The CONCRETE REVIEW

GERMAN METHODS IN PORTLAND CEMENT MANUFACTURE

DRY AND WET PROCESSES

By DR. OTTO SCHOTT

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German Methods in Portland Cement Manufacture. Dry and Wet Processes.

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Gentlemen: Last year, when seeking information concerning the manufacture of cement in the United States of America, I had the opportunity of inspecting a large number of your cement works and studying American equipment and methods of manufacture. The impressions I gathered are probably known to you for the most part from the publication of some of the lectures I have given in Germany and Austria on the subject. Although it is difficult from a mere inspection to form a correct picture of the working methods of the different factories, still I think that on the whole I have correctly judged the American Portland cement industry.

To-day I want to give you a picture of the German cement industry, based not only on the inspection of various factories, but also on an experience of many years in this industry. In many respects the German cement industry has a different manner of working from the American, and I think it will interest you all if in my remarks I refer particularly to these divergencies. I think that in this way you will learn more than by visiting different factories in Germany.

Although the German cement industry is considerably older than the American, and Portland cement was manufactured in Germany more than fifty years ago, the total production has to-day only reached the figure of 30,000,000 barrels, which are made in about 100 factories, of which 96 factories are united in the Association of German Portland Cement Manufacturers. In comparison with the enormous increase of the young American cement industry, with its production of 73,000,000 barrels last year, it might seem that the German cement industry has not made the progress it ought to have made. But you should bear in mind that Germany is only a small country, not even as large as the State of Texas. In proportion to its area, it still holds the first place with its cement production. You should further bear in mind that, partly on account of narrow-minded building regulations and partly through the presence of sufficient quantities of natural building stone, Portland cement is not nearly so much used in Germany as in America. The Germans have not yet engaged in the use of cement in such an admirable manner as I have found in your country. As regards the quality of the cement and the cost of manufacturing, I think I can conscientiously assert that Germany is ahead of many countries. With the large overproduction, which greatly exceeds the demand, the manufacturers were forced to manufacture the cement as cheaply as possible, and constantly to improve the quality.

I will first give you a picture of how the cement works are distributed over all Germany. You see that in various places the factories lie close together, as is the case in the Lehigh district or in Kansas. If you bear in mind that the area of Germany is not larger than the States of Pennsylvania and New York together, and if you also consider that the adjoining countries, as Belgium, France, Austria, and Switzerland, also produce cement, and are able to import it free of duty into Germany, while, on the other hand, the countries levy a high duty on Portland cement from Germany, you can then form an idea of the great difficulties with which the German cement industry has to contend. About one-fourth of the cement works are in Rheinland and Westphalia, where they are as close together as here in the Lehigh district. The proximity of the coal mines and an excellent raw material have favored the building of so many works in one spot. Similar groups of cement works are found near Hannover, Hamburg and in Silesia, only the 30 factories situated in south Germany being fairly evenly distributed. That, with this large number of factories and their large producing capacity, the German cement industry still prospers to a certain degree, is to be attributed, in the first place, to the formation of syndicates, which fix "quotas" for the various factories and take care that no more cement is manufactured than can be sold, and which also regulate the prices by fixing minimum prices at the commencement of each year.

We have at present in Germany five syndicates, the oldest and firmest of which is the South German Cement Syndicate, which was prolonged last year until the year 1925. Each factory is given a "quota" in proportion to its producing capacity, and it participates in proportion to its "quota" in the increase in consumption. The sale of the cement is done through a central office, which has five further sales-offices under it to facilitate the transaction of business. No factory can sell direct to the consumers, and all sales must be made through the sales-offices. The sales territory of each syndicate is carefully defined by contract, so that each syndicate may only sell within a definite circuit of the factories belonging to it, whereby large economies in freight are made. The price of a barrel of cement is at present $1.00 to $1.25.

The fixing of the price is determined so that the smaller factories belonging to the syndicate shall have a normal profit, but the price of foreign cement and of other building materials has also to be considered.

It would certainly be wrong to assume that the regulation of prices is done arbitrarily for the sole object of getting the highest possible prices. The principal merit of the syndicates is that they balance the production of the factories with the sale of the cement. The syndicate in Rheinland and Westphalia operated its factories last year 57 per cent. of their producing capacity, and the South German syndicate 78 per cent.

The syndicates in the different districts of Germany are connected by agreements, which determine how far each factory can sell in its environs.

Raw material for Portland cement is found pretty nearly all over Germany, principally limestone with shale, and it frequently has naturally the proper combination for Portland cement. Such deposits you will find in south Germany, principally in Württemberg, in the Swabian Jura, around Hannover and also on the Rhine. Some factories, principally in central Germany, use limestone with clay, which is mostly very damp. The cement works on the northern coast around Hamburg and Stettin use wet chalk and clay as raw material and work on the wet process.

Such pure limestone as is used for cement-making in many places in America is not met with in Germany. On this account white Portland cement is not made in Germany on a large scale.

The quarry of a German cement factory presents quite a different aspect from an American one. The steam-shovel, which is found here in almost every cement factory, is not yet used in Germany, as the factories are mostly so small that the purchase of a steam-shovel would not pay. Where the lime stratum, as in Westphalia, is only 20 feet thick, the stone is loosened by hand and shoveled into the cars. Only small tip-cars containing about 1 square yard are used, and they are hauled direct into the factory by means of a wire rope-way. You will find nowhere in Germany such large locomotives as are customary here in many places. The wire rope-way and the suspended rail are preferred, as by them smaller quantities of raw material are regularly transported to the factory at quite even intervals, and can then be tipped direct into the crusher without any interruption.

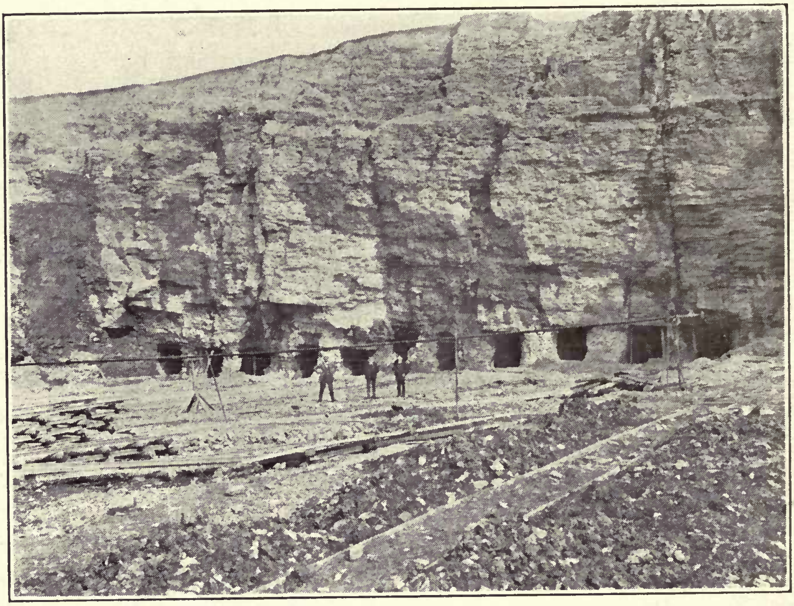


Fig. 1.—Gallery-work. Wall of Quarry Prepared for Blast.

When the limestone strata is thicker, *i. e.*, from 65 to 100 feet high, the so-called "gallery-work" is applied.

The entire wall of the quarry is undermined to a breadth of 65 to 160 feet by driving single horizontal galleries 65 feet long into the wall. At a depth of 33 feet these are joined together by a cross-drift, so that finally the whole side of the quarry rests only on single pillars 6½ feet high and 6½ feet in diameter. Each of these pillars is then bored in three places and the drill-holes are charged with donarit, dynamite not being used in Germany on account of its dangerous properties.

As soon as the so-called "fall" is prepared, the charges are all fired simultaneously by electricity, the pillars are all blown away at the same time, the side of the quarry loses its support and falls to pieces, at the same time breaking up the large rocks. The material is then shoveled into cars by hand. This work could certainly be done profitably by one of the steam shovels used in America, and which have recently been introduced into Germany. The preparations for such a "blasting" take up months, but the material loosened and broken up in this way lasts for months, and while it is being loaded off and worked up, preparations are made for the next blast-

Fig. 2.—Gallery-work after the Blast.

ing. The heap of material you see here contains 50,000 square yards, and sufficed for the making of 300,000 barrels. This way of quarrying has many advantages: above all things, all danger to the workmen is eliminated, as they do not need to climb about the steep sides of the pit. All work is done at the bottom of the pit. A fairly uniform mixing takes place in the pit by the rock all falling down together. The layers rich in clay are mixed with those rich in lime.

A disadvantage, however, is that with frequent rains the heap of material often gets wet, and the drying is rendered difficult. On this account some cement works in Germany have recently introduced the glory-hole method. At the foot of the quarry a single passage 100 to 130 feet deep is driven into the quarry side, and from the end of the same a shaft is bored straight upward, until the surface is reached. At the foot of this shaft there is fitted a horizontal door sliding on rails, which can be opened and shut by means of a lever. They then start to widen the top of the shaft funnel-shape by loosening the material around the shaft and letting it simply roll down to collect on top of the closed sliding door.

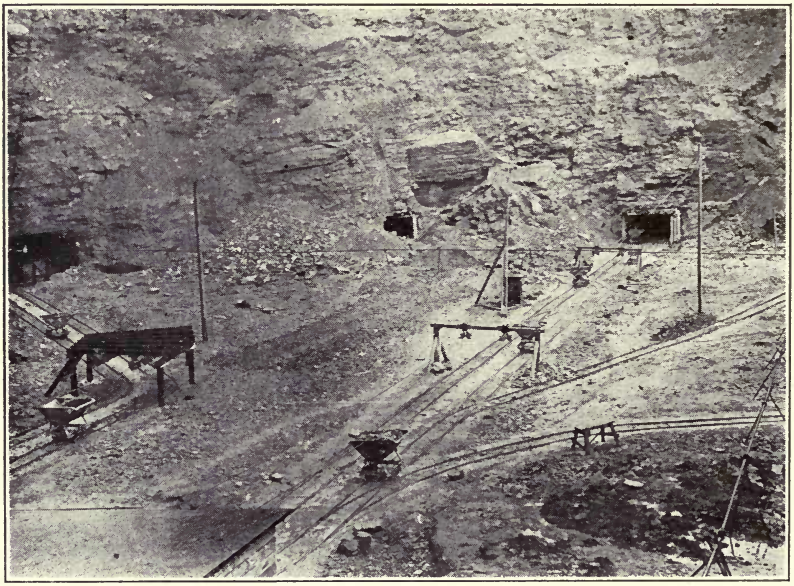


Fig. 3.—Floor of Quarry with Passage for Glory-hole and Wire Rope-way.

The wire rope-way is brought right up to this slide, the cars are run under, the slide opened until a car is filled and then closed. The full car now runs automatically on the wire rope into the works. Such a glory-hole yields with four men (two up above, two down below) 300 square yards of material in a twelve-hour day. The benefit of this method lies in avoiding the picking up of the material with the hand or steam shovel, and at the same time it has the advantage of safety and of blending the different layers. Besides, in rainy weather the water runs off down the steep sides, so that the material keeps dry. Boring is generally done with compressed air and small boring machines, similar to those you have here in America.

As I have already remarked, the material forwarded by wire rope or suspended monorail direct into the works is tipped direct into the crushing machinery. Unlike America, the Blake crusher is still preferred in Germany, and the Gates crusher is very seldom met with. If the material is not so hard, the so-called crushing-worm is often used. The same consists of a thick shaft provided with

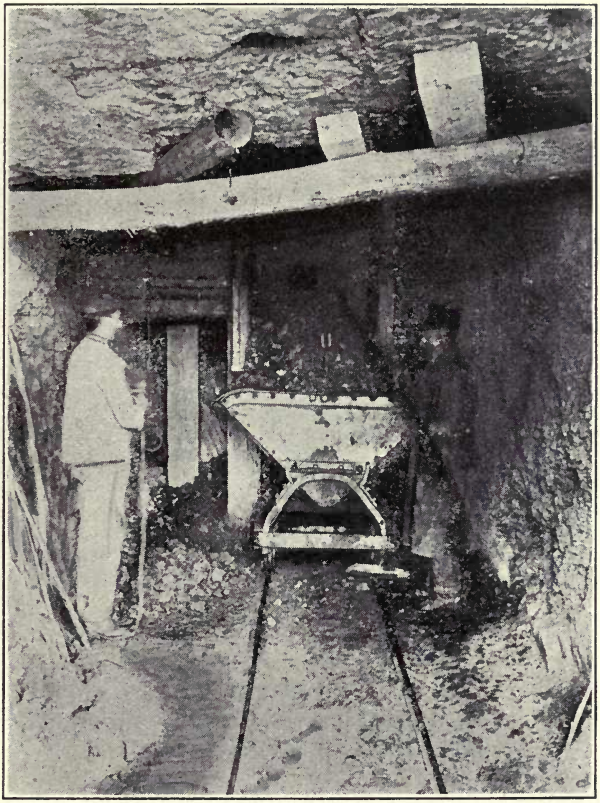


Fig. 4.—Car being Filled from the Glory-hole through the Sliding Door.

grooves, which rotates between horizontal bearings inside a casing lined with steel plates.

For drying, the Cummer rotary drier is much used in Germany. In general, the German rotary drier has a much smaller diameter than the American, usually only 39 inches. In America coal-dust has been applied in recent years for heating the rotary driers, an arrangement which the Portland Cement Works of Heidelberg and Mannheim introduced twelve years ago in all their works, except that there was built in front of the cylinders a chamber with grating in which the firing took place. It has been proved that with the use of coal-dust the drying of the raw material is much more thorough and the coal consumption less.

