March 26, 1929. T. RIGBY 1,706,748

MANUFACTURE OF CEMENT BY THE WET METHOD IN ROTARY KILNS

Filed July 8, 1926 2 Sheets-Sheet 1

Fig.1.

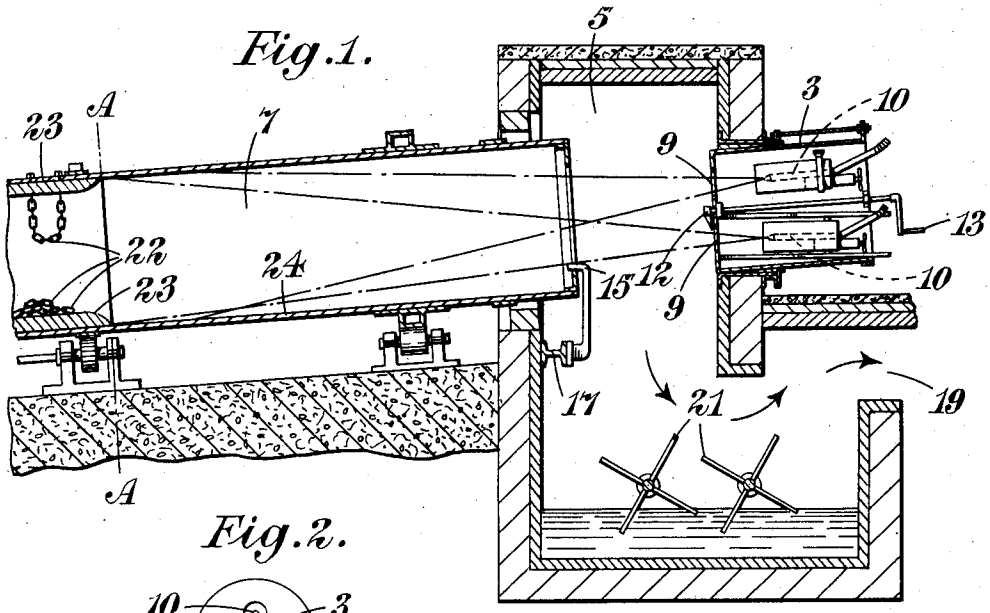


Fig.2.

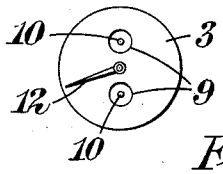


Fig.3.

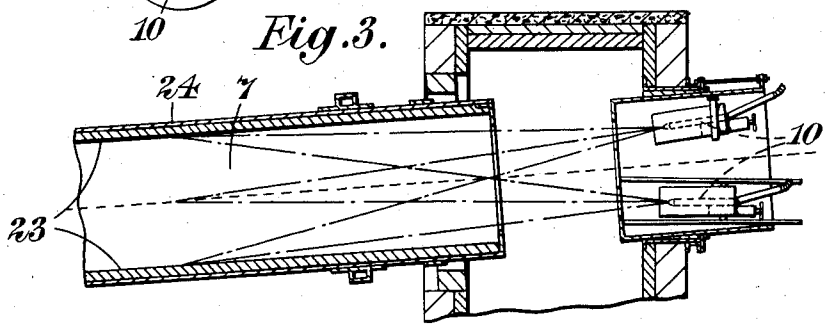
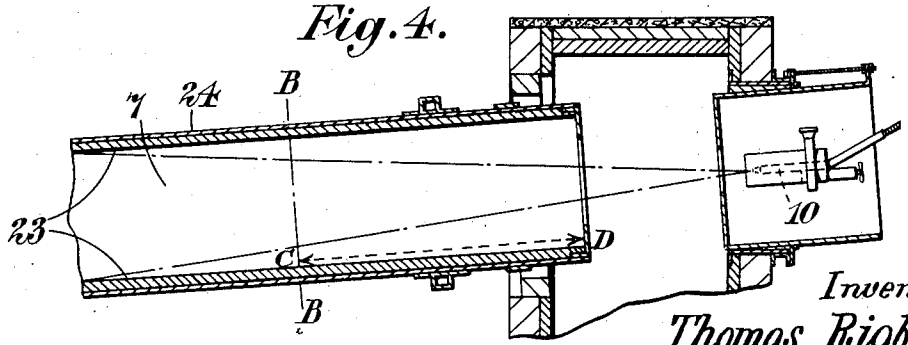


Fig.4.



