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DEDICATION OF THE NEW CERAMIC ENGINEERING BUILDING UNIVERSITY OF ILLINOIS

On December 6th and 7th, the University of Illinois dedicated its new Ceramic Engineering Building. The dedication exercises were opened at 1.30 P.M. on Wednesday, December 6th, by a meeting of the Advisory Board of the Department followed by a reception in the building, at which all of the laboratories were thrown open to the visiting guests and the University public.

On the evening of Wednesday an introductory session was held in the University Auditorium, presided over by Dr. Edmund J. James, President of the University. At this session, Dr. S. W. Stratton, Director of the National Bureau of Standards, gave an address of "The Ceramic Resources of America." This was followed by an address on "Science as an Agency in the Development of the Portland Cement Industries," by Mr. J. P. Beck, General Manager of the Portland Cement Association of Chicago. Dr. Stratton discussed the organization and formation of the different types of clay deposits together with their most prominent geological and geographical positions in the United States. This was followed by a discussion of the reactions occurring during the burning of clay products. A detailed classification of the various clay products fashioned from ceramic materials was also presented. The whole address gave a very clear idea of the great variety and extent of the clay resources of the nation and the multifold products which are manufactured from them.

The second dedicatory session was of a technical nature and assembled on Thursday morning in the University Auditorium. It was opened with an address on "The Manufacturer's Dependence upon Ceramic Research," by Mr. W. D. Gates, president of the American Terra Cotta and Ceramic Company, of Chicago. This was followed by further discussions by Mr. Ross C. Purdy, Research Engineer of the Norton Company, and by Mr. L. E. Barringer, Engineer of Insulations for the General Electric Company. Mr. C. H. Kerr, who was to discuss the same topic from the standpoint of the problems of the clay industries, was unable to be present, but sent his discussion for presentation.

The second address of this session was given by Mr. W. W. Marr, Chief State Highway Engineer of Illinois, upon the topic "The Use of Ceramic Materials in Highway Construction." This paper was discussed in a very interesting manner by Mr. Blair, Secretary of the National Paving Brick Manufacturers' Association, of Cleveland, Ohio, and by Mr. G. G. Wooley, Engineer for the Road Bureau of the Portland Cement Association, Chicago.

A paper on the topic "Ceramic Products as Structural Materials" was presented by Mr. H. J. Burt, Structural Engineer, of Chicago, and discussed by Mr. A. V. Bleininger, Ceramic Chemist and Head of the Clay Products Laboratory of the United States Bureau of Standards.

The last topic for discussion at this session was "The Use of Ceramic Products in the Artistic Embellishment of Buildings." The discussion was opened with a paper by Mr. Claude Bragdon, author and architect, of Rochester, New York, which was discussed by Mr. G. C. Mars of St. Louis. Mr. F. Wm. Walker, who was to have discussed the same topic, was unable to be present.

At the close of the forenoon session, the speakers and guests of the University were entertained at luncheon at the University Club by the dean and heads of departments of the College of Engineering. The formal session of dedication convened at the University Auditorium in the afternoon. It was presided over by Dean W. F. M. Goss of the College of Engineering. Introductory addresses were made by the Honorable Edward F. Dunne, Governor of the State of Illinois, and by Honorable W. L. Abbott, President of the Board of Trustees of the University of Illinois. The principal address of this session was then given by Professor Charles F. Binns, Director of the New York State School of Clayworking and Ceramics, upon the topic "The History of the Ceramic Arts." The exercises were closed with an address by the President of the University, describing the history of the growth of the Department of Ceramic Engineering. After singing "America," the audience marched to the new building where the prayer of dedication was delivered by the Rev. John Mitchell Page.

On the evening of the 7th, an Illinois student branch of the American Ceramic Society was formally installed by Mr. L. E. Barringer, President of the Society.

The addresses by Mr. Beck, Mr. Gates, Mr. Barringer and Mr. Kerr appear in full below.

DESCRIPTION OF THE CERAMIC ENGINEERING BUILDING

The Ceramic Engineering Building, exclusive of the kiln laboratory to which it is connected by means of a corridor, covers a ground area of 67 × 189 feet, with a basement under all. It is a three-story building and is constructed of materials which are representative of the ceramic arts, high-grade brick, tile, terra cotta, cement and gypsum products being used throughout.

The entire basement is given over to the fan system and storage rooms. The first floor contains the ceramic materials laboratories and an office and private laboratory. On the second floor will be found the offices of the department, offices and private laboratories for two professors, the library, lecture, class and drafting rooms, and several laboratories devoted to chemical and physical work and to high temperature investigations. For the present, the offices and laboratories of the Geological Survey occupy the third story of the building, and a portion of the first floor is also given over to the concrete testing laboratory. Space is provided on a fourth floor for the distilling apparatus which furnishes a supply of pure distilled water for the building.

The walls of the main corridor on the first floor have been decorated with display panels showing different styles of face brick. These panels were donated and erected by the following firms:

Western Brick Company, Danville, Illinois.

Sheldon Brick Company, Urbana, Illinois.

Hydraulic-Press Brick Company, St. Louis, Missouri; Indianapolis, Indiana; Aledo, Illinois.

West Salem Hollow Brick and Tile Company, West Salem, Illinois.

Streator Brick Company, Streator, Illinois.

Decatur Brick Company, Decatur, Illinois.

Acme Brick Company, Cayuga, Indiana.

Brazil Clay Company, Brazil, Indiana.

La Salle Pressed Brick Company, La Salle, Illinois.

C. E. Poston, Attica, Indiana.

THE LABORATORIES AND THEIR EQUIPMENT

The laboratories of the building are provided with outlets for water, gas, compressed air, vacuum, distilled water, and alternating and direct current.

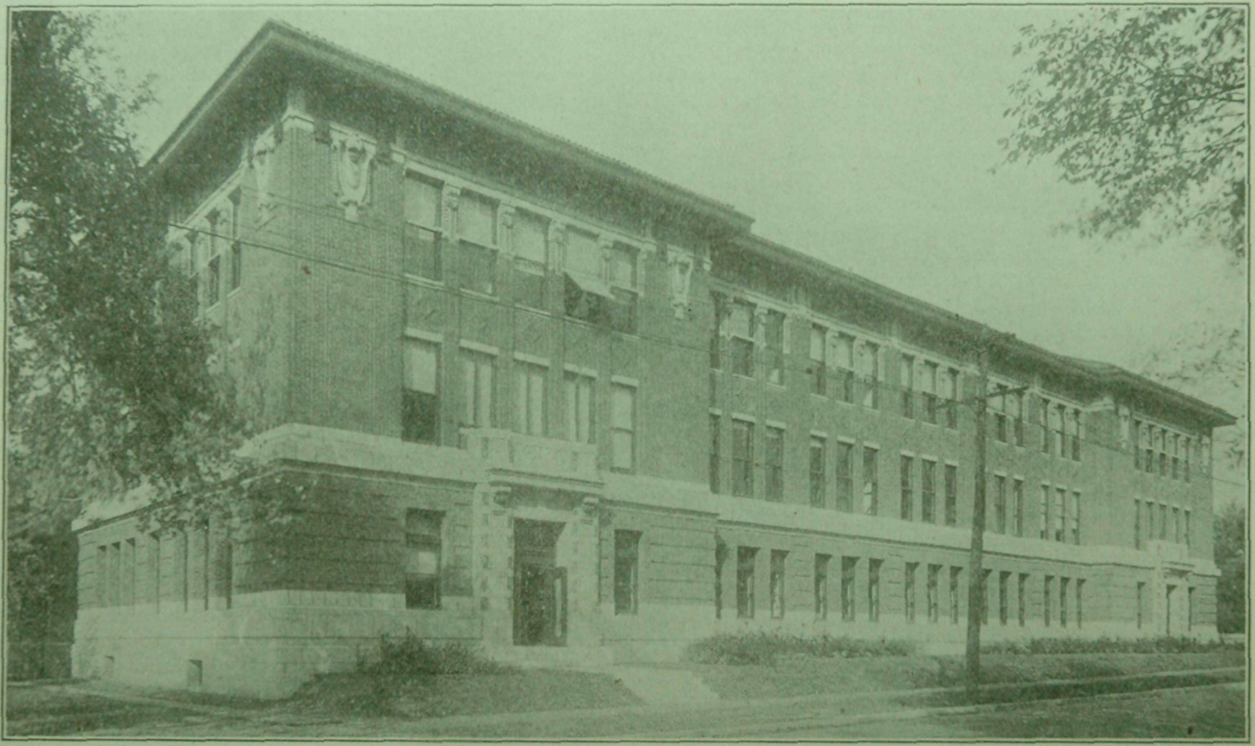
The laboratories on the first floor are arranged for the preparation and handling of ceramic materials. In the store-room, the supplies of ceramic materials are stored in large bins ranging in capacity from 2 tons to 100 pounds. The ceramic materials laboratory is equipped with laboratory tables and lockers to meet the needs of 40 students. Adjoining it is the glaze laboratory with tables and lockers for 24 students. The glaze preparation laboratory is provided with machinery for grinding and mixing slips and glazes. This equipment consists of ball mill racks for the accommodation of twenty 1-gallon jars; two double racks for 5-gallon jars; three 12-inch Buhrstone mills; 3 power mortar mills and 8 slip blungers; and a large porcelain lined ball mill; all driven from a line shaft.

The pottery laboratory is provided with the necessary equipment for the manufacture of tile and of tableware. It includes a mixing unit consisting of a blunger and agitator, a lawn, and a filter press with a capacity of 30 to 40 pounds of clay per charge. A pulldown and jigger with heads and rings suitable for the making of large pieces of hollow ware, and two friction jolleys with heads and rings for the manufacture of medium and small sizes of flat and hollow ware are also provided. One of these is arranged for use as a thrower's wheel. The other apparatus in this laboratory includes a tile press with dies for the preparation of ware by the dust process; a potter's lathe of the most modern type; bench whirlers; and a decorator's printing press. A large drying closet and a damp closet are also included in the equipment for the work in pottery.