Fig. 5.—View from Top of Glory-hole. The Material is Loosened and Rolls down before the Closed Sliding Door.

I should like to make mention here of a special rotary drier, with which the utilization of the hot gases is profitably increased by the division of the inside of the cylinder in separate cells. By this means a more uniform distribution of the material in the interior of the cylinder is obtained, and the surface is also increased, which facilitates the drying. With very wet material there is naturally the danger of some of the cells getting blocked up, but for drying coal a more ideal rotary drier cannot be imagined.

With such a drier, 6 feet 6 inches in diameter and 33 feet long, 180 tons of rather small moist coal are daily dried at Heidelberg.

For grinding the raw material the same systems of mills are used in Germany as here in America, namely, ball-mills, Kominor, tube, Griffin, and Fuller mills.

The Portland Cement Works, Heidelberg, have nothing but Griffin mills running in six of their seven factories, on both raw material and cement. They are extremely well satisfied with them, and get a larger output with them than the Americans. However, some improvements have been made on the mills. Recently two large Fuller mills were started running at Heidelberg; the trials with them have not yet been concluded. In Germany the Kominor with the tube mill is most met with, though this does not by any means prove that this system of grinding is especially economical. But, on the other hand, the ball and tube mill is a very reliable method of grinding, and it requires little attention.

It will interest you to know that in Germany experiments have also been made with burning the material before grinding. It was also a success when the raw material was crushed to 1-inch lumps. This burnt raw material proved, however, very difficult to grind. The output of the mills was reduced by one-half, and on this account the matter was not followed up. In any case the burning of the raw material is nothing new.

On the other hand, I have seen in another factory the very soft and wet material—similar to that in Sandusky—being dried in a rotary drier 120 feet long and 6 feet 6 inches in diameter and slightly burnt at the same time. In front of the furnace there is a special combustion chamber. The firing is done with coal-dust. This factory, which formerly could never get its raw material dry, is now working very successfully.

The mixing of the raw material in most factories in Germany differs from the American method. The arrangement you have here in many places, of weighing the clay and the lime and then mixing it, is rarely met with in Germany.

Most works are able, on account of their favorable raw material, to make approximately the correct composition and mixing in the pit, where the removing of the raw material is done exactly in accordance with the instructions of the chemist. The chemist knows exactly which layers contain more lime and which contain more clay. In accordance therewith he has the proper proportion of clay and lime sent up. In the German works the chemist takes the first place, and he also supervises the whole of the machine plant. You will therefore mostly find at the head of the cement works in Germany a so-called technical chemist, who has a few assistants at his disposal in the laboratory. Every two hours the percentage of lime in the raw material is determined in the laboratory, and according to whether it turns out high or low, instructions are given to send up more clay or more lime. Frequently it is not necessary to make any change for days together, as the lime and clay strata are fairly uniform in their composition. No importance is attached to the mixture being absolutely even as it comes from the quarry, as usually the real mixing is done only after the grinding of the raw material. For this purpose there are large mixing silos, which hold 25,000 barrels and which are filled up in regular layers during the course of a week, and are then mixed together when withdrawing the ground material. The ground material can be laid in horizontal or vertical layers. A small example will best illustrate this.

A factory has to adjust its mixture to from 76 to 77 per cent. carbonate of lime. The ground material is passed for seven days into the same bin, and care is taken to spread the ground material in uniform layers by means of suitable conveying machinery.

If the material has been stowed in horizontal layers, the different layers fall together when emptying the bin, and so give an average of 76.6 per cent. carbonate of lime.

With vertical layers the conveyor is placed under the bin, and the material is allowed to run regularly into it from each layer through special openings, and by this means an average of all the different layers is obtained. As the composition of each layer is determined daily in the laboratory, a calculation can be made in advance as to what the average of the seven layers will be. There are usually two bins, and while the one is being emptied the other is being filled. The great advantage of this mixing plant is that very large quantities are mixed together, by which great uniformity is obtained. Besides, no machinery is required and the making of the proper mixture is entirely in the hands of the chemist.

In Westphalia the raw material has naturally nearly the correct composition, and the ground material is only once more passed through a mixing machine.

The burning of the cement is to-day done in rotary kilns in two-thirds of the German factories. Vertical kilns and Hoffmann ring kilns are still found, but only in places where wages are very low. As the latter do not come into question in America, I will not dwell upon them. Regarding the construction of the rotary kilns, they differ only slightly from the American kilns. The first kilns were built 81 feet long and 6 feet diameter, but the length was gradually increased to 120 feet, and recently kilns have been erected 150 feet long. These are the longest up to the present. People in Germany are not yet quite clear as to whether the long kilns are better, especially as they have been able to use the waste heat with advantage for other purposes. The economy of a kiln and not the output turns the scale in Germany, and people would sooner put up two kilns of smaller capacity, if the burning can be done therewith more economically than with one large kiln.

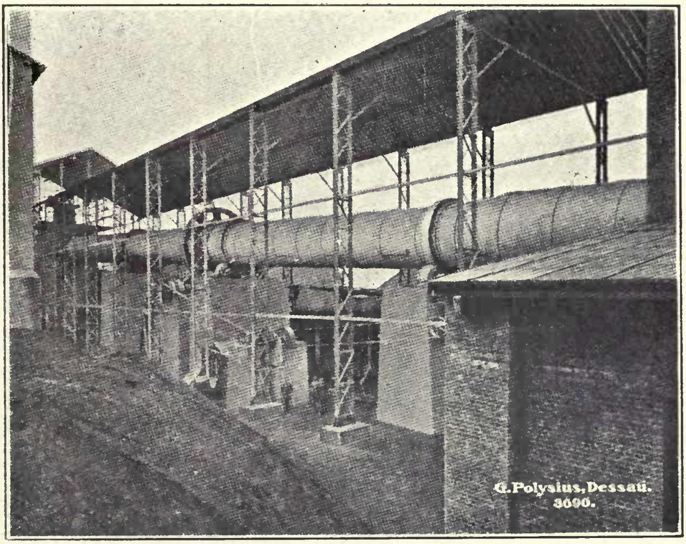


Fig. 6.—Dreadnaught-Kiln; 240 feet Long, 10.5 feet Diameter.

The engineering works, it is true, recommend long kilns, 250 feet feet in length and 9 feet in diameter, as with these the end gases have a temperature of only 200° centigrade, and the heat is best utilized in these long kilns. But no kiln of such length is in operation in Germany.

In Germany, where, as you know, fuel is very dear, it was sought from the commencement to utilize the heat as much as possible. On this account each rotary kiln is provided with a cooler, in which the clinker is cooled by drawing air through it. The same fan which blows the coal-dust into the kiln draws the air through the cooler, which is thus heated to 250° centigrade. Thus the fuel is saved which would be required to heat the large quantity of air required for burning to 300° centigrade. Many works also use this hot air to dry the coal. Coolers with a double casing have also been constructed, so that the clinker, after having passed through the inner cylinder, is led back through the outer cylinder, and so perfectly cooled. The air, which in this case is forced from the front into the cooler, reaches a temperature of 300° centigrade.

One company uses water very successfully for cooling the cylinder, the hot water being utilized for feeding the boilers and for the bathing arrangements of the workmen.

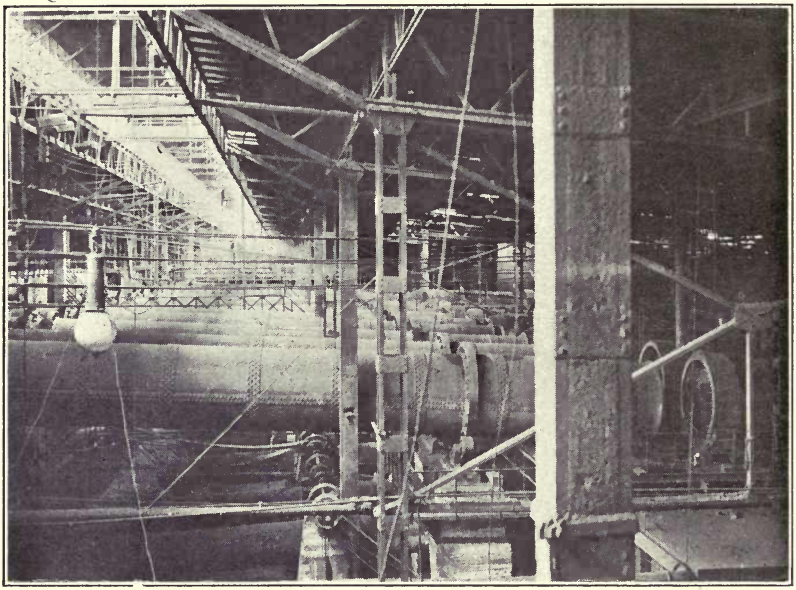


Fig. 7.—Installation of Fourteen Rotary Kilns; Largest Installation in Germany, Producing 4500 Barrels a Day.

The waste heat is utilized in three ways—either to dry the raw material, to warm the air for the kilns, or to raise steam in the boilers.

When drying the raw material with the waste gases from the kilns, the difficulty for a long time was that considerable dust and fine material went out of the chimney, but this is now arrested by water, producing mud which is burnt under the kilns.

When the waste gases are utilized for heating the air of combustion, there are built behind the kilns so-called blast-heaters,

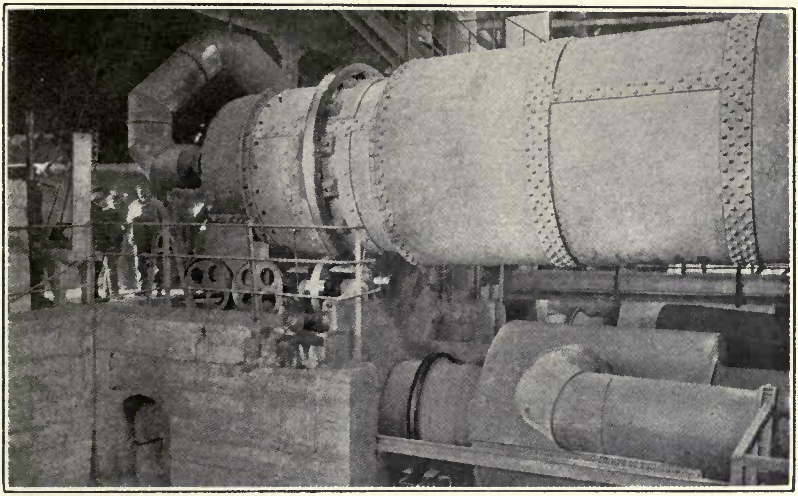


Fig. 8.—Rotary Kiln for Thick Slurry in the Weisenau Plant near Mainz, Germany. A double cooler with cooling by compressed air is shown below kiln.

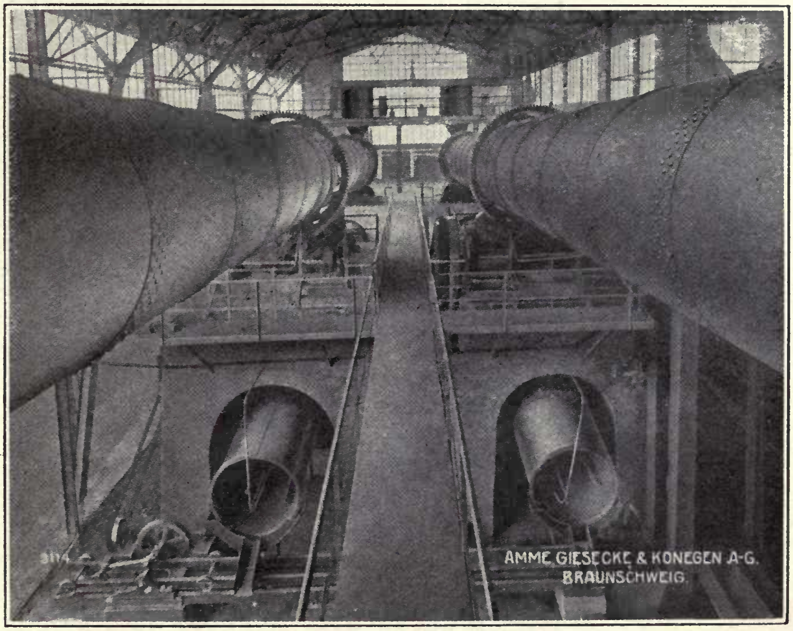


Fig. 9.—Rotary Kiln Installation for Thick Slurry Process. Kilns 150 feet long, 9 feet diameter. A newly patented shaker is shown at the end of the kilns.

which are said to heat the air to 600° centigrade. Many attempts have been made to utilize the waste gases for raising steam, but in most cases without success, as no means were known of keeping

