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The Wisconsin Engineer

APRIL, 1912

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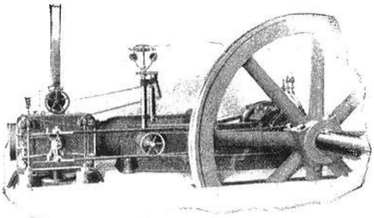

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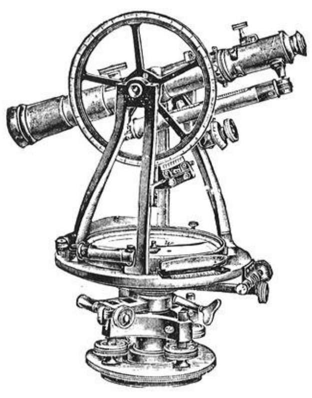

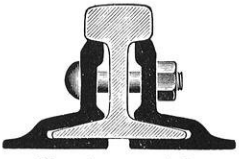

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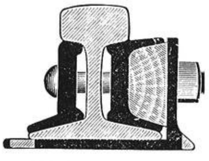

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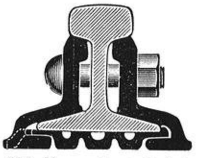

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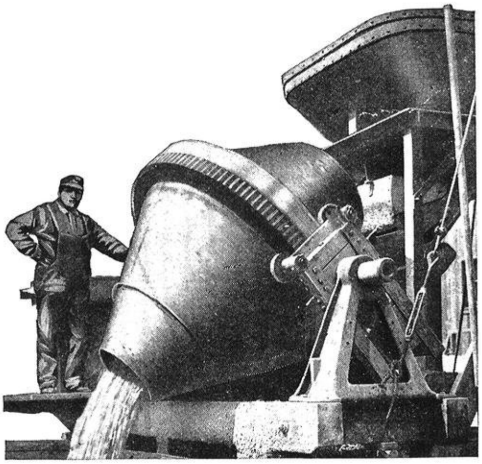

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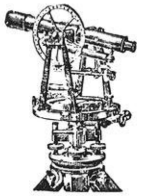

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The Wisconsin Engineer

VOL. XVI APRIL, 1912 NO. 7

STUDENT LIFE AT THE GERMAN TECHNICAL SCHOOLS.

A Letter from CARL C. THOMAS.
Professor of Steam Engineering.

*To the Editor of The Wisconsin Engineer:**

During the past year I have visited a number of the technical schools of Europe, and have had opportunity to observe somewhat closely the work done at one of the best German institutions. The first thing which would naturally, I think, impress an American is the absolute freedom of both students and professors. An excellent preparation is required before a student is admitted,—in some cases a year's work, also, in some engineering establishment, but after he is once enrolled, he is left absolutely to his own devices. Lectures are given regularly at appointed hours, and he may go, or may not go as he chooses. There are no reports, no quizzes, no embarrassing questions of any kind to interfere with the students' perfect enjoyment of life. This is obviously not without its advantages also from the instructors' standpoint. An examination is given, a problem to be worked, also, at about the middle of the course,—that is, after two years' work is completed, for the length and arrangement of the course is very similar to ours,—and again at the end of the course, but a student may take as long as he chooses before presenting himself for an examination, and he may repeat courses as often as he likes, or elect different courses. Students have been known to remain

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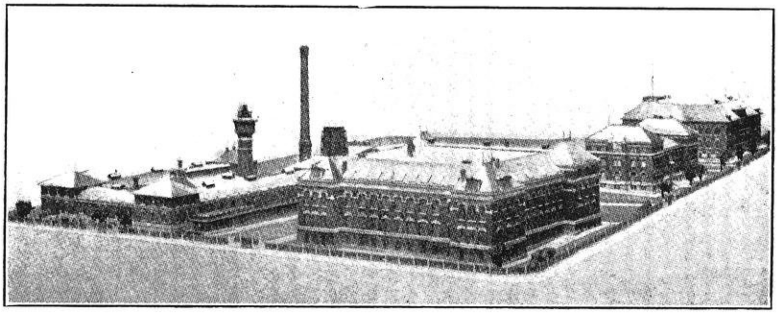
* This letter, received from Professor Carl C. Thomas, who is on leave of absence and is visiting Germany, presents his observations of student life at German technical schools.

in the German universities, or in the Hochschules, for ten years, —they liked the life!—and it is also possible to finish in less than four years.

Richard Wagner, in his Autobiography, tells of his entering the University of Leipzig, immediately joining one of the "corps"—which take the place of our fraternities—making arrangements for nine duels, spending some weeks in a whirl of dissipation, and then it occurred to him one day, he says, to go to one of the lectures. He chose one in Philosophy, but found it uninteresting and never went again. A second choice was more fortunate; he went a few times, but did not complete the course. Wagner was full of the eccentricities of genius and could not be expected to be an average student, indeed he soon left the university and devoted himself to music, but the same conduct is quite possible now. On the other hand, the earnest student can get what he wants, and can forge ahead without being hindered by any less able members of a class. During lectures questions are not customarily asked and the professors do not expect to devote outside time to students, although this is left entirely to the option of the professor. The members of the faculty are absolutely free to conduct such research work as they may desire. That work is not usually carried on in connection with the student, as is done in our laboratories, but it is done almost entirely by the officers of instruction. Our system of allowing the students to assist so far as possible in the investigations made in the laboratory would seem to have



The Technical High School, Dresden, Germany.

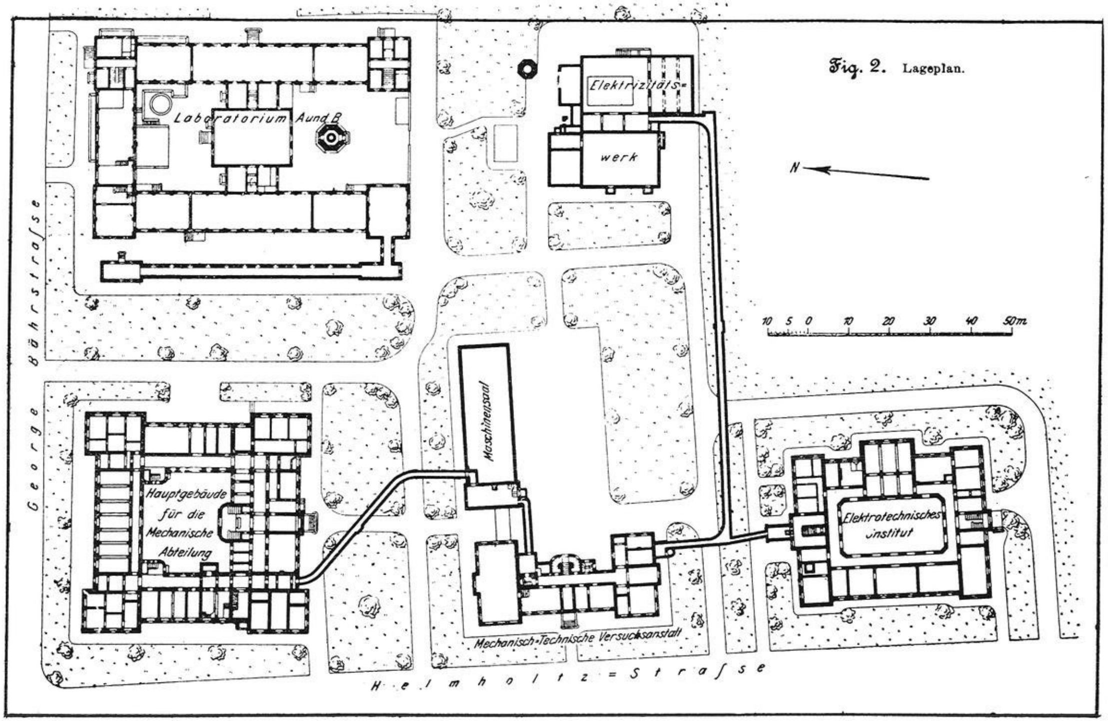


Fig. 2. Lageplan.

Ground Plan of Technical High School at Dresden, Germany.

its advantages. Of course advanced students in the German schools are encouraged to do research work and may at times assist members of the faculty in such work.

The question naturally arises as to the result of the methods. The streams of knowledge flow for those who thirst, but an American undergraduate, who frequently thirsts for so many things more than for knowledge, would perhaps miss the suggestive hints to study. The excessive freedom and absence of personal assistance from the professors, together with an inadequate knowledge of the language, certainly act as a decided handicap to many American students coming here for work. Also, frequently an earnest student misses a great deal of the force of a course of lectures from some slight misunderstanding early in the work, which a little help would clear up for him. Apropos of this, I was in a cafe recently, and an attractive looking young man came over to my table to borrow a newspaper. He was a graduate of one of our less well known colleges, and had come several months before to study in one of the German technical schools. I asked him if he had sufficient command of the language to get all that was said in the lectures. He assured me, "O yes, I get along first rate." Soon after, he said, "By the way, I want to ask you what does the word *"Steurung"* mean? I'm taking a course where the professor uses that word an awful lot."

I said, "Why, that means 'valve-gear.' "

"Oh," he said, "of course, *that's* what he's talking about! Valve-gears!"

But for Germans, the system evidently works. The engineering students are a sincere and well-prepared lot of men, and their attitude towards their work is, as a whole, much the same as obtains among students in America. It tends, perhaps, to educate very completely a few picked men for high technical positions, rather than to prepare great numbers. The professors, due to the time given them for research and study, are very learned men, and are very highly honored in the nation. Germany is, as a whole, an educated nation, and perhaps Saxony leads in this respect. I believe statistics show that Saxony leads the world by a very large percentage in the number of men who have been honored by two or more of the world's great learned societies. The students, moreover, are well informed on all subjects. Not, perhaps, because they are students, but from national characteristics. They have the *habit of reading*. They know and talk about political conditions in all countries, including our own. They are familiar with the literature, not only of their own, but of several other languages. An American young man is seldom able to converse with mature people. He can talk,—talk about football, athletics, the affairs of his college world,—but he does not, as a rule, *converse*. A foreign youth can discuss almost any subject of art, music, literature, or world events, very intelligently. There are countless lectures given in every German city, on all sorts of subjects, from the eye, or anatomy, to astronomy, and these are often two hours, or even more, in length, and in general well attended. They are not at all connected with the universities, however,—simply for the public. In that connection I may add that I never saw Shakspere so well given as here. One or two plays are given each week and almost every time the seats are all sold in advance. As for music and opera, almost any workman can whistle the airs of the best operas, or discuss classical music with you. So that it is small wonder the students have a large fund of general information.

