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The Wisconsin Engineer

JANUARY, 1912

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VOL. XVI JANUARY, 1912 NO. 4

CHICAGO BUILDING FOUNDATIONS.

A. M. WOLF,* '09.

The purpose of this article is not so much to describe in detail the various classes of foundations used in Chicago building construction, as it is to set forth the disadvantages of those types of foundations which, with the advent of the skyscraper, led to the use of the so-called caisson foundations resting on hard pan or bed rock.

The character of the soil overlying the bed rock in Chicago has given rise to various types of foundations. The soil above the city datum in the business district is mostly fill, the grade of the city having been raised from 12 to 15 feet after the Chicago fire of 1871. Below this filled in material is a layer of solid blue clay or hard pan from 5 to 10 feet thick. From this point to a depth of 40 or 50 feet below datum, a blue clay of varying degree of saturation and quality, sometimes mixed with clay or gravel and generally soft and sticky, is found. Below this the clay is hard and firm with occasional seams of gravel and quicksand. This condition prevails down to limestone bed rock which is 80 to 115 feet below datum due to the slight dip of the surface of the rock stratum.

This nature of the soil is an important factor in the allowable bearing value. The Chicago Building Ordinance limits the allowable bearing values upon earth and rock as follows:

"If the soil is a layer of pure clay at least 15 feet thick without admixture of any foreign substance, excepting gravel, it shall not be loaded more than at the rate of 3,500 lbs. per square

* With T. L. Condron, Consulting Engineer, Bridges and Buildings, Chicago, Ill.

foot. If the soil is a layer of pure clay at least fifteen feet thick and is dry and thoroughly compressed, it may be loaded not to exceed 4,500 lbs. per square foot.

"If the soil is a layer of dry sand fifteen feet or more in thickness, and without admixture of clay, loam, or other foreign substance, it shall not be loaded more than at the rate of 4,000 lbs. per square foot.

"If the soil is a mixture of clay and sand it shall not be loaded more than at the rate of 3,000 lbs. per square foot."

The ordinance further specifies that, "Foundations shall be proportioned to the actual average loads they will have to carry, and not to theoretical and occasional loads."

At the outset it may be well to give a short descriptive outline of the various types of foundations in the order of their importance and as they will be more fully described later on.

1. Ordinary wall and pier footings built upon natural soil with the load distributed over sufficient area by means of projections in footings.

2. Walls and columns supported by timber platforms, rafts or grillage resting upon earth.

3. Grillages of steel bars, I-beams, rails or built-up steel girders encased with concrete and resting upon earth.

4. Wood piles driven to bed rock, hard pan or to such a depth as to secure sufficient bearing to loads imposed upon the foundations without settlement.

5. Concrete piles driven or molded in place reaching bed rock or hard pan, or of such lengths as to secure sufficient bearing by means of friction.

6. Caissons as constructed in Chicago by excavating an open well or shaft and curbing it with timber, then filling with concrete.

In New York steel cylinders or caissons of timber or steel are sunk to bed rock by excavating within the shell, which is weighted with masonry and other material as pig iron or steel billets. The pneumatic process is used almost exclusively on all heavy foundations in New York.

The first type of foundation can be used only for buildings of a limited height, say from one to six stories, built on a compressible soil, since a greater load would necessitate very large and expensive footings. These would in most cases be limited in size by the fact that the wall footings cannot be spread on both sides without encroaching upon the adjoining property. This in turn lessens the efficiency of the footing, for in order to secure uniform pressure upon the soil the center of pressure should coincide with the center of the base.

The footings for columns carrying heavy loads must necessarily be large and unless put below the basement floor level, with expense of excavation, will cut down the available basement room.

These disadvantages, together with the inability to provide for settlement which is certain to occur and which is dangerous if unequal, prohibit the use of these foundations for very large buildings.

Timber grillage foundations are limited to temporary work or to work where the timber will always be below the water line. For these conditions a timber grillage is a very satisfactory foundation. In cases where the loads to be carried are comparatively small and in buildings of a more or less temporary character it is an economical type of construction. The World's Fair buildings in Chicago and the Chicago Auditorium are built upon timber grillages. Excessive settlement has taken place in portions of the Auditorium foundations, thus showing that the timber grillage is not satisfactory for very large buildings unless of large dimensions, in which case a steel grillage encased in concrete would be cheaper and would also permit a thinner footing with greater offsets. Not many large buildings have been constructed on timber grillages, since they are unsafe to use unless it is absolutely certain that the water level will always be above them. If it is not, they soon rot out and become worthless.

Steel grillage foundations have been used extensively in many large buildings, especially the earlier buildings of more than ten stories. They were the outgrowth of the plain concrete and masonry footings which in large buildings occupied most of the basement. The steel is put in to stiffen and increase the offsets in the concrete, thereby securing a comparatively shallow foundation. This advance made possible the "skeleton" or cage type of steel construction in office buildings.

The Chicago Building Ordinance defines "skeleton" construction as follows: "The term 'skeleton' construction shall apply to all buildings wherein all external and internal loads and strains are transmitted from the top of the building to the foundations by a skeleton or framework of steel or reinforced concrete."

After the introduction of grillage foundations and the "skeleton" type of construction, the height of buildings increased very rapidly; for it was found that if the column loads were properly distributed over the site, the loads thereon could be increased to within the safe limit of bearing on soil until the entire site was covered by the foundations.

In general the grillage foundations rest upon the upper layer of solid blue clay. Experience has shown that a more uniform settlement takes place if this layer is disturbed least. This type of construction has the advantage over the ordinary plain footing in the matter of basement space, maximum space being obtained without the necessity of cutting deeply into the clay. The weight of the footing is also very much less, being about half that of a plain stepped footing; thus allowing for extra load other than the dead load of the footing. The time saved in construction is a large item, and one that plays an important part in present day construction. The steel grillage also eliminates the difficulty of providing bearing area for party walls attendant with plain footings inasmuch as cantilever footings can be built to carry the wall column loads.

The first grillage footings were steel rails placed in three or four courses at right angles to each other and covered with concrete. It was customary to use 75 lbs. rails and to make each course project not more than 3 feet beyond the course just above. Later steel I-beams were used in combination with steel rails. At present I-beams are used almost entirely in combination with concrete in preference to rails. Concrete reinforced with steel bars is not used for footings for large buildings.

The principal disadvantage of grillage foundation is the almost certain initial settlement followed by a gradual settlement which may at any time increase due to nearby disturbances such as excavation and tunneling. Just what will happen to many buildings when the Chicago subway is built is doubtful, but some settlement is almost certain to take place unless the utmost precautions are taken. Various buildings with grillage foundations have settled from 4 to 10 inches. One of the most striking examples of the results of unequal settlement of foundations is given by the U. S. Post-office and Custom House in Chicago which was built in 1877. The building, although very heavy in some portions and light in others, was built upon a foundation consisting of a layer of concrete 3 ft. 6 ins. thick which was considered strong enough to take care of all the loads brought upon it. The building was a failure having settled 24 inches in places. It was nicknamed the "Ruin" and was replaced about seventeen years ago by the present structure founded on piles.

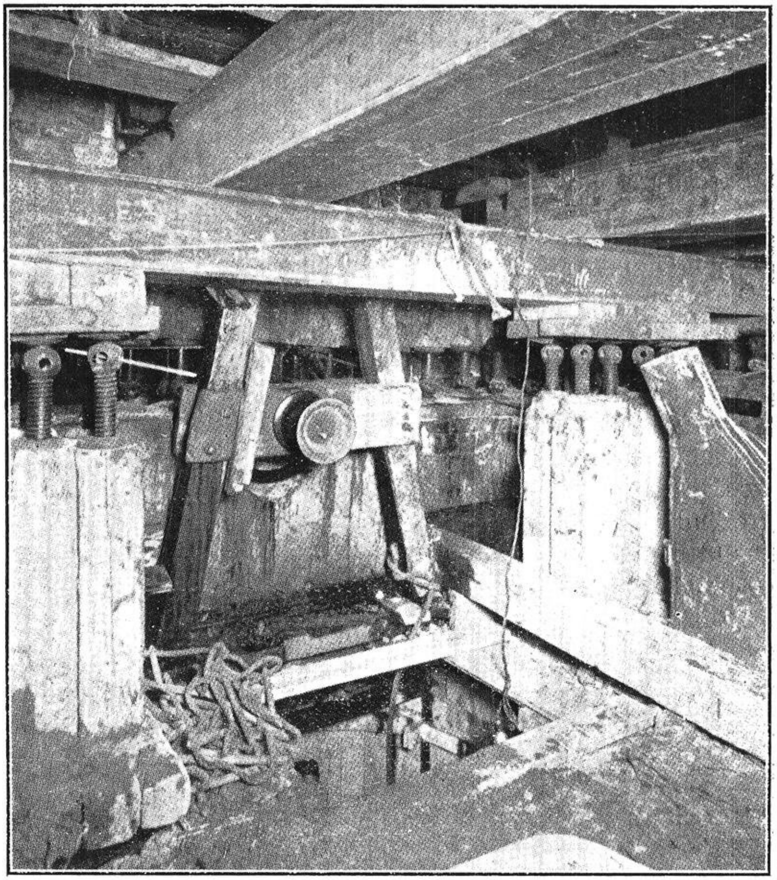
Where there is a possibility of unequal settlement due to the nature of the soil, and the importance of the building does not warrant the expense of caisson foundations on bed rock, piles driven to hard pan or rock can generally be relied upon to bear the loads of moderately high buildings without settlement. They are, however, not suitable in places where the ground water level lies below their tops because of the danger of decay and subsequent settlement of the building.