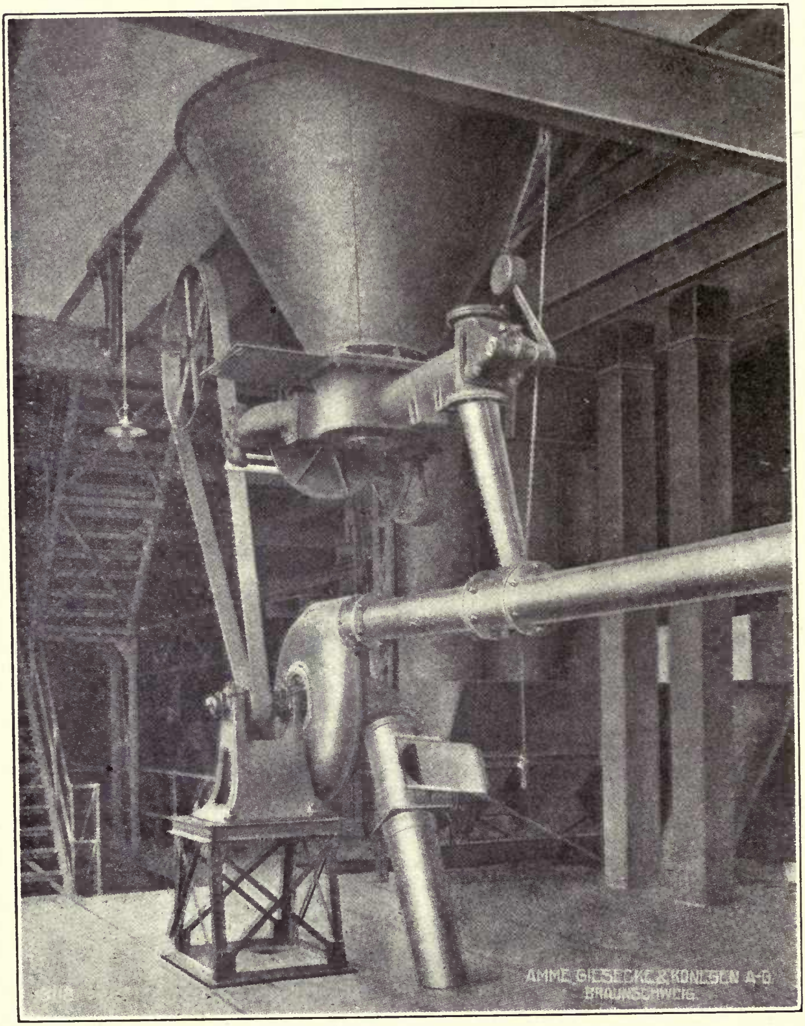


Fig. 10 —Coal-feeder and Fan for Rotary Kiln.

the dust from the tubes of the boilers. However, three factories are to-day using the waste gases of the kilns for raising steam. Two of these factories have kilns 90 feet long, while one uses kilns 120 feet long. The production of steam even with the 120-foot kiln is satisfactory. The steam raised by the waste heat not only suffices to drive the whole of the rotary kiln plant and the coal mill, but also furnishes the power for the larger part of the raw mill. However, special devices of a rather simple nature must be used to keep the dust from the boilers.

The injection of the coal is done by fans, which, as I have already mentioned, draw the air from the coolers. In order to obtain perfect and uniform combustion the coal-dust is fed into the air-current of the fan by means of a system of double worms. By this means the

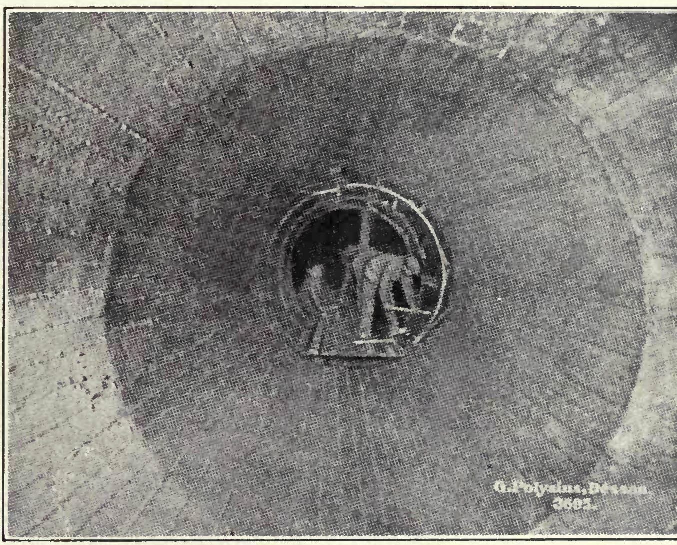


Fig. 11.—Concrete Lining of a Kiln.

same effect is said to be arrived at as that aimed at by Dunn's uniform pulverized fuel feeder. But according to my observations the problem appears to be better solved by Dunn's apparatus.

Compressed air is not used in Germany for injecting the coal-dust. Experiments therewith showed no benefit. The pipes through which the coal is injected are generally wider than here—usually 8 inches.

The clinkering zone is 13 to 16 feet distant from the head of the kiln.

The lining of the kilns is done either with adhesive sandbricks, firebricks, or bricks made of clinker and cement.

Adhesive sandbricks are useless unless a crust is formed in the kiln, as otherwise the hard clinker causes heavy wear. But if a protective layer of clinker is deposited, then they are the cheapest kiln lining.

In some factories attempts have been made to simply line the kilns with concrete made of a mixture of rotary kiln clinker and cement. It has been found that the concrete in the kiln will last a long time (one year), if the kiln is allowed to stand a few days after the lining, so that the concrete can harden properly.

As you are aware, a patent has been taken out in Germany for a so-called widened clinkering zone. According to this patent, the front part of the kiln, in which the clinkering proper takes place,

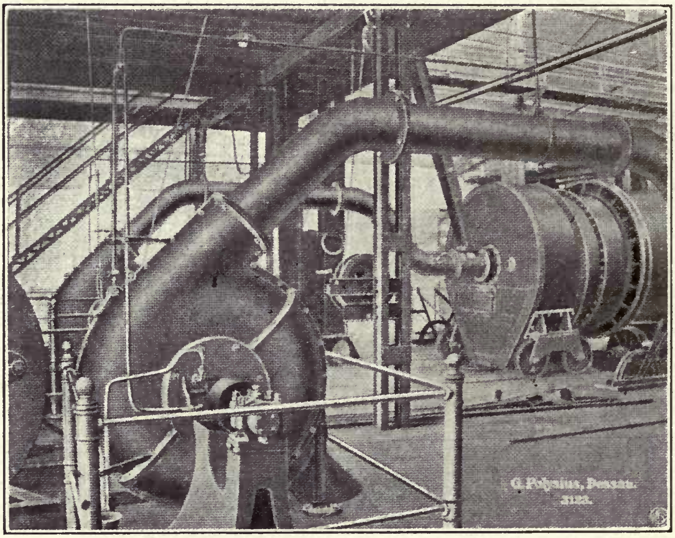


Fig. 12.—Burner-stand with Fans and Pipes.

and which otherwise was only 6 feet 6 inches in diameter, is enlarged to 8 feet 2 inches diameter. It is asserted that by this the output of the kiln is increased and the coal consumption reduced. It is very difficult to get an opinion on this point from actual experience. The manager of a factory who works with such kilns told me the only advantage he saw was that a very thick crust formed in the widened part and protected the kiln-lining very well. In general, the advantages of the widened clinker zone are not yet clear, and preference is given to a kiln the diameter of which is at the outset made wide enough in its entire length.

Whereas formerly the opinion prevailed that the ground raw material should be moistened before being fed into the kiln, many factories have found out a device to burn the dry material. The material falls direct from the conveyor through a pipe into the kiln. By this means the mixing worm, which required attention and much power, is no longer required, fuel is saved, and the output of the kilns is increased by being fed with dry material. Rotary kilns without coolers are not found in Germany, and vertical coolers are also unknown.

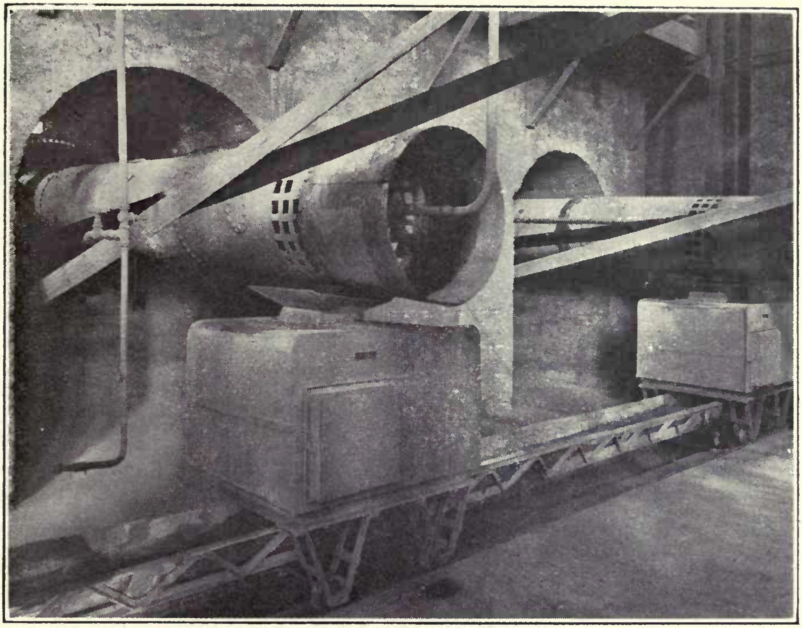


Fig. 13.—Cooler, Weighing Machine, and Shaking Conveyor.

The cooling-cylinders are always placed under the kilns and above the floor. The foundations of the kilns are therefore much higher than is usually the case in America.

The lubrication of the bearings is done with calypsol grease. Some works have central lubrication, by which eight to ten bearings are automatically greased by a grease pump.

In general, three kilns are attended to by one burner. Ordinary workmen are usually trained as burners, and on account of their easy work they are paid comparatively low wages. Most works train two or three times more men as burners than they require, and set them to other work.

When the waste heat of the kilns is used for raising steam in the boilers, one man can attend to six boilers, his sole duty being to feed the boilers with water.

The front end of the cooler is perforated like a screen to sort the clinker, and only the coarse clinker requires to be crushed for the cement mill. In front of each cooler an automatic weighing machine is placed, which also makes automatic records, so as to afford an exact check on the output of each kiln. The coal-dust for each kiln is weighed in the same manner, and coal consumption and output are noted hourly on a special board.

We now have in Germany a drum weighing machine, with which everything can be weighed—pulverized coal, cement, and hot clinker. It is very exact and reliable.

As regards conveyors, preference is given in Germany to the belt conveyor and to the worm or spiral conveyor. For hot clinker the so-called shaking conveyor is much used, and it has proved very satisfactory; it is not the type oscillating on wooden spring legs, however, but a shaking trough running on small wheels. This conveyor can transport any quantity, even up slight inclines. I know of a factory which formerly took the clinker away in tip-cars, and now saves fifty workmen after installation of a shaking conveyor.

Some large works have so-called clinker stores, where the clinker is stored and allowed to season.

The clinker is raised by means of a bucket elevator to a height of about 33 feet, and then distributed over the store by means of a shaking conveyor, which is designed to drop the clinker in different places. The removing of the clinker from the store to the cement mill is also done by means of such a shaking conveyor placed in a channel under the clinker store and covered with boards. When the boards are taken up (which one man can do) the clinker falls from the store into the conveyor and is carried away.

The storing and seasoning of the clinker has many advantages. In the first place, the clinker, being dry, grinds better, and the large lumps become soft through storage and easily break. Further, the storage is good for the quality of the cement, and greater uniformity is obtained by being able to again mix the burnt product of several days before grinding.

The cement mill in a German works has the same appearance as in American works. Ball-mills, Kominor, tube-mills, Fuller mills, and Griffin mills are used.

The finished ground cement is stored in large square bins of 25,000 to 100,000 barrels. Preference is given to the largest bins possible. This is to get, when withdrawing the cement, as large a quantity as possible, by which great uniformity is obtained. Round concrete silos, which of late are frequently met with in America, are seldom used in Germany. On the other hand, a large stock of cement ready packed in bags is kept, the bags being piled twenty-five high.

The piling of the sacks is done by a band conveyor.

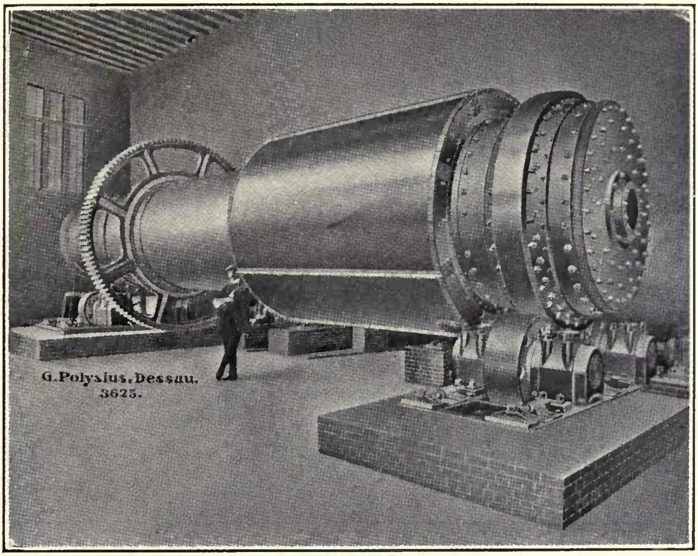


Fig. 14.—"Solomill" for Cement Grinding; a Combination of Ball- and Tube-mill.

For packing, the automatic twin scales, system iron-work Ahlefeld, are much used, which weigh very correctly. Capacity, 1800 bags in ten hours.

Last year I heard that certain American cement manufacturers who had visited German cement works expressed astonishment at the primitive way in which the cement is packed and loaded in Germany. I presume that the gentlemen in question had only visited some unimportant cement works.

With the high wages of $1.25 to $1.50, which have to be paid in Germany to men in the packing house, you will find to-day well designed plants in the larger cement works. I will give you a detailed description of one.