The plaster shop is intended for the preparation of models and molds for pottery and other clay wares. It is equipped with a bench whirler, two potter's wheels and a potter's lathe. Concrete-topped tables for modeling terra cotta forms and casting molds, together with shelving for the storage of models and molds, complete the equipment of this room.

The kiln laboratory, which is in a separate structure connected with the main building by a corridor, is equipped with two open fire downdraft test kilns with chambers of one cubic yard capacity and one muffle kiln with two-thirds of a cubic yard capacity. These kilns are fired with coal or coke. A round downdraft kiln with a 2-foot chamber, a load-test kiln for testing refractories under load at high temperatures, and a muffle furnace for enameling and decorating work are arranged for oil firing. A battery of 4 gas-fired frit furnaces, a small gas-fired test kiln with a preheating arrangement for the gas and air, a Monarch tilting furnace for the fusion of glass batches, and several small pot furnaces for fusion work are also provided. The various kilns and furnaces are connected by underground flues to a 60-foot stack. A small room adjoining the kiln laboratory is provided with indicating and recording instruments which are connected to thermocouples in the kilns. A Simmance-Abady carbon-dioxide recorder is connected with the three coal-fired kilns for the study of atmospheric conditions in the firing. A steam-heated dryer is provided for the drying of wares and test pieces.

The machinery equipment of the kiln laboratory consists of a 5-ft. dry pan elevator and a Jeffrey shaking screen; a 4-compartment steel bin for storing ground clay above the 8-ft. double shaft pug mill; a 5-ft. wet pan; and auger brick machine with a capacity of 6,000 bricks per day with a take-off belt and a hand-power side delivery cutting table; a miniature auger brick machine; a hand-power repress; and a hand-power dry press for full-sized brick as well as a miniature dry press for briquettes; two hand-power blunger machines for briquette molding; a saggar press; a tile press; a 14 × 28-in. iron ball mill;



THE NEW CERAMIC ENGINEERING BUILDING, UNIVERSITY OF ILLINOIS a set of laboratory rolls and a small jaw crusher. An air compressor is provided for special needs and a rotary blower and oil pump supply the oil burners. The kiln building also provides bins for the storage of fuel, clays and refractories; and a small classroom and a laboratory equipped with tables for the testing of clays and specimens burned in the kilns.

The department library is provided with a well selected set of books dealing with ceramics and its allied sciences, as well as complete sets of the ceramic journals.

The museum has a small but growing collection of ceramic wares and samples of raw materials.

The lecture room has seating capacity for 90 students, and is equipped with the necessary lecture table and lantern facilities. Wall cases for the storage of mineral and clay samples and specimens required for class demonstration, will be provided in this room.

The drafting room provides space for the accommodation of 16 students, as well as filing cases for the storage of plans and blueprints of the various types of industrial plants.

The chemical, physical and research laboratories on the second floor are equipped with the usual laboratory desks and other equipment necessary in such laboratories. The high temperature laboratory is intended for research work with electric furnaces. A 5-kilowatt motor generator set and a 10-kilowatt transformer are provided in this room.

The department also possesses a variety of measuring instruments, such as indicating and recording pyrometers and optical pyrometers for the measurement of high temperatures, amperemeters, voltmeters, various types of electric furnaces and petrographic microscopes for general research work.

The buildings and equipment of the Ceramic Engineering Department represent an investment of about $200,000.

An illustrated booklet describing the Department of Ceramic Engineering, its organization, purposes, and equipment was published by the University for distribution at the dedication exercises.

SCIENCE AS AN AGENCY IN THE DEVELOPMENT OF THE PORTLAND CEMENT INDUSTRIES

By J. P. Beck
General Manager Portland Cement Association

Probably few laymen are aware of the debt which modern industries owe to scientific research. To Dr. Stratton, fellow alumnus of this University, the Portland cement industry, as one example, is indebted to a remarkable degree. Under his able guidance, the United States Bureau of Standards, of which he is the distinguished head, has been of incalculable benefit not only to the Portland cement industry itself but to the many industries which have sprung from it as parent. Leaders of industry recognize that in the face of present-day conditions, correct standards of measurement, quality or performance call for continuous scientific, technical research of the highest order. To this end the Bureau of Standards has contributed far more liberally in many industries than is generally known.

The topic which has been assigned to me might lead you to think that I am a scientist. Let me disabuse your minds of that thought. When I received Dr. Goss' invitation to address you at my alma mater on this occasion, I could look at it only in the light of a command. I feel that he might have chosen more wisely, because although my varied connections with the cement industry have afforded me some opportunities to learn what an agency science has been in developing the Portland cement industries, these connections have not qualified me to discuss this development from the scientist's aspect. I shall, therefore, disclaim originality for the thoughts which I shall endeavor to present to you, because they have been gleaned largely from the writings of those really responsible for placing the Portland cement industry and the industries dependent upon it, in the position which they occupy to-day.

For a number of years, all manufacturing industries have recognized the importance of conducting scientific research and applying the disclosures which such research has made. Science has improved processes and has disclosed a better knowledge of the properties of materials upon which the useful qualities of those materials depend. Science helps modern industry to meet competition, to raise standards of product, to decrease cost of production, to raise standards of living. Science has been at the base of all these ends at least to a contributory extent in practically every industry of any magnitude. For years it has been the underlying policy of all great industrial leaders to surround themselves with and make partners of competent experts, the best scientific equipment and that keen intuition supplemented by long experience such as the laboratory expert, for instance, possesses.

The manufacture of Portland cement combines the mechanical and chemical—processes largely suggested by the mechanical engineer and the chemist.

As time is measured, Portland cement is still something of a youngster. It may be said to have had its origin in 1756 from researches made by John Smeaton, an English engineer. Smeaton was employed by the English Government to build a lighthouse upon a group of partly exposed rocks in the English Channel. His work demanded a cementing material that would set under water as well as in air, and in searching around for such a material he discovered that an impure or clayey limestone, when burned and slaked, would meet requirements better than anything so far known. The clayey limestone which he used was found in Cornwall. From it he made a hydraulic lime which, when mixed with puzzolana, a pumice-like material of volcanic origin, produced a satisfactory mortar which he used when building the Eddystone Lighthouse.

But although Smeaton's cement was undoubtedly an excellent structural material, it was never widely used because puzzolana is found only in a few volcanic regions, notably Italy, where from almost time immemorial it has been used in the making of the so-called Roman cements.

Smeaton's discovery, however, paved the way for that improvement and development in the lime and cement industries which ultimately led up to the original Portland cement, made and patented by Joseph Aspdin, in England in 1824. The fact that Aspdin's product resembled in color, after hardening, the famous old English Portland stone, is responsible for the name Portland cement. Aspdin's patent involved calcining a mixture of limestone and clay, these materials being raised to a temperature sufficient to result in a clinker. Scientific knowledge was scant during the early stages of the development of the Portland cement industry in England, so proper proportions of limestone and clay to be used were discovered by burning experimental mixtures and testing the physical properties of the resulting product.

THE CHEMISTRY OF CEMENTS

The first knowledge of the chemistry of cements probably came from various investigations carried on in France. Of these early researches the ones that have no doubt done most to establish studies which followed, were those of M. Vicat. Vicat made an attempt to determine the relation between the quality of hydraulic lime, cement and the chemical composition of the stone from which they are derived; likewise the nature of the chemical compounds formed during burning and the changes which took place when the cement was mixed with water and hardened. Although Vicat did not attain the ends which he sought, his studies resulted in some interesting theories that have done much to guide scientific research since his time.

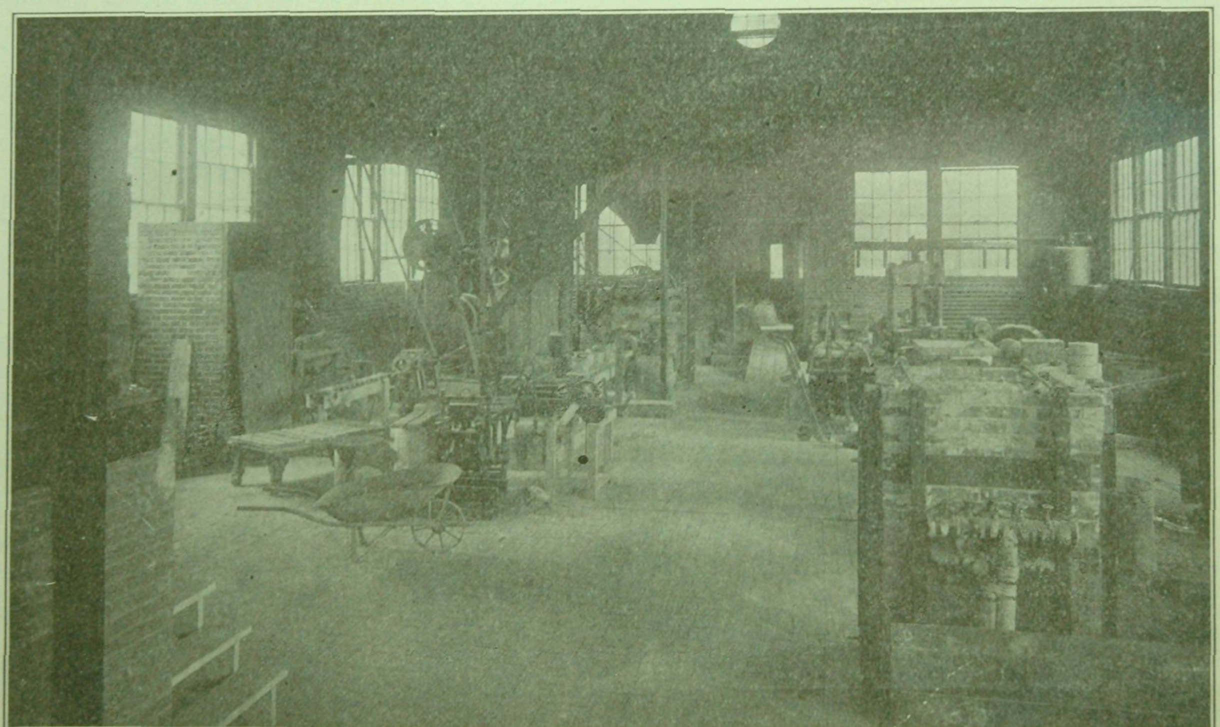
When the manufacture of Portland cement was first undertaken in the United States, the natural tendency was to follow closely the practice prevailing in Europe, both as to raw materials and processes. Then nearly all of the European plants used soft natural raw materials which were mixed and ground in a wet condition and burned in stationary vertical kilns, the resulting clinker being then ground in a manner similar to the grinding of wheat into flour by the old familiar millstones. But this process was not best adapted in all instances to the great bulk of raw cement materials in the United States. It involved reducing them to powder or to a wet paste or "slurry," or forming the materials into bricks or balls and feeding them by hand in these forms into a vertical kiln in which they were burned. The kilns also had to be unloaded by hand and the clinker finally ground in a way that to-day would be regarded as particularly ineffective and inexpensive. When both of the raw materials were naturally wet and naturally soft, as when marl and clay were used, the earlier stages of the wet process were, of course, considerably simplified and relatively inexpensive.