As to social life among the students, so far as I can learn there is very little of the sort of life we have in our colleges. Athletics plays very little part in the student life. There are various athletic or "sport-clubs" in each city, and in a university town many students are likely to be found among the members. Football is quite largely played in Germany between teams from the various sport-clubs, and often games are played between teams representing different cities.

The social life of students, apart from their friendships, consists principally of the meetings of the various student "corps," for purely social purposes, or in connection with duels between the members of different corps. There are other more general meetings for social and convivial purposes, called "Kommers."

At these the students sit at tables, each society at its own table. Speeches are made, some by students and some by members of the faculty, often enthusiastically applauded by striking the table with sabers or steins, or both.

Torchlight processions frequently celebrate important events, or holidays, feast-days, etc. During the recent carnival in Dresden, just preceding Lent, the students of the Hochschule took an important part in contriving various humorous floats and other features of the parade, and were much in evidence among the many masks and fancy costumes.

In regard to equipment, the engineering schools here have excellent machinery and apparatus, and large amounts of money and effort are spent on the investigation of engineering problems. The results of these investigations are published and circulated most extensively, and are of great value to the engineering world. For American students, however, I believe that the equipment, methods of teaching and opportunities offered to students, are fully as adequate and complete in our country as in European countries, and are probably better adapted to the education of prospective American engineers. Of course, after graduating from a technical school in any country, a man can profit greatly by visiting and observing the industrial conditions and methods of dealing with engineering problems in other countries. If one is aiming to be a specialist in some particular line, he may find that a post-graduate course can advantageously be taken in some country other than his own.

Just a word to the Senior Engineers. I am sorry not to have known you as seniors. We can't all enjoy the privileges of close association and at the same time travel around in foreign countries! I understand that you have proved to be a class worthy of the best traditions of Wisconsin. You are going out to grow into honored places among a large and successful body of alumni. First of all, let me urge you to try to make yourselves experts in your line, by a thorough grasp of details from the bottom up. Don't be conceited! Remember that the other man's work is important too. Beware of being jealous of others! One of the surest means to success is to help make the other fellow successful. It is better to advance even a little more slowly, with a body of firm friends, than to advance more rapidly at the expense of others. The open minded, generous hearted man makes the best engineer as well as the best citizen.

"I speak not as having attained," but to pass on to you some ideals gained from observation of the men I admire most in the engineering profession.

Dresden, March 10, 1912.

THE SHERARDIZING PROCESS.

OLIVER W. STOREY, '10.

One of the most important problems confronting the engineer of today is the prevention of the rusting of iron and steel. Of the large number of methods proposed and used for rust prevention the sherardizing or dry galvanizing process is one of the most recent. This process is similar to hot and cold galvanizing in so far as zinc is used for the protective material, but the method of applying the zinc differs from either of the older processes. Cold galvanizing is essentially an electroplating process, while in hot galvanizing the zinc is applied to the articles by dipping in a bath of molten zinc. In the sherardizing process the articles are heated in zinc dust, which does not melt, and a coating of a zinc-iron alloy is obtained on the surface. The nature and formation of this alloy will be discussed later.

The sherardizing process is the invention of Sherard Cowper-Coles, an Englishman, who is an authority on the various galvanizing processes. His patents were allowed about seven years ago, but it was some years later before the process was introduced commercially into the United States. The patents in this country are controlled by the United States Sherardizing Company of New Castle, Pa.

In the latter part of 1908 the first successful commercial work in this country was turned out by the National Metal Moulding Co. of Pittsburgh. The progress of the process was quite slow during the first year, but during 1910 and 1911 it was adopted by a large number of companies, so that it has made tremendous strides during the past two years. With the improvements that are bound to come in the process, sherardizing will not only supplant a large part of the hot and cold galvanizing being done at present, but will also be used on material now impossible to treat by the older methods.

Sherardizing was not entirely unknown previous to the time of Mr. Cowper-Coles' patent, for in 1838, Miles Berry, an Englishman, took out a British patent in which he coated iron and copper in a manner similar to the present process. Various other patents of a similar nature were granted from time to time, but none were of commercial importance.

The process of sherardizing may be likened to the process of making blister steel by the cementation process, except that zinc dust is used instead of charcoal. Also, sherardizing is merely a skin effect, as in the case hardening of steel, and does not penetrate the metal to any appreciable extent.

Zinc dust is a by-product of the smelter and until a few years ago very little use was found for it. When zinc is distilled from the ore a large percentage is condensed in the condensers as metallic zinc, which is run off into pigs as spelter. From three to twenty per cent, depending upon the efficiency of the plant, does not condense, but is carried over and solidifies into a fine powder that is caught in dust-bags. This is the "blue dust" used in sherardizing, and is a fine impalpable powder resembling ordinary portland cement. If this "blue dust" is examined under the microscope it will be seen to consist almost entirely of very fine globules of zinc covered with zinc oxide, though there is a certain portion of unoxidized zinc also present. This oxide has a very beneficial effect, for it prevents the melting of the zinc in the sherardizing retorts, should the melting point of zinc be passed.

This "blue dust" varies somewhat according to the constitution of the zinc ore used and care used in roasting and condensation of the zinc fume. The best "blue dust" on the market at present is the German dust. This dust has a higher metallic zinc content than the American, and is therefore much more suitable for sherardizing purposes. Generally the German dust will contain from eighty-nine to ninety two per cent of metallic zinc, while the domestic product usually ranges from seventy-five to eighty-five per cent. On the other hand, the domestic material contains less than one per cent of lead while the German always contains above two per cent. The effect of the lead on sherardizing has not been determined.

The sherardizing process is carried out in the following manner. The clean articles to be sherardized are imbedded in a drum of zinc dust, heated to the proper temperature, usually from 700° to 800° F, for the proper length of time, removed from the furnace and allowed to cool. Theoretically this is a comparatively simple process.

In the following description of sherardizing methods I am giving the methods in use at the plant of the National Metal Moulding Co. at Economy, Pa. This plant is capable of sherardizing forty to fifty tons of conduit pipe daily, and is at present the largest plant in the United States and probably in the world. A variety of articles are sherardized, including conduit, metal moulding, electrical fittings, couplings, screws, bolts, locknuts, bushings, etc.

The retorts used are a little over ten feet in length and twenty-six inches in diameter. They are made of boiler plate and can be opened only at one end. The furnace is large enough to hold ten of these retorts and is fired by natural gas. The process is continuous in that the retorts are fed in at one end of the furnace and removed at the other. In this way all retorts are subjected to similar heat conditions in passing through the furnace and a uniform coating can be obtained.

While in the furnace the retorts revolve at the rate of one revolution every four minutes. Revolving the retorts insures uniform and quicker heating of the material in the retort, a uniform dust, and a continuous coating. The furnace is usually kept at a temperature of about 750° to 850° F. This temperature varies with the richness of the dust, amount of bulk in the retort, and the length of time the retorts remain in the furnace. With the zinc dust containing forty per cent metallic zinc, and with the retort filled with one-half inch conduit and the necessary amount of dust, the usual length of time required to sherardize the conduit to the proper thickness is about six hours at 800° F. The temperature of the furnace is controlled by means of pyrometers placed at various points while pressure gages are placed on all burners. This gives absolute control over the furnace, and by going over the records the source of any trouble can be immediately found.

There has been a great deal of discussion as to the proper percentage of metallic zinc in the zinc dust. Many plants are using a twenty per cent dust with excellent results, but owing to peculiar conditions we are using forty per cent zinc dust. With a dust low in metallic zinc there is more trouble owing to the dust clinging to the pipe while the richer the zinc dust the more delicate the temperature control has to be to obtain a coating that will be of the correct weight. A balance has to obtain between these two factors to obtain the best results.

The condition of the material previous to sherardizing largely determines the appearance of the finished coating. A few years ago the claims that were made for this process would lead a person to suppose that iron in any condition could be thrown into a retort of zinc dust and when removed after heating would be sherardized properly. But such is not the case, though the surface need not be prepared as carefully as in hot and cold galvanizing. As with hot and cold galvanizing, all scale and dirt must be removed from the articles to be treated. But it is not necessary to remove the lighter oils from the surfaces to be sherardized, though oil would be fatal to the cold galvanizing process. On the contrary, a light oil on a clean iron surface will result in a very bright coat of sherardizing. This is not true of heavy oils, varnishes, pitches, tars and such organic materials that deposit carbon upon heating. The sherardized surface will present a black dirty surface if these are not removed. Rust or the red oxide of iron when present on a surface in small amounts also tends to give a bright metallic appearance to the coating. But if this rust should be too thick the coating will be black and dirty in appearance. Oil mixed with rust always results in very black and dirty sherardizing. It is therefore the aim to obtain as smooth and bright a surface as possible before sherardizing. Since the zinc dust clings to a rough surface it will be seen that it is a distinct advantage to have as smooth a surface as possible. The problem of overcoming the adhering of zinc dust to sherardized articles is at present receiving the largest amount of attention. A piece of cold rolled steel or any polished surface will sherardize to a brilliant white crystalline coating, while a piece of rough or porous iron or steel will usually become a gray color to which the dust adheres more or less tenaciously.

As zinc in this finely divided condition is oxidized easily, it would appear that the retorts would have to be completely filled and also air tight to prevent oxidation. But in practice the retorts are seldom more than half filled with zinc dust. There is some oxidation, but the other advantages gained more than offset this loss. By using a small amount of dust the retorts can be brought up to a sherardizing heat quickly, cooled quickly and are also very much easier to handle, owing to the small bulk of zinc. Formerly it was thought that if a retort was opened while too hot the zinc dust would catch fire and burn completely. In practice it is found that the zinc catches fire, but the surface merely smolders, resulting in a very small loss.

It has often been claimed that the interior of the retorts do not sherardize. We find here that all interior surfaces of retorts are sherardized to a depth of 1/32 inch to 1/16 inch, but this coating does not become any thicker. Retorts having been in daily use for over two years have not shown any signs of appreciable deterioration from that source. Probably the continual pounding and grinding on this sherardized surface has the effect of hardening it and preventing further action.

All material sherardized is tested according to the Standard Preece copper sulphate test. Samples of ½″ and ¾″ pipe are taken from various retorts in any one heat and the middle and both ends of each pipe are tested. This pipe must stand four dips in the copper sulphate solution or it is rejected and is resherardized. This insures an ample and evenly distributed coating on all material. A heavier coating than five or six dips is not only undesirable owing to the increased amount of zinc used, but also because a coating heavier than seven dips will flake when bent. Since most specifications call for a coating standing at least four dips in copper sulphate and also one that does not flake when bent to a certain arc, it will be seen how these conditions in addition to the economic reasons limit the heaviness of coating.