The Chicago Building Ordinance requires that piles be driven to rock or hard pan, cut off at a uniform level of at least one foot below city datum. The heads of piles must be imbedded in concrete or covered with a grillage so proportioned that in the transmissions of the load from the structure to the piles the stresses in the materials shall not exceed those prescribed by the ordinance. The load on a single pile must not be more than 25 tons. If a timber grillage is placed on the piles the top of such grillage must be at least one foot below city datum.

One of the objections to pile foundations is the fact that in many cases the piles cannot be driven without interfering with adjacent buildings, and if the piles are driven too close together, those already driven may be forced up by the driving of more piles in this manner destroying the bearing value of the foundation. Many times piles are sheared off and seriously broomed by careless driving in an effort to drive them to refusal. The same objections apply to poorly driven concrete piles. Recent methods of molding concrete piles in place do away with these objections to some extent. However, since the shells must be driven with a drop or steam hammer, the displacement of soil caused by such driving is likely to cause settlement in the foundations of adjacent buildings. Concrete piles have not been used for high buildings, possibly for the reason that they are of very recent date and perhaps because they have inherited unjustly some of the disfavor into which wooden piles have fallen. It is only fair, however, to this type of foundation to say that where properly driven and capped below water level they have in most cases given the best of satisfaction. Many warehouses and grain elevators along the Chicago River are founded on piles and even with their constant varying load have given no trouble due to settlement.

Piles have been used in combination with steel grillages with very satisfactory results. In the Fisher Building, built in 1896, short piles about 25 feet long were driven about three feet centers under the grillages to compress the clay and thus permit a greater unit bearing value per square foot on the soil. The direct bearing power of the piles was neglected and the grillages were designed as spread footings with a soil pressure of 6,000 lbs. per square foot, or almost double the allowable value. In another building, where it was necessary to keep the footings entirely within the lot lines, piles were driven in the central portion of the lot up to within 6 feet of either side wall. Upon each row of piles were placed plate girders extending across the lot and upon them cross-beams and column castings. Concrete was used to cover the piles and metal.

Although the disadvantages of foundations mentioned above have done much to bring into use the caisson foundations on bed rock, another factor had much to do with the change. Within the last few years, real estate values have increased so that as much basement room as possible is utilized. With the raft foundations founded on the first firm layer of clay, about 15 feet below street level, deep sub-basements are impossible. Such grillages are satisfactory only when built upon this first firm layer of clay; if cut through there is danger of unequal settlement. This precludes the possibility of four story basements as are now built where caisson foundations are used. Heavy retaining must be built to hold back the earth on the outside when such large basements are built, and if large buildings abut upon the area, these walls must be underpinned or supported upon the new foundation. This could not be done if pile



[Courtesy Universal Portland Cement Co.]

Fig. 1.—*Caisson Construction of the City Hall Square, Theatre Building. Showing old building held up on jacks while caissons were being put in.*

foundations were used, for it would be necessary to drive the piles through 20 or 30 feet of earth which would later be excavated thus reducing greatly the carrying capacity of the piles.

Concrete caisson foundations are then the result of a demand for a type of foundation for high buildings which would have a greater bearing power, would not settle or be injured by lowering of the ground water and would allow safe sub-basement construction. These caisson foundations can be built in open wells and the limit of bearing is the crushing strength of the concrete.

A most important item in building construction, or reconstruction, is the time required. It is often economical to build the foundations for the new building before the old building is torn down, thus obtaining the rent for the old building for a somewhat longer period of time. This is done by jacking up the old building and putting in the caissons before wrecking is begun. This method of procedure was used during this spring, in building the City Hall Theatre. It is readily seen that this method could not be used with any other type of foundation.

The completed caisson foundations are often called "caissons" which is not in keeping with the meaning of the word. They are more truly concrete piers built in open "caissons;" the word "caisson" meaning the form or box in which the piers are built. Before entering a detail discussion on caissons, it would be well to clear up the apparent misuse of the word. The following extract from "Baker's *Masonry*" may help to do this:

"Unfortunately there is an ambiguity in the use of the word caisson. Formerly it always meant a strong water tight box having vertical sides and a bottom of heavy timbers in which the pier was built and which sinks, as the masonry is added, until its bottom rests upon the bed prepared for it. With the introduction of the compressed air process, the term caisson was applied to a strong water tight box open at the bottom and closed at the top upon which the pier is built, and which sinks to the bottom as the masonry is added. At present, the word caisson generally has the latter meaning. In the pneumatic process, a water tight box open at the top is usually constructed on the roof of the working chamber inside of which the masonry is built, this box also is called a caisson. A caisson employed in other than pneumatic work will be called an open caisson."

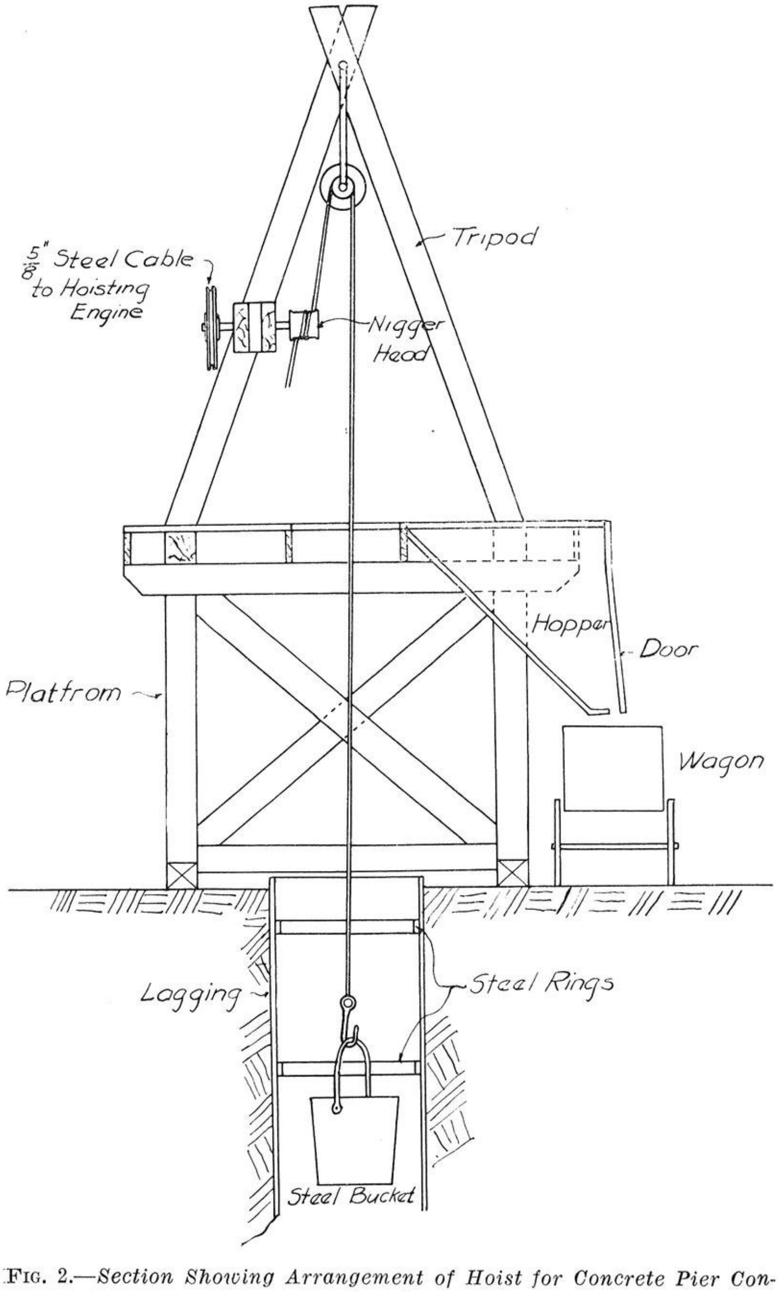


FIG. 2.—*Section Showing Arrangement of Hoist for Concrete Pier Construction.*

CAISSON CONSTRUCTION.

Caissons are in general located in rows across the lot, two alternate rows being worked at a time. The hoists for raising the excavated material from the caissons are set up either on a heavy platform, at street level, covering the entire site, or on the ground at basement level to which depth excavation is usually made before starting the caissons.

The hoists, Fig. 2, consist of a stand about 9 or 10 feet high upon which is placed a tripod fitted with a high "nigger head" on a shaft with an 18 inch sheave. The sheave is operated by a continuous steel cable wound around the drum of a hoisting engine and then around the sheave. Eight to ten hoists are operated in this manner by one engine.

The wells, as they are called, are cylindrical and are dug by successive excavations of from 4 to 8 feet, depending on the character of the soil, and are then curbed with 2x6 inch maple or other hardwood lagging dressed and matched with tongue and groove. Wrought iron rings, generally of ¾x3 inch material, are made in two sections and are placed inside near the top and bottom of each set of lagging to hold it in place and resist the inward pressure of the earth. Where the material excavated is very soft, or if long lengths of lagging are used, three rings are placed in each section. If quicksand is encountered, steel sheet piling or steel cylinders are used to curb the well.

The clay which is excavated by hand with grub axes and spades is placed in the bucket of the hoist and raised to the surface. The material is then hauled to a disposal station where it is dumped into barges and taken out in the lake. The time required to excavate a well depends, of course, upon the diameter of the well and the quality of the clay; but even under like conditions it is a variable quantity. Some caissons of same diameter as the others on the same job require twice as many eight hour shifts of workmen to complete them due to the great variety in the texture of the soil. When the excavation reaches bed rock, the surface of the rock is thoroughly scraped and cleaned and made ready for concreting.