But with the hard dry raw materials, such as those so abundant in the Lehigh district, for instance, the wet process was not only expensive but absurd. It was soon recognized by those who had commenced experimentally the manufacture of Portland cement in the United States, that the relatively higher priced labor and cheap fuel of America as contrasted with the cheap labor and expensive fuel of Europe, would call for great changes in the technology of the industry if it were ever to be established on a firm commercial basis.

The most interesting features of the days that marked the early development of the cement industry in this country were a realization of these conditions and the careful search for alternative methods. In the general effort to cut down the excessive labor cost of the product, two distinct, though closely allied points of attack, were obvious. Both the burning and the grinding processes would have to be cheapened by mechanical improvements. These received prompt consideration and careful study. Advancement became a reality when the old stationary kilns and millstones were displaced respectively by the rotary kiln and by modern grinding machinery. Of the two changes, substitution of the rotary for the stationary kiln demands the greater attention because of its important effects on the cement industry.

THE ROTARY KILN

It will be sufficient to describe briefly the rotary kiln as a steel cylinder lined with fire brick and set at a slight inclination to the horizontal. The raw mixture is conveyed in at the upper end and travels slowly by gravity as the kiln is revolved. The fuel is blown in at the lower end where the burned clinker also falls out. When the rotary kiln was first planned for use in this country it was expected that producer gas would be the fuel, but as a matter of fact petroleum was used and for some years this continued to be current American practice. The rotary kiln was first used successfully in this country at South Rondout, N. Y., in 1899. At the South Rondout plant it was found possible to charge the mixed and ground raw materials direct to the kiln without wetting. This marked another step in the progress of science in the Portland cement industry. In 1891, at Montezuma, N. Y., naturally wet raw materials (marl and clay) were charged into the kiln without preliminary drying.



East End of Kiln Laboratory Showing Brick and Molding Machinery

The two main types of present American practice in Portland cement manufacture were thus brought into existence, the dry process used with limestone or cement rock, and the wet process used with marl. Of the two, the dry process has become the most universally used.

The next step in the development of American cement manufacturing methods began about 1895, when powdered coal first replaced petroleum as fuel. This soon became standard practice throughout the United States except in a relatively few localities where petroleum or natural gas abounded.

The most recent development in the rotary kiln has been purely a matter of dimensions. By 1903 these kilns had become practically standardized in size and capacity. Almost every kiln in the country used on dry materials was 60 feet long. Such a kiln had a rated capacity of 200 barrels of cement a day. Beginning with the proved success of longer kilns, a rapid tendency toward lengthening kilns was noted about 1905, since when nothing like fixed standards in length have prevailed. Kilns now installed range from 100 to 150 feet in length and have an output of from 400 to 800 barrels a day. A few kilns 250 feet in length are in operation.

In line with changes in type and capacity of kilns, it is natural that there should be changes in crushing and grinding machinery which have also contributed to the enormous tonnages of raw and finished material. The cracker crushers and millstones of the early days of the cement industry have been replaced by larger and more efficient reducers. At present the gyratory crusher is almost exclusively used for the first stage of reduction.

In 1905 the United States Geological Survey published as its Bulletin **243**, a report of the cement materials and industry of the United States, prepared by Edwin C. Eckel. The introduction to this bulletin was written in 1904 and called attention to the marvelous growth of the Portland cement industry during the ten years preceding. Mr. Eckel then said:

"In its importance to our present-day civilization, cement is surpassed among mineral products only by iron, coal and oil. In rate of increase in annual production during the last decade, even these three products cannot be compared with cement. In 1890 the total production of Portland cement in the United States was 335,000 barrels, valued at $439,050. In 1903, it exceeded 22,000,000 barrels, while the value was over $27,000,000.

"During the 16 years which witnessed the development of the American Portland cement industry, two of the greatest gold discoveries in the world's history were made in Colorado and Alaska. The annual gold production of Alaska and of the Cripple Creek District in Colorado have impressed themselves on every citizen of the United States, while the Portland cement industry has attained its growth in comparative obscurity. Yet on comparison it will be seen that the gold production of Cripple Creek is only slightly greater than the output of Portland cement, while the production of Alaska sinks into comparative insignificance. Moreover, the greater part of this increase has been within the last decade. The production of Portland cement has risen from a little less than $2,500,000 in 1896 to over $27,000,000 in 1903."

These figures now have only a historical interest. But they are interesting because of the growth which the Portland cement industry has undergone since they were published. In 1915 the total production of Portland cement in the United States was 85,914,907 barrels valued at $73,886,820. The recent growth of the American Portland cement industry has been so rapid that its present relative standing among our great industries is realized by few, sometimes not even by those most directly interested.

Nature has provided an abundance of calcareous and argillaceous materials suitable for the manufacture of Portland cement and its manufacture does not involve a secret process. Portland cement is but one of a dozen chemical compounds which harden or set when mixed with water. It has attained its great importance because of the ease and relative cheapness with which it can be manufactured and not because of any peculiar properties not possessed by certain other compounds. But simple *mechanical mixing of silica, alumina and lime in the proportions* usually found in standard Portland cements will not yield a compound possessing the required properties. It is essential that the ingredients be properly combined, not exactly as a true chemical compound but rather as a physical chemical solution of one or more chemical compounds in each other. The best, and practically the only way, in which such a union can be attained is by a complete or partial fusing of the silica, alumina and lime, in other words, reducing this mixture to a clinker, then grinding it to a fine powder.

Knowing the chemical ingredients of Portland cement and the steps necessary to combine these materials properly, it is evident that plants of the industry should be widely distributed. A mixture of clay and limestone can be so prepared artificially that when the combined water in the clay and the carbonic acid of the limestone are driven off by heat, the residue will form clinker of the desired composition. Assisted by the mechanical equipment devised and perfected by the mechanical engineer, the chemist then controls the process of cement manufacture.

The Portland cement industry is a chemical industry in that Portland cement is the result of reactions going on at high temperatures between the silica, alumina and lime in predetermined proportions. For this reason it is necessary that the scientific side of the industry be given proper recognition and research work be highly developed and persistently maintained. Chemical research may be and has been directed in various directions in industries which involve chemical principles. Take, for example, the manufacture of dyes, in which chemistry, by the manipulation of coal tar, has evolved practically every conceivable color. Chemical research may also be directed toward the development of new processes or the modification of old methods, and toward a proper interpretation of the reactions to which the formation of different products are due, in order that the conditions under which they originate may be made the most favorable for producing the highest grade of material at the lowest cost.

The Portland cement industry, like many other industries, has benefited because of persistent research and study along the last two lines. In the early days of its development, manufacturing processes were carried on largely by rule of thumb methods, and the preëminence of Portland cement has been made possible solely because of the control which the chemist can exercise over the finished product before and during its manufacture.

THE AMERICAN CEMENT INDUSTRY

John W. Eckert has been called the father of cement chemists in this country. While working as an assistant at Lehigh University, South Bethlehem, Pa., he was asked to make analyses of rocks from the different beds in the quarries of the Coplay Cement Works, of which D. O. Saylor was then President. Mr. Eckert was finally engaged by the Coplay Cement Works to devote his entire time and knowledge to the process of manufacture and in this way became the first cement chemist in the United States. His efforts resulted in more certainty and less chance in the preparation of proper mixtures. A more nearly uniform product naturally resulted. This was in the latter seventies. Somewhat later, Robert W. Lesley, one of the pioneer manufacturers of the country, in coöperation with George W. de Smedt, then a Government chemist, worked at various problems that had been puzzling cement manufacturers; among these was a search for something to retard the setting time. Chance brought to light the fact that gypsum added in certain quantities accomplished the desired end.

But although chemistry has had a great deal to do with progress made in the manufacture of Portland cement, the work of the chemist has been most effective in perfecting technical processes. Only within the past year has it seemed likely that the chemical structure of the material will soon be disclosed. Studies now in process at the Geophysical Laboratory, Carnegie Institution, Washington, appear to point to this conclusion.