The percentage of metallic zinc in the dust is kept under control by daily chemical analysis. The new dust is added to the unloading pit, a certain quantity being added as each retort is unloaded. The conveyors then mix it with the old dust, a fairly uniformly mixed dust being obtained from the loading spout.

In the sherardizing process every part of the surface is coated with the protective layer, the coating conforming to the surface. This makes this process very valuable in the treatment of screw threads. Heretofore the two older processes were used with little success for this class of work. With the sherardizing process fine threads and finished machined articles can be treated. The government is specifying sherardized bolts and nuts and various other material for the Panama Canal. Some of these articles will have to stand 10 dips in copper sulphate owing to the severe weathering conditions. To treat screw threads successfully and obtain a 10 dip coating with the older processes would have been an impossibility. With this process the coating is under control so that a 20 dip coating is as easy to obtain as a 1 dip coating.

Probably the latest and a very important use to which sherardizing has been put is in the protection of expanded metal lath. After a great deal of experimental work sherardizing was found to be as durable as any protective coating and also cheaper to apply. Sherardizing is adapted very well to this process owing to the large number of small surface areas to be protected. Another desirable effect for most work obtained with sherardizing is the annealing action of slow cooling in the retorts. This anneals thoroughly and prevents any chilling strains that are likely to be developed as in hot galvanizing.

The theory of the formation of the zinc-iron alloy constituting the sherardized coating is a debated question. Two different theories have been advanced at the present time. Mr. J. W. Hinchley of England, who has done extensive work in sherardizing, advances the theory that the magnetic oxide of iron, $Fe_3 O_4$ is first formed on the surface and that this is subquently reduced by the metallic zinc, zinc being an excellant reducing agent. Mr. Alfred Sang of France advances the vapor theory in which he claims that the zinc is in the form of vapor when it unites with the iron. I will not discuss these theories, but there are many arguments in favor of both. I am rather inclined to believe that the sherardizing action is merely a direct chemical contact action resulting in the union of the iron and zinc.

The sherardizing action results in the formation of an alloy of iron and zinc on the surface of the iron. This alloy is not merely a mixture of metals, but is a definite chemical compound of definite composition, the formula being $Fe\ Zn_{10}$. When a piece of pure iron is dissolved in pure zinc the zinc ceases dissolving the iron when iron to the amount given in the above formula is dissolved. The resulting alloy is a mass of hard silvery crystals that have some very peculiar properties.

A similar action takes place in the sherardizing furnace. When a piece of iron is sherardized the zinc unites with it to form the crystalline compound $Fe\ Zn_{10}$ which is the protective coating. As the crystal growth is very slow the coating is continuous. As most coatings are about 0.001 inch in thickness it will be seen that only a very small portion of iron is needed for the coating, and therefore the iron base is not weakened. The coating is very hard and will quickly ruin cutting tools. It is also capable of taking a brilliant polish similar to nickel. When zinc dust is used as the sherardizing material a very thin coating of zinc, which is so thin as to be detected with difficulty, is formed on the exterior.

A large number of analyses of sherardized coatings made at this laboratory show that in the work here the amount of iron in the coating is between 10.75% and 11.00%, which is three per cent higher than the theoretical amount. As we do not know what effect such impurities as lead, cadmium, copper, tin and aluminum in the zinc and carbon, manganese and other elements in the iron, have on the coating, we can only surmise that these impurities result in the high iron content.

In some of the first literature on this subject, and even in some of the present, the statement is made that the sherardized coating is made up of a series of alloys of zinc and iron. The outside coating was pure zinc, which was followed by an alloy high in zinc, after which came a series of alloys each of which was richer in iron than the preceding until the iron base was reached. But chemical and microscopical analyses at this laboratory fail to reveal any such condition, but merely show three layers, a very thin, superficial layer of zinc, the Fe Zn_{10} and the iron base.

If a piece of sherardized iron is carefully etched the crystals of Fe Zn_{10} show up plainly. In some cases the crystals are so regular that the surface appears to have been ruled. They are quadrilaterals and a large number are almost perfect squares.

Of the utmost importance is the protection of the iron by this alloy. The Fe Zn_{10} is electrically positive to iron by about 0.25 volts, which accounts for is protective action. But when a piece of sherardized iron is subjected to corrosive action, it will often be noticed, especially if the surface is rough, that a thin film of yellow rust appears on the surface. At a first glance it would seem as though the iron had rusted. But when we consider that a piece of iron being protected by galvanic action, as by zinc, is protected at the expense of this coating the explanation of the presence of this rust is very simple. When we have a pure zinc coating, the zinc corrodes, but since the zinc salts are white, no discoloration results. When a piece of sherardizing is corroded, the iron in the alloy coating is corroded along with the zinc, and since the iron salt is yellow, it appears as rust. But if this rust is removed the zinc-iron protective alloy beneath is found intact. The iron beneath the alloy has not been touched and has not contributed to the rusty appearance. Corrosion, such as has just been described, takes place where an electrolytic action between the sherardizing and the iron beneath or some other metal is set up.

In other cases, where a piece of sherardizing is weathered without being subjected to this electrolytic action the yellow appearance is due to another cause. This conclusion is the result of various weathering tests extending over a period of two years. Since the dust used always contains some iron and is not thoroughly removed from the articles, this dust will discolor when set out to weather. This discolors the articles, especially if the surface is rough. The more dust there is left upon the article, the worse will be its appearance after weathering, while perfectly clean articles with a smooth surface will not turn yellow.

After this rust makes its appearance it gradually becomes dark so that at the end of a year it is usually black. This black coating is the magnetic oxide of iron, $Fe_3 O_4$ and is a very valuable asset as it practically renders the sherardizing immune to further corrosion. On sherardized articles that do not turn yellow this black coating forms very much more slowly.

A simple experiment illustrates the protective action of sherardizing. In a beaker of salt water a bright nail and a piece of sherardized iron are set up in the form of an electrolytic couple. The two are connected by means of a copper wire, care being taken not to allow the copper to touch the liquid. The nail will remain bright indefinitely, while the sherardizing will become slightly yellow or black and a mixture of zinc and iron hydrates due to the corrosion of the $Fe\ Zn_{10}$ will be deposited in the beaker. If the sherardizing is replaced by copper the iron will begin to corrode in less than an hour while the copper will remain bright. The iron is positive to the copper and protects the copper at its own expense.

Professor C. F. Burgess has made a very thorough investigation of sherardizing and his results are very interesting. The results of the comparative corrosion tests that he made on the different types of galvanizing and enameling are favorable to sherardizing. His reports on the different phases of the process give the results of the various investigations in detail.

Another phase of the dry galvanizing process that is but little known is the sherardizing of copper. If a piece of copper is sherardized at about 600 degrees Fahr. a bright silvery coating is obtained. If the sherardizing is carried on at a dull red heat a brass colored coating is obtained. By combining these two, copper can be sherardized to two distinct layers that are sharply defined. The brass layer appears to be about the color of a 60-40 brass, while the silvery coating seems to consist of crystals containing about 30 per cent of copper. This white coating is very hard, cannot be touched by a file, and is capable of taking a very brilliant polish. This property of copper has been made use of in the making of some very beautiful imitations of inlaid metal work.

With the gradual bettering of the mechanical design of sherardizing furnaces and retorts for various materials, especially wire, this process will probably be used to protect a large variety of materials now subject to corrosion or improperly protected by the older processes. With the mechanical and chemical end gradually being worked out, sherardizing will soon be as widely known as hot and cold galvanizing.

WOOD PRESERVATION.

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One of the most important means of conserving the timber resources of the country is to prolong the life of the wood when in use. To do this, preservative methods must be employed.

The question of wood preservation is becoming of more and more importance each year as the demand for timber increases. The supply of the better grades of wood is rapidly diminishing so that in many cases it has been necessary to substitute woods of an inferior grade. Many species which are now used decay very readily, and means of increasing the life of this class of timber has now become a question of vital interest to the large users of wood.

In spite of the increased use of steel, concrete and other structural materials of this class, the demand for timber has been greater in proportion than the increase in population.

The use of treated timber will result, not only in a saving of the forests, but also in many cases in a most important financial saving to the consumers of timber. Though the initial expense is greater, this is more than offset by the saving due to the increased life of the treated wood. When frequent renewals must be made it is readily seen that the maintenance cost will be excessive. By proper treatment of the timber this maintenance cost may often be greatly reduced. At present there are over 120 million ties used annually in the United States. It is estimated that by properly treating the ties, this number can be reduced more than one-half. Railroad companies are beginning to provide for their future needs by using larger numbers of treated ties each year.

According to those who have made a study of forestry conditions, it is estimated that at the present rate of consumption the supply of the better class of timber will be exhausted in the near future. Reports of the Forest Service show that the total annual cut of timber in the United States is over twenty billion cubic feet, and that the annual growth does not exceed seven billion cubic feet. By using preservative methods it is estimated that this annual cut can be reduced one-third. For many of the species of wood now used, there is no question as to the economy and efficiency of preservative treatment, and from the commercial standpoint it is unquestionably a paying proposition. The figures in regard to the increased life of treated wood are not theoretical estimates, but are based on actual experience. Both in this country and in Europe there are numerous examples of treated timbers that have stood the test of time. Some of these timbers have been in use for twenty or thirty years and today are as sound as when first placed.

It has been found that the woods which decay readily are in most cases easily treated, and it is in the treatment of this class of timber that the use of preservatives will be of the greatest importance.

The principal causes of the destruction of wood are decay, fire, mechanical abrasion, and destruction by insects and marine borers. By far the greatest loss is caused by decay. The decay of wood is produced by the action of low forms of plant life called bacteria and fungi. Fungus growth is the most common cause of decay. The spores may find lodgment in the wood and if conditions are right for decay, the spores germinate, sending out fine threads that branch out and finally penetrate the entire structure of the wood. The wood is dissolved by substances secreted by the fungi, and food is thus furnished for fungus growth. Fungi may also enter sound timber by growing through, or over damp ground, or decaying timber which may be in contact with the sound wood and thus start decay.

Four things are necessary for fungus growth, namely, food, heat, air and moisture. The moisture content of the wood plays a most important part in the progress of decay. It is therefore of the greatest importance that the timber be properly seasoned and the moisture reduced below the point necessary for decay conditions. One of the most efficient methods of preventing the growth of fungi is to poison their food supply by treating the wood with chemicals.