Concrete is poured into the wells either directly from wheelbarrows or carts, or through tremies. The former method is more generally employed, however, the manner of mixing and

[Courtesy Universal Portland Cement Co.]

FIG. 3.—*Caisson Construction at the Insurance Exchange Building, Chicago, Ill.*

placing varies with nearly every job. At the Insurance Exchange Building, in 1911, where 90 caissons of an average diameter of 6 feet, were completed at the rate of two per day, a gravity chute was used as shown in Fig. 3. After placing each successive batch of 6 or 8 feet of concrete, the workmen go down into the caisson and level off the concrete and remove some of the rings supporting the lagging if the pressure of earth is not so great as to deform the caisson when the rings are removed. The lagging is left in place, the pressure of the wet concrete being relied upon to press the lagging firmly against the earth. Concreting is usually carried on continuously, except when the concrete is being leveled and the rings are being removed, until the concrete is brought to the required elevation to receive the column castings.

DESIGN.

Concrete piers built in caissons resting on solid rock are limited only in carrying capacity by the allowable unit stress for concrete in compression. This allowable stress is given by the Chicago Ordinance as 400 lbs. per square inch for 1:2:4 concrete and 350 lbs. per square inch for 1:3:5 concrete. In designing caissons founded on rock, a diameter is chosen such that the concrete at the bottom will not be stressed beyond the allowable amount by the load transmitted to the pier by the column combined with the dead load of the pier itself. The customary load on piers is about 20 tons per square foot. The usual sizes of caissons are from 4 feet 6 inches to 6 feet in diameter, although some as large as 12 feet in diameter have been sunk. Caissons smaller than 4 feet in diameter are little used, as sufficient room for efficient work is not provided. It is cheaper to construct one somewhat larger to facilitate excavation. The prices paid for 6 feet diameter caissons have varied from $12 to $16.50 per lineal foot. Larger and smaller size caissons vary in cost in proportion.

Where caissons go only to hard pan, the caisson is belled out at the bottom in the shape of a frustrum of a cone in order to give sufficient bearing area as determined by the allowable pressure on the clay. The portion of the pier above the bell is of such diameter as to keep the stress in the concrete within the allowable limits. The bells are made of such height as to give a slope of not more than ½ to 1 to the surface of the same. Caissons which are very near adjoining buildings and property lines cannot be belled out as mentioned above, but one or more bells the shape of a frustrum of a rectangular pyramid must be used. These bells or brackets, as they are called, have a width equal to the diameter of the caisson in a direction perpendicular to the lot line and are belled out parallel to the lot line. The projections are generally made equal to about one half the height of the bell, unless reinforcement is used, in which case they can be made greater. Where the load on a caisson requires projections greater than the diameter of the caisson, it is better practice to use two bells, one some distance above the other; thereby cutting down on the size of the projections. Brackets with projections larger than the diameter of the caisson are of doubtful utility in distributing the load.

Caisson foundations, as they are now built, on account of their stability, permanence, rapidity, and reasonable cost of construction and their adaptation to present day methods of building construction, are the ideal foundations for large buildings. Their use in all large buildings under construction is a convincing proof of this fact.

ELECTROPLATING ON ALUMINUM.

O. P. WATTS.
Assistant Professor of Applied Electrochemistry.

The wide-spread use of aluminum in the mechanic arts in recent years has given rise to a problem which is still unsolved, viz: a reliable method of electroplating upon this metal. There are various reasons that make the solution of the problem of general commercial interest. It is often desirable to protect aluminum from mechanical wear by a coating of some harder metal; sometimes the corrosion which occurs under certain conditions must be prevented, and occasionally a plating of some more beautiful metal would add materially to the saleable quality of the manufactured articles. Then, too, the process known as spot welding cannot be used on aluminum, but could an adherent plating of some other metal be given to aluminum, this method of welding could be readily employed.

While it is easy to deposit coherent films of various metals upon aluminum by the electric current, these deposits do not adhere well to the underlying metal, but blister or strip off, either in the process of polishing, or in subsequent use. This action is so characteristic of all electro-deposition on aluminum that one method of preparing thin sheets of various metals is to electro-plate the metal on an aluminum cathode, and strip off the sheet when it has attained the desired thickness. The cause of this poor adhesion is a film, generally considered to be the oxide, upon the surface of the metal, and in the preparation of the aluminum for receiving the deposit especial attention is usually given to securing the removal of this film. Another factor, not generally mentioned, but which the writer believes contributes to poor adhesion on aluminum is its high potential in comparison with that of the metals which are deposited on it. In many cases this results in the deposition of metal by mere immersion of the aluminum in the plating bath, without the application of any external electromotive force. Since such deposits are caused by the dissolving of a quantity of the metals receiving the deposit equivalent chemically to that deposited, it is to be expected that such deposits will be less adherent than upon metals which do not receive a deposit by immersion.

The following are a few of the many processes claimed by their originators to give saitsfactory deposits upon aluminum.

1. Margot's process [1] consists in immersing the aluminum in a solution of an alkali carbonate, treating it with hot hydrochloric acid (1 to 20), and finally immersing it in a dilute solution of copper sulphate to produce a coating of copper, over which any other metal may then be deposited by the aid of the electric current.

It should be noted that this is a case of plating by immersion, and it is not credible that a permanently adherent coating can be obtained by this process.

2. The aluminum is cleaned [2] and the surface roughened in hot concentrated caustic soda, rinsed, and electro-plated in a bath consisting of one volume of nitric acid (sp. g. 1.3) to 17 volumes of a ten percent solution of copper sulphate.

3. A. Fischer [3] states that copper, silver, nickel, zinc, and tin may be deposited electrolytically directly upon aluminum. The metal is cleaned by immersion for fifteen seconds in a ten per cent solution of caustic soda, saturated with sodium chloride, washed, and rubbed with powdered pumice; the original dipping is then repeated for twenty seconds, the metal is scoured with a German silver scratch brush, and dried. Before putting the aluminum into the plating bath it is scoured with pumice, using a bristle brush. The copper bath consists of 100 grams of copper sulphate and 60 grams of nitric acid (sp. g. 1.3) per liter. It is stated that the copper cyanide bath cannot be used on account of its attacking the aluminum. The composition of baths for plating with zinc, nickel and tin is also given in the paper referred to.

This process differs from copper plating on other metals than aluminum in a more careful preparation of the surface, and in the use of nitric acid instead of sulphuric acid in the electrolyte. A study of the aluminum rectifier has shown that

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[1] J. Soc. Chem. Ind. 16, p. 49 (1897).

[2] Metal Industry, May, 1907, p. 152.

[3] Electrochem. Ind. 1, 584 (1903).

a film of high insulating power can be formed on an aluminum anode in a thousandth of a second. It therefore seems unlikely that any process of cleaning outside of the plating tank can secure good adhesion on aluminum, for during the transfer of the cleaned metal to the tank there is ample time for the film to re-form. The use of nitric acid would seem to be of questionable benefit as far as improving adhesion is concerned, for oxidizing agents tend to form this film rather than to destroy it.

4. Burgess and Hambuechen [4] clean the aluminum by immersion in dilute hydrofluoric acid until the surface is slightly roughened, rinse, dip for a few seconds in a mixture of 100 parts concentrated sulphuric acid and 75 parts concentrated nitric acid, rinse, and transfer to a zinc plating bath consisting of the sulphates of zinc and aluminum with the addition of about one per cent of hydrofluoric acid. After fifteen to twenty minutes deposition of zinc, any other desired metal may be deposited. Zinc was found to adhere better to aluminum than other metals similarly deposited, and the inventors of the process suggest that this may be due to the superior alloying power of zinc with alumnium, in comparison with copper, silver, nickel, etc.

There are two novelties in this process:—the use in the plating bath itself of a solvent, hydrofluroic acid, for the film on the aluminum, and the selection of zinc as the metal to be deposited, instead of the copper or silver generally used by others. The writer would suggest that a very probable explanation of the superior adhesion of electro-deposits of zinc on aluminum is to be found in the fact that its potential is much higher than that of other metals used for plating on aluminum. As a general principle this should result in better adhesion of the deposited metal as there will be less tendency for deposition "by immersion."

5. A. Lodyguine deposits copper on aluminum by the use of a copper anode in water to which a few drops of sulphuric acid have been added, using a current density of 0.2 amperes per square foot.

This process evidently depends upon the reducing action of

[4] Electrochem. Ind. 2, 85 (1904).

the hydrogen evolved at the cathode for the removal of the film from the aluminum.

6. F. S. Loeb [5] nickels aluminum as follows: After removing grease, it is dipped in fifteen per cent hydrofluoric acid until there is a vigorous evolution of gas, then immersed five seconds in a solution of 56.7 grams hydrocyanic acid, and 3.5 grams mercurous nitrate in 3,785 grams of water, dipped again in hydrofluoric acid, then plated with copper or silver from the cyanide bath, and finally is given a deposit of nickel.

Although the use of the copper cyanide bath here is contrary to its express prohibition in 3, the previous amalgamation of the aluminum probably prevents its being attacked by the cyanide.

7. The Aluminium Gesellschaft of Neuhausen recommends copper nitrate as a plating bath. This was tested by Langbein and found unsatisfactory.

8. The patented process of Prof. Nees [6] is recommended as the most reliable. This consists in immersing the aluminum, freed from grease, in a solution of lye until gas is evolved, transferring it without rinsing to a solution of mercuric chloride, and finally plating it in the silver bath.

9. E. C. Szarvasy [7] cleans the aluminum with a polishing powder containing fats, and without further preparations, electro-plates it in a bath consisting of the anhydrous chloride of the desired metal, dissolved in alcohol. The purpose of the fat is to preserve the metal from oxidation, and the alcohol is supposed to dissolve the fat and so permit of perfect adhesion of the deposited metal to the aluminum.

