P. C. VAN ZANDT.

COMBINATION MILL AND PROCESS OF EFFICIENT OPERATION THEREOF.

APPLICATION FILED OCT. 2, 1916.

1,361,205. Patented Dec. 7, 1920.

Fig. 1

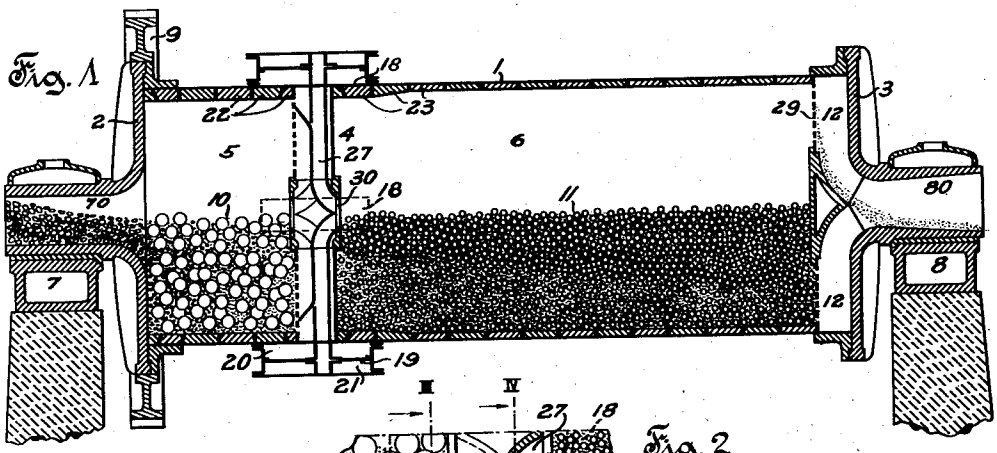


Fig. 2

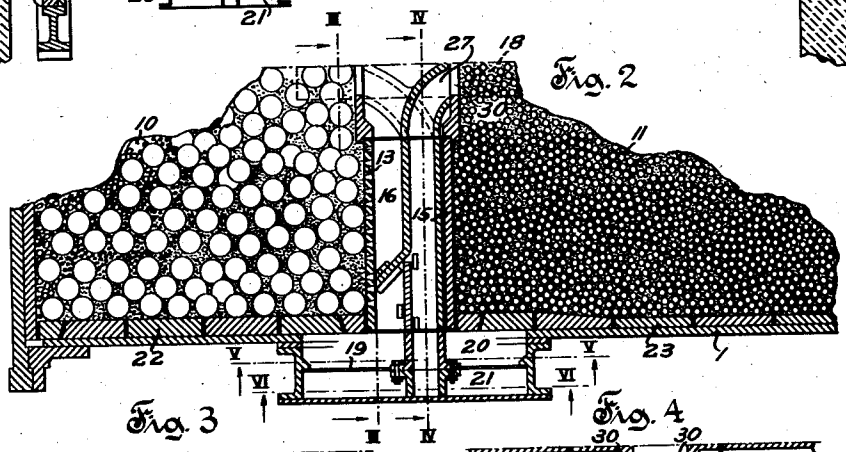


Fig. 3

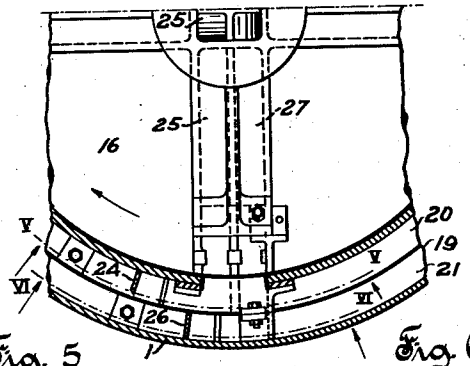


Fig. 4

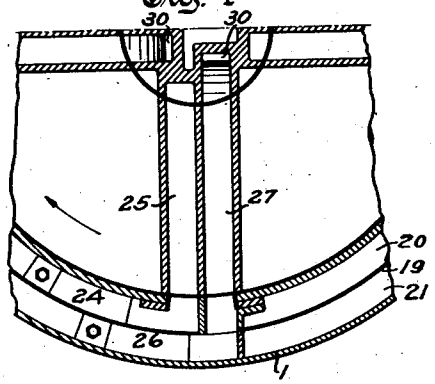


Fig. 5

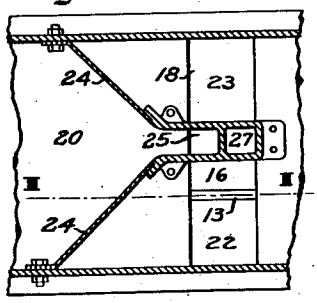
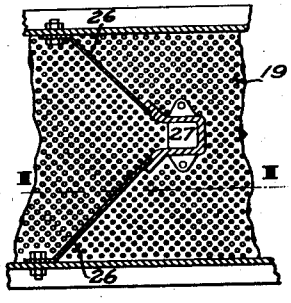


Fig. 6



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COMBINATION MILL AND PROCESS OF EFFICIENT OPERATION THEREOF.

1,361,205. Specification of Letters Patent. Patented Dec. 7, 1920.

Application filed October 2, 1916. Serial No. 123,783.

To all whom it may concern:

Be it known that I, PAUL C. VAN ZANDT, a citizen of the United States, residing at River Forest, Chicago, in the county of Cook and State of Illinois, have invented a certain new and useful Improvement in Combination Mills and Processes of Efficient Operation Thereof, of which the following is a specification.

This invention relates to mills for comminuting cement-making materials, coal, rock, ore and the like, more especially combination mills, and to the process of efficient operation of such combination mills.

The object of the invention is to provide a combination mill and a process of efficient operation thereof, producing a maximum rate of comminuting of the materials to a predetermined degree of fineness with a minimum expenditure of energy per unit weight or bulk of finished product. The process is effected by apportioning the work done in the chambers of the combination mill. Such apportionment may be accomplished by a relative variation of the volumetric capacity of the several chambers of the combination mill in any manner, as, for instance, by varying either the length or the diameter or both, of one or more of the chambers. The invention further contemplates the provision of other details of combination mill construction whereby the cost of installation and of maintenance are reduced to a minimum.