The chemicals used in treating timber are either oils or metallic salts. Of the oils used, coal-tar creosote is the one most commonly employed. Water-gas-tar creosote and crude oil are also used to some extent. Coal-tar creosote is obtained from the distillation of coal-tar. The products of distillation are: oils lighter than water, creosote, which has a specific gravity slighter greater than that of water, and pitch. Crude oil is used to some extent as a preservative, since it serves to keep out moisture and for this reason helps prevent decay, although it has no very important antiseptic properties.

One of the great advantages of creosote is that it does not wash, or leach out readily when once forced into the timber. Creosote is also most effective in preventing the ravages of insects and marine borers, which do so much damage to wharves and other timber exposed to their attack.

The metallic salts used are zinc chloride, and mercurie chloride.

Zinc chloride is the most important of these salts as mercuric chloride is very poisonous, and its use has been practically abandoned. The zinc chloride is used more largely in dry climates and under conditions where there is not much danger of the moisture dissolving the salt and causing it to leach out of the wood. Zinc chloride is a much cheaper preservative than creosote, but on account of its tendency to leach out it cannot be used under all conditions. Like zinc chloride, creosote also has some objectionable features. In the first place it is expensive compared with the other preservatives. It is also objectionable in the treatment of certain classes of timber on account of the disagreeable odor and color given to the wood. For this reason it is used most largely in treating ties, piling, poles, posts, paving blocks and other timbers exposed to the weather.

The methods used for forcing the preservatives into the wood are divided into two general classes: first, those processes in which no artificial pressure is used, and second, the processes using artificial pressure.

A very cheap and common method of treating small amounts of timber is to coat the timber with hot creosote, using an ordinary paint brush. In some cases it is much quicker to dip the timber into a vat of creosote heated to about 215 degrees Fahrenheit. This method is more thorough than the brush treatment, as all the checks and other openings in the wood are filled. Either the brush or dipping treatment is very useful where a more expensive treatment would not be warranted. A more efficient non pressure treatment is known as the open-tank method. In this treatment the timber is immersed in the creosote (heated to about 215° F.) and left in the hot bath for an hour or more, depending upon the condition of the timber and the species to be treated. The timber is then changed quickly to a cold bath of the preservative at about 120° Fahrenheit. While heated the air and moisture in the wood expand and are partially driven off. Upon cooling the contraction of the air and moisture remaining in the wood causes the preservative to be forced into the vacuum thus formed. This is a simple and very useful means of treating fence posts and similar timbers where only a small quantity is to be treated.

The processes in which artificial pressure is employed are the most extensively used, although the most expensive. The principal piece of apparatus for a treating plant of this kind consists of one or more cylinders constructed of boiler steel, a common size being seven feet in diameter and 132 feet long. At the ends of the cylinder are heavy doors that can be sealed perfectly tight. Power cranes are used for handling the timber. Powerful pressure and vacuum pumps are necessary as well as large boilers for supplying the steam for power and heat. Storage tanks, supply and drain tanks and other machinery are also needed in the equipment.

In the treatment by the Bethell process, which is one of the most widely used pressure processes, the timber is run into the cylinder on cars specially constructed for the purpose. The doors are then closed, and the timber is given a preliminary steam bath for several hours, the steam pressure being kept at about twenty pounds per square inch. When the steam bath is finished a vacuum is drawn to take out as much air and moisture as possible from the cylinder and from the wood.* Creosote is then pumped into the cylinder at a temperature of 160° F. to 180° F. until the required amount of creosote has been absorbed by the timber. After returning the surplus preservative to the measuring tanks the charge of timber is withdrawn from the cylinder.

The Burnett treatment is similar to the Bethell process, only in this case a solution of zinc chloride salt is used instead of creosote. A two and one-half per cent to five per cent solution is commonly used. If a strong solution is used the timber is made brittle and its strength thereby injured. The method of injecting the solution into the wood is practically the same as in the Bethell process.

In what are known as "empty cell' processes the aim is merely to coat the cell walls of the wood. In this way a lighter absorption with a given penetration is secured than is obtained in the Bethell or full cell treatment. The advantage claimed for the empty cell processes is that, in the case of ties, since the tie is protected from decay throughout its mechanical life, the lighter absorption is more economical than a full cell treatment.

There as several other patented processes which are more or less successful.

A number of these processes combine creosote and other substances with the zinc chloride solution to protect the zinc salt from leaching out. The Card process uses an emulsion of cresote and zinc chloride. A centrifugal pump is used to keep the two preservatives thoroughly mixed during treatment. In the Wellhouse treatment a solution of glue is mixed with the zinc chloride solution and injected into the wood. A separate treatment is then given of a tannin solution. The glue and tannin combine to form a leathery compound which is designed to protect the salt from moisture.

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* Steaming is done only on green timber for the purpose of seasoning. However, it is considered better practice to treat air-seasoned timber.

Another treatment known as the Allardyce process uses a zinc chloride solution as a first treatment and a final treatment of creosote. The apparatus used in these different processes does not differ much from that used in the Bethell and Burnett processes.

For several years previous to the time that the Forest Product Laboratory was established, the Forest Service made experimental investigations in wood preservation. This was done by co-operating with large users of timber in plants designed and built under the supervision of the Forest Service, or in the plants of commercial treating companies or railroads. The treatment of the wood was conducted under the direction of representatives of the Forest Service who were thus enabled to determine the methods used and the kind and condition of the timber treated. These experiments were usually made on the treatment of timbers of commercial size. This treated material was then usually placed under service conditions in various parts of the country, and inspections made from time to time to investigate the efficiency of the methods and preservatives used. For the reason that treatments were conducted at commercial plants the field of the experimental work was limited to a large extent.

The object of the section of wood preservation at the Forest Product Laboratory is to study all of the various problems connected with wood preservation. Investigations are made of the efficiency of the preservatives in use, the methods of applying these preservatives, and their effect on the different species of wood under various conditions.

Research work is also planned to determine new preservatives and new methods of treating timber. The equipment of the laboratory is such that experiments may be carried on under the most uniform conditions which will insure means of obtaining reliable data on the subjects investigated. A fungus pit is used in testing the resistance to decay of the different preservatives. In this pit the temperature, moisture, and other conditions are regulated so as to obtain the conditions most favorable for decay. Test specimens as nearly alike as possible are selected from the same piece of wood. These pieces are impregnated with the preservatives to be investigated and then exposed to the action of fungus. While in the fungus pit the specimens can be observed at any time and the progress of decay studied. There are four treating cylinders of varying sizes so that small specimens, paving blocks, and large timbers of commercial size can be treated. These treating cylinders have in connection auxiliary apparatus such as pressure, air, and vacuum pumps, storage and measuring tanks, and all other equipment necessary for a complete treating plant. In the large treating cylinder, ties and other large timbers are treated to determine the relative efficiency of standard preservatives and processes. Many of these treated timbers are later placed in test tracks and other structural work where studies are made of their life while in service. Similar experimental work is carried on with treated paving blocks. By cooperating with the various organizations using large quantities of timber this department is enabled to make extensive experimental investigations in different parts of the country besides the research work done at the laboratory. The results of the work of this department are published in the form of circulars and bulletins and may be obtained from the Office of Publications, Forest Service.

THERMAL CONDUCTIVITY AND RESISTIVITY.

Students frequently ask for information on the thermal conductivity of materials. Until quite recently, all the available data were scattered and the curious and interested would be referred to the works of Landolt and Boernstein, Peclet, Richards, Hering, Hutton and Beard, and Wologdine. Within the last two years so much interest has been stimulated in the questions of flow of heat through furnace walls and electrical and heat and cold insulation that considerable work has been done in determining the resistivity or conductivity of materials (such as that of Clement and Ergy of the University of Illinois on the thermal conductivity of fire clay) and in correlating such results. Messrs. Hering, Queneau, and others have been active in publishing the results of recent and previous experiments in *Metallurgical and Chemical Engineering* and in transactions of scientific societies.

In finding the relative conductivity of various materials, Messrs. R. S. Hutton and J. R. Beard have used an apparatus devised by C. H. Lees and J. D. Chorlton (*Philosophical Magazine*, June, 1896, p. 495). A digest of the methods and results of their determinations of the insulating qualities of refractory materials is published in the *Electrochemical and Metallurgical Industry*, Vol. 111, p. 291.

The conductivity, K, is the quantity of heat in gram calories which is transmitted per second through a plate 1 cm. thick per square centimeter of its surface, when the difference of temperature between the two faces of the plate is 1°C.

The appended values of K apply to a temperature range from 20 to 100°C; the materials were generally in the form of powder passed through a sieve with 600 meshes per sq. cm.

Sand, White Calais	K = 0.00060
Carborundum, fine	0.00050
" coarse	0.00051
Quartz, enamel	0.00036
" fused	0.00039
Fire clay brick	0.00028

Retort graphite	0.00040
Lime	0.00029
Magnesia, fused	0.00047
“ Mabor brick	0.00050
“ Calcined Greek	0.00045
“ “ Veitsch	0.00034
“ Pattenson's light calcined	0.00016
Kieselguhr (infusorial earth)	0.00013

Yet it is not advisable to choose a material by reason of the above data alone. It is always necessary to know the physical behavior of such materials at high temperatures, such as their degree of shrinkage or expansion, their porosity and other properties. Chemical action, such as oxidation, renders some insulators unsuitable. These considerations are discussed by Hutton and Beard, who also suggest that the transmitter of heat, such as a retort body, should be of different material to the insulator, such as the furnace wall, and propose certain methods of construction which would enable us to realize the value of certain insulating materials without risk of impairing these by too high or too long continued heating. For if materials shrink and become less porous they often decrease in efficieny as insulators.

In No. 12, Vol. IX, of the journal mentioned (*Chemical and Metallurgical Engineering*), Mr. Hering publishes the properties of many substances in terms of thermal resistivity.

In Vol. VII, numbers 9 and 10, Mr. Quenneau describes S. Wologdine's methods of determining heat conductivity, gas permeability and porosity. In summarizing the results, he represents the conductivity in gr. cal. sec. per cubic cm. per 1°C. Accordingly, the figures in the scales of Quenneau are the reciprocal of those of Hering. Thus Queneau:

		CONDUCTIVITY		
No.	Material	Gr. cal. sec. per cm^3 per 1°C	Kg. cal hour per m^3 per 1°C	Relative Conductivity
1	Graphite brick	.025	9.0	100%
2	Carborundum brick	.0231	8.32	92.4
3	Magnesia brick	.0071	2.54	28.4
4	Chromite brick	.0057	2.05	22.8
5	Fireclay brick	.0042	1.50	16.7
6	Checker brick	.0039	1.42	15.8

7	Gas retort brick	.0038	1.36	15.2
8	Building brick	.0035	1.26	14.0
9	Bauxite brick	.0027	.96	12.4
10	Glass pot	.0033	1.19	13.2
11	Terra cotta	.0023	.84	9.3
12	Silica	.0020	.71	7.8
13	Kieselgubr	.0018	.64	7.1

The figures selected are representative of the ordinary commercial grade of refractory materials. The coefficients were determined for temperatures of 1000° to 1200°C.