10. It has been proposed to plate the aluminum first with copper or tin from a fused electrolyte.

The above examples are representative of the many methods proposed for electroplating on aluminum. It seems as if the mention of aluminum in connection with electro-deposition were fatal to veracity. In spite of scores of claims that aluminum has been deposited from aqueous solutions of its salts,

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[5] Brass World, 4, 470 (1907).

[6] Langbein's Electro-deposition of Metals, 6th edition, pp. 272–274.

[7] Metallurgical and Chem. Eng. 7, 325 (1909).

and the certification by reputable men that this has been accomplished, all experimental attempts of others to verify these claims have failed. With regard to plating on aluminum the situation is somewhat similar. So far as published reports are available nearly all of these processes give unsatisfactory results in the hands of all except their inventors. Under these circumstances the only way to secure definite information upon these processes is by personal experiment. It is hoped that reliable data upon this subject may be obtained in a thesis recently undertaken in the Department of Chemical Engineering of this university.

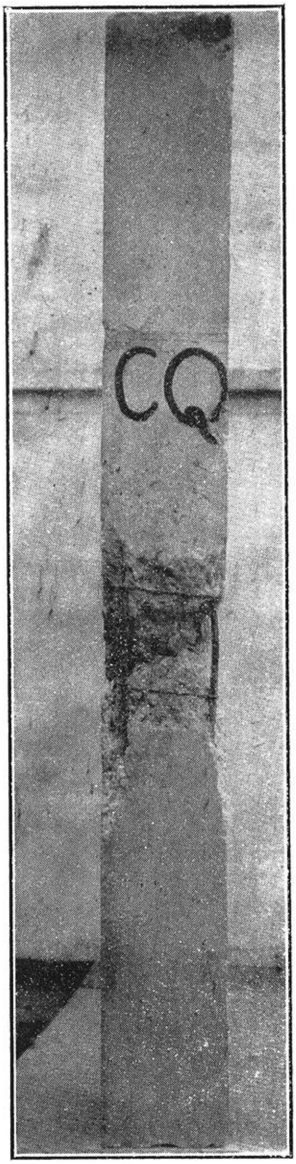
COMPARATIVE TESTS OF SOME REINFORCED CONCRETE COLUMNS.

A THESIS BY F. W. ULLIUS, '11, ASSISTED BY H. E. PULVER, '10, AND L. E. DEQUINE, '11.

Abstracted by S. E. JOHNSON, Instructor in Mechanics.

During the past few years the constantly increasing use of reinforced concrete in structural work has made it necessary that a large number of tests of this material in its various forms be made, upon which to base the design of the structure in which it is to be used. A not inconsiderable part of the testing has been done in the Materials Testing Laboratory of the University of Wisconsin, and the wide publicity given to the tests has resulted in frequent inquiries for information regarding reinforced concrete design. During the years 1909 and 1910 several such inquiries were made for information that might be obtainable relative to the allowable loads on a spirally hooped column *with square core.*

In the usual reinforced concrete structure it is customary to use columns having vertical reinforcing rods at the corners of the columns, these rods being tied to one another throughout their length by heavy wire bands at intervals equal to the diameter of the column, as will be seen in the cut of column C. Q.; or to use one having the vertical rods held at intervals of from one to three inches by a coil of wire wound to form a circular core as shown in column C. A. Columns of type C. Q. are almost always made square because of the economy in construction of the necessary moulds; and the smaller sizes of columns of type C. A. are usually made square while in larger sizes they are made either square or octogonal. In factory or ware-house buildings the size of the columns is not usually a vital factor in deciding for or against the use of reinforced concrete, but in office buildings and in congested centers space is very valuable, and in structures having the framework and floors otherwise of reinforced concrete it is not unusual for steel or cast iron columns to be used because of their small

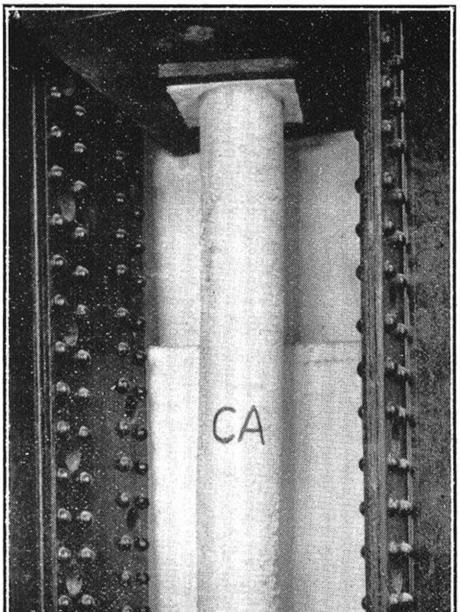


Column Q—Ordinary Square Tied.

size. So it is frequently desirable to know what kind of columns will carry the maximum load for a given diameter. During the spring of 1910 the Gabriel Concrete Reinforcement Co. of Detroit, Michigan, contributed to the University the reinforcement for four of the circular core and four of the square core, spirally hooped columns, and later added reinforcement for four columns with ties, for tests to determine whether there is any advantage in using the square spiral columns because of their small size. It was thought that the results of tests could be made of greatest value if a comparison was made of the strength and the elastic properties of columns of practically the same outside diameter, reinforced in the three different ways.

The cement used in these experiments was Atlas Portland cement, which satisfied the requirements of the American Society for Testing Materials. The sand was of a high grade quality coming from Janesville, Wisconsin, and the stone was a rather soft crushed limestone quarried near Madison. A 1:2:4 mixture was made for all the concrete used in making the specimens, the proportions being by volume, and the material was mixed in a Smith batch mixer. In order to obviate as much as possible the confusion of results caused by the resistance of the concrete outside of the core of the columns, the moulds were made to allow but a thin shell of concrete outside the reinforcement. All vertical reinforcing rods were made of the same length and not more than 1/32 of an inch of concrete was over the ends of the bars. Each column had four vertical deformed Ovoid bars of a total cross section of .935 sq. in. Tensile tests of the reinforcement gave a yield point strength of nearly 50,000 lbs. per square inch for the vertical bars and about 87,000 lbs. per square inch for the spiral reinforcement. From every batch of concrete made, auxiliary cylinders were made for testing to determine the strength and properties of the plain concrete.

About two months after the columns were made, they were tested in the 600,000 lb. hydraulic testing machine. Roller dial extensometers were attached on four sides of the column and longitudinal deformations were measured over gage lengths of about 52 inches, readings of deformation being taken



Column A—Circular Spiral.

for additions of load of from 100 to 500 lbs. per square inch on the working cross section of the column. The general method of preparing specimens and making tests was practically the same as has been more fully described in University bulletins on Columns tests.*

Table of strength and elasticity of columns.

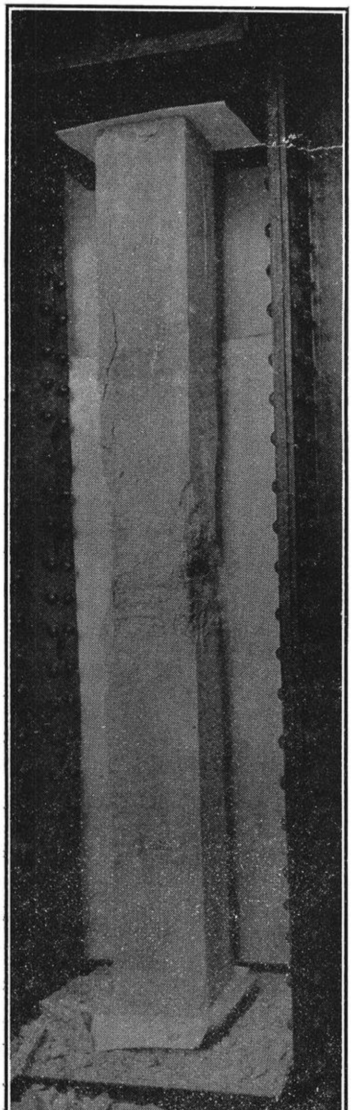
Length of columns: 7 ft. 6 in. Areas given refer to concrete resisting stress.

Column Name		Approximate Dimensions of column	Area of Cross Section	Age in days	Ultimate strength in lbs. per sq. inch	Modulus of Elasticity at a stress of 500 lbs. per sq. in. in lbs. per sq. in.
Round Spiral	A	8½ in Diameter	45.66	63.	4,640	3,230,000
	B	" "	47.17	62	4,000	4,000,000
	C	" "	46.40	62	2,375*	2,500,000*
	D	" "	46.00	63.	4,730	2,860,000
Average		....	46.31	63	4,459	3,360,000
Square Spiral	M	10 in. × 10 in.	71.00	65	3,895	4,000,000
	N	" "	71 00	74	4,060	5,000,000
	O	" "	71 00	63	3,935	4,350,000
	P	" "	71.00	63	3,685	4,000,000
Average		....	71.00	66	3,879	4,340,000
Ordinary Tied	Q	10 in. × 10 in.	60.80	63	3,472	6,250,000
	R	" "	60.80	64	2,611	5,000,000
	S	" "	60.80	66	2,852	5,000,000
	T	" "	60.80	68	2,585	4,340,000
Average		....	60.80	65	2,880	5,150,000

*Not included in average.