In grinding with tumbling comminuting bodies it is found that the efficiency increases as the mass of the grinding body increases, up to a point where the mass is many times greater than that of a particle of material being ground. Any increase beyond this will cause the efficiency of grinding to again fall off.

For these reasons it has heretofore been customary in installations having a comparatively extended range of reduction, to utilize several mills in series, as, for instance, a ball mill for effecting the preliminary coarse grinding, delivering to a fine grinding tube mill.

It has also been proposed to utilize the so-called combination mill in which a single rotary drum is divided into two or more grinding chambers separated by one or more partitions, in the one chamber of which mill there are grinding bodies of certain physical characteristics and in the other chamber of which there are grinding bodies having other physical characteristics.

Prior practice has established the law that the most efficient point to which to charge a horizontal rotary comminuting mill with grinding bodies, is at or near the centerline of the mill, and that specifically heavy bodies are more effective in comminuting due to their greater weight per unit volume. It may here be mentioned that if a mill is charged to the centerline with grinding bodies alone, the combined charge of the material and grinding bodies will not extend an appreciable amount above the centerline, as most of the material lodges in the voids between the grinding bodies. It has also been established that when so loaded a mill will operate with maximum capacity; it will also require maximum total power to rotate the mill; but in spite of the fact that the power is a maximum, the efficiency is also a maximum, that is, the energy expended per unit of material ground is a minimum. When the mill is loaded an appreciable amount either above or below the centerline, the capacity, power and efficiency materially decrease, the total power decreasing less rapidly than the total capacity.