Hering uses the thermal ohm to express that resistance through which 1 watt of heat flow will pass when the temperature drop is one centigrade degree. Hence, if R is the thermal resistance in thermal ohms, W the flow of heat in watts, and T the temperature in centrigrade degrees,—

$$W = \frac{T}{R}$$

Again, if r is the specific thermal resistance in thermal ohms per centimeter cube, then

$$R = \frac{rL}{S}$$

in which L is the length and S the cross-section of a thermal conductor.

To reduce a thermal conductivity in gram calories per second to the resistivity in thermal ohms, multiply the reciprocal of the conductivity by 0.2388, when both are for 1 cm. cube. To reduce gram calories per second to watts, multiply by 4.186. In order to compare the thermal resistivities, Mr. Hering called that of silver the unit and reduced all values in the various works consulted to figures relative to this base.

The data appended may be used for steam heat, refrigeration, etc., as well as for calculation of electric heat, by first completing the simple calculation in terms of watts flowing through the insulation and then turning these watts into horsepower, sq. calories per minute, or other expressions of energy.

e. g., Watts x 0.00134111 = horse powers.
Watts x 0.0568776 = b. t. u. per minute.
Watts x 0.0143329 = sq. calories per minute.

To reduce units in terms of 1 cm. cube to those for 1 inch cube, multiply by 0.393700 when they are resistivities, and by 2.54001 when they are conductivities. To reduce thermal conductivities given in terms of B. T. U. per hour per sq. ft. surface, multiply the reciprocal of that number by 273.013.

TABLE OF THERMAL RESISTIVITIES.

Approximately in Order of Resistivity Temperatures in Centigrade Degrees.

	Thermal Inch Cube	Ohms Centimeter Cube
Silver, 0°–100°	0.094	0.24
Copper (electrode mean), 100°–197°	0.090	0.23
Copper (electrode mean), 100°–837°	0.11	0.27
Copper, 0°–100°, about	0.11	0.27
Copper	0.13	0.32
Copper, cast	0.12	0.29
Copper, rolled	0.11	0.28
Copper, rolled	0.13	0.32
Aluminum, 0°–100°	0.27	0.69
Graphite, Acheson (electrode mean), 100°–390°	0.28	0.71
Graphite, Acheson (electrode mean), 100°–914°	0.32	0.82
Brass, 0°–100°	0.36	0.92
Iron (electrode mean), 100°–398°	0.28	0.71
Iron (electrode mean), 100°–398°	0.43	1.1
Iron, wrought	0.22	0.55
Iron, wrought, 0°	0.46	1.2
Iron, wrought, 275°	0.76	1.9
Iron, wrought	0.79	2.0
Iron, cast	0.26	0.66
Iron, cast, 30°	0.63	1.6
Steel	0.24	0.60
Steel	0.81	2.1
Steel, various	0.81	2.1
Steel, 10% manganese	3.0	7.7
Platinum	0.25	0.63
Platinum, 18°–100°	0.55	1.4
Platinum	1.1	2.9
Carbon (electrode mean), 100°–942°	0.72	1.9
Carbon (electrode mean), 100°–360°	1.05	2.7
Lead	0.33	0.83
Lead	1.10	2.8
Lead, 0°–100°	1.2	3.0
Plumbago brick, about 1000°	3.8	9.6

	Thermal Inch Cube	Ohms Centimeter Cube
Carborundum brick, about 1000°	4.1	10.3
Mercury, 0°–50°	5.5	14.1
Quartz, 0°	5.9	15.
Graphite (probably plumbago), 7°	8.0	21.
Retort carbon, 0°	9.1	23.
Magnesia brick, about 1000°	13.	34.
Stone, calcareous, fine	16.	42.
Chromite brick, about 1000°	16.	42.
Ice	16.	42.
Boiler scale, 60°	17.	44.
Marble, fine grained, gray	9.8	25.
Marble, coarse grained, white	12.	31.
Marble, 30°	19.	48.
Stone, calcareous, ordinary	20.	51.
Fire brick, (probably room temp.)	21.	53.
Fire brick, about 1000°	22.	57.
Fire brick, mean for 500°–1300°	23.	57.
Fire brick, mean for 0°–1300°	30.	77.
Fire brick, about 400°–800°	44.	112.
Fire brick, mean for 0°–500°	67.	171.
Checker brick, about 1000°	24.	61.
Gas retort brick, about 1000°	25.	63.
Slate, 94°	26.	67.
Building brick, about 1000°	29.	72.
Glass pot, about 1000°	35.	89.
Porcelain, 95°	38.	96.
Feuerstein	39.	99.
Terra cotta, about 1000°	41.	104.
Chalk (solid?)	43.	109.
Cement, Portland, neat, 35°	44.	110.
Cement, Portland, 90°	132.	336.
Lava	47.	120.
Silica brick, about 1000°	47.	120.
Kieselguhr brick, about 1000°	52.	133.
Baked clay, brickwork	57.	140.
Building brick wall, average, 8″ to 40″ walls	62.	160.
Water, room temperature	72.	180.
Glass, 28°	87.	220.
Plumbago, 20°–155°, 26.1% solid matter	96.	240.
Fine sand, 20°–155°, 51.4% solid matter	109.	276.
Coarse sand, 20°–155°, 52.9% solid matter	110.	280.
Cork (solid?)	131.	333.
Plaster of Paris, 0°	105.	266.
Plaster of Paris, 20°–155°, 36.8% solid matter	221.	562.

	Thermal Inch Cube	Ohms Centimeter Cube
Slag concrete, 34.3 lbs. per cu. ft., 50°, 1 pt. by weight slag and 0.61 cement	178.	453.
Pumice stone, 18.2 lbs. per cu. ft., 50°	169.	430.
Pumice stone	187.	477.
Pumice stone, 20°–155°, 34.2% solid matter	219.	558.
Brick dust, sifted	204.	518.
Asbestos, 20°–155°, 8.1% solid matter	139.	353.
Asbestos, 36 lbs. per cu. ft., 600°	166.	422.
Asbestos, 36 lbs. per cu. ft., 50°	221.	562.
Asbestos, with air cells	416.	1060.
Card board, below 0°	239.	606.
Ebonite, 48°	251.	637.
Petroleum, 13°	265.	672.
Wood pine, parallel to fiber	313.	796.
Many liquid compounds (hydrocarbons, oils, etc.), about	313.	796.
Anthracite coal	317.	803.
Chalk, 20°–155°, 25.3% solid matter	332.	844.
Very porous slag, 22.5 lbs. per cu. ft., 50°	356.	905.
Zinc, white, 20°–155°, 8.8% solid matter	398.	1010.
Fire felt, 21°–175°	418.	1060.
Gas works breeze	440.	1120.
Infusorial earth (fossil meal), 21°–175°	415.	1050.
Insusorial earth, 20°–155°, 11.2% solid matter	435.	1110.
Infusorial earth, 20°–155°, 6% solid matter	472.	1200.
Infusorial earth, burnt, 12.5 lbs. per cu. ft., 450°	263.	675.
Infusorial earth, burnt, 12.5 lbs. per cu. ft., 50°	477.	1220.
Infusorial earth, loose, 21.8 lbs. per cu. ft., 350°	427.	1090.
Infusorial earth, loose, 21.8 lbs. per cu. ft., 50°	562.	1430.
Infusorial earth	745.	1890.
Magnesia, carbonate, 85%, 20°–188°, average	537.	1370.
Magnesia, calcined, 20°–155°, 28.5% solid matter	160.	407.
Magnesia, calcined, 20°–155°, 4.9% solid matter.	544.	1380.
Magnesia, calcined, 20°–155°, 2.3% solid matter.	554.	1410.
Magnesia, calcined, 21°–175°	572.	1450.
Charcoal, pine, 20°–155°, 11.9% solid matter	494.	1260.
Charcoal, from leaves, 11.9 lbs. per cu. ft., 100°	537.	1370.
Charcoal, from leaves, 11.9 lbs. per cu. ft., 50°	603.	1530.
Charcoal	723.	1840.
Feathers, 20°–155°, 2% solid matter	577.	1470.
Sawdust, 13.4 lbs. per cu. ft., 50°	614.	1560.
Sawdust	620.	1570.
Sawdust, 13.4 lbs. per cu. ft., 50°	765.	1950.
Cork, granulated and compressed, 20°–188°	467.	1190.

	Thermal Inch Cube	Ohms Centimeter Cube
Cork, ground, 10 lbs. per cu. ft., 200°	614.	1560.
Cork, ground, 10 lbs. per cu. ft., 50°	797.	2030.
Air, 20°–155°	143.	364.
Air, 0°	1700.	4320.
Cotton wool, 20°–155°, 1% solid matter	596.	1520.
Cotton wool, 20°–155°, 2% solid matter	659.	1570.
Cotton wool, 5.05 lbs. per cu. ft., 100°	572.	14*0.
Cotton wool, 5.05 lbs. per cu. ft., 50°	627.	1600.
Cotton wool	830.	2110.
Cotton wool, loose	2170.	5500.
Cotton wool, compressed	2810.	7120.
Hair felt, 20°–155°, 9.2% solid matter	633.	1610.
Hair felt, 21°–175°	790.	2010.
Hair felt	865.	2200.
Hair felt, below 0°	1080.	2740.
Lampblack, 20°–155°, 5.6% solid matter	697.	1770.
Fine quartz sand	718.	1820.
Silk, 6.3 lbs. per cu. ft., 100°	662.	1690.
Silk, 6.3 lbs. per cu. ft., 50°	752.	1920.
Wool, sheep's, 20°–155°, 2.1% solid matter	616.	1570.
Wool, sheep's, 8.5 lbs. per cu. ft., 50°	676.	1720.
Wool, sheep's, 8.5 lbs. per cu. ft., 100°	745.	1890.
Wool, sheep's	803.	2050.
Mineral wool, 21°–175°	737.	1870.
Mineral wool, 0°–18°	1010.	2570.
Hard rubber	1060.	2680.
Wood, pine, radially	1070.	2720.
Loose fibrous materials, 9°	1540.	3920.
Flannel	2650.	6720.

Mr. Hering has correlated these results. Some of them will probably be changed when more thorough and more numerous determinations have been made. Authorities are stated in Vol. IX, No. 12 of Chem. and Met. Engineering.

