Year a more prosperous one. Let us tell you how we can do it.

Readers should not miss the January Issue. Professor Mead will write on his "Trip to China."

The Wisconsin Engineer

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