The chemist has shown that a true Portland cement can be made from blast-furnace slag, once a waste product, and has thus been responsible for a great industry producing considerably over 10 per cent of the total Portland cement manufactured in the country. He has proved that the cement rocks, as found, for instance, in the so-called Lehigh district, need not be depended upon as a source of high-grade product. He has found that almost every state in the Union contains materials which, when properly combined, will produce Portland cement of high quality. He is able to control even variations in composition of raw materials and as the requirements of engineering specifications have called for a material of better quality, the demands have been met.

The first semblance in this country to anything like standard specifications for Portland cement was a report of a committee of the American Society of Civil Engineers, January 7, 1885, which served for a few years; but it soon proved too indefinite for the growing needs of engineering as applied to concrete. In 1896, at the suggestion of Mr. Richard L. Humphrey, a series of editorials appeared in the *Engineering Record* calling attention to the inadequacy of the 1885 report of the committee mentioned, and urging the appointment of a new committee to revise and amend the first committee's work. Following this, a resolution was presented at a meeting of the American Society of Civil Engineers held November 4, 1896, requesting the Board of Direction to report on the advisability of appointing a committee to report on the proper manipulation of the tests of cement. The Board reported at the annual meeting of the Society, January 20, 1897, and after a vote by letter ballot, appointed in July of the same year a committee which may be considered as the first definite organization delegated to prepare comprehensive cement specifications.

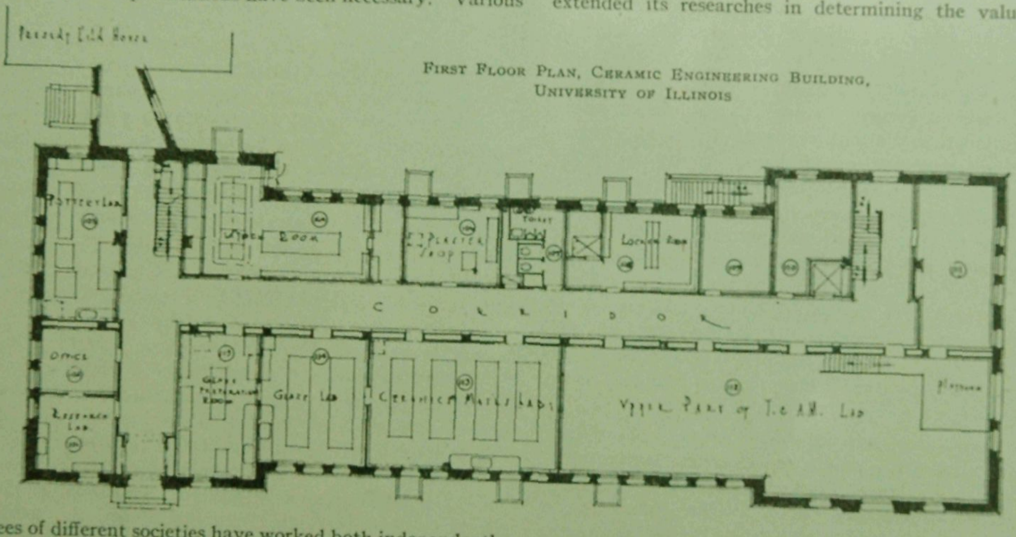
With the rapid development of concrete engineering, further changes in standard specifications have been necessary. Various

materials; but as the science of concrete design developed, rapid recognition was given to concrete as a distinctive building material. It has many desirable qualities peculiarly its own. Probably none is greater than its resistance to fire, when properly manufactured and used.

It differs from all other structural materials in that it is not a finished product until some weeks after fabricated. Other building materials are either provided by nature ready for use or are made and finished in a plant in which rigid inspection of all processes is possible.

The fact that concrete is composed largely of inert materials called aggregates, which are bound together by Portland cement, has led many to believe that as a building material the quality of concrete depends largely upon the Portland cement used in its manufacture.

In order that the engineer may be able to make a proper selection of materials, to proportion them properly, and to mix and place the concrete, it is necessary that the influence of each ingredient entering into it be fully understood. No other material used in building construction depends so much for its value upon the widest possible knowledge obtainable as to the influence of each step in the process of manufacture. So science has extended its researches in determining the value of concrete



First Floor Plan, Ceramic Engineering Building, University of Illinois

committees of different societies have worked both independently and jointly in perfecting cement specifications. But so many societies or different bodies brought forth cement specifications that little short of chaos has existed until within the past year, when various societies and interests united in efforts to evolve one specification that would serve all interests best. These are the specifications of the American Society for Testing Materials which will become effective on the 1st of January, 1917. It is an end to be desired—one that has long been sought not only by cement manufacturers but by many recognized leaders in engineering lines.

CONCRETE

The industries dependent on Portland cement to-day are numerous. As a binder for the finished product known as concrete, Portland cement has no equal. The uses for concrete are many. It is employed in the construction of roads, streets, alleys, sidewalks, houses, dams, bridges, tunnels, office and factory buildings, farm structures, ornamental products, building units such as block and brick, sewers—both monolithic and pipe—for pipe and tile used in drainage, and for many scores of other uses—practically all that have heretofore been satisfied by the older building materials and many that have not.

When concrete first won popularity, it was often abused because looked upon as a substitute for some of the older structural

aggregates. The studies which have been made along these lines would form many printed volumes. Only within comparatively recent times has it been proved that the aggregates determine in a far greater degree than most people know, what qualities the resulting concrete will possess.

In making aggregate determinations, many laboratories, individuals and scientific bodies have been leaders. Probably it would be impossible to refer to any one of these without seeming to slight the others. Yet at the present time the Structural Materials Research Laboratory, located in Lewis Institute, Chicago, perhaps stands foremost, at least in the diversity of its research. The studies on cement, for instance, which have been made during the past year or more in the laboratory mentioned, have been responsible for disclosures that suggested important modifications in the Standard Specifications for Portland cement. The aggregate determinations that have been made and are now being made at this laboratory will, it is believed, eventually disclose how little in a relative sense has been known in the past, both of cement and concrete.

One of the earliest students of the properties of concrete was General Q. A. Gillmore, of the United States Army, who conducted an extensive investigation in New York during the years 1858–1861. A book written in 1863, entitled "Practical Treatise on Limes, Hydraulic Cements and Mortars," gave the results of these studies. A second volume was published in 1871 which gave the results of other studies. Paul Alexandre and R. Feret, French scientists, made important contributions to our knowledge of the strength and other properties of hydraulic mortars and concrete during the years 1888–1892.

The first uses of concrete considered taking advantage only of its compressive strength, that is, its ability to bear loads placed directly upon it. But like building stones, for instance, concrete is strong in compression but weak in tension and little progress was made in developing the possibilities of concrete as a structural material until it was combined with metal, such as iron or steel rods or other fabricated reinforcement, to compensate for its deficiency in tension. To-day the value of concrete as a structural material is due largely to the development of reinforced construction. Such concrete has been referred to in various ways, the terms "ferro concrete" or "armored concrete" were once general and even to-day are in popular use abroad. The combination of steel and concrete has resulted in a building material different in properties from any other and for which the usual formulas of design, such as those involving stress distribution, do not apply. Therefore, it has been necessary for a time to assist in developing the men of science who have aided in solving the problems that were and are still sometimes encountered in making the best use of this most modern building material.

REINFORCED CONCRETE

The early history of reinforced concrete is most interesting. It appears that the first use made of metal reinforcing in combination with concrete was by certain French artisans about 1855 to 1865, in making small boats and flower pots. These men conceived the plan of strengthening their concrete products by embedding iron wires in the fresh concrete. Little did they dream at this period of the importance this principle would have.

The first instance of any importance in which the principles of reinforced concrete construction were applied was in a dwelling at Port Chester, N. Y., built in 1875 by W. E. Ward. This was the first example of reinforced concrete construction which in any way approached our present conceptions of this material. The further development of reinforced concrete construction was extremely slow, as fifteen years elapsed before we find another example of its use in any important structure in the United States. It is probable that reinforced concrete would still be one of the curiosities of building construction were it not for the fact that men of science have searched for and discovered the principles underlying the action of this material, and have shown how structures of reinforced concrete may be designed in a rational way.

The first scientific study of a combination of concrete and iron in the form of reinforced concrete was carried out about 1875 by the laboratory of David Kirkaldy, of London, at the request of Thaddeus Hyatt. Hyatt was a citizen of the United States at that time residing in London. In 1877 a book was published by Hyatt giving the results of these investigations. Although this book was printed for private circulation and has long been out of print, it has attained rank as a classic in the literature of reinforced concrete. Hyatt was probably the first to recognize the fundamental principle of reinforced concrete which involves the use of reinforcement to take the tensile stresses which would otherwise be thrown upon the concrete. At the same time he recognized the necessity of a permanent bond between the concrete and the reinforcing metal, and the importance of similar action of the two materials when subjected to changes in temperature. The tests described by Hyatt were carried out for the purpose of securing information on these subjects.

The use of concrete as a structural material has given rise to many problems which have commanded the attention of scientists. The combination of two materials of entirely different characteristics into a single structural unit has made it essential that new principles be developed which could be applied to the analysis of members of this character. For the first time we are able to construct buildings in such a way that they are of monolithic nature. This has made it essential that methods of analysis be developed which would apply to continuous beams and slabs, and combinations of beams, columns, walls, etc., in a manner that has not been necessary with other materials.