The storage house is built so that thirty railway cars go direct into the middle of the house on two tracks running side by side. The room in which the cement is packed is situated on the second floor directly over the railway cars. The cement is taken from the bins by elevators and conveyors to the thirty automatic packing machines on the second floor, where it is put into bags. The workmen who fill and tie the bags simply let them slide from the second floor down curved tubes, which may be turned around, and which lead into the opened railway wagon. In each case there is a man who takes the

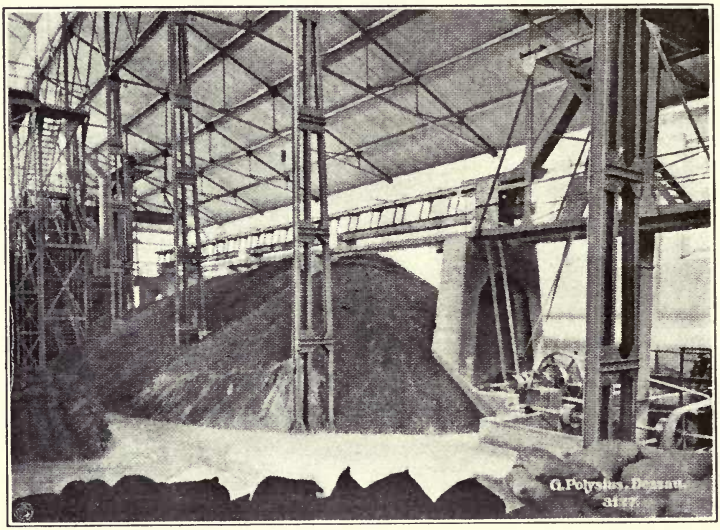


Fig. 15.—Clinker Store-house with Shaking Conveyor.

bag from the tube and drops it into its place. The packers on the second floor fill the bags as quickly as the man down in the wagon can stow them.

In other works where the railway siding is a long way distant from the packing shed, a belt conveyor leads from the packing shed to the railway cars, and the bags slide down an inclined chute directly into the car, where they are stowed by one man. The belt conveyor runs directly in front of the packing machines on a level with the floor, so that the workmen can lay the bag directly on the conveyor as soon as it is filled and tied up. If six automatic scales are at work, the bags follow one another on the belt conveyor at intervals of $6\frac{1}{2}$ feet, and a car can be filled in ten minutes, though I should here remark that the German railway cars do not hold more than 300 bags.

A special arrangement for packing cement, invented and introduced by the firm of Smith & Co., has been running in some works for about a year. The cement is put into the bags by vacuum.

Gentlemen, you are aware that Germany exports one-tenth of its production. Exports are chiefly from the factories which lie on the coast and the big rivers. As cement is only exported in barrels, all these works have a special cooperage and packing plant for barrels. In order that the barrels may withstand a long oversea voyage, the cement must be tightly pressed. In most factories the packing of these barrels is done by hand, the filled barrels being well beaten with clubs until the cement has thoroughly settled. But there are also machines for this work. The barrel stands on a revolving plate and is kept rotating while receiving a number of powerful shakes from a mechanical device. In order to render them perfectly water-tight, the barrels are lined with water-tight paper.

The making of these barrels forms a special department, which, on account of its liability to catch fire, is usually in a building separated from the other buildings. In Heidelberg, for instance, over a hundred workpeople are employed in this department. With the exception of the putting on of the wooden hoops and the fitting of the lids, the barrels are all made by machinery. The large works have their own saw mills, where the wood, as it comes from the forests, is sawn into cylindrical staffs, grooved, molded, and fitted together by special machinery. The making and putting on of iron hoops is also done by machinery.

Bags made of jute are mostly used, rarely of canvas. Paper bags are still too dear in Germany and therefore not used. The cleaning of the bags is done in the same way as in America, namely, in large revolving drums. Electric sewing machines, with dust exhaustors, are used for sewing and mending. It will interest you to know that a group of twenty cement works in Westphalia have a so-called "bag central," where new bags are made and the old ones cleaned and repaired. The empty bags are sent by the customers to the "central," where they are sorted, repaired, cleaned, and returned to the different works.

The cost of the whole work does not amount to quite half a cent per bag. Only women are employed for mending.

The same group has also its own barrel factory, in which the barrels for about twenty works are made. This, of course, can be done only when the works are close together.

As the German cement works are mostly somewhat old, you will find in them, in contrast to American factories, long, complicated line-shafting, from which the mills are driven. Compared with America, the motor drive is much rarer, but it is gradually being introduced, especially in the more recent works. The firm of Dycker-

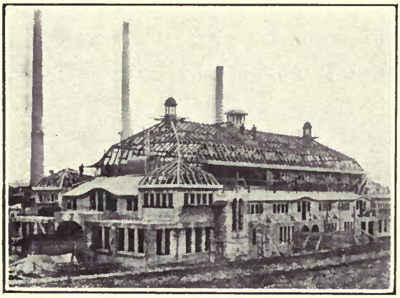


Fig. 16.—The Music Hall under Construction.

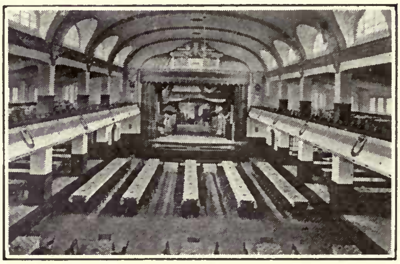


Fig. 17.—The Music Hall Inside with the Stage.

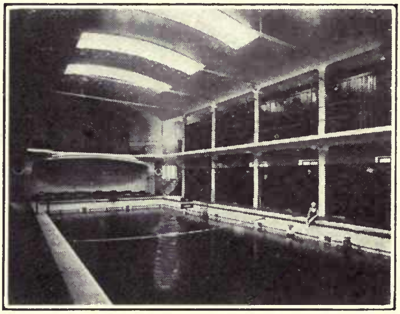


Fig. 18.—Swimming Bath for the Laborers.

hoff has installed in its new works steam-turbines, and for driving the grinding machinery nothing but motors.

For raising steam you will find all boiler and stoking systems represented. The stoking is mostly automatic.

The Leimen factory has a swimming bath 100 feet long by 50 feet wide for the workpeople. Slipper-baths and shower-baths are connected with it. The picture shows you that it has been fitted up rather luxuriously in order to encourage the workpeople to make use of it.

The same works built a music hall two years ago for the workmen, in which they hold their festivities every week. Connected with it there is a "kindergarten," a library, and a reading-room.

Gentlemen, the same as here in America, many factories have built houses in the neighborhood of the works, in which the workpeople can live at a low rent. Recognizing that it is a great advantage for a factory to have old, well-trained workmen, they are given every consideration. Almost every factory has its own

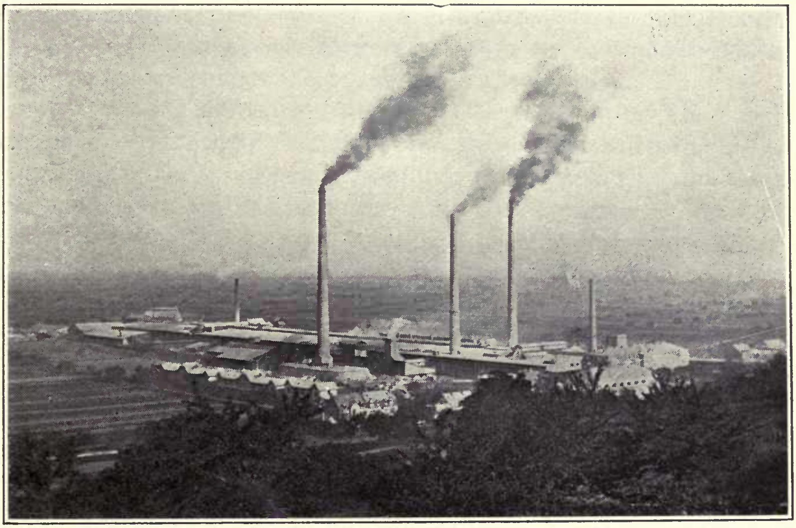


Fig. 19.—Cement Factories in Leimen near Heidelberg. In the foreground is shown a Music Hall and Houses for the Laborers.

sick fund, saving club, pension fund, eating houses, and canteen. It is nothing unusual for workmen to remain twenty-five to forty years in one factory. Following the example set by America, almost every factory has its own repair shop, and at the Portland Cement Works of Heidelberg and Mannheim, for instance, the repair shop is as large as an engineering works. Not only are all repairs and improvements on mills and machinery made there, but the works have their own foundry, to which a steel foundry is now being added. New machinery is also made there; it is a sort of experiment station for new ideas.

As far as I can judge, the cost of production is lower in Germany than in America, and for this the lower wages are not alone responsible. To counterbalance this, fuel is dearer in Germany. But the German does more calculating; he tries to save every cent, and makes full use of every advantage, as, for example, the temperature of the waste gases, new conveyors, etc. But what gives a special advantage to the different works are the monthly actual cost calculations, which show clearly and to the smallest detail how high the actual cost is in every single branch. The art of correctly calculating the actual costs, of studying the same, and drawing from them the proper conclusions as to where the lever should be applied to lower the cost of production, this art enables many factories to manufacture much cheaper than others, who otherwise are just as favorably placed.

A well-managed works sees from this statement of actual costs where faults are to be corrected, and is urged by it to make the cost still cheaper in the following month by the application of improvements and by making use of certain advantages. And in this manner people have managed in Germany continually to reduce the actual cost of a barrel of cement, in spite of higher wages and dearer fuel. A limit will no doubt be reached in time, but from what I have seen my conviction is that in America you are much further from this limit than in Germany. The Germans have taken lessons from the Americans with regard to their kilns and grinding machinery; let the Americans learn from the Germans how to make use of everything in order to save every cent and make cement as cheap as possible.

I cannot predict offhand which will eventually prove to be more advantageous for America, the wet process with thick slurry or the dry process. But it is possible that in America the wet process may prove cheaper, because fuel is considerably cheaper than in Germany, and therefore the cost of burning the cement, which in any case is higher with the wet process than with the dry, may not be of so great account.

As I am aware that the American cement industry is greatly interested in the wet process, I will say a few words about it at the close of my lecture.

Many of the works situated in the north of Germany make their cement from the chalk on the coast and on the Baltic islands, and are forced to use at the same time a clay containing much sand and flint, and they have, like most of the works in England, always given preference to the wet process. Chalk and clay contain naturally a high proportion of moisture, and are also so soft that they can be reduced to the requisite fineness without mills, simply by washing. In these factories the raw materials are washed very thin with about 80 per cent. of water, and, according to the arrangement of the plant, the stones and the coarse sand either settle to the bottom as the heavier constituents, or they are separated from the thin slurry by screens. The slurry runs from the washing basins into large settling basins, where it is allowed to settle. The water collecting on top is let off from time to time, and the sun and air help gradually to dry out the water remaining in the slurry until it becomes stiff enough to be dug out with a spade and pressed into bricks for the shaft or ring kilns, which are still used by most of the factories that work on the wet process. Some of these factories, however, have recently installed rotary kilns, and pump the slurry containing 40 to 55 per cent. water direct from the settling basins into the kilns. It is often months before the slurry gets the consistency desired, and it is certainly a disadvantage of this wet process that so much time is lost before the product made months ahead can be actually turned to value. Enormous values are often represented by this half-finished product.

The wet process is considerably more advantageous, when pure chalk and clay are to be had, and it is not necessary to pay attention to eliminating impurities in the shape of quartz sand and flint. The addition of 40 per cent. water then suffices to grind the material in the wash-mills. This slurry is then simply run into the so-called mixing basins, where it is stirred up until the mixture is uniform. It is not necessary to thicken further this 40 per cent. slurry, and it can be pumped direct to the kilns.

With these two ways of wet preparation it is presumed that the chalk and clay are naturally so soft that no special mills are necessary for grinding.

But it should especially interest you in America that recently some works have started to prepare hard materials like limestone in the wet way by using special mills. This so-called thick slurry process has so far been introduced in Germany into seven factories, of which I inspected five during my last stay in Germany.

Before I give you a full explanation of why, according to the opinion at present prevailing in Germany, thick slurry preparation is to be preferred to dry preparation, I should like to give you a short description of the working of a thick slurry plant.

Such a plant is mostly built in four stories, one above the other. The material comes from the pit to the top floor. The large pieces of limestone are here crushed to the size of a fist and fall directly onto the wet-kominors placed below. The soft wet clay and marl are fed directly into this wet-kominor, and roughly ground with the addition of water. The rough slurry, which has 35 to 45 per cent. moisture, runs into the wet tube-mills, which are placed in the floor below under the wet-kominors, and here it is ground quite fine. The factory has, according to its size, a number of large mixing basins, which lie below and in front of the wet tube-mills, and the slurry runs through pipes into these basins. A factory producing 1000

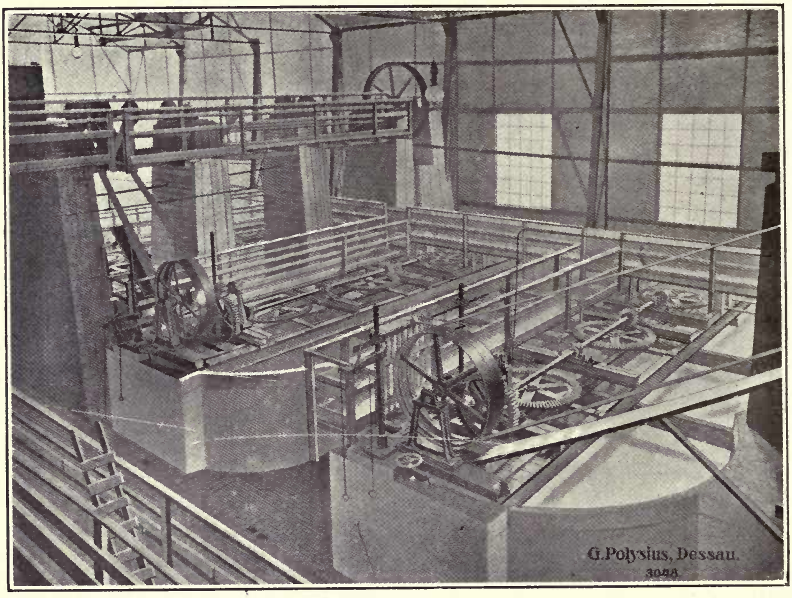


Fig. 20.—Triple Mixer with Practicable Gangway all Round.

barrels daily requires at least four mixing basins of 500 barrels capacity each. As soon as a basin is three-quarters full, the mixture is made by testing the slurry every two hours and then grinding material either richer in clay or richer in lime and allowing it to run into the basin. The final adjustment can also be done by letting the slurry run from one basin into the other. The mixing basins are usually oval in shape; three stirrers run in each basin to keep the slurry in constant motion and mix it.