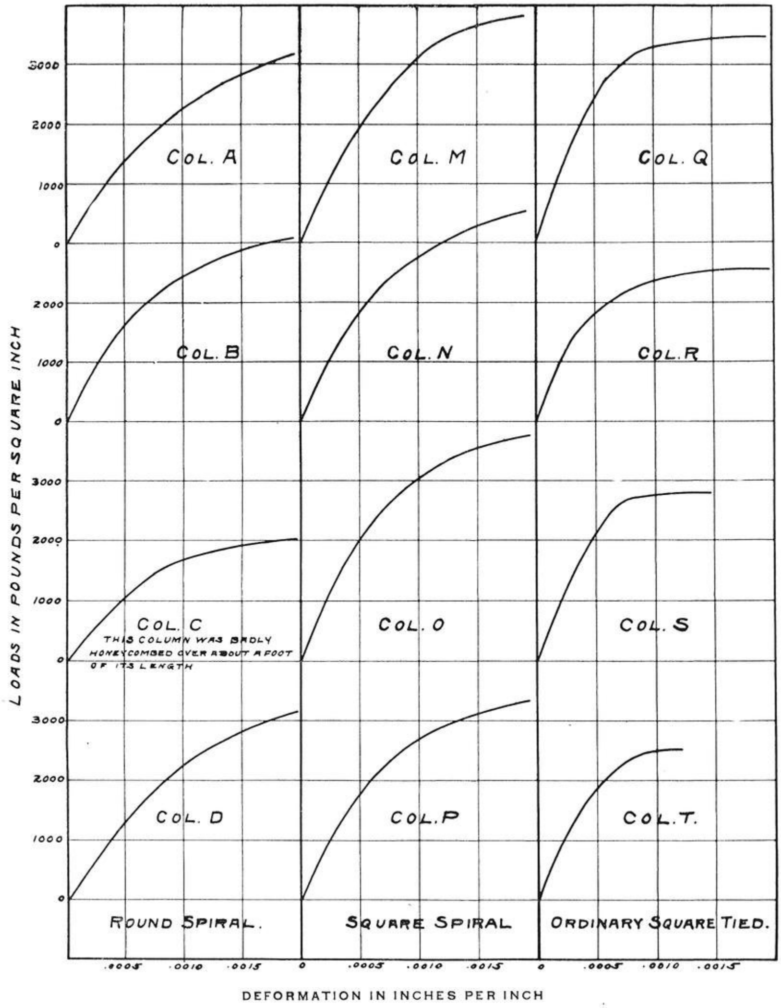
The accompanying table shows the value of the ultimate unit strength and modulus of elasticity for the various columns, while the curves show the deformations with the application of the load. Under load the ordinary tied columns were stiffer than the other types and failure was sudden. The square spiral columns were not quite so stiff as the above and failure was rather gradual, indications of overload being apparent some time before failure occurred. The circular spiral

* Bulletin No. 300—Tests of Plain and Reinforced Concrete Columns. Bulletin No. 466—Tests on Reinforced Concrete Columns, Series of 1910.



Column M—Square Spiral.

columns were the least rigid of the series, and gave indications of failure long before the ultimate load was reached. As was expected, the ultimate strength of the circular spiral column



Stress Deformation Curves for Columns (Partial).

was greatest and that of the ordinary tied column least. The square spiral shows a unit strength somewhat higher than the mean between the other two. If allowance is made for the variation in the percentage of vertical reinforcement due to the difference in cross sectional area of the columns, the ratio of the resistance of the concrete in the square spiral to the concrete in the circular spiral would be nearer unity. So it would appear safe practice to allow a working stress on the concrete in the square spiral column of 80% of that allowed on the circular spiral column. It is fair average practice to allow 500 lbs. per square inch on the ordinary tied concrete column, and 1000 lbs. per square inch on the core of the circular spiral, and hence on this basis it would seem safe practice to allow 800 lbs. per square inch on the core of the *square spiral column*. There would seem to be little gain in column strength by changing from a circular spiral to a square spiral, for while the gain in cross section for a given diameter for the square column is about 30%, the gain in the carrying capacity of the entire core is very small.

NOTES ON THE HISTORY AND DEVELOPMENT OF THE FIRECLAY AND REFRACTORIES INDUSTRY.

FRANCIS T. HAVARD.
Associate Professor of Metallurgy.

It would tax the imagination of the most enthusiastic antiquarian to set a date for the beginning of the clay working era, since even the birds and beasts use clay and earth in their nests and lairs, and we have no doubts that neolithic man was a potter of some skill. It must very soon have been realized by prehistoric man that some of the earthly materials which he found beside the streams lent themselves to shaping into vessels which would hold water. He would quickly have learnt that these vessels became firmer when dried in the sun; that again they rapidly lost this firmness and became soft when filled with water. Later he learnt that the clays could be made permanently firm by heating. Such burnt clay pottery was indeed made by prehistoric man. The discovery of glazing must have been made about the same early time, for often the contact of pot and hot ashes would result in producing a glazed surface on the clay.

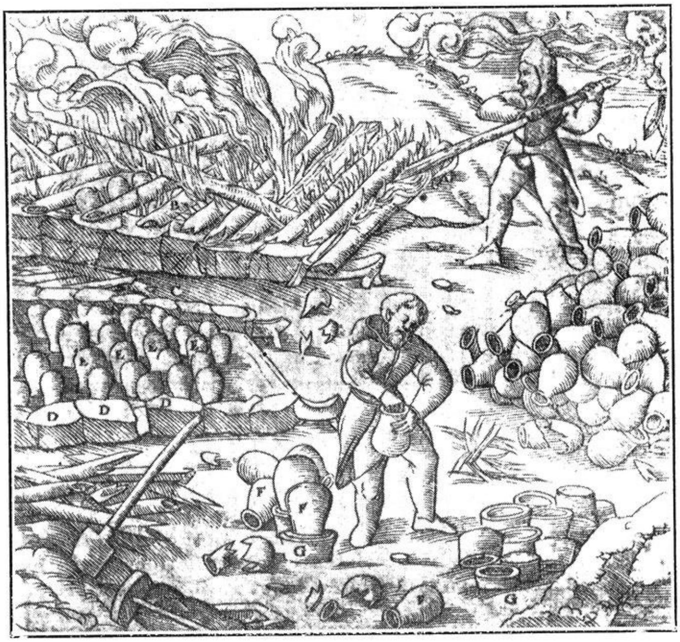
Archaeological discoveries prove that bricks were used in Egypt as far back as 12000 years B. C. The height of a stadium about the temple of Belus, built at this time, was some 700 ft., and a brick wall, eight miles in circumference, surrounded the whole. Some pyramids were made of brick, and one built by King Aeychis bore a stone plate with an inscription to the effect that the brick pyramid regarded itself as towering over the stone pyramids as Zeus over the Gods.

The earliest stone arches carried a brick keystone made from the clay of the Nile. From the old testament we learn that the tower of Babel was built of brick and that the principal occupation of the children of Israel, while in captivity in Egypt, was brick making. Particular attention was paid to the burning of brick and we are told that those in the tower of Babel were especially well burned. Some of the Greeks and the Romans made clay pottery and used bricks of many kinds. These are described by Vetruvius under the names of "Lateres" and "Testae;" the former correspond to our adobes or sun-dried mud bricks and the latter to burnt bricks.

From Rome the mason's art spread over the whole of Europe,

Preparation of Furnace Hearths in the Sixteenth Century. (*Agricola.*)

but brick buildings did not become general until the fourteenth century and it was only in the seventeenth century that the art of the mason and the skill of the brickmaker combined to produce results at all comparable with those of our own day. With the development of the ceramic and metallurgical industries, demands were made for bricks and furnace materials which would stand higher temperatures than had hitherto been used. With the advent of the chemist and the geologist, progress was made in the selecting and the application of those clays which would meet the new requirements both in a physical and chemical sense. Yet the mediaevel alchemist was possessed of considerable information



Moulding and Burning Clay Pots. (*Agricola.*)

of the various clays and cleverly applied them in making fire-resisting retorts, crucibles and furnaces. Agricola describes the methods used in preparing fire-clay retorts and crucibles, and the practice in constructing furnaces. The clay was pugged, moulded, dried and burnt in wood fires. The hearth-furnaces were similar to the cupelling furnaces used at the present time in Germany, in which the movable roof, made of tile nicely fitted to form an arch inside a round angle-iron band, is a special feature.

In the early part of the Christian era, the art of making such pottery was lost. The Moors revived the pottery industry in

Europe, and produced the beautiful glazed ware which derived its name of Majolica, from the island of Majorca.

The manufacture of porcelain dates back to the ninth century and spread from the Orient to Europe, where it reached some degree of refinement in the seventeenth century. In 1710 the Meissen porcelain works were founded and took the lead which they still hold in producing hard white porcelain. From the early times the Chinese manufactured porcelain with a distinctive blue colour under gaze, but Palissy was the first to use manifold and beautiful colours, the application of which made his glazes unique. This art died with him. The art of painting under the glaze reached its perfection in Meissen; Sevres followed close on it's footsteps. Today the so-called hard porcelain is made only in Germany and France to any great extent.

The manufacture of clay wares was introduced into England by Astbury in 1725. A few years later, Wedgewood made the wonderful ware which placed England in the supreme position as a producer of fine serviceable china. Wedgewood made fire resisting white ware, coloured household china, highly artistic and skillfully wrought statuary and decorative pottery. In fact, almost all the beautiful household china of to-day is fashioned and decorated after samples of Wedgewood, and the works, which he founded at Etruria, still produce his masterpieces.

The infusible constituent of porcelain and indeed of all china ware is kaoline. This name is derived from a mountain of felspar in china, which, in desintegrating, supplied such kaolinite suitable for the manufacture of porcelain. The first class refractory bricks and vessels, which are made from clays, contain considerable kaoline and but little quartz; the silica refractories have much silica and little kaoline. Either constituent is fusible with difficulty; together they make a relatively easily fusible mixture.