The experiments carried out by Hyatt attracted considerable attention and showed the true principles of the action of reinforced concrete beams under load. However, developments in the uses of reinforced concrete were limited until about the beginning of the present century. Prior to this time a few isolated experiments had been conducted in Germany, Switzerland and France in promoting the use of certain so-called "systems" of reinforced concrete construction. These consisted of patented arrangements of reinforcing steel, many of which were of poor design and wasteful of materials. Practically no research work was done in the United States on the subject of reinforced concrete prior to the year 1900. Since that date the combined efforts of many investigators in the United States, Germany and France have furnished us with a large stock of information concerning the action of reinforced concrete.

The year 1903 saw the inauguration of several independent researches in the United States on the properties of reinforced concrete beams. Professor A. N. Talbot, of the University of Illinois, made his first experiments on reinforced concrete beams during this year. Experiments along similar lines were carried out during the same year by Professor W. K. Hatt, of Purdue University, Professor Edgar Marburg, of the University of Pennsylvania, and by Professor M. A. Howe, of the Rose Polytechnic Institute. Since 1903 numerous other experiments have been carried out by the above-mentioned institutions and by the University of Wisconsin, the United States Geological Survey, The United States Bureau of Standards and others. Prior to these extensive experimental studies, reinforced concrete was designed by purely empirical methods. It was impossible for reinforced concrete to reach its proper development until such experimental studies as those mentioned above had shown that:

(1) There is a definite and positive adhesion or bond developed between concrete and steel which can be depended upon to transmit the stresses from one material to the other.

(2) Iron or steel embedded in well-made concrete is perfectly protected against corrosion and deterioration of all kinds.

(3) The coefficients of linear expansion of concrete and steel due to changes in temperature are practically the same.

(4) Rational analyses may be applied in determining the stresses developed in reinforced concrete members due to applied loads.

It seems probable that no one institution has contributed more to the literature of this subject than the Engineering Experiment Station of the University of Illinois. This experimental work was begun by Professor A. N. Talbot in the year 1903, and has been continued up to the present time. Large numbers of tests have been carried out each year on reinforced concrete beams, columns, slabs, bridge girders, culvert pipes, footings, rigid frames, and on completed structures. A great deal of the development of reinforced concrete construction has come about as a direct result of the scientific studies of this subject which have been carried out by Professor Talbot and his assistants. The importance of Professor Talbot's contributions to this subject may be seen from the fact that the nomenclature used by him in some of the earliest publications of the Illinois Engineering Experiment Station has become the universal language in the literature of reinforced concrete.

To the Engineering Experiment Station of the University of Illinois the world is also indebted for the comprehensive tests tabulated in Bulletin 71 of the Engineering Experiment

Station entitled "Tests of Bond between Concrete and Steel." These tests, which were made by Professor D. A. Abrams, then Associate in Theoretical and Applied Mechanics at this University, and now Professor in Charge of the Structural Materials Research Laboratory, Lewis Institute, Chicago, have been a valuable contribution of science in furthering a number of the industries dependent upon Portland cement.

In a class by themselves stand the group of bulletins, monographs or whatever you choose to call them, that has been issued by the Bureau of Standards in its series of Technologic Papers. These constitute a contribution of inestimable value to those studies which have made many of the Portland cement industries realities, or have advanced them to a higher plane of efficiency than would have otherwise been possible. Among the Technologic Papers of the Bureau of Standards are these reporting:

Results of Tests on the Strength of Reinforced Concrete Beams.

Tests of Absorptive and Permeable Properties of Portland Cement Mortars and Concretes, together with Tests of Dampproofing and Waterproofing Compounds and Materials.

The Effect of High-Pressure Steam on the Crushing Strength of Portland Cement Mortar and Concrete.

Action of the Salts in Alkali Water and Sea Water on Concrete.

Special Studies with a View to Preventing the Action of Electrolysis.

Variations and Results of Sieving with Standard Cement Sieves.

The Standardization of Cement Sieves.

Studies on the Hydration of Portland Cement.

Investigation of the Durability of Cement Drain Tile in Alkali Soils.

Strength and Other Properties of Concrete as Affected by Materials and Methods of Preparation, etc.

Some of these studies are being extended at the present time with a view to reaching more nearly definite or final conclusions.

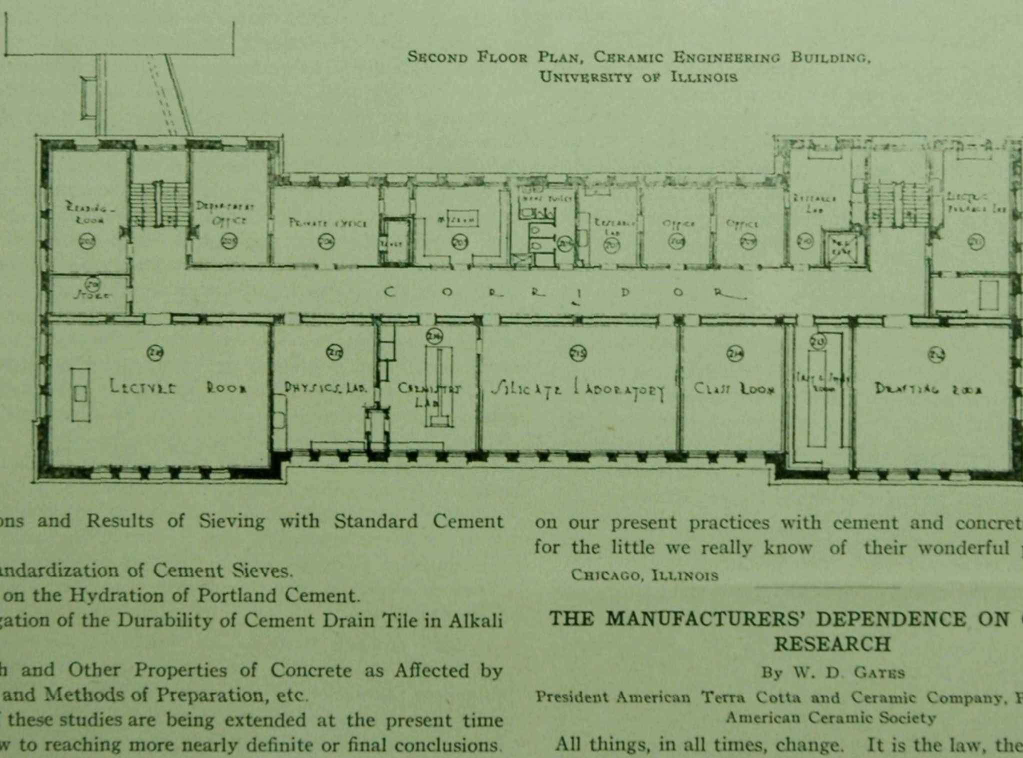
Without the studies and tests that have been made of concrete and reinforced concrete with a view to determine the resistance of this material to fire and other destructive agencies, there would be no reinforced concrete buildings, no concrete roads, streets nor alleys, no concrete sewers, no cement drain tile—none of the many other structures and products of concrete which science has made possible.

Among the latest achievements of science in the Portland cement industry itself are experiments tending toward conservation of resources, in the possible recovery of potash as a by-product of Portland cement manufacture. Experiments which have been made within the past year or two indicate that since our supply of potash from Germany has been cut off, because of the European war, recovery of potash is likely to be a profitable side issue of cement manufacture.

The pioneer experiments of this kind were made by the Riverside Portland Cement Company in its plant at Riverside, Cal. Experiments have been carried on also by the Security Cement & Lime Company, near Hagerstown, Md., and were made the subject of a quite comprehensive article in the *Manufacturers' Record* of May 11th, this year. While the recovery of potash from cement manufacture is in itself so new a development that its possible significance is not yet generally appreciated, it has, however, gone far enough to arouse many cement manufacturers to its possible importance. I refer to it only for the purpose of citing one more instance to prove that unthought-of possibilities in industry lie dormant awaiting the magic touch of the scientist.

To-day we find that concrete has attained a point where its application is almost universal in the construction field because of its practically unlimited usefulness. Yet those who are familiar with the cement industries realize that there is still need for the scientist to advance further our knowledge of the properties and uses of this material. I believe that to-day we stand only on the threshold of concrete's possibilities. I have no doubt that those who are most active in the cement and allied industries to-day will, ten or fifteen years from now, look back on our present practices with cement and concrete with pity for the little we really know of their wonderful possibilities.

CHICAGO, ILLINOIS



SECOND FLOOR PLAN, CERAMIC ENGINEERING BUILDING, UNIVERSITY OF ILLINOIS

THE MANUFACTURERS' DEPENDENCE ON CERAMIC RESEARCH

By W. D. GATES

President American Terra Cotta and Ceramic Company, Past President American Ceramic Society

All things, in all times, change. It is the law, the established order of things. Progression, speeding up, higher achievement, better wares and better service are strictly and rigidly demanded in each and every line of work. He who does not heed, who holds that what was good enough for his father is good enough for him, will be distanced, cast out, and left behind in the intense rush of the business life of to-day. It is absolutely the survival of the fittest.

From the days of the Cave Man, in the matter of maintaining personal rights, the bare fist gave way to the war club, that to the flint arrow, to the flint musket, to the breech loader, the machine gun, and the mammoth cannon of to-day. Man grew from killing retail to killing wholesale; from killing closely by personal touch, to killing at twenty miles, men that he could not see and that could not see him. He condensed mighty gases into compact form that he might suddenly loosen them with all their terrific power for his use, to do his bidding, to work his vengeance. He learned to govern them absolutely, to bind more power into a smaller package. When their smoke bothered him he stopped their smoking and made smokeless powder, so that the men he fought could not locate his hidden retreat. Man is like all animals in that he fights but unlike any animal in that he laughs, and this trait of his leads him to other things than war and slaughter.