The slurry is then pumped by means of special pumps to small slurry bins over the kilns, and is burnt in the rotary kiln in exactly the same manner as dry material. The feed pipe to the kiln must be steep and wide, so that it does not choke. A difficulty with the burning is that the slurry is apt to roll together into large balls, which pass through the clinkering zone too quickly and do not get thoroughly burnt inside. These are called "runaways."

The kilns for the thick slurry process have in Germany generally a length of 122 to 148 feet, and are 7 feet 6 inches to 8 feet 2 inches diameter. Only the kilns in the Dyckerhoff works are longer—150 feet long and 9 feet in diameter. Otherwise they are exactly the

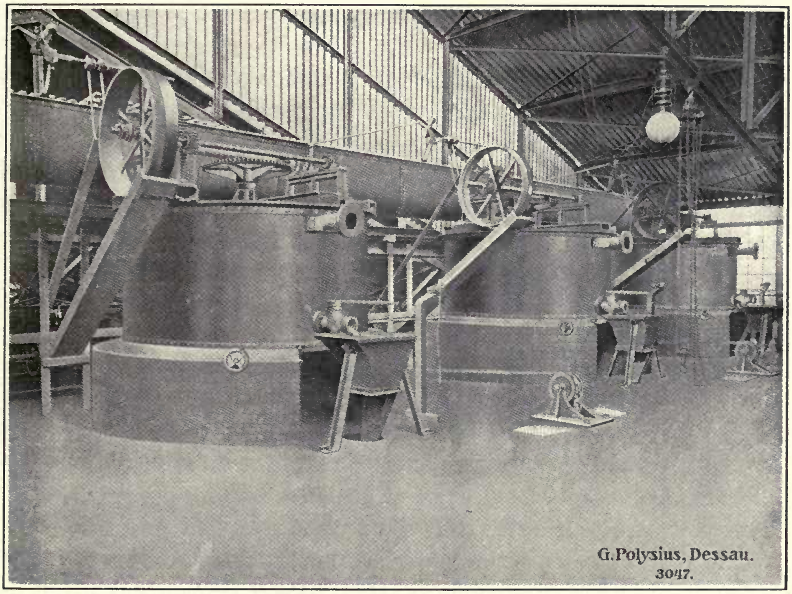


Fig. 21.—Slurry Storage and Mixing Tanks, with Feeders, and Slurry Worm Conveyor above the Rotary Kilns.

same as kilns for the dry process. The clinker is just as hard as the clinker made from dry material, and there is no difference in the further process of manufacture. Last year I often heard the view expressed here in America that people in Germany were going over to the thick slurry process quite generally. This is a mistake. As I have already told you, there are at the present time in Germany only seven such works, and with all of these special reasons led to the introduction of the thick slurry process. Two of these works used the wet process from the beginning. At the moment only a single factory is altering its plant to the wet process, and from this you may see that the majority of the German cement makers still consider the dry process better, and in any case more economical. Only very special reasons, such as peculiarities of location or a naturally very wet raw material that could not be dried, have induced the German cement maker to introduce the thick slurry process in a few places, although three engineering works are already making wet mills, and on this account are, of course, advocating the wet process. The best German cements with the highest degrees of strength are still the cements made with the dry process, so the question of quality is no inducement to go over to the wet process. With proper attention just as good cement can be made in the dry way as in the wet, if the correct arrangements are made for a thorough mixing. Still there may be instances where the wet process is to be preferred to the dry, but such cases can only be decided separately after a thorough testing of the raw material. I will give you the points of view to be considered before deciding, especially in Germany, where fuel is very dear and forms a considerable part of the cost of manufacturing. In this respect the position in America may differ somewhat, as you have cheap coal and oil at your disposal for burning the cement. But if you can save only a few cents a barrel with the dry process compared with the wet process, then here, too, you must give the preference to the dry process of making cement.

The economy in burning cement in rotary kilns depends on the following four points: (1) Cost of the installation; (2) wages; (3) power consumption; (4) coal consumption.

The cost of plant is undoubtedly lower for the wet process, as various arrangements are not required which are necessary for the dry process. No rotary driers are required nor bins for ground raw material, the latter being substituted by the cheaper mixing basins. There is not required for the wet process the dust-collecting arrangements for the raw mill. The buildings for the dry process also take up rather more room. The opinion that with the wet process the kilns would have to be longer and larger has proved wrong, so that with the dry process the same cost of installation has to be taken into account for the kilns as with the wet process. However, the extra cost of a dry plant compared with a wet plant is not as much as might be assumed from the foregoing. It amounts to 3 to 5 per cent. on the complete plant, and plays no great part when calculated on the barrel.

In America an important consideration is whether the wet process will reduce labor costs. According to the experience in Germany, this is not the case. As many people are required for attending to the wet grinding machines and the mixing basins as with the dry process for attending to the mills and ground material bins. The power consumption of the mills is generally lower with the wet process, especially with materials which are not of a hard nature, such as marl, clay, chalk, etc. With such stuff the washing with water is effective and divides the material into its finest parts, so that the mills have little work to do. But it is a different thing if hard limestone and shale are to be ground wet, as the water is then of no assistance, and the mills have to do the same work as with the dry process. The economy in power is then very low and out of proportion to the higher coal consumption necessary to evaporate in the kiln the added water; and the higher the proportion of water in the slurry, the higher the coal consumption naturally is.

In judging the relative economy of the two systems, the main question is the coal consumption. Because, as the situation lies in Germany, coal is the chief factor in the actual cost of manufacture, amounting from one-third to one-half of same, according to price and other circumstances. Thus when making cement consideration must be given in the first place to saving coal.

Most of the factories with the thick slurry process work with a 40 per cent. proportion of water. It depends on the nature of the raw material whether more or less water must be added. Occasionally slurry with 45 per cent. water is still so stiff that it can hardly be pumped. There are works which burn even 55 per cent. slurry in the rotary kilns.

With 55 per cent. water there has to be evaporated 190 parts of water to 100 parts of finished cement, which is a very unfavorable ratio. With a thick slurry containing 40 per cent. water the ratio is much better, but 104 parts of water have still to be evaporated to 100 parts of cement. It is clear that an increased expenditure of coal is necessary to burn cement out of a material containing so much water. Experience has shown that with the kilns mostly used in Germany, 115 to 148 feet long and 7 feet 2 inches to 8 feet 2 inches in diameter, the burning of a slurry containing 35 to 40 per cent. moisture requires in round figures for every 100 kilos of cement 5 kilos more coal of medium quality than the burning of a slightly damped ground raw material, including the preliminary drying of material from the quarry with the average moisture in the pit.

The bill for fuel is therefore increased by fully 20 per cent. with the wet process.

These figures thus result from the comparison of the burning of thick slurry and dry raw material in kilns of the same length and diameter, and after taking into account the amount of coal required by the dry process for drying the raw material before grinding. Besides this, the dry ground raw material was moistened with 8 to 10 per cent. water before burning. All these are very unfavorable conditions for the dry process. In a properly managed kiln plant with the dry process the result will turn out much more unfavorable to the wet process than I have shown to you.

In the first place, it is not necessary to damp the raw meal with 8 to 10 per cent. water when running it into the kiln. Some factories have long had a device which renders it possible to burn directly the dry meal, so that the fuel for evaporating this 8 to 10 per cent. water can also be saved. There has also been left out of consideration the fact that with kilns 115 to 148 feet in length the waste heat when burning thick slurry only amounts to 250° centigrade, whereas with the dry process the waste heat has a temperature of 500° centigrade and over. As I have previously explained to you, this waste heat can be utilized for warming up the air of combustion in blast-heaters, or, better still, for raising steam in the boilers. On the other hand, when burning thick slurry the heat produced by the fuel is all used up in evaporating the water, so that the waste gases have a temperature of only 250° centigrade, and cannot be further utilized.

But it is precisely the utilization of the waste heat that enables further economies to be made, which I estimate very high if properly planned. The firm of Polysius, in Germany, which, as the first factory for the construction of rotary kilns, has much experience in this line, explained a year ago, through their Director Bruhn, the advantages of the dry process in a lecture given at the meeting of the German Portland Cement Makers, and the theories set forth coincide exactly with the statements made by me to-day. Dr. Bruhn also comes to the conclusion that the dry process is to be preferred to the wet process, unless the raw material has naturally more than 15 per cent. moisture and by its softness is specially suitable for wet grinding and washing. This firm builds at the same time wet mills and kilns for thick slurry.

But Dr. Bruhn is not of my opinion that it is best to utilize the waste heat for the driers or boilers, as this makes the plant complicated, and he recommends building the kilns of such a length that all the heat is thoroughly utilized in the kiln itself in burning the raw meal, so that the waste gases have a temperature of only 250° centigrade. It was ascertained by experiments that to fulfil these conditions a kiln must have a length of 262 feet by 8 feet 2 inches diameter.

When the firm of Polysius now builds new works, it seeks to introduce these long kilns, which are said to reduce the coal consumption and to increase the output of the kiln.

However, the wet preparation has in any case several advantages, the principal of which is that the plant is much simpler with wet grinding, and the adjustment of the proper mixture is easier with thick slurry than with raw meal. Any mistakes can be corrected without difficulty in the mixing basins. But I do not mean to say that on this account the quality of cement burnt from thick slurry is better than that made from raw meal. With the employment of proper mixing arrangements and with care the same uniformity and accuracy in the composition of the raw meal can be attained with the dry process. When this is not the case, it is not the method but the arrangements that are at fault.

The disadvantage of the thick slurry process is thus undoubtedly in the extra expenditure in fuel and the increased cost of manufacture caused thereby, which will become the more palpable in comparison with the dry process when the burning of dry meal and the utilization of the waste heat are properly understood.

On the other hand, the thick slurry plant has some advantages which may be briefly stated as follows: (1) Smaller capital investment in the installation. (2) Little dust. (3) The possibility of proper adjustment of the mixture without difficulty. (4) A simpler plant and fewer conveyors. (5) Saving of power in wet grinding.

The saving in power is very small, however, and is not nearly compensated for by the larger expenditure in coal required for the burning of the thick slurry, and it would not be right, therefore, to give the wet process the preference over the dry on account of the saving in power. Dr. Bruhn gave in his lecture last year the following explanations, which will show you the position clearly: "With our steam-engines of to-day 0.7 kilo of medium quality coal is sufficient to produce 1 horse-power-hour. With kilns of equal length, 5 kilos less coal per 100 kilos clinker are used when burning raw meal than when burning slurry containing 35 to 40 per cent. water. These 5 kilos of coal are thus equal to 7 HP-hours. With a production of

10,000 kilos per hour, equal to 300,000 barrels per year, this higher consumption of fuel in the thick slurry kiln is equivalent to a constant higher expenditure of 700 PS per hour. But the whole plant for this production only requires some 300 to 400 HP for crushing, drying, and grinding the raw meal."

Gentlemen, I can only confirm this from the experience made by a company to which I formerly belonged, and which altered one of its works to the thick slurry system. The factory in question works at much greater cost than the other factories with the dry process.

It is very difficult to give a general opinion as to whether the dry process or the wet process is more advantageous. Where emphasis is placed on having a plant as simple as possible, and that can be easily supervised, or where there are difficulties in attaining a good mixing with the dry method, in such cases the wet process is perhaps suitable, even if the raw material is naturally hard and not too damp. But in any case it must be taken into account that the cost of manufacture will be considerably higher than if the same material were worked dry. The method of making is certainly simple and easy, but it costs more.

It is somewhat different if the materials are naturally soft or impure and contain much moisture, so as to render the drying difficult. In such a case the wet process would be preferable. As far as I had the opportunity of examining the raw materials used in America for making cement, I am convinced that most of them are more suitable for the dry process than for the wet process.

I have already mentioned that a cement works in Germany is now about to change from the dry process to the wet; the reasons are that the factory in question has to work a clay containing 15 per cent. moisture, and adds 12 per cent. water to the raw meal before it runs into the kiln. Under such circumstances the superintendent said that it did not matter so much whether he added a further 10 per cent. water and introduced the thick slurry system, especially as he was never able to dry the clay properly. But I know of another works which is at present making alterations, but is retaining the dry system, although the clay contains nearly 20 per cent. water. The works in question has constructed for itself a special cylinder drier with coal-dust firing, and as they know how to burn the raw meal dry, I do not doubt that this factory will manufacture cheaper than the other factory with the thick slurry system. You see, gentlemen, that also in Germany the question as to whether the wet or dry process is better has not been sufficiently cleared up. My personal view is that wet preparation should only be chosen if the raw materials are not hard or plastic, and if the natural proportion of moisture already approaches that necessary for wet working. I consider it a mistake to work hard, dry material according to the wet process simply for the purpose of facilitating the mixing or of avoiding the dust. For to solve both these problems it is not necessary to introduce the more expensive wet process; it can be done just as well with the dry process.