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MANUFACTURE OF CEMENT BY THE WET METHOD IN ROTARY KILNS

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Fig. 5.

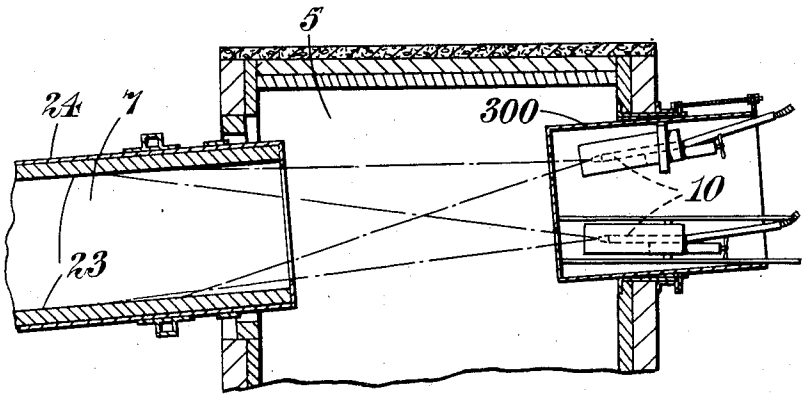
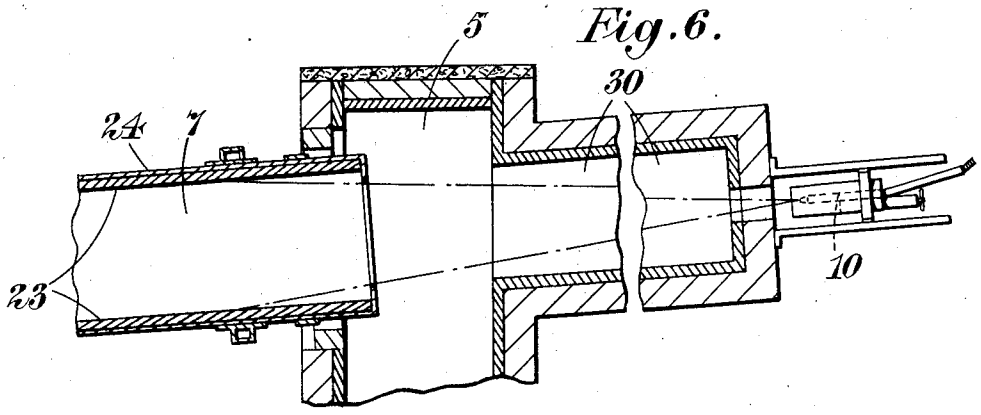


Fig. 6.



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UNITED STATES PATENT OFFICE.

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MANUFACTURE OF CEMENT BY THE WET METHOD IN ROTARY KILNS.

Application filed July 8, 1926, Serial No. 121,184, and in Great Britain July 24, 1925.

In making cement by the customary wet method by pouring the slurry of cement making material in a stream into a rotary kiln there are produced sooner or later in the course of the working of the kiln near its upper or drying end large agglomerations of partly dried material. These agglomerations may, for example, take the form of detached, large rounded masses or balls (sometimes one foot in diameter) or may be what are known as "slurry rings" adhering to the kiln wall and thereby obstructing the gas space and preventing the regular flow of cement making materials down the kiln. These I have observed, in fact often produce ill-effects that may occur without being observed since such agglomerations when formed frequently break up in time during the rotation of the kiln (and their travel down it) so that they may actually produce, while they last as masses, their ill-effects on output without their presence being suspected and without the true capacity of the kiln (were such agglomerations not being first formed and then broken up) being realized. This is particularly true where the kiln is regularly forming round masses or balls of large and fairly uniform size which gradually diminish as they travel down the kiln to the clinkering zone because then although a quite regular output from the kiln of apparently quite satisfactory clinker is being obtained the material is in fact for a long portion of its travel down the kiln in the form of masses ill-suited for efficient absorption of heat from the gases.