INFLUENCE OF TEMPERATURE.

In proportion as substances increase in conductivity, so thermal insulators decrease in resistivity at higher temperatures. Wilhelm Nussel, in *Zeit. Ver. Deut. Eng.*, June, 1908, finds that the thermal conductivity of such insulation increases at the rate of 1/273 part for every degree centigrade above 0°C. This is of interest, but must be accepted with caution since, as Hering points out, materials would become, under this law, absolute insulators at absolute zero.

Much work is still to be done in this subject. The metallurgist and engineer needs, most of all, determinations of the resistivity at temperatures between 1200° and 2000°. The results cited disturb some generally accepted theories of insulation. Thus, cold air at 0° is an excellent insulator, whereas air heated from 20° to 150° is a better conductor than sifted brick dust and about the equivalent in conductivity of warm cement.

Magnesia brick is a good conductor, while mass of calcined magnesia insulates fifty times as efficiently. All loose material must be tested at different temperatures to realize its efficiency, since the air in the pores increases in quantity and in conductivity and therefore the whole mass insulates less efficiently the higher the temperature employed. Readers will probably learn more interesting facts from these qualities which are suggestive of change in many of our accepted maxims and axioms of furnace and fire-proof construction.

Mr. Hering also discusses (*Metallurgical and Chemical Engineering*, January and February, 1912) the subject of contact resistances and heat emission from surfaces, and the influence of shape, joints of construction and other factors. He pub--lishes lengthy and interesting tables (pp. 42, 43 and 44, same journal, January, 1912) of flow of heat from solids to gases at certain temperatures (e. g., brick to air), of metal to water, water to metal to air, gas to metal to water (e. g., fire gases to boiler), gas to metal to gas. Mechanical, chemical and electrical engineers are referred to these tables for interesting and useful information. Appended are a few examples of flow of heat through contact surfaces in thermal ohms per sq. inch:

SOLID TO GAS.

60° surfaces of dynamos to air at 20°	100.
90° brick to air at 20°	112.
220° brick to air at 20°	74.

1000° graphite to vacuum	65.8
2600° graphite to vacuum	28.6
927° tungsten wire, 0.229 mm. diam. to hydrogen	2.0
1727° tungsten wire, 0.0088 mm. diam. to hydrogen	0.26
Silver polished to air per degree difference	10300.
Sheet iron polished to air per degree difference	2970.
Sheet iron not polished to air per degree difference	483.

METAL TO WATER.

143° brass to water at 40°	0.154

WATER TO METAL TO AIR.

107° water to cast iron to air at 20°	258.

GAS TO METAL TO WATER.

Fire gases to iron to steaming water (boiler)..... (approx.)	34.

GAS TO METAL TO GAS.

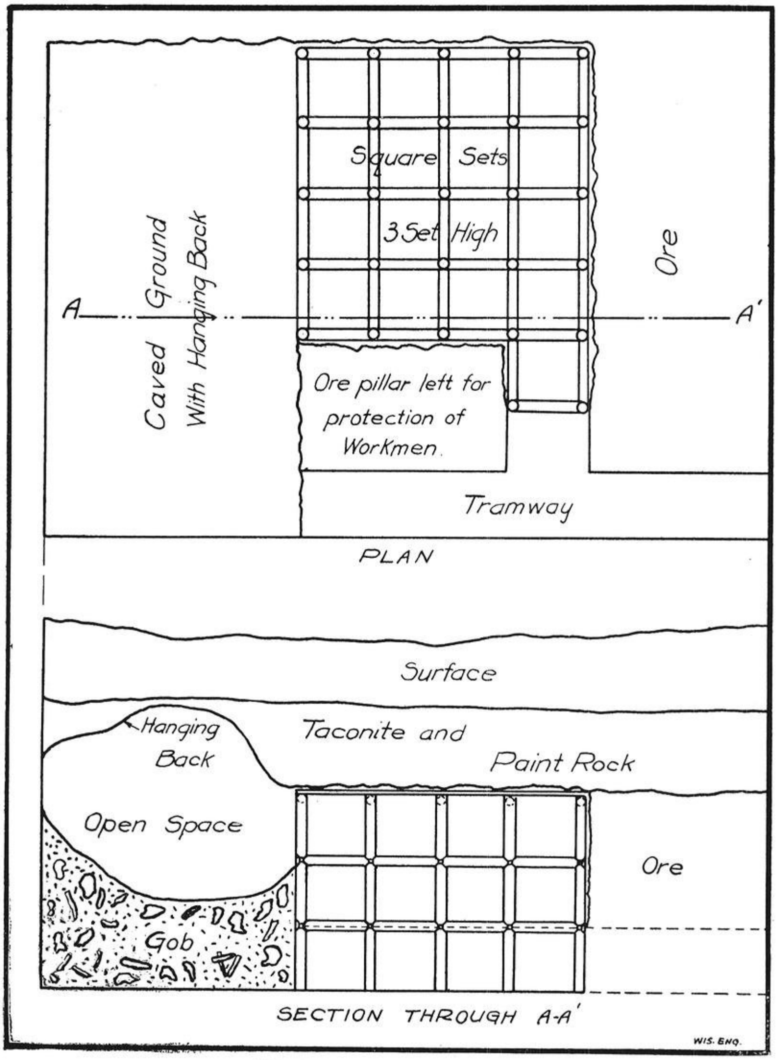
107° steam to bronzed cast iron to air to 20°	171.

SPECIAL METHOD OF MINING ON DANGEROUS GROUND ON THE MESABA RANGE, MINNESOTA.

B. M. CONCKLIN.

Some of the simplest and most useful practices among mines and mining men are occasionally overlooked for no other reason than their entire simplicity. It may be interesting to note a method of mining observed on the Iron Ranges of the Lake Superior region, which is simple in itself and also affords protection to the miners. In this case the ore is capped by a tough taconite and paint rock, both of which are more or less disintegrated, while the bottom of the ore body is solid taconite. The ore body is from eighteen to twenty-four feet in thickness. The method used in the extraction of this ore is usually the Square Set, the ore body being too thick to be adaptable to the slicing method operated from one level and too thin to develop more than one level. It the extraction of the ore at the start of operations the back refuses to cave entirely down, but arches for considerable distances, making it extremely dangerous to the miners working along the semi-caved area. To protect the workmen and also to extend and weaken the arch which holds the ground from caving properly, square-setting is started two or three sets back from the semi-caved ground. The work from this point is carried on just as if a new pillar was to be worked out. The slice or drift is first driven the full width of the pillar and when this point is reached square-setting is started towards the open room. When the room is reached, square-setting is then carried on from the slice drift or cross-cut to the open room until the tramway is reached, when the timbers supporting the square-set room are shot down and the ground allowed to cave. This process is repeated until the ground caves satisfactorily, when the square-setting is again resumed, this time immediately along the caved ground. The accompaning sketches show the process.

There seems to be one serious objection to this method, that being the probable loss of ore in the last pillar between the square-set room and the tramway, due to the fact that the ex-



Mining on the Messaba.

tension of the arch and the resultant weakening of the same has a tendency, as the timbers and pillar take weight, to crush this pillar. This disadvantage, and the additional cost of mining due to the driving of the cross-cut through solid ore across the pillar, is offset by the greater protection afforded the miners.

THE FLOW OF WATER THROUGH A POROUS MEDIUM.

L. R. Balch, '05, C. E. '09.
Research Assistant in Hydraulic Engineering.

The flow of water through a filter medium is a question of important practical application upon which our knowledge is so imperfect that a great deal of further investigating in the laboratory is required. The final object of such experimental research is to determine what factors influence the variation in results under various conditions, and what the effects of those factors are. In conducting the experimental investigations, the principal, and also the most difficult, thing is so to design the apparatus and conduct the tests that these various factors either be eliminated or be determined in effect. A large amount of work and a great deal of study is required before this can be accomplished. It often happens that, though an investigation promises to be comparatively simple, the additions and revisions found necessary as the work advances cause it to become quite complicated before satisfactory results are obtained.

Through the work done on this subject by Mr. Allan Hazen for the Massachusetts State Board of Health, and by Prof. C. S. Slichter, of the University of Wisconsin, a fair knowledge is had of the conditions influencing the flow of water through a soil column and of their effects. A number of conditions which have a very great effect on the rate of flow are quite difficult to determine, making the experimental work a matter of great care and thoroughness. The conditions which influence the rate of flow as shown by previous experiments will be taken up somewhat in detail.

The hydraulic gradient or difference in pressure from point to point, measured in the direction of flow, is the primary cause of the flow of liquid, and the greater the gradient, the greater will be the flow. The value of the hydraulic gradient is measured by means of gage tubes, similar to the piezometer tubes familiar to those acquainted with experimental hydraulics.

The porosity or amount of void space in the porous material has a great influence on the rate of flow, which varies directly with the porosity. In experimenting with a mass of spherical shot, Prof. Slichter found that a number of values for the porosity could be obtained with the same material, depending upon the arrangement or manner of packing. The minimum value was found to be 25.95 per cent of the whole space occupied. The great effect of the porosity on the flow may be shown by a tabulation given by Prof. Slichter in Water Supply and Irrigation Paper No. 67, published by the U. S. Geological Survey. From this it appears that if the porosity of the same sample of sand is changed from 30 per cent to 37 per cent, other conditions remaining the same, the flow in the latter case will be twice that in the former.

There are several methods which may ordinarily be used to determine the porosity of a sample of sand. Probably the most successful method is that used by Messrs. Cenfield and Urbutt, which is described in their thesis for the degree of Bachelor of Science in 1909. This method, by which repeated trials gave substantially the same results, is to fill the testing receptacle with thoroughly dry sand by allowing it to flow through a tube maintained at a constant height above the sand surface in the receptacle. Water is added through a pipe connected to the bottom of the apparatus from the outside. This method of filling the voids drives out the air as the water rises. A difference of two per cent by weight was found in the amount of sand necessary to fill the apparatus in various determinations by packing the sand in any other way than by the tube method. This method has a disadvantage in that the tanks used in the flow experiments are not packed n the same way and the consequence is that the correct value for porosity to use in the computation of results is not known.

Probably the most satisfactory way would be to measure the void space in the sand when in place in the flow apparatus. This would be open to criticism, since the value obtained could not be checked, and in case the determination was incorrect, the results would be unreliable.

The larger the size of the separate pores, the greater will be the flow through the porous material. The value of this factor depends upon the "effective size" of the soil grain in the sample. The flow through the interstices of an ordinary sand bed is similar to the flow through capillary tubes and is proportional to the first power of the head causing the flow. When the grains become about three millimeters or larger in diameter, the condition for free flow obtains and the flow varies in accordance with $\sqrt{2gh}$.