I hear that a factory is being changed in America to the wet system, and it will then be seen whether the wet system is preferable for your country, which is not impossible, as fuel does not play such a large part in the cost of manufacturing as with us in Germany.

The Laboratory of the Association of German Cement Makers and the New German Rules for the Uniform Testing and Delivery of Portland Cement.

By Dr. Otto Schott

When in the year 1877 the representatives of the German cement industry, which at that time hardly produced two and one-half million barrels, joined together to form an Association of German Cement Makers, this association set itself the task of furthering all interests touching the Portland cement industry, and of contributing by scientific work to the knowledge of the properties of Portland cement. How energetically it went to work is probably best seen by the rules it laid down on a scientific basis in the same year for uniform methods of testing Portland cement, and which have become a pattern for the cement industry of the whole world, although they have undergone many changes in the course of time. Notwithstanding that Portland cement had been made in England for fifty years, it is rather remarkable that this was the first attempt, with the help of experience and researches made up to that time, to lay down uniform methods for the testing of Portland cement. This meant immense progress for the cement industry, as the users of cement were thereby enabled to test and work the cement in a proper manner, and to judge the quality correctly.

The laying down of the rules had, however, a further advantage for the cement makers in that they showed that much was still to be cleared up with regard to the properties of cement, and that next to nothing was known regarding the constitution and cause of hardening of Portland cement, so that the impulse was given to study these questions. The German cement makers applied themselves with much diligence and zeal to these questions. Many works appeared which gave explanations regarding the properties of Portland cement, and so contributed to clear up the questions as to the proper way of making, testing, and treating Portland cement. The value of a chemical laboratory for the Portland cement industry came to be recognized, and as early as the seventies every German cement factory had a well-founded laboratory and one or two chemists. The progress of the German cement industry is largely to be attributed to the close and fertile work in these cement laboratories. The laboratories offered their services unselfishly when it was a question of carrying out scientific work for the "Association." Shortly after the establishment of the first rules in 1877, a committee was elected to work out new rules, and the whole of the scientific work which was necessary for this purpose was done by the chemists of the different cement factories. How conscientiously and thoroughly this was done is best proved by the fact that the new rules set up in 1887 on the basis of this work were fully valid until 1909; that is, for more than twenty years.

Many matters which are nowadays looked upon as self-explanatory had at that time to be cleared up by troublesome and tedious experiments. With the growth of the German Portland cement industry, constantly increasing calls were made by the Association of German Portland Cement Makers on its members for collaboration in tests and chemical experiments, especially after the Association decided in 1885 to watch permanently over the quality of the German Portland cements. For this purpose every cement had to be bought in the open market at least once a year and submitted to the standard test.

With the 86 different brands of cement which existed in 1898 this was no small task, but it was willingly done up to that time by a few of the large German works free of expense in the general interest. You will be interested to learn that the chief reason for this purpose was to see that no foreign matter, such as ground slag or limestone, was mixed in the cement by works belonging to the German Cement Association, which they bound themselves by signature to refrain from doing.

Up to the year 1909 there was only allowed an addition of 2 per cent. gypsum or coloring-matter to regulate the setting time and to color the cement. The new rules allow 3 per cent. And even to-day every member must bind himself by signature to mix no kind of foreign matter with his cement, on pain of being expelled from the Association. The Association of German Portland Cement Makers has by this step won in a high degree the confidence of the users of cement.

The question became more acute when, at the end of the last century, the so-called iron Portland cement works came into existence, which added 30 to 70 per cent. of ground blast-furnace slag to the cement after grinding. New methods of analysis had to be found to show in an approved manner any adulteration, and in connection with this a lot of other work cropped up, which could not all be done in the laboratories of the different cement works. At the same time the Association was confronted with the task of making numerous tests for the purpose of revising the rules, and the question of the constitution of Portland cement gained more interest, so the building of its own laboratory was decided on in the year 1899. The

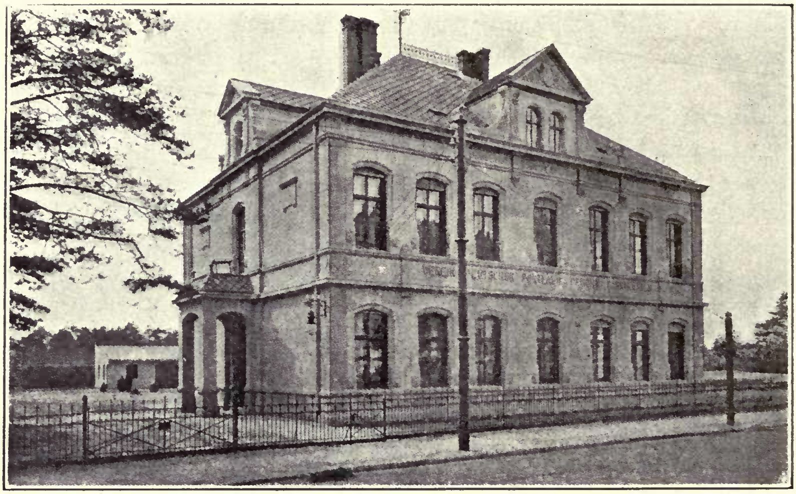


Fig. 22.—Laboratory of the Association of German Portland Cement Manufacturers at Carlshorst.

cost of it was defrayed by each factory belonging to the Association paying an extra subscription of $50 per share. Here I should explain that each factory has one share and one vote in the Association for every 50,000 barrels production. A factory with a production of 1,000,000 barrels has thus twenty shares.

In consideration of the meetings of the Association being always held at Berlin, and of the royal material testing office, with which it was desired to collaborate, being also at Berlin, it was decided to establish the laboratory there. The plans for the Association laboratory were submitted to the next general meeting, and the building of the same was commenced the same year.

The building is carried out in concrete and cement bricks, and it is covered with cement tiles. On the ground floor there is a large room for the preparation of test matter, and a small room for storing the same. There are also in separate rooms testing ovens, an electric motor, a compressor, and the boiler for the steam heating.

On the first floor are the rooms of the laboratory proper, consisting of a large chemical laboratory, a weighing room, a physical laboratory, and the room where the testing matter is broken and the cubes are crushed. Here is also the manager's office. The second floor is

Fig. 23.—The Office of the Manager. The picture shows the first President, Delbrück.

built as a dwelling for the laboratory manager. The laboratory is fireproof; all the floors are made of concrete and covered with linoleum. Next to the building is a small shed for keeping the cements in, and also for storing the standard sand, which is sold by the Association laboratory to all factories, builders, and officials. The land cost \$7000, the house itself \$15,500, the shed \$1000, and the inner fittings about \$3000; altogether, about \$27,000.

The mechanical, chemical, and physical laboratories are fitted up with all necessary apparatus, but without extravagant equipment.

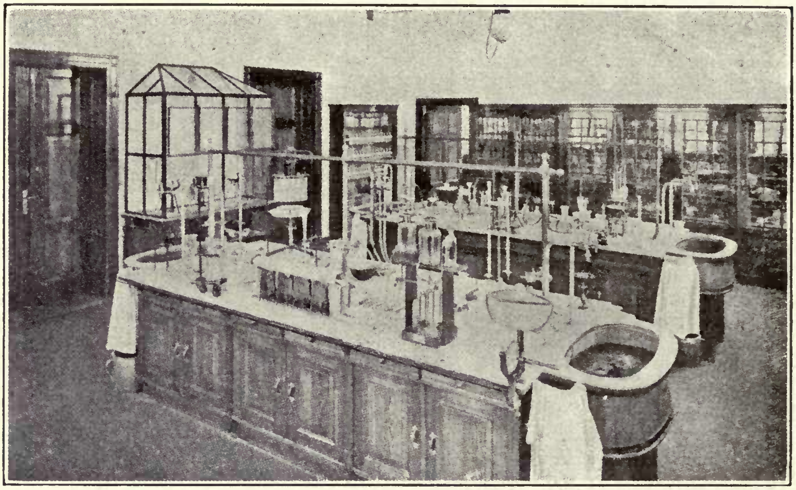


Fig. 24.—The Chemical Laboratory.

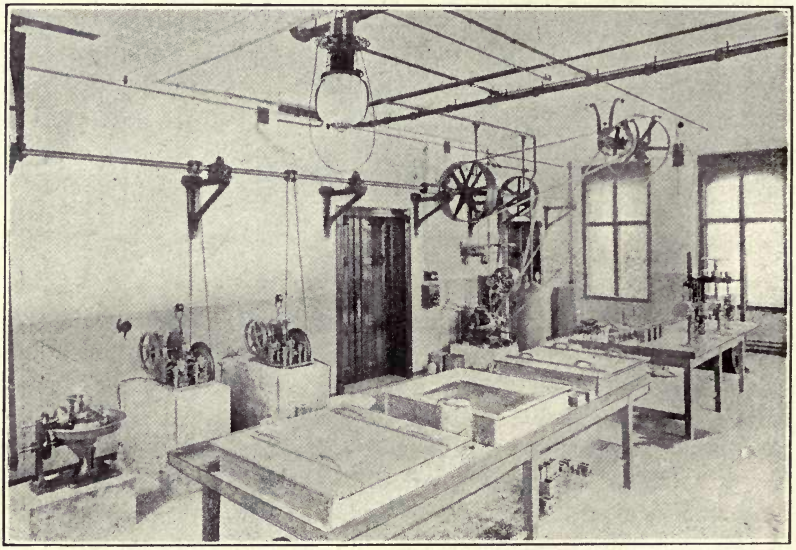


Fig. 25.—The Physical Laboratory.

The laboratory possesses further an extensive library, containing all books and papers on cement. A small museum has also been fitted up, in which everything worthy of notice concerning cement is collected.

The "Association Laboratory" is under a management-council, composed of seven members of the Association of German Portland Cement Makers. There are certain rules for the management of the laboratory. Paragraph No. 1 says that the laboratory is to serve,

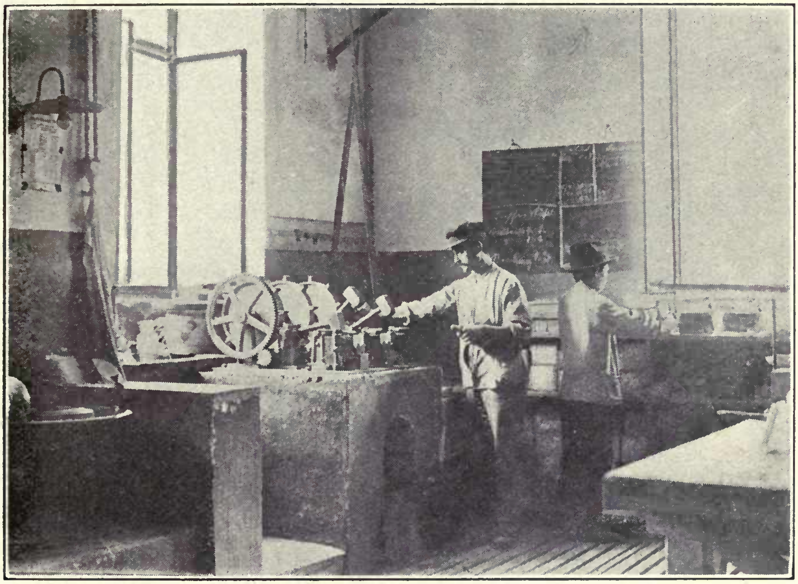


Fig. 26.—Making the Cubes with the Hammer Apparatus. On the Left the Steinbrück Mixer.

in the first place, for the working out of scientific problems which are in the general interest of the entire cement and concrete industry.

It is further stated in the rules that tests of chemical and physical nature and breakage tests are to be carried out against payment of fixed fees. But, above all things, all the German cements are to be bought by the laboratory as often as possible from the trade, and tested according to the rules, whereby a check is exercised on the German cements by the Association. A complete analysis is made each year of all German cements.

The management of the laboratory is in the hands of a chemist, who has under him other chemists, laboratory workers, and assistants. He has to report every month to the management-council on the work done in the laboratory.

In the reports to the management-council the cements tested are to be distinguished by numbers and not by the names of the factories.

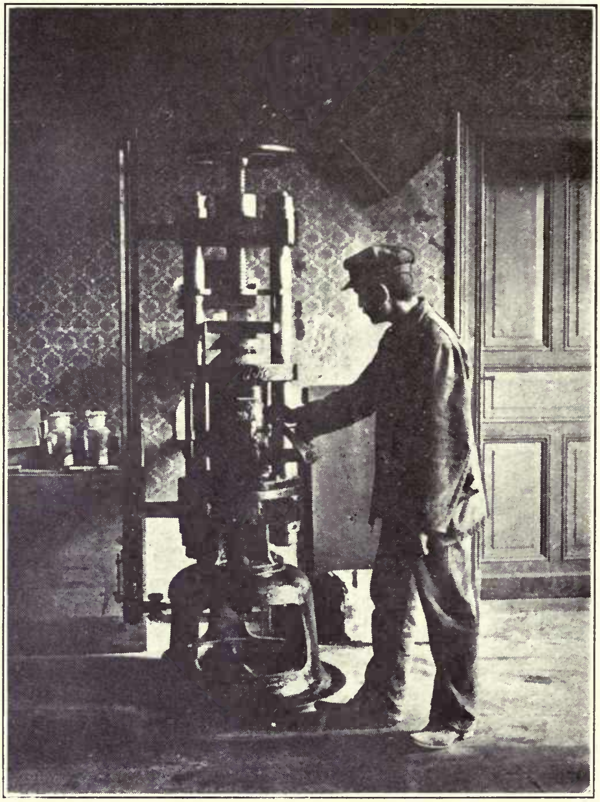


Fig. 27.—Crushing the Cubes with the Amsler-Laffon Press.