It has been proposed in Bamber's British specification No. 22,734 of 1902 to expose the slurry in an atomized condition to the action of the gases in the kiln before the slurry becomes deposited on the kiln wall so as to secure an extra cooling of the gases before they leave the kiln.

In my British specification No. 243,410 I have described cement-making processes in which the slurry is sprayed across the kiln head into the kiln by spraying devices situated outside the kiln. The methods therein described, though offering considerable advantages over the usually practised pouring method, do not of themselves entierly obviate the difficulties hereinbefore referred to.

It is the object of this invention to obviate these disadvantages by delivering the slurry into the kiln in an atomized condition and controlling the amount of the drying which the slurry is subjected to by the atomization before it deposits on the kiln wall so that the material by the time it reaches the kiln wall while still appreciably moist has yet been dried to a semi-solid or pasty condition. I have found that if conditions are created under which the atomized material before being so deposited is not dried beyond a certain point but is dried up to a certain degree one can secure that the cement material, on the one hand, deposits itself effectively on the kiln wall, does not tend to be carried to an undue extent out of the kiln by the gases and retains the proper intimacy of admixture of its ingredients and yet, on the other hand, there shall occur as compared with the production of cement from the same slurry in the same kiln by pouring it thereinto in the usual way practically complete absence of objectionable masses or agglomerations as referred to adhering to the kiln wall, that the cement material as it travels down the kiln does not form into large balls but forms from the first into comparatively small, and, in the main, fairly regular pieces of small size which admit of a most thorough calcination and subsequent burning of the cement. Owing to this novel state of affairs there is obtained a higher rate of kiln output of clinker that usually will be composed of pieces of small size and is therefore not only composed of thoroughly well burnt cement but is very economical to grind.

The point beyond which the drying should not be carried before the deposition of the atomized slurry on the kiln wall is probably not subject to any very considerable variations and is preferably a water content of about 10 per cent. The point of which the drying should at least be carried to guard against the formation of agglomerations and secure to the full the other advantages above described may vary considerably with the geological character of different cement-making materials and the degree of plasticity or tackiness which the particular slurry possesses at various water contents, since cement materials vary in these respects to a considerable degree according to the locality whence they are derived. For example, with a slurry originally containing some 40% of water the drying should ordinarily be carried to such a point that some 50 per cent of the water of the slurry is removed, leaving a water content of round about 25 per cent as an average in the material when it reaches the kiln wall. In some cases however the desired results may

be obtained where the water dried from the slurry before its deposition on the kiln is substantially less, say 20 per cent of the whole of the water in the slurry dispersed into the kiln.

A criterion of the right conditions having in fact been attained in the kiln as regards securing a high kiln output in this novel manner will in many cases be the formation of a clinker that on the average is noticeably smaller and more regular in formation as compared with the clinker obtainable when feeding the self same kiln with the self same slurry by the customary pouring method. This difference in clinker size will vary under different conditions and be very considerable in some cases so as to be a definitely desired and advantageous result while in other cases it may be less marked and then become principally a mere indication that the control conditions are correct for that case.

The requisite degree of exposure of the atomized material to secure the chosen best degree of dryness of the material before it deposits on the kiln wall is, for any particular slurry, a function of the water content of the slurry, the fineness of atomization, the time of exposure of the atomized material to the gases, and the temperature of these latter, though under any circumstances it requires the filling by the atomization of a volume of the kiln with dispersed slurry, the length of which volume is at least equal to the internal diameter of the kiln.

Figure 1 illustrates a plant by which the above results can be secured.

Figure 2 is a view of a part shown in Figure 1, viewing this part from the direction of the kiln mouth;

Figure 3 illustrates a plant wherein a plurality of jets delivering slurry to one general region of the kiln are employed,

Figure 4 illustrates a modification where only one jet is employed,

Figure 5 shows a construction with a modified form of kiln head,

Figure 6 illustrates a further modification of the kiln head.