While in Europe the potter's art preceeded that of the brick maker, in the United States, the reverse is the case. In 1640 some Dutch settlers on Long Island erected both potteries and brickyards. While the brick industry has flourished, the pottery industry has made relatively little progress. The production of clay products ranks as an important industry; its value follows closely that of iron and coal. Yet the makers of good china ware to-day may be counted on one hand. It is in the field of brick, and especially of refractories, that the United States have been close pursuers of the success achieved by England.

The character of the clay brick which was used for general purposes up to a comparatively recent date was not suitable for standing the very high temperatures produced in the furnaces, which it was necessary to build to meet the improved methods of smelting ores and metals. Indeed it was found that some of the more highly silicious natural rocks such as pudding-stone, granite and dinas, or other quarzites were better suited for withstanding the corrosive action of metals and slag at high temperatures. In the case of the cupellation of silver-lead and fine burning of the silver recourse was made to bone-ash, by which is understood the product obtained from grinding bones, washing away the impurities and burning the residual calcium double phosphate. An improvement was made in the first types of open hearth furnace by using a lining of silicious clay, which paved the way for the introduction of bricks made from the grinding of very silicoius rocks and bonding with a small percentage of lime or plastic clay. The first raw materials used for this purpose were the dinas rocks found at Dinasfels in Glamorganshire and ganister, found beneath the coal beds near Sheffield in England and near Dusseldorf in Germany; other preferred materials were the Kieselschist found in especially fine quality in Silesen. Some of the blown sands found near the old Welsh smelting works carry some four or five percent of lime in the shape of minute fragments of shells and these produced a partial fritting of the sand when this was used as a bottom for reverberatory furnaces.

From the earliest times considerable care was exercised in selecting suitable sands for casting moulds. Kampmann in the *Ann. des Mines* gives the following analysis of sands employed for fine casting and states that a good sand for moulds may be artificially made from a mixture of 93 parts fine quartzose sand, 2 parts red English ochre and 5 parts of aluminous earth as little calcareous as possible.

Composition of various casting-sands.

	I	II	III	IV
Silica	92.083	91.907	92.913	90.625
Oxide of Iron	2.498	2.177	1.249	2.708
Alumina	5.415	5.683	5.850	6.667

I. Sand from the foundry of Freund at Charlottenburg. II. Sand employed at Paris for bronzes. III. Sand from Manchester. IV. Sand from the establishment of Lagua near Stromberg.

The sand used at the works of Count Stollberg-Wernigorde, in the Hartz mountains famous for its bronze and iron monuments and large but fine castings, consists of a mixture of two dried and de-hydrated argillaceous sandstone sand from solid sandstone in the proportions namely; one part common argillaceous sand, one part alluvial sand and two parts sandstone sand. The analysis of this mixture showed 79 parts silica, 13.7 of alumnia, 2.4 protoxide of iron, O. & magnesia and 4.6 of potash. Analyses of some of the famous Japanese casting sands show a similar composition.

With the development of the porcelain industry, attention was drawn to the refractory character of the kaoline and other highly aliminous clays. The potteries of Germany and France proved the value of these high grade clays in the use of crucibles and furnace brick.

The early metallurgist Berthier learned the importance of applying these clays for the manufacture of metallurgical furnace brick. Following close on the introduction of aluminous brick came the realization of the value of graphite as material for crucibles and furnace linings. It is interesting to note that a patent No. 767, Jan. 25, 1762, was granted to Wm. White for a "new invention in the manufacture of crucibles for the melting of metals and salts." The specification directs that Stourbridge and Dorsetshire clay are to be mixed with Woolwich sand and water and that the mixture is to be trodden with the feet. The use of coke in admixure with Stourbridge clay in the manufacture of crucibles was patented by Anstey who used two parts of fine ground clay with one of pounded gas coke, and prescribed that the coke was not to be crushed finer than one-eighth of an inch and that the mixture should be worked with water and well trodden. Ansteys pots withstood eighteen successive fusions of cast iron provided they were not subjected to frequent and rapid cooling, and earned for him a prize of a silver medal and the sum of twenty guineas for his invention from the Society of Arts. It was not long afterwards, that an effort was made to substitute plumbage for coke and in 1828 Mr. Charles Sidney Smith was awarded £20 for the manufacture of crucibles composed of Stourbridge clay, coke and plumbage. The process of making these pots or crucibles is described in Vol. 47 of *The Transactions of the Society of Arts*. They seem to have been of an even homogeneous character and of considerable strength and refractoriness. In 1856 Deville made alumina crucibles from a mixture of gelatinous alumina with a proper proportion of calcined alumina and from an intimate mixture of equal parts of alumina and pounded marble. These crucibles when exposed to a high temperature acquired a remarkable degree of solidity and resisted sudden and great changes in temperature. In 1869 bauxite which had been previously analyzed by Berthier was suggested as a raw material for crucibles. It obtains its name from the hill called "Colline des Baux" from which Berthier obtained his sample. Some bauxite in Andalusia had been used by the Moors for the manufacture of terra cotta ornaments but it was not until the end of the '60s that it was used as a lining for furnaces. It is not surprising considering its physical properties, that it has not obtained a wider application for this purpose. Lime crucibles were made at this time, and experiments were conducted by Deville in applying them for smelting; but on account of the reaction of lime with carbon and ts tendency to slag with any silicious or aluminous material it did not obtain a wide field of use. Furthermore the lime crucibles disintegrate when kept for a long time and are unsuted for the melting of iron or iron ores on account of the tendency to form calcium ferrate. Magnesia on the other hand, soon obtained wide and favorable reputation as a refractory lining and was used as far back as 1870 in Bessemer concerters and open hearths. Since that time it has steadily grown in favor and is perhaps today the most favored of all refractories. Hardly less useful than magnesite is dolomite which has been favored by the English and German iron masters as a lining for open hearth furnaces and Bessemer converters. Unburnt limestone, when mixed with clay, has been used as a lining in more recent years to replace the old-fashioned bone-ash and marl, both of which were used in the 18th century, but it in turn has given way to magnesite. It is only within recent years that the high grade magnesite bricks manufactured form Grecian and Styrian deposits have obtained the high reputation they now deservedly enjoy. Within the last twenty years chromite has been used as a refractory material and the lining of many furnaces have withstood long sieges owing to the assistance which chromite brick lent it. by being used along the slag line, as a buffer layer between the magnesite bottom and the fire brick foundation, or between the magnesite lower, and fire-brick upper, furnace walls. Thus chromite prevented the possible agglomeration or fritting of these two materials together. The use of steatite (magnesia and alumina silicate) is a comparatively modern innovation, for use principally in electric furnaces. Perhaps the most recent, or at any rate, the most satisfactory of the more recently introduced refractories is carborundum or silicide of carbon which is produced in an amorphous condition just outside the region of heat at which crystalline carborundum is produced by the combination of silicon with carbon at the intense heat of the electric arc furnace. Carborundum enjoys widespread use both as a protective paint for preserving bricks against acid fume and slag and also in form of bricks made by mixing the fine carborundum with a small quantity of fire clay or lime. Other carbon-siloxicon compounds like siloxicon C_2Si_2O seem not to be as satsfactory sa carborundum, in fact siloxicon changes into carborundum at very high temperatures. Another realm of refractories is found in the metals particularly iron, both cast and wrought, nickel, gold and platinum. Cast iron kettles wear exceedingly well provided they are not exposed to high or sudden changes in temperatures. They are especially useful in metallurgy of argentiferous lead by both the Parks and Pattinson processes. For certain purposes, crucibles of cast and wrought iron are very economical and highly efficient. Platinum finds its greatest use in the chemical laboratory for holding slags and mixtures which are subjected to high temperatures in fusion and in the form of kettles for holding 66 degree sulphuric acid in the process of refining. Finally the manufacture of asbestos mixtures in recent years has enabled us to develop the application of insulating and protective covering.

The Wisconsin Engineer.

EDITORIAL.

It is with some sense of pride that we meet discussions of the various attributes of usefulness and efficiency in our applied scientific work, conceded by public men. We may instance the lively correspondence in the "Engineering and Mining Journal" on "Co-operation in Research Work between Industrialist and University," which was invoked by an article from Mr. R. C. Benner of Pittsburgh. This gentleman selected as examples of university professors who vindicated his claims of the practical value of college research work, Messrs. Nernst, Richards, Van

Hise, Burgess and Cottrell. There can be no doubt that if these, and many other university men, should elect to change their form of activity and become "practical industrialists," society would suffer material loss. Mr. Cottrell—a man of high and practical ideas—has turned over to the Smithsonian Institute, his important invention of the electrostatic deposition of fume and dust, and Mr. Richards has advanced methods of ore dressing more than any operator in the world and has refused to create such emoluments, as would have been his, from patenting his machines. Of the two professors of the University of Wisconsin who are mentioned in this illustrious band, it becomes us not to wax eloquent. Their work is sufficient. Tributes to their service have been paid in many ways and in many tongues.

Wisconsin engineers read with especial sympathy the eulogy given to Professor Burgess by Sir Robert Hadfield on assuming the hood accompanying the degree of Doctor of Metallurgy granted him by the University of Sheffield.

Need we write more! To the wall with you, Sir Captious Critic!

* * *

We cannot too strongly emphasize the wisdom of every young engineer affiliating himself with one of the great national engineering societies. It is not so much in their publications that these scientific bodies confer benefits, as in the fraternal association with professional men. They constitute the parliaments of engineers wherein discussion is never delayed or unduly protracted for political whim, where papers may not be halted for party exigencies, and where the vote of the informed youth may carry the weight of the voice of the oldest member.