Thank God not all his conquests are by war. There are other ways than by blood, others than by physical force. Chemistry can work out other things than high explosives, things useful and beneficent rather than destructive and abhorrent. Mechanical and Chemical Arts have been advanced far beyond the fondest dreams of our fathers. Man talks across the ocean, travels under its surface, flies in the air; from using the lightning as a plaything he makes it his servant and commands its mighty power, binding and harnessing it to do his bidding, even before he really knows just what it is. He hunts out its laws and, knowing them, compels it to do his will. Utilizing the force of gravity in our lakes and rivers, he has harnessed that power, and, compelling it to make lightning, has lit up his cities with it and turned night to day with water. What would your grandfather have thought of the statement that the waters of Lake Michigan would eventually light the city of Chicago? Jules Verne's dream is no longer a dream and ships go under the water. Darius Green and his flying machine are no longer a joke, for man flies at an hundred miles an hour, outstripping the birds, and not that only but he fights other men there. From the big things to the little, the invisible, man has made a new eye and sought out the little, invisible, teeming microscopic life; has hunted disease germs and, having found them, has fought them and conquered. Life has thus been prolonged and saved. The great doctrine of prevention has been established without which such great achievements as the Panama Canal could not have been accomplished.

Manufacture has always been dependent on research, from the time of the first manufacturer, and ceramic research is one of the oldest of all such lines employed. It was not a lack of research but of quality and extent and the effort and energy employed. Ceramists have always been enthusiasts, optimists in the extreme, dreamers. The very first experimenter when he, or more probably she, found she could shape a cup in a plastic mass of clay, hesitated not at all but proceeded at once in the attempt to make a better one, in the which, every ceramist since has followed her example. Nothing was so good that a better was not sought. Perfection was always sought but never acknowledged as achieved. Always a better body, better glass, better shape and greater beauty were sought. Utility and beauty were the objects ever pursued. To make the best possible has been the effort and to this end all the workers have wrought tirelessly, enthusiastically and intelligently to the very best that was in them. Their effort was right but they had small opportunity. It was individual and not collective effort and the problems were too much for an individual; team work was required. At first there was no fund of research accumulated and it had to be hunted out, built up and made available. This necessity being apparent, this first discoverer of the fact that clay was plastic, could be fashioned, made into a cup that would hold water, did not stop. It was a memorable discovery but not final. The discoverer, having the true spirit of the potter, kept at it and made the further discovery that it would dry and harden. Undoubtedly, the very next discovery was the disconcerting one that it would wet up and dissolve when wet again. Long research must have been exercised here to correct this which, however, resulted finally in utilizing the great mystery of fire to fix it lastingly. This changed its whole nature and made it indeed a new material, useful, beautiful and lasting. From the first experimenter on, through countless ages, beauty of form has been the objective. Utility was a pressing requisite but effort to make it beautiful was always shown, and protected and preserved the article when made, causing it to be treasured and cared for. I have no doubt but that the first discoverer, in fashioning her cup, shaped its form to lines of beauty, possibly crude but seeking beauty none the less. Ceramic research had thus progressed to the forming of a cup, doubtless crude, probably porous, but a great achievement and prophetic of the future. Later on research brought out the quality of vitrification—nonabsorbent and waterproof—and, later on, wedded the cup to glass and glazed it. This one thing of the glaze bound the art irrevocably to close ceramic research and committed every succeeding potter to cast aside all else in the fervent, tireless effort to surpass, to make a better body and a better glaze than any one before him had made, and, in his fervent, tireless effort to surpass, and in his enthusiasm to this end, make any sacrifice, endure any privation, surmount any obstacle and never give up hope. Pallisy was not the only potter who burned furniture. All potters have done so: burned furniture, bridges, luxuries, clothes, necessities even, and to-day, all over the world, they are feeding their kilns with clothes and automobiles and sacrificing their luxuries and comfort, they are eating dry crusts instead of cake, that they may feed their kilns, try their experiments and make something better and more beautiful than has yet been wrought. All this has brought clay wares into a very extended use. You drink your morning coffee from a cup of clay, more than a thousand times a year you eat your food from a plate of clay, you wash your face in a clay bowl and you take your bath in a clay tub. All the modern use of electricity would fail were it not for clay insulators. The paper you write on and the paper on your walls are largely composed of it and even the sugar you put in your tea is more than likely to have made its acquaintance but in the latter case not through ceramic research.

While the ceramic art is perhaps the most ancient of al the arts of to-day it has been probably, through the past ages the most secretive. Progress in it has been, of necessity, by means of a multitude of experiments, mostly of necessity failures, being wrought so crudely and blindly. Occasionally one proves good and capable of reproduction. Many were freaks and depended on chance conditions which were not present on the next attempt and were, therefore, discontinued and lost. Sometimes, however, these were traced out and led to new processes, thus utilizing these very accidents. When these processes stood the tests and produced a new effect, the process was surrounded by every possible safeguard to hold it secret; often so closely guarded that it was lost on the death of the discoverer. Often, too, it was handed down, from father to son, as a family heirloom, thus remaining in use for generations. Imitation, however, prevailed more than invention. Men feigned idiocy to get into factories, living on crusts and being kicked and buffeted about, that they might finally worm out the secret and then go and imitate. Even where invention was used it was employed in a blind fashion, feeling the way with this and that material, and with very little real knowledge as to real possibilities. So earnest was the work, however, and so extensive the experimentation, that much of good was accomplished, and these experimenters are entitled to very great credit for having, under such conditions, wrought out methods many of which are used to this day.

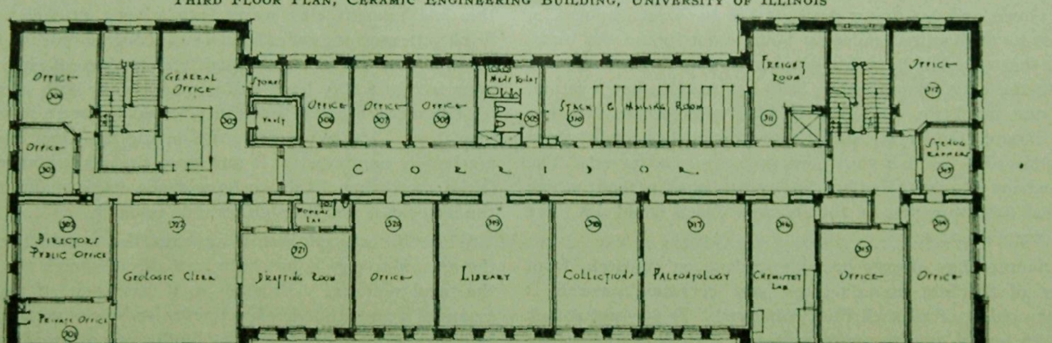
But even the excessive secretiveness of the potter has had to yield to the modern spirit. Men have become broad-minded enough to subserve their personal interests to the good of their Art: to add their contribution to that of the one who had gone before them, and not only that, but to hand over their contribution to the fellow coming after them, and thus get the whole, cumulative effect. They have learned to glory in the upbuilding of their art as an Art indeed.

The Almighty has prepared the material in abundance. In the great laboratory of Nature, He ground it with mighty glaciers, chemicalized it through countless ages, washed it, spread it out, compressed it under millions of tons pressure and covered it over deeply for man's use when required. Men have constantly labored and schemed with this crude material. They have dug deep but, as yet, have only scratched the surface. They have mixed one clay with another clay and have thus improved their wares by the mixing process. They have earnestly and faithfully sought to find out and follow Nature's Laws and have broadened from ancient usage radically in publishing their findings for the good of the Art and for the benefit of those coming after. The active work of the American Ceramic Society and the work done in the Ceramic Departments of our State Universities have done much and will yet accomplish wonders in the clay art in the future history of our country. The names of Orton and Bleininger will be spoken in reverence by the workers in clay in generations yet to come. The taking of a crude, waste material and making it into a thing of utility and beauty is indeed something of which to be proud The digger of the clay, working with the pugger, the presser, the chemist, the modeller and the burner, all working earnestly and honestly, each giving the very best there is in him, will produce useful and beautiful wares, as yet undreamed of, out of this hidden, unused extend over quite a period of time. The experiment started to-day may require a week or a month or more. The intimate chemical changes that occur when the material is molten are very perplexing and intricate To all the complexity of mixtures of flint and spar, of flux and frit, there is added that of color, for the production of which the ceramist's palette is extremely limited. Only a few metallic oxides will withstand the heat and even these are of a most erratic nature, as for instance copper which is capable of making black, blue, green or red according to the atmosphere in which it is produced.

But ceramic research is not confined to chemistry. Engineering and general management enter largely into the field of this research. Large quantities of crude material must be handled, must be plentifully and economically provided and, to this end, there must be the most intelligent treatment. Machinery must be largely used and great intelligence exercised in its construction and employment. Men must be selected for the various places and as nothing varies more than men, very great intelligence must be exercised in their selection and placing. The right man in the wrong place or the wrong man in the right place is as disastrous with men as with machines, so a properly balanced working plant for manufacture is really a complicated mechanism, and like any other complex piece of machinery, a bad cog in the wheel will throw the whole out of gear and stop all perfect working of the machine.

Beyond these generally recognized essentials of ceramic re-

THIRD FLOOR PLAN, CERAMIC ENGINEERING BUILDING, UNIVERSITY OF ILLINOIS



material that has so long been waiting under the prairies of Illinois. Lying crude and hidden, the material does no one any good. He who fashioned it, who so patiently prepared it and laid it away, left it lacking in admixture with one thing in particular—brains. Unless mixed with these it will never come into its own. The clays must be good and the brains must be good, and the mixture must be right. Both may be good but lack the mixture. In Italy, to-day, there is crude clay, still in the bank, from beside which other clay was dug five hundred years ago. That other clay, under the touch of Della Robbia, grew into a beauty that has placed it, worth its weight in gold, yes priceless, treasured in the choicest museums of the world, while this undug clay, untouched by a skilled hand, unmixed with brain, remains inert, despised, unused, awaiting the touch of another hand to bring it into the life, the individuality, that shall make of it a thing of beauty, shall fix into it the vigor and enthusiasm of him who fashions it into lasting beauty. So there lies all under this State of Illinois a wealth of this crude material waiting the touch that shall give it life and beauty. I believe that the men who will do this are those that shall go out from this school with brain skilled and trained for that work, working, not blindly as of old, but with trained intelligence.