In Figures 1 and 2 there is shown a chamber 3 inserted in the rear wall of the kiln head 5 and in line with the kiln 7. The front wall of the chamber 3 has openings 9, 9 in it and it is from points 10 behind these openings that jets deliver sprays of slurry through the kiln head and into the kiln.

The sprays interpenetrate, the one travelling further into the kiln than the other. At 12 is shown a scraper that by a handle 13 (on a shaft extending through the front wall of the chamber 3) may be rotated occasionally to clear any deposits of partly dried slurry (that may be blown out of the kiln), from the front wall of the chamber 3 while at 15 is shown a fixed scraper (extending from a mounting 17 below the kiln and out of the way of any material dropping from the kiln mouth) that as the kiln rotates keeps the kiln mouth unobstructed.

Any material detached by the scrapers 12 and 15 as well as any other material falling directly down the kiln head 5 is caught by a mass of liquid (preferably fresh slurry) in the base of the kiln head which the gases leave at 19 to pass to the chimney. The cement material thus collected by the liquid can be conveniently drawn off in admixture with the liquid and becomes available again for atomization into the kiln. At 21 are shown paddles ensuring the proper mixing of the deposited matter and the liquid.

In one instance in such a plant where the distance between the points 10 and the location A—A (Figure 1) where the longer spray had its maximum spread was about 30 feet using a slurry obtained from the blue lias district of Southam in Warwickshire not only were the gases leaving the kiln found to be cooled to a temperature of 150° C. as compared with 400° C. when working that same kiln by the customary pouring method but the above mentioned advantages were obtained, the kiln output being in fact increased from 4.6 tons per hour (which had formerly been the output when feeding the kiln in the customary manner with slurry by pouring it in a liquid stream into the upper end of the kiln) to 6.2 tons per hour (when working as described with reference to these figures of the drawings). Calculations and observations show that the average water content of the particular slurry then being used (containing 40 per cent of water when atomized) when it reached the kiln wall under these conditions was between 20 and 25 per cent. In thise case it was noted that whereas clinker composed mainly of pieces of some half-an-inch diameter was the customary result of working that kiln by the pouring method a clinker composed mainly of pieces of no more than one-eighth to three-sixteenths of an inch in diameter could be obtained under the novel conditions indicated.

The invention may be carried out in many different ways particularly since the results achieved by the control (within limits as indicated) of the drying of the slurry while in the atomized condition are, quite apart from any resultant heat economy in the working of the kiln itself, of such considerable importance to the cement manufacturer that the mode used of dispersing the slurry in the kiln may be chosen with little regard to the securing of exceptionally high heat economy and yet considerable benefits be obtained. For instance, the requisite dispersal may be secured by a group of jets all delivering the slurry to but one general region inside the kiln.

In such a case the jets will preferably con-

verge, for example so that the interpenetrating sprays which they deliver all reach their maximum dispersion (corresponding in diameter approximately to the internal diameter of the kiln) at the same distance from the kiln mouth at a point where the axes of the sprays intersect or approximately intersect the kiln axis and to effect this the jets may be arranged either inside or outside the kiln the latter, for example, being indicated in Figure 3 and the whole cross section of the kiln at this region is then well filled with atomized slurry through which all the kiln gases must pass.

On the other hand but a single jet may be used though in such an event the spray may need to be of rather considerable length to ensure the requisite drying action on the slurry before it deposits on the kiln wall, a condition presenting some disadvantages in so far as a material portion of the kiln wall between the kiln mouth and the point of maximum dispersion of the spray may cease to receive deposited slurry and become useless for continuing the drying of deposited slurry. By reference to Figure 4 it will be understood that with an arrangement as there indicated much of that region C—D of the kiln which is nearer the kiln mouth may receive but little deposited slurry as compared with the amount received by the portion of the region C—D nearer the line B—B or by the portion of the kiln adjacent the line B—B but on the side of the latter remote from the kiln mouth.