The method of determining the effective size will be briefly taken up in a discussion of Hazen's Formula.

The rate of flow varies directly with the temperature. This is because of the effect of temperature on the viscosity of water. An idea of the effect of change in temperature on the flow may be had from the fact that a change from 50 degrees to 60 degrees Farhenheit will produce a change of about sixteen per cent in the flow.

It has been found that the shape of soil particles is an influencing factor, though it is impossible to express it in the flow formulas. It is plain that sand grains that are round, flat, rough or smooth will have varying effects on the results even though the effective size is the same for each kind. Cleanliness, chemical composition and distribution of sizes in the sample also have greater or less effects upon the flow, but are exceedingly difficult to express. The distribution of sizes is shown by the "uniformity coefficient" used in selecting the value for C in Hazen's formula.

There are two accepted formulas for the flow of water through soil, one by Allen Hazen, resulting from his work at the Lawrence Experiment Station, and one by Prof. Slichter, resulting from his investigations of the flow of underground water.

The former is generally used by American engineers in their designs and has become standard. This formula is

$$V^2 = c\,d\,\frac{h}{L}\,(0.70 + 0.03t)$$

V is velocity of flow in meters per day.

C is a constant depending for its value upon the shape, cleanliness, chemical composition and distribution of sizes of grain. In practice its value is assumed by comparison of the results of mechanical analysis of the given sand with those of a sand which has been tested.

d is the effective size of soil grain. It is the diameter in millimeters of a sphere whose volume is equal to the volume of that soil grain of such size that 10 per cent of the grains in the sample are smaller. The size of grain is found by thoroughly shaking the sample through a set of sieves and finding that size which just will not pass each sieve. The results are platted and the effective size taken from the diagram. The size than which 60 per cent of the sample is smaller divided by the effective siz is termed the "uniformity coefficient," the comparative value of which is considered in selecting the proper value for C.

h is the loss of head or the head causing the flow measured between points just inside the ends of the soil column.

L is the length of sand column through which the water passes in losing the head h.

t is the temperature in degrees Centigrade. It may be noted that when t is 10° the last term of the equation becomes unity. The equivalent temperature, 50° Fahrenheit, is taken as the standard in Slichter's formula.

Prof. Slichter expressed his conclusions by the formula:

$$Q = 0.2012 \frac{h}{L} \frac{d^2 a}{w k}$$

Q is the volume flow in cubic feet per minute.

$\frac{h}{L}$ is the hydraulic gradient and has the same value as is used in Hazen's formula.

d is the mean size of soil grain and is defined as that size such that if all the grains were the same, the flow would be what it actually is. This term takes care of the size of voids, the cleanliness, chemical composition, shape and distribution of sizes in the sample.

W is a number called the viscocity coefficient which depends upon the temperature for its value. It is defined as that force necessary to maintain unit difference in velocity between two strata of water unit distance apart.

K is a constant depending upon the porosity for its value. Tables of values of both K and W are given in the water supply paper previously mentioned.

Experiments which have been made show the necessity for observing certain principles in conducting investigations of the flow through sand.

Water used in the tests should be treated with some agent such as formaldehyde to prevent the growth of organic life, and should be filtered through charcoal before using. It has been found that water treated in this manner answers the purpose about as well as distilled water. The water should not be used in the tests a second time. In passing through the sand the water may dissolve material which affects its viscosity.

The temperature of the influent water should not be different than that of the effluent by more than one-half degree. In varying the temperature, the experiments should not be conducted at a temperature much above about 65° Fahrenheit until a satisfactory amount of data has been taken at the lower temperatures. The reason for this is that the heated water seems to cause an entirely new arrangement of the material. The increase in temperature of runs should be made in small increments to discover the critical temperature if such exists.

The Wisconsin Engineer.

EDITORIAL.

Engineers are prone to look upon politics as a field of endeavor and usefulness entirely outside of their profession. In this view they are likely to be entirely mistaken, for an engineer is eminently fitted by training and experience to take an important part in politics.

Consider for a moment the chief functions of municipal government as it appears to a citizen. These comprise the paving, cleaning and lighting of streets, the disposal of sewage and refuse, the water supply and fire protection, means of transportation, the maintenance of bridges, parks and playgrounds, the regulation of building construction, the granting of franchises, and, lastly, the provision of police and school systems.

With the exception of the last two items, all the functions lie within the field of the engineer. By reason of his expert knowledge in these matters, it is logical that the engineer should be chosen for office in the municipal government where his services would be of benefit to the community at large. The business man, the lawyer, the doctor and the professional politician have little or no real knowledge of the essential requirements or reasonable costs of much of this work. Yet the government of the city is usually turned over to such a body of men, and unless close vigilance is exercised the corporation may be involved in unsatisfactory contracts and needless expenditures, with inadequate results and returns for investments.

An administrator in public office should combine sterling honor and integrity with capacity for organization. He should have an intimate knowledge of the engineering and business sides of city administration and of the relations of his own department to other departments of the city government. Above all he should be able to take a broad view of local conditions and to look forward. Vast sums of money have been spent in municipal undertakings which, when completed, did not provide for the growth of the city and had to be superseded or abandoned after a few years.

Not every engineer has the qualifications or the natural talents that would make him an ideal administrator. Yet his college work and his experience in commercial work give him a splendid training for the duties involved in municipal government. Wisconsin men, with their broad engineering education, should find it easy to fill such responsible positions.

Setting aside questions of public service, there are many other reasons why young engineers should go into politics. First the young engineer should be a good mixer. He should be able to mix with the gang and learn how to get the views of the men under his supervision. The struggle between capital and labor is becoming more acute every day and it is of the utmost importance for every engineer who expects to have charge of a large number of men, not only to be able to mix with them and to learn their views, but also to have their confidence and to be able to impress his own views on the men.

It can thus be seen that, in addition to the duties of citizenship, there is much to be gained in politics by every young engineer. Each Wisconsin graduate should therefore make it a practice to get interested in local politics wherever he may be and to do his best to uphold the ideals of citizenship and to improve the quality of local municipal government.

* * *

The class of 1912 has set a precedent in the adoption of the St. Patrick's theme followed by many of the engineering schools throughout the country,—a precedent full of possibilities for future development. Though we have always taken pride in our spirit of sticking together, we have never before had a day which was peculiarly our own. We have taken major parts in All-University festivals; we have held our own in intercollege competitions; but we have never had a celebration which was distinctively ours, to shape as we might choose.

In the other engineering colleges which have adopted St. Patrick as their patron saint, the celebration has grown in popularity and in significance each year. It has brought the engineers of the student body, the faculty and the alumni in closer touch and sympathy with one another. This year has provided the opening for us here at Wisconsin. It has given us some little idea of what the day may be brought to mean. "St. Patrick was an Engineer" is being sung throughout the University. Next year when the 17th of March comes round, we will have another chance. Why not try to make it a still more notable Engineers' celebration? Expand it beyond the parade and the minstrels to a day when every engineer cooperates with every other engineer in showing the whole University that he is glad and proud to be an engineer.

* * *

The prominent place to be given the Engineering Exhibit at the University Exposition is indicative of the fact that the Engineering School is still, as it always has been, recognized as one of the most active divisions of the University. The postponement of the Exposition until May gives the committee additional time for the preparation of their displays. The concrete and definite nature of much of the work done in this College renders it especially adaptable for exhibition purposes. Though plans have not as yet been completely formulated, the wealth of material available assures a creditable showing. Nor is the interest in the event confined to the Engineering School alone. Nearly every department of the University has planned to place some characterization of its work before the public. Applications for floor space to the extent of double that available have been received by the committee in charge. The Exposition seems destined to be a great success, not only as an educational exhibit, its main object, but also, through its ligher features, as a thoroughly enjoyable entertainment.

* * *

The letter of Professor Thomas, which appears in this issue, is a most interesting portrayal of student life at the German technical schools. Professor Thomas, who has an intimate knowledge of the American colleges and who is now studying the German institutions, is eminently fitted to discuss this subject. We commend the perusal of his letter to all students and specially to the seniors. Those of us who have learned to know Professor Thomas regret very much that we can not have him with us during our senior year, but we are happy to know that he has our interest at heart and has used this method of communicating with us.

DEPARTMENTAL NOTES.

MECHANICS DEPARTMENT.

A brief summary of the undergraduate theses which are being conducted in the Materials Testing Laboratory is given below.

Mr. W. Hathaway is about to make some tests upon malleable iron specimens manufactured by the cupola, air furnace and open hearth processes. Specimens made by representative firms employing these different processes will be tested in tension, compression and cross-bending; both annealed and unannealed specimens will be tested. Some of the problems which will be studied are the effect of differences in diameter in both tension and compression tests, the effect of the skin in increasing the strength of malleable iron in tension and compression, and the effect of the thickness of the skin. Several tests will also be made to determine the modulus of elasticity of the malleable iron specimens.

* * *

In the thesis of Messrs. F. W. Braasch and R. H. Kellogg, the efficiencies of gasket-packed hydraulic cylinder heads are being tested. The variables which are being studied are the number and size of bolts, the kind of packing, the area of the packing, the character of the face of the cylinder head, the area of the cylinder and the pressure to which the cylinder is subjected. The tests will be carried out upon two cylinders, one 4–3/8″ in diameter and the other 6–2/10″ in diameter, equipped with flanges 8–3/4″ and 12–4/10″ in diameter respectively. The bolts will vary in number from 3 to 18 and in diameter from 1/2″ to 7/8″. The intensity of the pressure at which the joints leak will be determined for all practical combinations of the above variables. In addition, the stress-strain curve for the various packings will be determined in order that the limiting stresses to which the packing should be subjected may be estimated.

In the thesis of Messrs. J. M. Bischel and W. H. Griffith, tests are being made to ascertain the effect of a preliminary heating of the ingredients upon concrete laid in low temperatures. The tests are being made upon cylinders and prisms differing in volume and encased in iron or wooden molds. Variations in the temperature of the concrete specimens and in the temperature of the refrigerator in which the specimens are placed will be introduced during the tests. By means of resistance thermometers, a record of the internal temperature of the specimens is being obtained.

* * *

Mr. A. J. Barclay in his thesis is experimenting on the effect of different methods of mixing, molding and curing upon the strength of neat cement and 1:3 motar briquettes. Tests have been made with several brands of cement to determine the effect upon the strength of varying the length of time of dry and wet mixing, the effect of the method of placement in the molds and the effect of length of time of removal from water bath previous to breaking. A brief study has also been made of the effects upon strength of differences in the kind of mixing water.