The national engineering societies which now offer membership to students deserve loyal support. Engineering students may enjoy most of the privileges of association with such societies without assuming the responsibility and fee of full membership. We believe that similar advantages are derived from the association of students in the various local engineering clubs and societies. Let the student belong to his particular professional club, be a member of the mining club for instance, but he would find his interest and usefulness increased if he also became active in a more catholic society, such as the U. W. Engineers' Club. The "smokers" and other social entertainments of the C. E. Society and the U. W. Engineers' Club are a most useful medium for bringing students of all kinds and professors of all ranks and descriptions into close association. Time, thought and care are demanded in planning these meetings and the officers of the societies are to be congratulated on their success and efforts in the past. May we suggest the possibility of making these meetings the occasions on which all students may join with the faculty in realizing the good spirit existing in the College of Engineering. Let these meetings be organized under the auspices of one of the engineering societies, but best of all, let there be one society in the college in which every kind of engineer would find interest and profit, and let this very catholic society, by skillful proselytizing and advertising, insure the success of at least one meeting of the whole College of Engineering during the year.

* * *

What is "one hour per week," or "one fifth?" "One hour per week," or its synonyms "one credit" or "one fifth," is the unit by which the work of the engineering student of the University of Wisconsin is measured. One hundred and fifty-four of these units are required for graduation. Twenty units constitute a normal semester's work, and the student who wishes to take more than this amount must have an exceptional record and get special permission by vote of the Engineering Faculty.

There exists, however, a remarkable state of confusion as to the interpretation of "one hour per week," and this introduces a variable factor which interferes seriously with the uniformity of distribution of work. One lecture per week, unaccompanied by outside work, appears to be the low limit, while the upper limit approaches and even exceeds six laboratory hours per week. The standard for the Engineering College appears to be "one hour of class room" and two hours in the laboratory, shop or drawing room per week.

The engineering profession is working for uniformity in standards, and this question is therefore pertinent. Why cannot the "one hour per week" be standardized.

We have been fortunate in being able to publish articles which have brought forth most favorable comment. Several of the articles have been reprinted in the eminent engineering magazines. These articles came to us from the members of the faculty and from the alumni. Our pages have lacked in student articles. This defect will be remedied in the succeeding issues. A number of the under graduates are at work abstracting and preparing various valuable theses for publication. In connection with these thesis abstracts we will print original undergraduate articles and wish to encourage more students to become actively interested in the "Wisconsin Engineer."

* * *

THE ENGINEERS' MINSTREL SHOW.

This is the year for the "Engineers' Minstrels." The enthusiasm and keen interest shown at the preliminary meeting points to a "bigger, better than ever" show. At this meeting, William A. Kietzman was elected director, and the following men were appointed to make nominations for the various executive positions: A. M. Bleyer, R. E. Branstad, E. E. Browning, G. W. Trayer, and H. D. Wile.

Mr. Herbert Stothart, instructor of musical dramatics, addressed the meeting and outlined a plan which departs somewhat from the orthodox minstrel show and which will give the engineers more than ample opportunity to demonstrate their ability as entertainers. Mr. Stothart's success as musical director of the *Haresfoot* plays lends assurance that the show will receive hearty public approval.

We urge it upon all engineers to assist to make the 6th Engineers' Minstrel one which will reflect due credit upon the engineers. To accomplish this, it is necessary that besides the "yes, go ahead" spirit there be a host of the more substantial kind. Success will be insured if every one is willing to get into the work with a spirit which will sacrifice time and energy. The plans, as outlined, call for a large cast and we hope that the engineers will make the most of this opportunity.

The first "*Wisconsin Engineers World-Famous Minstrel Production*" was presented by Mr. Storm Bull on March 5th, 1903. Previous to this date the engineers held social gatherings at various times throughout the year to which only engineering students with lady friends and members of the faculty were invited. One of the objects of these gatherings was to encourage the students to sing the typical college songs. The first minstrel show took the place of one of these regular engineering sociables. The financial backing was furnished by the social committee, which made it possible to issue invitations to all engineering students and their ladies. The performance was given at Library Hall to a capacity house.

The next show appeared in 1905 and was followed by one on March 30th, 1906. The success of the third minstrel show gave hopes of having a show annually. The class of 1908 failed to perpetuate this custom and it was not until March 24, 1909 that a complete minstrel performance was given. The class of 1909 made extensive preparations and secured the Fuller Opera house for the event. The remarkable interest shown in this performance did not end with the show, but remained active and was instrumental in the production of another engineers' minstrel show in 1910. During the year 1911 no attempt was made to stage a performance. The time is now ripe for the engineers of 1912 to work for a "bigger, better than ever" minstrel show.

DEPARTMENTAL NOTES.

CHEMICAL ENGINEERING.

The Forest Products Laboratory has donated to the Chemical Engineering department a still which had been in use in investigations on Aurpentines; this piece of apparatus will be erected in the chemical engineering laboratories, where it will be available for investigations on a commercial scale of problems involving the fractional distillation of raw materials for the recovery of valuable products.

The Sarco Fuel Saving & Engineering Company, of New York, has loaned the Chemical Engineering Department a "Beasly Patent, Recording Gas Calorimeter," for purposes of test. The instrument is one of a number that is being tested at the university in connection with the work of the "Committee on Calorimetry" of the American Gas Institute, of which Prof. C. F. Burgess and Prof. O. L. Kowalke are members. It is of interest to note in this connection that the company which loaned this instrument imported it from England, paid the duty on it, and sent it out here for purposes of test.

At the last meeting of the American Electrochemical Society, held at Toronto, Canada, Prof. Burgess and Mr. Aston presented a paper on the "Electrical Resistance of Iron Alloys." Mr. Alvan Hirsch, who received his Ph. D. degree in this department last June, presented the results of his thesis work on "The Production and Properties of Cerium." His perseverance in overcoming the difficulties in isolating this rare metal in considerable quantities, and his subsequent painstaking work on the properties of the metal and numerous of its alloys, were most favorably commented upon, and Mr. Hirsch was the recipient of numerous congratulations. The results have been reprinted in various domestic and foreign scientific periodicals.

Prof. Burgess has been appointed consulting engineer by the recently created United States Bureau of Mines, and will co-operate with them in various problems connected with metallurgical practice. He has also been appointed to the Committee on Corrosion of the American Society for testing Materials.

Prof. Burgess recently gave a talk before a joint meeting of the local section of the American Chemical Society and the American Society of Mechanical Engineers on some problems in the training of chemical engineers.

It is of interest to note that Sir Robert A. Hadfield, upon the occasion of the conferment upon him of the honorary degree of Doctor of Metallurgy by the University of Sheffield, England, in 1911, refers to Prof. Burgess of our chemical engineering department, as among the dozen prominent iron and steel metallurgists of his acquaintance in America. Sir Robert Hadfield is one of the world's authorities on iron alloys, and his efforts and interest were a factor in securing for our university the grant from the Carnegie Institution of Washington, under which much work on electrolytic iron and its alloys was done.

HYDRAULIC ENGINEERING.

During the seven years of existence of this department, many valuable data have been secured by the students doing advanced work in the hydraulic laboratory, but on account of the lack of time and experience, the experimenters have not been able to put their data in form which is available to the engineering profession. A satisfactory analysis and discussion of experimental results and their co-relation with experimental work done in other laboratories can only be made by one of considerable experience in the derivation and use of engineering co-efficients and formulas. In order to make the results of student experimental work available as soon as possible, Mr. Leland R. Balch, B. S. '05, C. E. '09, has been engaged for the winter months to devote his time to the preparation of a number of theses for publication. His first work is in connection with experiments on hydraulic curve resistance in three inch pipe, which he and J. W. Becker, '09, performed in 1909–10.

LECTURES.

During the past month several interesting and instructive lectures have been given to the students of the College of Engineering by outside professional men. On December 4, Mr.

Willard Behan, of the Engineering Department of the New York Central Lines, spoke on the subject of "Railway Location," in which line he has had extensive experience. The lecture was illustrated by various field instruments involved in the work, the use of which was explained by Mr. Behan.

On Friday, December 15th, Mr. Haughton, of the International Harvester Company, gave a lecture, illustrated by lantern slides and moving pictures, on the manufacture and use of harvesting machinery from an engineering standpoint.

Prof. Smith gave a talk on the subject of "Roads and Pavements" on Friday, December 15th, before the Civil Engineering Society. The numerous lantern slides that were shown to illustrate the various elements of roads and pavements helped make the talk a valuable one.

Mr. F. E. Schmitt, B. S. '00, C. E., made a visit to our college recently. Mr. Schmitt is associate editor of *Engineering News*, and occupies a prominent place in the engineering profession of this country.

* * *

Arrangements have been made under which C. E. Pickard, '75, member of the firm of Band, Adams, Pickard and Jacobson, patent attorneys, will give a lecture to the students of the College of Engineering on Friday, Jan. 5, 1912, on the subject of the "Patent Laws and their Application to Engineering Practice."

MINING AND METALLURGY.

During the past fall considerable progress has been made in preparing the ore dressing and assay laboratories for use during the second semester. Power, shafting, pulleys, and belting have been placed to drive the various machines, and the latest addition to the classifying equipment, a Richards-Janney classifier, is now being set up. A Fort Wayne electric rock drill has been added to the already extensive collection of rock drills.

For the metallurgical work pressure reservoirs are being connected to a new battery of gasoline furnaces, and a large American gas muffle will also be in operation. These additions will allow of a large increase in the number of students to be accommodated, besides giving them necessary experience in handling different types of furnaces.

A reverberatory furnace and a high temperature kiln are also being added to the metallurgical equipment for smelting work and special clay testing.

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TAU BETA PI ELECTIONS.