To obviate this shortcoming in the case where a single jet is used or in the case where a plurality are used the maximum dispersion of the sprays (Figure 3) or of that one which reaches its maximum dispersion nearest the kiln mouth (Figure 1) is considered to occur too far from the kiln mouth or again in any of these several cases in order to allow a very fine atomization of the slurry to be obtained by using one or more sprays discharged under unusually high pressure and therefore of considerable length, the point or points of origin of the spray or sprays may be moved back a distance further than the 7 or 8 feet or thereabouts contemplated in the cases shown in Figures 1, 3 and 4. This may be readily possible with a very wide form of kiln head such as is sometimes used (see Figure 5) and the requisite distance between the point or points of origin of the spray or sprays and the kiln mouth may be regulated in such a case merely by the greater or lesser projection of a jet chamber 300 (Figure 5) corresponding to the chamber 3 already described but of suitable length into the kiln head 5. Where the width of the kiln head does not allow of this, an extension 30 (Figure 6) coaxial with the kiln may be provided on the kiln wall and the jet or jets projected from one or more points 10 just outside it.

Having regard to the relatively poor gas-cooling capacity of the spray for much of its length from its point of origin as compared with its gas-cooling capacity (and by consequence its slurry-drying capacity) nearer its region of maximum dispersion the balance of advantage, in some cases at least, will favour the use of such special measures that the greater portion of the length of the spray is located outside the kiln and to bring the most finely dispersed portion only of the spray which has the greatest gas-cooling capacity into the kiln and as near the kiln mouth as is practicable.

While in the particular cases described above the atomizing means is or are illustrated as being located outside the kiln it should be understood that this is not necessarily so nor even where such means is or are outside the kiln need the same as in the particular cases described be outside the gas chamber 5 of the kiln head. Generally speaking it will be preferable as has been assumed in the above description to create the spray or sprays merely by forcing the liquid under suitable pressure through a jet or jets of appropriate form for example on the principle of a rotary motion being given to the slurry leaving the jet or jets; the atomization may however be effected by spraying devices of other kinds, for example of the type in which a blast of compressed air passing over the end of a duct delivering the liquid reduces the liquid thus delivered into the condition of fine spray.

In any event an important factor to observe is the disposition of the axis or axes of the spray or sprays in relation to the kiln axis so that wet spray shall not impinge with any appreciable energy upon the kiln wall: the energy of the spray should be substantially exhausted in the gas space of the kiln and if the spray should anywhere impinge upon the kiln wall that should only occur after such a travel of the spray through the gases as ensures the impinging portion having before such impingement occurs been dried to a substantial degree and lost its tendency to form coherent masses on the kiln wall.

Whatever arrangement be employed the kiln may be so worked that in spite of atomization of slurry in the kiln a customary, or even abnormally high temperature of the gases leaving the kiln results and then measures may be resorted to if desired for recuperating the heat of the kiln gases after they have left the kiln, for instance by using those gases to heat boilers in which steam is raised for power purposes of the cement plant or for other purposes.

When so working kilns at the customary or higher exit temperatures there is a greater evaporation in the zone or zones of atomizing owing to the higher temperature differences between the gases being cooled and the slurry being dried and consequently a greater

output is possible if fuel economy as a result of atomization is neglected. With high exit temperature however there is a limit to the increase of output obtainable owing to the large amount of fuel required to be burned in the combustion zone of the kiln unless the combustion portion of the kiln is specially contrived to burn this relatively large amount of fuel. I have found in practice when working with gas exit temperatures below 150° C. and using an atomizing system as hereinbefore indicated that some 25 per cent less fuel is required per ton of cement made as compared with the fuel required in the same kiln when working with the old pouring method. As a further result I have found that as much as 35 per cent increased output can be obtained with the lower exit-temperatures above mentioned burning approximately only the same total weight of fuel in the combustion zone of the kiln as is burned with the old pouring method and the lesser output and consequently there is no trouble in that case in effecting the combustion of the fuel. On the other hand as the exit gas temperature of the kiln mainly governs the amount of fuel required per ton of cement made it will be understood that the extra output obtainable when atomizing and working with the higher temperature differences above indicated can in fact only be realized provided extra fuel required to be burnt can indeed be properly burnt in the combustion zone of the kiln. For instance if the gas outlet temperature when so working is of the order of about 400° C. instead of below 150° C. (as above referred to) the extra fuel to be burnt might be as much as 40 per cent more than that when working the kiln according to the old pouring method to obtain about 40 per cent more output approximately than that obtained by the old pouring method because the fuel consumption rate per ton of cement made is under these conditions approximately the same as required in a kiln working on the old pouring method. The kiln may be worked however with any desired exit temperature and special measures taken where necessary to burn the fuel required to produce the output desired as for instance by increasing the diameter of the kiln in the combustion zone or by the application of devices for securing greater intensity of combustion or by both.