The strictest attention is given that business interests shall in no manner be prejudiced by the reports.

However, if it happens that a cement does not pass the standard test, then the name of the factory and the tests are communicated to the management-council, which then takes further steps. With this exception no factory learns anything of the tests of the other factories. On the other hand, the manager of the laboratory communicates every year to each factory the results ascertained in the Association laboratory with its cement as bought from the trade. But no advertisement may be made of these tests.

To ascertain whether the cement contains any foreign admixture, a special process, the so-called suspense analysis, has been worked out. Cements which are at all suspected of being adulterated are frequently bought from the trade and tested.

The tests naturally embrace also slag cements, foreign cements, natural cements, and iron-Portland cements, which are regularly bought and tested.

I can probably best give you an idea of the activity and utility of the Association Laboratory by naming some of the work which has been done in it during the last eight years.

1. The influence of a slight uncleanness of the standard sand, through brown coal products.

2. Regarding the Ljamin methods of determining the free hydrate of lime in hardened Portland cement.

3. Analyses respecting the constitution of Portland cement.

4. Methods for determining the free hydrate of lime in hardened Portland cement.

5. Influence of the addition of blast-furnace slag to Portland cement.

6. Influence of the hardness of water on the setting time and strength of cement mortar.

7. Swelling phenomena of Portland cement in distilled water.

8. The behavior of cements on the addition of various means of adulteration, such as trass, ground sand, blast-furnace slag, and artificial slag.

9. Concerning the question of mixing slag.

10. Influence of ground water on concrete channels.

11. Experiments regarding the permissible percentage of sulphuric acid, made with ninety different cements.

12. Storage of cement bodies exposed to the weather.

13. Testing process with atmospheric hardening.

14. Methods of recognizing foreign admixtures in cement.

15. Working out of a method for determining the sulphide sulphur.

16. Comparative strengths with different manners of seasoning made on over ninety cements.

17. Testing of ninety cements with increased proportion of gypsum.

18. Testing of ninety cements with combined atmospheric and water-hardening.

19. Finding of shortened ways of testing the constancy in volume of hydraulic cements.

20. Comparative tests of Portland cements with iron-Portland cements.

21. Comparative strength tests of "Association" cements with different methods of hardening.

22. Concrete experiments with different sands and gravels.

23. Concrete experiments with ground-damp and plastic mixture.

24. Experiments on the setting of all "Association" cements in a fresh state, and after three, six, nine, and twelve months' storage.

25. Chemical analysis of sea-water testing bodies.

26. Uniform testing of hydraulic cements by means of prisms.

27. Experiments on bending, crushing and tensile strength of prismatic test bodies according to Schule and Ferret.

28. Attempts to make test bodies out of pure cement with the hammer apparatus.

29. Regarding the storage constancy of Portland cement.

30. Experiments with Belgium natural cements.

31. Experiments on the calcination loss and the specific weights of Portland, natural, and slag cements.

32. Experiments on the water porosity of mortars.

33. The behavior of Portland and slag cements when hardened in salt solutions.

34. Testing of Portland cement mortars with regard to water porosity with addition of ground limestone, hydrate of lime, hydraulic lime, and trass.

35. Establishment of a uniform method of analysis for Portland cement.

36. Influence of the proportion of sulphide sulphur with atmospheric hardening.

37. The oxidation of sulphide sulphur in iron-Portland cement.

38. Testing of mortar mixtures of iron-Portland cement with pumice sand.

39. Testing of all "Association" cements according to the Le Chatelier test.

40. Experiments on the increase in temperature with the setting of cement.

Gentlemen, this is an extract from the scientific work done in recent years by the "Association" laboratory. The chief activity of the "Association" laboratory is directed to the regular testing of the "Association" cements, to the making of tests for private parties, and to work ordered by and together with the different commissions of the Association of German Cement Makers. Of such commissions we have: (1) The sea-water committee; (2) the rules committee; (3) the sand committee; (4) the setting time committee; (5) the committee for concrete experiments in moorland; (6) the committee for reinforced concrete.

For all these committees the "Association" laboratory has to carry out the experiments, which are generally very comprehensive.

The rules committee ordered in one year alone the making of 14,000 test bodies. The standard sand is also under the supervision of the "Association" laboratory.

Within a few years the sale of standard sand has been transferred to the "Association" laboratory, which derives a considerable income therefrom.

Besides this, the laboratory is being in recent years more and more employed by the factories of the "Association" and by private parties. The number of tests asked for from this side in the past year amounted to over 500. Most of these were tests according to the rules, but there were also raw meal analyses, suspension analyses, tests of trass, tests of concrete, sand samples, oil samples, tests of building bricks, tests of caloric values, and tests of feed-water for boilers. Various cement works have subscribed to have their cement tested every fourteen days in the "Association" laboratory.

The cost of up-keep of the laboratory is covered by the revenue from these testing fees, together with the profit on the sale of standard sand.

The greatest amount of work done by the laboratory is, however, the testing according to rules of all the brands of cement belonging to the "Association," the number of which has now risen to 96.

Each cement is subjected to all the tests prescribed by the rules. It is tested for fineness, specific weight, volume weight, setting time, volume constancy, tensile and crushing strength both with water-hardening and combined atmospheric and water seasoning. There are further made with each cement accelerated tests for volume constancy, including the Heinzel ball test, the kiln test, and the boiling test. The last was not passed in the year 1909 by thirty-two cements, which otherwise were of the best quality and showed great strength. No objection was, of course, made to these, and the boiling test is only made to show its uselessness.

A complete analysis is also made of each cement. In this way very abundant and valuable analytic material is obtained, from which conclusions can be drawn with regard to the making of a good Portland cement. In the year 1909 it was ascertained that the mean lime percentage of all German cement brands reached 63.47 per cent., the highest point up to that time. The maximum contained in a cement was as much as 66.47 per cent. CaO. It will interest you to know that although the German rules call for only 250 kilos pressure strength at the end of twenty-eight days, more than half of all German cement brands had 350 kilos, and of these eight cements showed as much as 450 kilos pressure strength at the end of twenty-eight days.

The annual results of all cement tests and analyses of all German cements are tabulated and published every five years in a special pamphlet, which enables cement investigators to have at their disposal very conscientiously prepared and copious material. In this summary the various cement brands are, of course, not designated by names but by numbers.

Gentlemen, I can to-day only draw for you in bold lines a picture of the activity of the "Association" laboratory; if I went into details, a whole book could be written about it, although it has hardly been ten years in existence. I think, however, you will already have formed an idea as to how very useful it is to the German cement industry. The laboratory would have fulfilled its purpose if it had done nothing further than supervise the quality of the German cements. The "Association" laboratory has, however, far exceeded the expectations that were placed in it. At the commencement there were, of course, difficulties to be overcome; the proper man could not be found at the start to manage it, and the revenue did not suffice to cover the expenses. But the laboratory has now stood for a number of years under the management of an able and cautious chemist, who succeeded in a short time in making the laboratory pay for itself.

If I have indicated to you to-day the importance of this institution, I have done so with a special intention. When I had the opportunity last year of studying the American cement industry, I admired nearly everywhere the splendid arrangement of the factories, and I was impressed by the fact that the young American cement industry had made enormous progress in a short time. But on the whole it seemed strange to me that here in America so little laboratory work is done in the general interest by the cement makers, and that you have no "Association" laboratory, such as has been founded in different countries after the pattern of the German. Some of your members inquired at that time about our "Association" laboratory, and I therefore thought it would be of interest to you to learn something about its arrangement and activity.

The preliminary work which was necessary for the establishment of the new German rules was mostly done in the "Association" laboratory, and it was only when the work was sufficiently advanced to enable definite methods of testing to be built up, that the latter were further worked out and completed by the members of the rules committee. You all know the new German rules which have been in force since last year for all German states, but it will interest you to learn the early history and to hear the reasons which led to the fixing of the different specifications.

As I have already mentioned, rules for testing Portland cement were first laid down in 1877. In the rules of that time the following was determined:

The cement should be sold in barrels of 180 kilos (396 lbs.). It should be constant in volume and seasoned.

Cement which had not set in half an hour was considered slow setting. Every cement should set in two hours at the most. The fineness of grinding was fixed at 20 per cent. on the 900-mesh sieve, which corresponds to your sieve No. 100.

The cement was tested for tensile strength only, as is to-day still the case in America, and the briquettes were rammed by hand, as you do it here. The tensile strength was to amount to ten kilos per square centimeter. These rules were in force in Germany until 1887.

But it was soon seen that the tests made on the basis of these rules were not reliable. A cement which was tested in accordance with the rules in six different places gave six different results. The reason of the poor agreement was soon recognized, first in the impossibility of ramming the briquettes uniformly by hand, and in the great influence of the sand on the strength.

The problem had now to be solved to make the testing procedure as uniform as possible, and to eliminate all sources of error in the preparation of the samples. A sharp, fine quartz sand of as uniform a grain as possible was first sought for. Such a deposit was found at Freienwalde, and it was brought to a definite fineness by screening. The preparation of this standard sand is under the control of the royal material testing office and the "Association" laboratory.

The elimination of the sources of error could only be obtained by substituting machinery for hand work, and therefore Steinbrück's mortar-mixer was tried for mixing the mortar, and Böhme's hammer apparatus for ramming the briquettes in the molds. It was also attempted to regulate the addition of water. In the meantime the conviction was arrived at that the testing of the concrete for pressure strength was just as important as for tensile strength; an apparatus was sought to crush the cubes, and it was found in the Amsler Laffon press. When the new rules were introduced in the year 1887, the terms of the same had been so well worked out by experiments that they stood proof for twenty-two years with success. These rules, which were in force until 1909, differed from the old rules chiefly in the following points:

1. A definition for Portland cement was laid down. The object of this was to exclude from the definition "Portland cement" all cements which had been diluted by the admixture of blast-furnace slag or limestone. The members of the Association were bound to bring into the market nothing but pure, unmixed Portland cement. The declaration they had to sign ran: "The members of the Association may only bring into the market under the designation of 'Portland cement' a product made by an intimate mixing of finely ground calcareous and argillaceous materials or calcareous and argillaceous silicates burnt to incipient fusion and ground to a flour. They bind themselves to not acknowledge as Portland cement any product made in a different way from that described above, or to which foreign matter is added during or after burning, and to look upon the sale of such products as deception of the buyer. But this bond does not apply to slight additions up to the amount of 2 per cent. which may be required for the regulation of the setting time or for other special purposes."

2. In addition to tensile strength, the pressure strength was introduced. At the same time the claims on the strength were raised considerably, namely from 10 to 16 kilos per square centimeter. For the pressure strength 160 kilos per square centimeter was fixed.

3. The standard sand was introduced as uniform sand, and the preparation of the briquettes by machinery was determined on.

4. The residue permissible on the 900-mesh screen was reduced from 20 per cent. to 10 per cent.

5. The Vicat needle was introduced for the determination of the setting time, and it was resolved that slow-setting cements should have at least two hours' setting time.

The old rules regarding the volume constancy were retained unchanged.

At the commencement of this century concrete construction and the use of concrete for building found a larger field; it was soon recognized that the claims on the strength would again have to be increased, and that the preparation of the test bodies would have to be more suited to the practice. If with the previous rules the seasoning in water was laid down, it was done because the results agreed closest with this method. In years of work, in which many hundred thousand sample bodies were stamped and crushed by members of the Association, a serviceable method was at last found in the so-called combined seasoning, that is, immersion for six days in water and then keeping for twenty-one days at room temperature.

As cement is now often worked in a plastic condition, endeavors were made to test sample bodies made of plastic cement mortar. But all the results from many thousands of experiments were insufficient. No conformity could be attained. So it was decided to again make the briquettes out of ground-damp cement mortar the same as before. You are aware that the International Commission is trying for the testing of plastic cement mortar, but according to the results yielded by the experiments in Germany it will hardly be possible, especially if value be placed on agreement in the results of the tests, which is the chief thing.

In accordance with actual practice, the briquettes have been kept in the open air, exposed to heat, cold, rain, and sunshine, and tested after twenty-eight days. The degrees of strength ascertained were very high, but did not at all agree with each other. This method was therefore abandoned.

Trials were then made with simply leaving the samples to harden at room temperature. But even with this method the tests made in different laboratories did not show the desired conformity. Dr. Michaelis then proposed to imitate actual practice by placing the samples alternately in cold water, in the atmosphere, and in a box at high temperature, and testing after twenty-eight days of such treatment. The results were favorable, and much higher strengths were determined than by immersion in water. In spite of this, however, the method was not adopted, owing to it being so complicated. The method proposed by Dr. Goslich met the same fate; his suggestion was to let the bodies harden in a closed box over burnt lime, while excluding the carbonic acid.

The only serviceable way of seasoning the samples proved to be the combined seasoning, that is, six days in the water and then twenty-one days in the atmosphere. This method was again checked by the making and testing of several thousand sample bodies.