The semi-annual banquet of the Alpha of Wisconsin chapter of Tau Beta Pi was held at Keeley's on November 10th. Covers were laid for forty members of the chapter. The occasion of the banquet was the initiation of the following new members:

Class of 1912—C. B. Bradish, W. E. Jessup, L. J. Markwardt, N. Osann, H. A. Page, L. F. Pope, L. A. Smith, O. G. Ward, F. R. Zimmerman.

Class of 1913—R. D. Hughes.

Professor M. O. Withey acted as toastmaster. Toasts were responded to as follows:

Efficiency .... F. E. Turneaure
Fields of Force .... M. C. Beebe
News from Alpha of Indiana .... L. V. Ludy
Address of Welcome .... E. R. Hoffman
Response .... N. Osann

ALUMNI NOTES.

Edward O. Zwietusch is the business manager of a telephone manufacturing company in Charlottenburg, Germany. He was in the class of 1886.

Two mechanicals are with the Pfister and Vogel Leather Co. of Milwaukee, Henry Geerlings, '03, and Charles Bossert, '88.

Ragner Comer, M. E. '08, is in Panama with the Canal Commission.

A number of graduates in Mechanical Engineering are in railroad work. Some of these with the roads they are with are: Walter Alexander, '97, James Cook, '09, and R. H. Morrison, '03, all with the C. M. & St. P.; R. D. Lewis, '09, with the Great Northern; Arthur Larsen, '05, with the Grand Trunk; Thomas R. Cook with the Pennsylvania Lines, and John Dixon, '00, who is the assistant sales manager of the American Locomotive Works.

Felix Boldenweck, '02, is in the contract department of the Commonwealth Edison Co.

The following is a brief record of some of the 1911 graduates in chemical engineering:

F. L. Wurl is with Armour & Company, Chicago.

A. R. White is with H. M. Byllesby & Co., Chicago, contracting and operating engineers for public utilities plants.

F. L. Themer is with the Patton Paint Co., of Milwaukee.

E. C. Hoag is with the La Clede Gas Co., of St. Louis.

W. T. Cushing is with the Cutler Hammer Co., of Milwaukee.

Of the graduate students:

E. A. Richardson and J. A. Somdal are with the research laboratories of the American Rolling Mill Co. at Middletown, O.

L. T. Richardson is with Armour & Co., Chicago.

L. C. Turnock has been appointed instructor in electrochemistry at Pennsylvania State College.

Of the 1911 graduates in Civil Engineering:

H. M. Anderly is with the United States engineers at Rock Island, Ill.

W. C. Ball is assistant engineer with the Keystone Glue Co., of South Milwaukee, Wis.

J. H. Barth is with the United States engineers at La Crosse, Wis.

H. M. Beebe is draftsman with the Link Belt Co. at Chicago.

J. B. Bingham is engineer with John I. Blake, contractor at Madison, Wis.

Albert Birch is with S. Birch & Sons, contractors, Fargo, N. Dak.

H. N. Brue is with the Fuller & Johnson Mfg. Co. at Minneapolis, Minn.

C. R. Burt is surveyman with the U. S. Land Survey at Sheepshead, Nev.

W. H. Curwen is on irrigation work at Lamor, Colo.

J. R. Iakisch is with the U. S. Reclamation Service at Babb, Mont.

M. C. Koenig is with O. H. Bassert Co., contractors, Milwaukee, Wis.

J. W. Lowell, Jr., is draftsman in the Bridge Dept. of the Illinois Central R. R. at Chicago.

Andrew Ludberg is inspector for the city of Madison, Wis.

Carl Lueders is engineer with the LaClede Gas Co., at St. Louis, Mo.

A. E. May is with the United States Reclamation Service at Powell, Wyo.

G. H. Nickell is with the United States Engineering Corps at Dubuque, Ia.

E. J. Paulus is draftsman with the McClintic-Marshall Construction Co., Pittsburg, Pa.

E. L. Pflanz is with the State Railroad & Tax Commission, Madison, Wis.

W. A. Reinert is instructor in Applied Mathematics, Ohio Weslayan University, Delaware, O.

J. P. Schwada is with the State Railroad & Tax Commission, Madison, Wis.

D. P. Dale is office engineer with Houston & Mead, Memphis, Tenn.

L. E. Dequine is with the Madison Gas & Electric Co., Madison, Wis.

C. W. Esau is Asst. Dept. Mgr. with Gueder, Paeschke & Frey Co., Milwaukee, Wis.

C. R. Fisher is surveyman with the U. S. Land Survey, Sheepshead, Nev.

A. F. Goeke is with the Bridge Department of the Great Northern Ry. at St. Paul, Minn.

C. M. Halseth is draftsman with the Interurban Construction Co. at Hastings, Minn.

W. A. Hatch is with the United States Engineering Corps at Rock Island, Ill.

P. H. Hintze is county surveyor of Dane County at Madison.

F. J. Hoffman is inspector with the city of Madison.

W. R. Holmes is draftsman with the Canadian Northern Railway, Nipigon, Ontario, Canada.

W. L. Schwalbe is engineer with The Milwaukee Electric Ry. & Light Co., Milwaukee, Wis.

E. D. Steinhagen is with Gustave Steinhagen, civil engineer, Milwaukee, Wis.

F. A. Torkelson is with the State Railroad & Tax Commission, Madison, Wis.

F. W. Ullius is inspector with the Starke Dredge Co., Oconto Harbor, Wis.

Of the 1911 graduates in Electrical Engineering we find:

J. F. Alexander is with Wagner Electric Co., St. Louis, Mo.

C. O. Bickelhaupt is with the American Telephone & Telegraph Co., New York City.

C. W. Borecky is cadet engineer with the Denver Gas & Electric Co., Denver, Colo.

G. P. Cowan is with Nat'l Electric Lamp Assn., Cleveland, O.

Ernest Geltch is instructor of Physics in the high school at Grand Rapids, Wis.

L. E. Glover is assistant in Electrical Engineering at the University of Wisconsin, Madison, Wis.

E. H. Handy is with the Chicago Telephone Co., at Chicago, Ill.

K. R. Hare is apprentice with the General Electric Co., Schenectady, N. Y.

E. V. Hills is with the Utah Fuel Co., Somerset, Colo.

J. A. Hoeveler is with Vaughn & Meyer, consulting engineers, Milwaukee, Wis.

F. P. Hutchinson is with the Cutler-Hammer Co., Milwaukee, Wis.

H. F. Ilgner is apprentice with the General Electric Co., Schenectady, N. Y.

M. Johnson is apprentice with Westinghouse Electric & Manufacturing Co., East Pittsburg, Pa.

E. A. Kalsched is with the Chicago Telephone Co., Chicago, Ill.

A. D. Keller is apprentice with the General Electric Co., Schenectady, N. Y.

W. B. Kemp is with the Traffic Dept., Chicago Telephone Co., Chicago, Ill.

H. H. Kerr is with The Milwaukee Electric Railway & Light Co., Milwaukee, Wis.

H. Koenig is draftsman with A. O. Smith Co., Milwaukee, Wis.

J. E. Lauderdale is with the Traffic Dept. of the Chicago Telephone Co., Chicago, Ill.

F. H. Lawrence is with the Chicago Telephone Co., Chicago, Ill.

J. N. Lightbody and J. B. Whelan are with the Westinghouse Electric Mfg. Co., Pittsburg, Pa.

Jas. Mainland is assistant in Electrical Engineering, Ohio State Univresity, Columbus, O.

B. E. Miller is assistant in Electrical Engineering at the University of Wisconsin, Madison, Wis.

W. U. Murrish and A. G. Oehler are with the General Electric Co., Schenectady, N. Y.

S. R. Shapiro is with the Commonwealth Edison Co., Chicago.

S. W. Stanley and L. E. Voyer are with the General Electric Co., Harrison, N. J.

C. E. Terry is with the Nat'l Electric Lamp Assn., Cleveland, O.

G. L. White is with Mitchell-Lewis Co., Racine, Wis.

W. R. Woolrich is instructor in drawing and mechanics at De-Paul University, Chicago, Ill.

COALS AVAILABLE FOR THE MANUFACTURE OF ILLUMINATING GAS.

From JOHN L. COCHRANE, Bureau of Mines, Washington, D. C.

With the idea of finding coals throughout the United States available for the manufacture of illuminating gas in order that they may be substituted for the higher priced and rapidly vanishing Pennsylvania gas coals, the Federal Bureau of Mines some time ago completed a series of investigations which have just been embodied in a bulletin entitled, "Coals Available for the Manufacture of Illuminating Gas."

The authors are A. H. White and Perry Barker. In a statement of the investigations prepared by Herbert M. Wilson, engineer-in-charge of the Pittsburgh Experiment station of the Bureau, the following is said: "In a consideration of the various means whereby more economical and more efficient use may be made of the fuels of the United States, the possibility of obtaining other and cheaper fuels than the Pennsylvania coals for the productions of illuminating gas demands attention. For the government, as well as for private corporations and the householder, there can be no more economical and efficient way of using coals than through the medium of illuminating gas. In addition, the coke that remains after the gas has been recovered furnishes a smokeless fuel that has about the same heating value as anthracite coal. Hence any investigations that will indicate how local coals through proper treatment may be substituted for the higher priced Pennsylvania gas coals will bring about lower prices for both gas and coke and will also aid to conserve for use in metallurgical processes the coking coals of Pennsylvania and other states.

"The annual drain on the gas-coal resources of this country and the importance of the gas and coke industries are indicated by the fact that 8,390,129 tons of coal are carbonized in retorts in the United States in 1909. The resulting salable products from by-product ovens were 15,791,230,000 cubic feet of coal gas, 6,254,644 tons of coke, and 60,126,000 gallons of tax. The total value of all by-products was about $28,508,637."