Rotary cement kilns are customarily provided for a certain distance from the kiln mouth inwards of the kiln with slurry lifting or agitating devices adapted as the kiln rotates to lift portions of the material and drop them again through the gases and break up, by the constant dropping action, agglomerations that may have formed or at all events to increase the surface of the slurry that is exposed to the gases or else adapted to detach masses that may tend to adhere to the kiln wall. Such devices may, for example, take the form of fins arranged longitudinally of the kiln and extending inwards of the kiln radially or may take the form of loose bars or chains laid on the bottom of the kiln.

Where however slurry is dispersed in an atomized condition in the kiln the presence of such devices while apparently advantageous at the portion of the kiln further from the mouth than the region of atomization (and where the the material has already been deposited on the kiln wall) presents disadvantages in that portion where atomized material is being deposited. Apparently though such material when in the desirable condition already discussed deposits as (or forms, on depositing and some subsequent rolling down the kiln, into) comparatively small pellets or rounded pieces and no longer exhibits any marked tendency to form agglomerations it is still sufficiently coherent to be somewhat liable to pack itself into large pieces if unduly thrown about and the condition best favouring its continuing to remain in small pieces is the simple slow rolling motion of the pieces over each other on the smooth inside of the kiln until such time as by continued contact this capacity for cohesion has been lost and the more violent agitation of the material by such auxiliary devices inside the kiln as above referred to becomes advantageous in breaking down such conglomerations of the relatively small pieces as may perchance have formed and in exposing the mass of comparatively small and then entirely non-coherent pieces to the fullest degree to the action of the gases.

Consequently, it is preferred to leave the kiln bare of such slurry lifting or agitating devices for such of its length as is occupied by the spray or sprays and to provide them only beyond this length and where the deposition of any substantial quantity of atomized material on the kiln wall is no longer likely. Thus, in Figure 1, chains 22 for detaching the material are shown only beyond the location A—A aforesaid.

This freedom of the kiln at the portion referred to from internal additions may (especially as this adds to the effective internal diameter of the kiln at that part) advantageously be carried to the point of removing from that portion of the kiln its customary brickwork lining 23 so that at that portion the kiln consists only of its metal shell 24 with, it may be, an external lagging guarding against undue heat loss.

I claim:

1. In a process of making cement in an inclined rotary kiln having a separate drying zone, and calcining and clinkering zones, these steps of supplying a plurality of independently controlled streams of finely divided atomized slurry flowing along converging axes to the interior of the surface of the said drying zone, and passing hot gases

of combustion in countercurrent to the atomized slurry and for maintaining the slurry in suspension in the current of gases until the slurry is dried to an extent such that it will not tend to stick together and form large lumps.

2. In a process of making cement in an inclined rotary kiln having a separate drying zone, and calcining and clinkering zones, these steps of supplying a plurality of independently controlled streams of finely divided atomized slurry flowing along convergent axes to the interior surface of the said drying zone, passing hot gases of combustion in counter current to the atomized slurry, and maintaining said slurry suspended in the counter current of hot gases for a period of time sufficient for removing substantially twenty per cent of the water content of the slurry before depositing the latter in the drying zone of the kiln and wherein the average water content of the deposited slurry is maintained not less than ten per cent.

In testimony whereof I have signed my name to this specification.

THOMAS RIGBY.