Ceramic research has largely to do with chemistry. The various admixtures are formed when the materials are cold but the chemical changes occur when heated to a high degree of heat and are hence shut out of sight. They also, necessarily, search there is another, often missed in the general summing up but of the utmost importance, that of Art. Unless it have artistic beauty, no matter how skillfully compounded, the product will be a failure. The primitive Indian woman, fashioning the first clay pot, forming it for ordinary domestic use, recognized this requirement, shaping it to pleasant form in lines of beauty. Having so formed the first she soon progressed to adding something of ornament by scratching an ornamental design in that universal, never ceasing, effort to add beauty to utility. This effort of the first worker has never stopped but has acquired momentum as the years passed. Beauty has been a protection as well. Many of the relics that tell us of the dead and buried past are very fragile, not the big heavy affairs but delicate, breakable but beautiful things whose beauty appealed to all and for which they were prized and protected. I look forward confidently to the time when this will be better recognized and when this University will have a distinct department, housed in this beautiful clay building, in this clay State, in which talented, enthusiastic artists will lead and teach eager pupils in modeling clay into lasting beauty. Illinois has, I am sure, undeveloped Della Robbias in plenty and they only need encouragement and instruction to bring them out. If we can not do this work ourselves, if we have not the hand trained to the magic touch, if we have not the eye to see the hidden beauty in this crude material, if we cannot materialize the hidden beauty ourselves, if we have not the brain nor the training required to bring out its beauty and fix it lastingly, for the good of mankind, we can still so arrange things that the tools are here for the good of others, so the way shall be open, all the material provided, building and instructors ready, the opportunity shall be afforded those coming after us to use facilities we did not have and, lacking these, we came to know their value.

There is a wide field of experimentation that really cannot be done elsewhere than in a school such as this. Individuals have not the time to devote to it. It is broadly in the line of the advancement of the science, requires much time and careful attention, and would never be worked out except in such a school and by students who were building themselves up in the working out of just such problems. Instance of this is the formula for crystalline glaze given the American Ceramic Society and the eighteen hundred experiments made in this school with it in which very much of interest was added that never would have been worked out except under these conditions.

The manufacturers of Germany demonstrated their belief as to the value of such research and, utilizing it in every available form, they went conquering the world. They were indeed far on their way in such conquest up to the time that the war lords fell out and so stopped their work and dragged them back to the old, old aboriginal manifestation of brute force and the lust for blood. Had they but kept to their work, utilizing scientific research in their manufacture as they had been doing, their conquest of the world would seem to have been assured, but the war lords decided otherwise and chose the way of blood.

This gathering here to-day is not just an accident, not something that happened without cause or reason. This gathering itself is a complete demonstration of the pressing importance and insistence of the subject of which I am speaking. You are gathered here to-day because of the persistent demand of the manufacturers for more ceramic research. They have not only clamored for it, they have worked for it, earnestly and self-denyingly. They have labored personally and collectively. This department of ceramic engineering came into being because of their demands and their effort. They labored with the University authorities; they worked with every succeeding Legislative Assembly; they begged appropriations, and then, rallying the clay workers throughout the State, demanded appropriations, and they got appropriations. All this labor and effort has crystallized and materialized in tangible form in this building we here dedicate to-day to the furtherance of our Art, for the good of those who are to come after us and who will, we know, surpass us. We dedicate that they may not lack the facilities that we lacked, that they may grow to do the things that we could not do. We dedicate in reverence and hope as our best contribution to the progress and good of the work we love.

I have treated my subject in a wandering fashion, possibly in a wondering fashion, for the reason that the need of the manufacturers for ceramic research is, and always has been, so great, so well known, so constant and insistent as to be self-evident and needing no demonstration. This dependence has existed from the earliest times, the want has always been felt. What was needed was a proper opportunity for research. A place was needed and tools and then education in using the tools. Men must be educated to becoming skilled in knowing how to use material and tool. Must be so trained that when reactions occur they must know why they occur and work intelligently to the desired end, and not blindly, as in the past. The quest has been much of the time blindly, gropingly, in the dark, but now is coming to be openly, understandingly, and in broad daylight. State universities like this, and buildings and appliances like these, are the tools which shall furnish the opportunities and appliances, for the training of the brains to mix with the clays that will then place our Art where it belongs, and our pioneer work shall not have been in vain.

I may only add that the men on this board who have really done the most in the pioneer labor to bring this work to fruition are so modest and diffident and fearful of receiving the praise they so well merit for their efforts that they are sitting very tight, keeping very quiet and, following usage from time immemorial, are now putting forward that member of the board who probably did the very least in the real past work to now do the talking.

CHICAGO, ILLINOIS

DISCUSSION

By L. E. BARRINGER
President American Ceramic Society
Engineer of Insulations, General Electric Company

I prefer not to launch into the troubles of the electrical engineer, as I am afraid that would take a great deal of time because it is true that a large part of the electrical engineer's troubles to-day may be attributed to insulation and frequently to ceramic insulation. There are many forms of electrical insulation but true ceramic insulation forms a large part of the material used. I should like to tell you something about these electrical insulation problems but would prefer at this time to discuss the general aspects of ceramic research work as covered by the paper which has just been read.

In the first place, there is one point in Mr. Gates' paper to which I wish to take exception, and that is his last statement that the man who had done the least had now been put forward to do the talking. Mr. Purdy and I did not know whether he referred to us or to himself, but assuming that Mr. Gates referred to himself, in his modest way, I want to say that eighteen years ago, in his factory at Terra Cotta, Illinois, I was given the privilege of going into that factory and working during my summer vacation. I was then in the first engineering class in ceramics in Ohio State University and was given the opportunity of working in that factory, from the plaster shop to the decorating room, and of learning all that I could pick up in this way. While there I found that Mr. Gates had employed one of the first short-course students from Ohio State University and that he had set this young man experimenting upon all sorts of problems in colors and shapes of pottery, new kinds, unknown kinds, trying to develop something new and more beautiful, so I wish to say that in my opinion Mr. W. D. Gates is one of the pioneers in present day ceramic research. He had one of the very first laboratories, if I am not mistaken, and while Mr. Gates' motives may have been partly philanthropic (as he was always ready to encourage ceramic education and ceramic research), I suspect he had placed some dependence upon ceramic research for something that he really desired to obtain and that, therefore, he is a good example to put before you of the manufacturer's dependence upon ceramic research. Mr. Gates wanted something and he tried to get it by putting a technically trained man at work upon the necessary research.

Ceramic research is not different, or at least fundamentally different, from any other research. There is nothing to differentiate it in a general way. It requires the same sort of preparation and endeavor and the same attitude of mind but it is different in this respect—that it has taken longer to assume its proper place in the world's work. Personally, I think that this is largely because we have been handicapped by tradition. Ceramic industry is as old as the hills and from the ages past, we have record of the Chinese and Japanese potters producing most beautiful ceramic objects that are very rarely equalled, or excelled, to-day. We know that these old Chinese and Japanese potters worked by passing the secrets along from father to son. It was their greatest pride to discover something new and beautiful and then to have that live in the family as an heirloom, to be passed down to coming generations. That was the standard practice in China and Japan. Unfortunately the Germans, when they learned the secret of making pottery, particularly porcelain, in imitation of the wares from the Orient, followed the same course and produced the wares in secret, nay, even with royal approval and protection in maintaining such secrecy.

I think that ceramic research has been largely handicapped by this tradition, a tradition which is now fast being broken down and dispersed. Other industries have, I might say, been born in a new era, as the electrical industry, and have not been subject to this old traditional habit of passing these discoveries on from father to son.

I was looking around the other day for a definition of research and I ran across this statement in the Encyclopedia Britannica: "Without research no authoritative works have been written, no scientific discoveries made, no theory of any value propounded." That is a very broad statement, but I think, after due consideration, it will be admitted that it is generally correct. When I read that, I tried to think of discoveries which might be termed "accidental." We hear of "accidental discoveries" but in nearly every case I could think of I knew that the discovery had been made simply as a side issue or as a by-product of research in some other line, but that it was almost invariably the result of something some man had found or observed in the course of research work started for some particular purpose. As a matter of fact, the most skilled research men closely watch every development, not only to attain what they seek as the ultimate result, but to avoid missing anything by the way, something perhaps that may be useful, or new or valuable.

In this connection I recall Mr. E. G. Acheson having told me of his discovery of carborundum. While he was experimenting in electric furnace work in the Edison laboratories he observed in his arc furnace a few tiny iridescent crystals, crystals so small and so few in number that I dare say they would undoubtedly have escaped the attention of most investigators. He immediately focused his attention upon this tiny crystal and separated it from the other material, and in his interest tested the hardness by scratching a diamond in his ring and thus the discovery of carborundum, a hard abrasive of which he realized the value immediately. That might be termed accidental "discovery," but yet it was made by a research man endeavoring to find something, but with his eyes wide open so as to make sure of missing nothing while trying to find something, and to my mind such discoveries are legitimately the product of research.