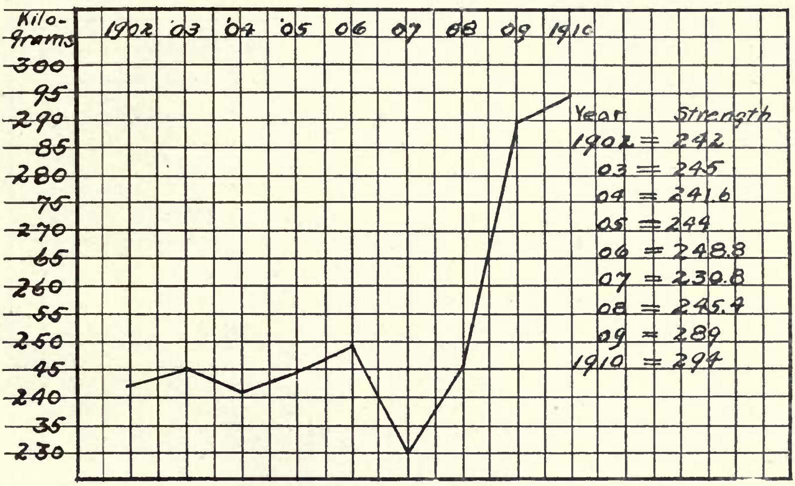
Concrete work has chiefly to withstand pressure, and it was therefore decided to meet the natural conditions in this respect, and the pressure test was introduced as the conclusive test. The test for tensile strength is now only of minor importance, and has only been retained as a preliminary test for the building place. After seven days' water seasoning the minimum strength shall be at least 12 kilos per square centimeter.

As it is often important for the concrete builder to make sure as soon as possible of the quality of the cement, this circumstance was taken account of in the new rules by the introduction of a crushing test after keeping the cube one day in moist air and six days under water. The crushing strength must amount to at least 120 kilos per square centimeter.

As, however, with the laying down of the new rules it was especially a question of increasing the minimum strength after twenty-eight days, which up to then had amounted to 160 kilos per square centimeter, it became necessary to test all the German cements after the new combined seasoning, and to fix the minimum strength in accordance. The result was that in place of 160 kilos per square centimeter in force up to that time, the minimum strength was fixed at 250 kilos per square centimeter in the new rules. Otherwise the only further change made in the new rules was that the fineness of the cement was again increased, and not more than 5 per cent. residue allowed on the 900-mesh sieve. You will be interested to hear that in Germany the grinding is done much finer. The residue on the 900-mesh sieve in 1909 averaged 1.39 for all the factories. Cement was bought from the trade which had only 0.1 per cent. residue, and was thus very finely ground. Five per cent. magnesia is permitted and 2.5 per cent. sulphuric acid. These limits were, of course, not introduced until the conviction had been arrived at by numerous experiments that neither 2.5 per cent. sulphuric anhydride nor 5 per cent. magnesia are in any way harmful to the quality of the cement. According to the new rules, an addition of 3 per cent. is allowed to regulate the setting time, in consequence of rotary kiln cements often requiring more gypsum to make them slow than ring kiln cements. The new rules no longer contain any stipulation as to when the setting must be finished; they propose, as of much more importance, to fix the commencement of the setting, which has been put down as one hour at the outside. The definition of Portland cement has been drawn up very carefully in the new rules, so that it is impossible in the future for other hydraulic cements to be mistaken for it. It runs:

Portland cement is a hydraulic cement with not less than 1.7 parts in weight of lime (CaO) to 1 part in weight of soluble silica (SiO_2) plus alumina (Al_2O_3) plus oxide of iron (Fe_2O_3) made by fine grinding and intimate mixing of the raw materials, burning to at least incipient fusion and fine grinding.

Owing to the tests for the new German rules being spread over a number of years, and to the tests being made with all the German cements in ten different places, the Association of German Portland Cement Makers possesses an enormous quantity of data on results of tests, which give very interesting conclusions as to the behavior of cements under different conditions of testing.



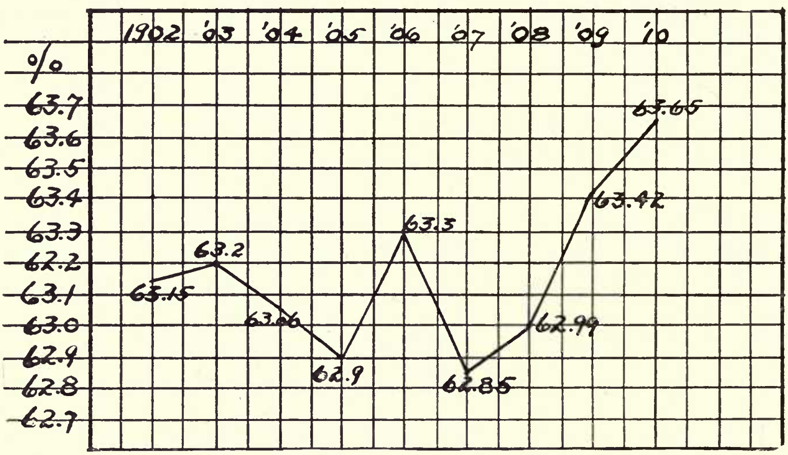
Average Crushing Strength of all German Cements During the Last Nine Years.

The 96 cements were tested in twelve different testing stations for both tension and pressure, according to the old and the new rules. It turned out that the results with combined seasoning agreed excellently.

The minimum of 120 kilos pressure strength was reached by all the cements with the exception of three. I would emphasize the fact that these tests were made before the new rules came into force, solely to ascertain how many cements at the time of the old rules corresponded to the higher standards of the new rules. Nearly all the cements already came up to the new standard.

Only one cement remained under 160 kilos, the standard of the old rules, while all cements with the exception of seven showed over 200 kilos pressure strength, so that it was decided to take this figure as the minimum strength. The seven factories had therefore to improve the quality of their cement to reach at least 200 kilos pressure resisting strength after twenty-eight days.

It is expressly stipulated in the new rules that this manner of testing with twenty-eight days' water-seasoning is only to be applied to those cements which are to be used for waterworks. Otherwise the combined seasoning is taken, that is, six days in water and twenty-one days in the air. As only nine of the 96 cements did not attain a strength of 250 kilos after twenty-eight days, it was decided to introduce 250 kilos as the minimum strength, in consideration that



Average Percentage of Lime in All German Cements During the Last Nine Years.

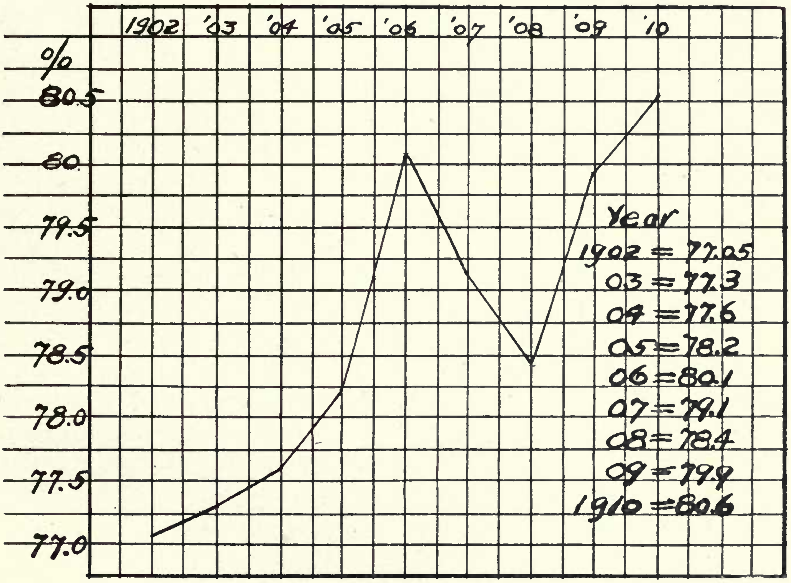
the manufacture of these nine cements could be so far improved as to bring them up to this limit. This test for pressure resistance with combined seasoning is thus laid down in the new rules as the most important and conclusive one. After its introduction all German cements passed the test made last year by the Association laboratory.

In scientific interest all cements have been tested in the same manner for tensile strength.

It is very interesting to see how the average strength of all the German cements tested in the Association laboratory during the years 1902 to 1909 considerably increased, in view of the probability of the introduction of new standards.

The average figure in 1902 was 240 kilos; then in 1904, 242 kilos; in the year 1906, nearly 249 kilos; and after a slight decrease in 1907, it amounted to 290 kilos in 1909 at the time of the introduction of the new rules. These are the values of the tests according to the rules valid at the time, which only called for 160 kilos.

But with the efforts constantly to make better cement, the average lime percentage of the German cements has also considerably increased of late years, so that it now amounts to 63.4. You see what interesting comparative material is produced by the work in the "Association" laboratory.



Average Fineness on Screen of 5000 Mesh per Square Centimeter of All German Cements for the Last Nine Years.

I think that from my remarks you will have formed an idea of the persistent and splendid manner in which for years the tests were carried out and which finally led to the establishment of the new German rules. A copious material, which probably exists in no other association of cement makers, has been collected, making it possible on the basis of the experience gained to establish new foundations for testing cement, which call for a better quality of cement, and which are more suited to actual practice than formerly. It is therefore to be hoped that the new German rules will stand proof for years and guarantee a satisfactory testing of Portland cement.

The Association of American Portland Cement Manufacturers is an Educational and Scientific Body, composed of the following Members:

ALLENTOWN PORTLAND CEMENT CO., Allentown, Pa.

ALMA CEMENT CO., Wellston, Ohio.

ALSEN'S AMERICAN PORTLAND CEMENT WORKS, 45 Broadway, New York, N. Y.

AMERICAN CEMENT CO. OF NEW JERSEY, Pennsylvania Building, Philadelphia, Pa.

ASH GROVE LIME & PORTLAND CEMENT CO., R. A. Long Building, Kansas City, Mo.

ATLAS PORTLAND CEMENT CO., 30 Broad St., New York, N. Y.

BATH PORTLAND CEMENT CO., Bath, Pa.

CALIFORNIA PORTLAND CEMENT CO., Los Angeles, Cal.

CASTALIA PORTLAND CEMENT CO., Publication Building, Pittsburg, Pa.

CAYUGA LAKE CEMENT CO., Ithaca, N. Y.

CHICAGO PORTLAND CEMENT CO., 108 La Salle Street, Chicago, Ill.

COLORADO PORTLAND CEMENT CO. Denver, Colo.

CONTINENTAL PORTLAND CEMENT CO., St. Louis, Mo.

COPLAY CEMENT MFG. CO., Coplay, Pa.

DEWEY PORTLAND CEMENT CO., Scarritt Building, Kansas City, Mo.

DEXTER PORTLAND CEMENT CO., Nazareth, Pa.

DIAMOND PORTLAND CEMENT CO., Williamson Building, Cleveland, Ohio.

DIXIE PORTLAND CEMENT CO., Richard City, Tenn.

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FREDONIA PORTLAND CEMENT CO., Fredonia, Kansas.

GERMAN-AMERICAN PORTLAND CEMENT WORKS, La Salle, Ill.

GLENS FALLS PORTLAND CEMENT CO., Glens Falls, N. Y.

GREAT WESTERN PORTLAND CEMENT CO., Kansas City, Mo.

HELDERBERG CEMENT CO., 78 State Street, Albany, N. Y.

HURON PORTLAND CEMENT CO., Ford Building, Detroit, Mich.

IOLA PORTLAND CEMENT CO., Iola, Kansas.

IOWA PORTLAND CEMENT CO., Des Moines, Iowa.

LAWRENCE PORTLAND CEMENT CO., Siegfried, Pa.

LOUISVILLE CEMENT CO., Speeds, Ind.

MARQUETTE CEMENT MFG. CO., La Salle, Ill.

MONARCH PORTLAND CEMENT CO., Humboldt, Kansas.

NAZARETH CEMENT CO., Nazareth, Pa.

NEW AETNA PORTLAND CEMENT CO., Detroit, Mich.

NEWAYGO PORTLAND CEMENT CO., Grand Rapids, Mich.

NORFOLK PORTLAND CEMENT CORPORATION, 604 Pennsylvania Bldg., Philadelphia, Pa.

NORTHWESTERN STATES PORTLAND CEMENT CO., Mason City, Iowa.

OGDEN PORTLAND CEMENT CO., Ogden, Utah.

OKLAHOMA PORTLAND CEMENT CO., Ada, Oklahoma.

OMEGA PORTLAND CEMENT CO., Jonesville, Mich.

PEERLESS PORTLAND CEMENT CO., Union City, Mich.

PENINSULAR PORTLAND CEMENT CO., Jackson, Mich.

PENNSYLVANIA CEMENT CO., 29 Broadway, New York, N. Y.

PHOENIX PORTLAND CEMENT CO., Nazareth, Pa.

PORTLAND CEMENT COMPANY OF UTAH, Salt Lake City, Utah.

RIVERSIDE PORTLAND CEMENT CO., Los Angeles, Cal.

SANDUSKY PORTLAND CEMENT CO., Sandusky, Ohio.

SECURITY CEMENT & LIME CO., Baltimore, Md.

SOUTHWESTERN STATES PORTLAND CEMENT CO., Dallas, Texas.

STANDARD PORTLAND CEMENT CO., Charleston, S. C.

STANDARD PORTLAND CEMENT CORPORATION, Crocker Bldg., San Francisco, Cal.

SUPERIOR PORTLAND CEMENT CO., THE, Cincinnati, Ohio.

TEXAS PORTLAND CEMENT CO., Cement, Texas.

U. S. PORTLAND CEMENT CO., Kansas City, Mo.

UNION SAND & MATERIAL CO., Liggett Bldg., St. Louis, Mo.

UNITED KANSAS PORTLAND CEMENT CO., Iola, Kansas.

UNITED STATES PORTLAND CEMENT CO., Coors Building, Denver, Colo.

UNIVERSAL PORTLAND CEMENT CO., 115 Adams Street, Chicago, Ill.

VIRGINIA PORTLAND CEMENT CO., 5 Nassau Street, New York, N. Y.

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WABASH PORTLAND CEMENT CO., Ford Building, Detroit, Mich.

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