CHEMICAL ENGINEERING DEPARTMENT.

Prof. Burgess gave a talk on "The Corrosion of Iron and Steel" at Milwaukee on Wednesday, March 13. The meeting was a joint session of the Milwaukee Engineering Society and the local section of the American Chemical Society.

The senior chemical engineers visited several plants representative of various lines of industrial chemistry during the latter part of March. These included the Solvay Coke Co., Patten Paint Co., Pfister and Vogel Leather Co., and the United States Glue Company at Milwaukee; The Illinois Steel Co., Indiana Steel Co., Inland Steel Co., Universal Portland Cement Co., Standard Oil Co., Grasselli Chemical Co., and Carter White Lead Works in the Chicago district; and the Illinois Zinc Company at La Salle, Illinois.

ALUMNI NOTES.

D. L. Fairchild, '90, is now vice-president of the Duluth Diamond Drilling Company, 205 Lonsdale Block, Duluth, Minn.

James M. Gilman, '04, has risen to the position of chief draftsman B. & B. Department, C., M. & P. S. Ry., 622 White Bldg., Seattle, Wash. Gilman was recently put in entire charge of the construction of a large electrical power plant near Seattle. He designed, built, and equipped this plant, which is a model one, and in five months had it in operation.

F. F. Washburn, '01, C. E. '09, is occupying the chair as president of the Federal Engineering Co., 218–219 Stephenson Bldg., Milwaukee.

R. L. Hankinson, '05, is superintendent of the 16th Light House District, and is situated at Ketchikan, Alaska.

B. F. Bennet, '10, is with the American Sheet and Tin Plate Co. at Vandergrift, Pennsylvania.

L. G. Arnold, '09, is now city engineer of Chippewa Falls, Wis.

F. S. Zeidlhack, '10, is employed by the Oregon and Washington Railroad and Navigation Co. Address, 924 Paulsen Bldg., Spokane, Wash.

H. L. Budd, '10, is with the National Electric Lamp Co., Cleveland, Ohio. Address, 4411 Hough Ave.

E. F. Curtiss, '10, is a cadet engineer with the Denver Gas and Electric Co.

A number engineering graduates have found employment on the Railroad and Tax Commission and on the State Highway Commission in Madison, as follows: L. F. Boon, '10, assistant chief inspector; Henry Bücher, '10; G. L. Gross, '08; S. P. Hall, '10; S. R. Hatch, '07; L. P. Jerrard, '08; A. L. Luedke, '10; H. A. Parker, '08; E. L. Pflanz, '11; R. G. Saxton, '09; F. A. Torkelson, '11; M. W. Torkelson, '04.

The United State Reclamation Service has given employment to a number of graduates, as follows: R. L. Balch, '05,

C. E., '09, assistant engineer, Powell, Wyo.; P. W. Beasley, '10, surveyman, Sunnyside, Wash.; E. C. Bebb, '96, engineer, Washington, D. C.; L. S. Davis, '10, junior engineer, Babb, Mont.; R. F. Ewald, '05, assistant engineer, Provo, Utah; L. M. Hammond, '10, junior engineer Strawberry Valley Project, Thistle, Utah; J. R. Iakisch, '11, engineer, Babb, Mont.; A. E. Kringel, '10, surveyman, Huntley, Mont.; H. C. Kuhl, '09, assistant engineer, St. Ignatius, Mont.; A. E. May, '11, Powell, Wyo.; E. A. Moritz, '04. C. E. '05. engineer, Helena, Mont..; A. L. B. Moser, '06, River Portal, Colo.; N. T. Olson, '10, assistant engineer, Seville, Mont; R. K. McComb, '09, junior engineer, Wagner, Mont.; W. L. Rowe, '07, junior engineer, Sunnyside, Wash.; E. E. Sands, '00, engineer, Powell, Wyo.

The army and navy have each claimed engineering graduates. E. B. Colloday, '09, is a lieutenant in the Coast Artillery Corps, Fort H. G. Wright, N. Y.; G. B. Ransom, '91, is a cap- U. S. Navy, address, Rooms 518–519, No. 6 Beacon St., Boston, St., Boston, Mass.; F. E. Bamford, '87, is a captain, 28th U. S. Infantry, stationed at Ft. Sam Houston, Texas.

J. W. Balch, '09, is with the Pacific Telephone and Telegraph Co., Spokane, Wash.

B. C. Brennan, '05, is now assistant city engineer of Kenosha, Wis.

J. H. Dousman, '84, is with the Builders' Material Supply Co., 301 Scarrit Bldg., Kansas City, Mo.

E. S. Ela, '96, is a civil engineer in Rochester, Wis.

J. F. Sidral, '10, is engineer at the Spokane Terminal of the C., M. & P. S. Ry., Spokane, Wis.

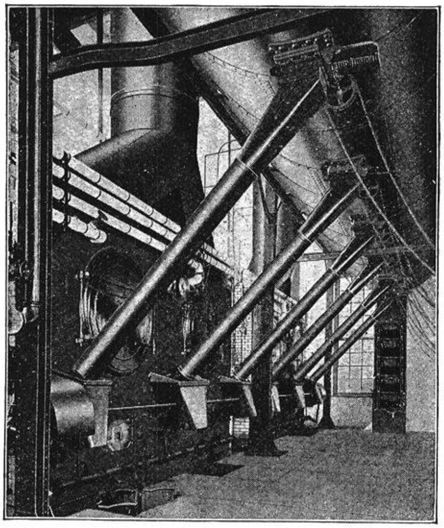
R. B. Ordway, '09, is foreman of the Barber Asphalt Co., Seattle, Wash.

D. Y. Swarty, '98, is with the Great Lakes Dredge and Dock Co., Boston, Mass.

H. A. True, Jr., '09, is assistant state engineer at Cheyenne, Wyo.

F. W. Ullius, Jr., '11, is a draftsman for the Milwaukee Bridge Co., Milwaukee, Wis.

A. M. Wolf, '09, is a civil engineer with T. L. Condron, consulting engineer, Chicago, Ill.



The University of Wisconsin

THE COLLEGE OF LETTERS AND SCIENCE offers a General Course in Liberal Arts; a Course in Commerce; a Course in Music; a Course in Journalism, Library Training Courses in connection with the Wisconsin Library School; a Course in Education; the Course for the Training of Teachers, and the Course in Chemistry.

THE COLLEGE OF MECHANICS AND ENGINEERING offers courses of four years in Mechanical Engineering, Electrical Engineering, Civil Engineering, Applied Electro-chemistry, Chemical Engineering, and Mining Engineering.

THE COLLEGE OF LAW offers a course extending over three years, which leads to the degree of Bachelor of Laws and which entitles graduates to admission to the Supreme Court of the state without examination.

THE COLLEGE OF AGRICULTURE offers (1) a course of four years in Agriculture; (2) a course of two years; (3) a short course of one or two years in Agriculture; (4) a Dairy Course; (5) a Farmers' Course; (6) a course in Home Economics, of four years.

THE COLLEGE OF MEDICINE offers a course of two years in Pre-clinical Medical Work, the equivalent of the first two years of the Standard Medical Course. After the successful completion of the two years' course in the College of Medicine, students can finish their medical studies in any medical school in two years.

THE GRADUATE SCHOOL offers courses of advanced instruction in all departments of the University.

THE UNIVERSITY EXTENSION DIVISION embraces the departments of Correspondence-Study, of Debating and Public Discussion, of Lectures and Information and general welfare. A municipal reference bureau, which is at the service of the people of the state is maintained, also a traveling Tuberculosis Exhibit and vocational institutes and conferences are held under these auspices.

SPECIAL COURSES IN THE COLLEGE OF LETTERS AND SCIENCE

THE COURSE IN COMMERCE, which extends over four years, is designed for the training of young men who desire to enter upon business careers.

THE COURSES IN PHARMACY are two in number; one extending over two years, and one over four years, and are designed to furnish a thoroughly scientific foundation for the pursuit of the profession of pharmacy.

THE COURSE FOR THE TRAINING OF TEACHERS, four years in length, is designed to prepare teachers for the secondary schools. It includes professional work in the departments of philosophy and education, and in the various subjects in the high schools, as well as observation work in the elementary and secondary schools of Madison.

A COURSE IN JOURNALISM provides two years' work in newspaper writing and practical journalism, together with courses in history, political economy, political science, English literature, and philosophy, a knowledge of which is necessary for journalism of the best type.

LIBRARY TRAINING COURSES are given in connection with the Wisconsin Library School, students taking the Library School Course during the junior and senior years of the University Course.

THE COURSE IN CHEMISTRY offers facilities for training for those who desire to become chemists. Six courses of study are given, namely, a general course, a course for industrial chemist, a course for agricultural chemist, a course for soil chemist, a course for physiological chemist and a course for food chemist.

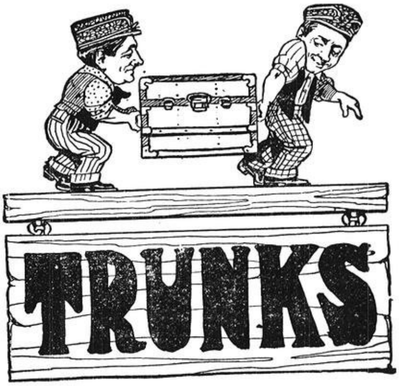
THE SCHOOL OF MUSIC gives courses of one, two, three, and four years, and also offers opportunity for instruction in music to all students of the University.

THE SUMMER SESSION embraces the Graduate School, and the Colleges of Letters and Science, Engineering, and Law. The session opens the fourth week in June and lasts for six weeks, except in the College of Law, which continues for ten weeks. The graduate and undergraduate work in Letters and Science is designed for high school teachers who desire increased academic and professional training and for regular graduates and undergraduates. The work in Law is open to those who have done two years' college work in Letters and Science or its equivalent. The Engineering courses range from advanced work for graduates to elementary courses for artisans.

THE LIBRARIES at the service of members of the University include the Library of the University of Wisconsin, the Library of the State Historical Society, the Library of the Wisconsin Academy of Sciences, Arts, and Letters, the State Law Library, and the Madison Free Public Library, which together contain about 380,000 bound books and over 195,000 pamphlets.

THE GYMNASIUM, Athletic Field, Boating Facilities, and Athletic Teams give opportunity for indoor and outdoor athletic training, and for courses in physical training under the guidance of the athletic director.

Detailed information on any subject connected with he University may be obtained by addressing **W. D. HIESTAND, Registrar, Madison, Wisconsin.**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