The country was never in greater need of research than at the present time, and particularly "organized research" where groups of investigators are working shoulder to shoulder to advance some particular field of knowledge. The great industries have recognized the value of research and particularly the value of organized research, as is evidenced by the research activities of the General Electric Company, the Westinghouse Company, the National Carbon Company, the Pittsburgh Plate Glass Company, the Norton Company and others I might mention. Then there are the groups in the colleges and the United States Government service. As an example of organized research I would say that I represent a company that employs over a hundred men engaged in research work, a company which has invested heavily and has invested because it pays and not only pays but the progress of the electrical industry is absolutely dependent upon systematic research and effort to advance. One of the best examples is electric lighting which has progressed tremendously in the last ten years. The old carbon filament was quite generally used ten years ago. Since then it has rapidly gone through the stages of metallized filaments, pressed tungsten filaments, drawn tungsten filaments and "gas-filled" lamps (nitrogen, etc.); all this has resulted from the determined efforts of the General Electric Co. and its research men to advance that particular field, which they have accomplished in a tremendously successful way. We have lighting to-day at a cost of one-third as much as a few years ago, giving three times as much light at the same cost as in those days.

I do not believe, then, that there need be any very strenuous argument as to the value of research to the manufacturer.

As another example I would say that Mr. M. T. Herrick in addressing the American Ceramic Society at its annual meeting last February, spoke of early research work by the National Carbon Co., with which he is closely identified, and stated that when that company was first formed it had great difficulty in producing electrode brushes and other forms of molded carbon to compete in quality and in price with the European articles. There was no high protective tariff available and it became necessary that his company either compete successfully or go to the wall. Representatives were sent to Europe to study methods. They traveled from factory to factory but very rarely were given the real secrets of the success of these European factories, and the representatives of the National Carbon Company came back empty-handed with this exception—that they had observed that there was one thing that every European factory had in common and that was a laboratory. Quite blindly, Mr. Herrick stated, the National Carbon Company put up a laboratory. Then they hired a man from the Massachusetts Institute of Technology and within a year he had introduced two or three valuable features. This is another example of the absolute dependence of the manufacturer upon research, and not only in this country but the world over. The Germans have been pioneers in the line of industrial research.

A few years ago we were called upon to develop porcelain bushings for high-voltage transformers. As you all know, very much greater voltages are being transmitted to-day over high-tension lines than a few years ago. Transformers had to be built for these higher voltage and where five or six years ago a transformer of 60,000 volts was considered large, the development rapidly made necessary transformers to be tested at 300,000 volts or more, and insulation had to be devised accordingly. We had been building comparatively small porcelain bushings to stand 50,000 to 70,000 volts and when it became necessary to go 300,000 we naturally thought the porcelain ought to be larger and thicker, so that we were soon making porcelain bushings five or six feet high. These large pieces proved very difficult to manufacture successfully and even when constructed did not entirely give the desired results. The interested electrical engineers studied the problem and after several months investigation found that the trouble was not in the porcelain but in the distribution of potential over the bushings and, as it were, the potential had piled up at certain points to such a degree as to be able to break through porcelain of almost any size or thickness. By devising the proper design and proper voltage distribution appliances the voltage was so distributed that instead of making bushings five or six feet high and correspondingly thick, we were actually able to reduce the size very considerably.

Now in this same development our next problem was to dry the bushings more quickly. I want to say in connection with this particular research in drying that although it was initiated by the ceramic engineer it was not solved by the ceramic engineer alone. I saw at the start that it had more to do with automatic temperature control and with accurate methods of measuring humidity and temperature than with the purely ceramic field, so a committee was organized with three mechanical engineers and one ceramic engineer and that problem was solved when the mechanical engineers provided the proper control apparatus. That was a mechanical engineer's problem, but the research men had to say that it was entirely a question of proper mechanical equipment.

I have pointed out these few things to show that while the manufacturer's progress must be dependent upon research, upon the other side of the balance he is entitled to a just return for his investment and to insure that just return the research engineer or the research chemist must be broad enough and big enough to recognize all phases of the subject and to carry along his work accordingly.

I think one of our commonest perils in research work is to get too close to the problem. It is a good thing, I think, to get away from one's work occasionally, to back off from the picture as the artist does, in order to acquire a perspective, to see it differently and then return better equipped and with a better understanding of the work as a whole.

It is this kind of research that the manufacturer expects. I hope then that the research work which this new Ceramic department undertakes will be of such a character as will have a vision of the whole field, and that in teaching ceramics to the undergraduates the point will be emphasized as to the value of organized research, group research, and of the great value of coöperative effort and of always maintaining proper vision and perspective. When it is shown that the manufacturer is dependent upon research, this places a responsibility upon the research engineers which they must prepare to meet successfully.

SCHENECTADY, NEW YORK

DISCUSSION

By C. H. KERR

Director Research Laboratory, Pittsburgh Plate Glass Company

That the practical status of any industry cannot proceed in development without the growth of the fundamental scientific facts upon which that industry is based must be evident to any well-informed man, be he scientist or layman. Or as Dr. Clarke, of the United States Geological Survey, has aptly stated it, "There can be no applied science until there is a science to apply."

To the glass and enamel divisions of the ceramic industry this thought is especially applicable—in fact, it should be written in italics and kept constantly before the minds of those men who in their respective positions are instrumental in regulating the course of new developments in the industry.

An extended discussion of the problem of surface tension as it relates to glasses took place in one of our courts not long ago and the nature of that discussion illustrates as well as anything could illustrate it, the great lack of scientific knowledge and to an even greater extent the real need of such knowledge in the industry.

Let us acknowledge at once that in the field of glasses, enamels and other similar fused silicates the present state of development of chemical and physical science does not permit us to presuppose an ability to arrive at a completely satisfactory scientific solution of most of our problems. The extent of our knowledge concerning the laws governing systems with as many components as usually are present in the silicates with which we are concerned, is decidedly limited and developing but slowly. But, let us at the same time emphasize very strongly these two things: (1) that there are many incidental problems in connection with each branch of the industry that are capable of easy and complete solution and these problems can be taken care of while the main work is in progress and in all cases it is safe to assume that the solution of these problems alone will more than repay the employer for all laboratory expenditures; (2) that in studying the main problems of reactions in the silicate melts of many components it will always be found to be true that while answers which are complete from a scientific point of view are rarely possible, still as the study progresses there are constantly occurring ideas based on reasoning along lines of analogy which are susceptible of adaptation to practice. In the actual operation of the laboratory it will always be found that where a worker would (or certainly should!) hesitate to offer a complete solution to any certain problem he will have ideas based on essentially sound data that extend beyond the range of present-day experimentation possibilities, but which nevertheless offer the best and safest foundations upon which to proceed with practical development work.

To name some of the unsolved problems in the glass industry is to show in the most conclusive possible manner the necessity of much greater development in the fund of scientific data and the manufacturers' dependence upon research. To name approximately all of the problems which present themselves to-day in an important bearing would exhaust the time of this meeting to the exclusion of everything else, but to name a few such problems will illustrate the present state of comparative ignorance in which the industry is struggling. Much work has been done within the past decade but it represents a mere beginning which is not more than an introduction to the real work which must inevitably follow.

What is seed or bubble in glass? This defect in glass is one that is common to all kinds of ware and one that causes enormous losses either directly in the manufacturing losses, or indirectly in the loss of business because of superior quality met with in competition. The defect is known under a variety of names, seed, blister, boil, bubble, etc., but practically nothing is known about it except its existence. Many assumptions as to the nature of this defect have been made, most of them based upon reasoning that proceeds from a highly questionable chemical reaction which looks well when written on paper, but nothing is known about the origin of the bubble, the nature of the material, if any, filling the void in the glass, or the conditions necessary to prevent its formation or accelerate its liberation.

Concerning the color of glass (meaning the great mass of commercial glasses which are supposed to be substantially colorless) there has been considerable investigation but the subject is still in a very unsatisfactory state. *What is the real nature of the coloring effect or iron impurities and how can it be controlled? When once standardized in control how can variations in purity of the raw materials be properly provided for? If neutralizing or decolorizing agents are required what is the best theory of overcoming the residual color effect of the original glass and how can this be applied?*

One great source of industrial loss is breakage traceable directly or indirectly to the annealing process. *What are the relations existing between the composition of the glass and its required annealing treatment?* And the converse of the problem may be equally important—*what is the correct annealing treatment as applied to the particular glass composition concerned?* Another question along the same line is of perhaps greater immediate importance—*what ar. the relations between certain common impurities in the glass and the necessary corresponding changes in annealing treatment?*

Another very large problem or field of problems lies in the relation existing between the glass and the containing pot or tank. *What defects are introduced from this source and how may the composition of the glass or of the containing vessel be altered to produce beneficial effects, or how may the process of manufacture be changed to avoid the resulting troubles?*

This list of problems might be added to indefinitely but it must be evident from even this small list that the fundamental problems of the glass and allied industries are far from a basis of satisfactory solution. Mechanically the glass industry has developed wonderfully, even magically, within the past quarter century and especially within the past decade. Chemically, the glass industry has stood still. There must be an awakening and a real development and the dedication of this building to-day is a very significant fact in this awakening. An industrial awakening is always of necessity a slow and tortuous process, but when the awakening once starts, its progress while often erratic must be in the right direction. The whole field of development in glass technology is before us and the future will undoubtedly bring forth progress resulting from scientific application that will certainly be more startling than the wonderful progress we have already seen as a result of mechanical developments.

Even this brief review of the status of the technology of the industry and the manufacturers' dependence upon ceramic research would be incomplete without reference to the pioneer work of the famous German glass firm at Jena. If any manufacturer doubts the dependence of developments in glassmaking upon scientific data, let him refer to the growth of the firm of Carl Zeiss in Jena where the development of manufacturing has gone hand-in-hand with the development of the scientific facts upon which the manufacturing is based. There is no more complete answer now available than this marvellous development. It is but typical of what the future must bring forth.

PITTSBURGH, PENNSYLVANIA