It has been customary in the construction of combination comminuting mills of the prior art, to arbitrarily predetermine the volumetric capacity of the grinding chambers, as by forming the mill with chambers of such diameters and lengths, and arbitrarily fixing the partition within the mill at such a point, as to produce the predetermined size of each grinding chamber. After a mill had been thus constructed, each chamber was filled substantially to the centerline with grinding bodies properly graded in size or weight, and a test run of the mill was made. If the arbitrarily predetermined size of the first chamber was too large in relation to the size of the second, this fact would be indicated by the fact that the material passing from the first chamber to the second, is finer than necessary for the second chamber, the result being that the first chamber would operate inefficiently. This defect could only be lessened, there being no means for further correction, by decreasing the charge of grinding bodies in

the first chamber substantially below the centerline decreasing the power somewhat, but thereby violating the law of centerline loading for maximum efficiency, the result being that the mill would still run at less than maximum efficiency. If the first chamber were too small in relation to the second, this condition would be indicated, first, in the case where fine screens prevent too coarse a product from leaving the first chamber, by the fact that the finished product would be finer than the required standard, and by the further fact that the first chamber fills up with insufficiently ground material on attempting to increase the rate of feed to such an amount as to make a coarser finished product; and second, in the case where material from the first chamber has free access to the second chamber regardless of whether it has been properly ground in the first chamber or not, by the fact that the second chamber will either become filled with particles too coarse to be ground by its grinding bodies, or, these particles, of size larger than the standard, will shortly pass out with the finished product. The product leaving the mill may therefore temporarily be of the standard degree of fineness. This defect can only be lessened by decreasing the amount of grinding bodies in the second chamber substantially below the centerline, thereby decreasing the horse power somewhat and decreasing the capacity of the second chamber to that of the first when the first chamber is delivering material of proper size, therefore again violating the law of centerline loading for maximum efficiency as stated above. Furthermore, in addition to the loss in efficiency, the total capacity of a given size of mill in either case is decreased below the maximum capacity attainable when the two chambers are properly proportioned.

The present invention effects efficient operation of combination mills by apportioning the work done in the chambers thereof, the charge of grinding bodies being maintained at the most efficient centerline point of loading as heretofore explained whereby is effected a maximum rate of grinding material to a predetermined degree of fineness with a minimum expenditure of energy.

A clear conception of the various steps of the present process and of one form of apparatus for carrying on the same may be had from the drawing accompanying and forming a part of this specification in which like reference characters designate the same or similar parts in the various views.

Figure 1 is a diagrammatic central vertical section through a combination mill embodying a form of the invention in which a partition is adjustable to vary the volumetric capacities of the several chambers.

Fig. 2 is an enlarged fragmentary central vertical section through a combination mill having an adjustable partition.

Fig. 3 is an enlarged fragmentary transverse vertical section through the mill, the section being taken along the line III—III of Figs. 2, 5 and 6 looking in the direction of the arrows.

Fig. 4 is an enlarged fragmentary transverse vertical section through the mill, the section being taken along the line IV—IV of Fig. 2, looking in the direction of the arrows.

Fig. 5 is an enlarged fragment of a development of a section through the mill, the section being taken along the line V—V of Figs. 2 and 3, looking in the direction of the arrows.

Fig. 6 is an enlarged fragment of a development of a section through the mill, the section being taken along the lines VI—VI of Figs. 2 and 3, looking in the direction of the arrows.

The combination mill illustrated as one form embodying this invention, comprises a rotary shell 1 having feed and discharge end heads 2, 3, respectively, and provided with an adjustable partition 4 dividing the shell 1 into chambers 5, 6. The mill is rotatably mounted in bearings 7, 8, and is adapted to be rotated by power applied to the driving gear 9.

The coarse grinding chamber 5 is filled substantially to the centerline of the shell 1 with relatively large comminuting balls 10, while the fine grinding or finishing chamber 6 is likewise half-filled with relatively small comminuting bodies or balls 11. The bodies or balls 10, 11, are preferably formed of iron or other material having high specific weight. The coarse grinding chamber 5 receives its supply of relatively coarse material through the feed trunnion 70 and delivers the material in partially reduced condition, through the partition 4 to the finishing chamber 6 from which the finished product is delivered through the discharge trunnion 80 by means of a series of elevating plates 12.

The adjustable partition 4 comprises a holdback screen 13, and a centrally perforated end wall 15, these elements being spaced apart to form a chamber 16. The portion of the shell 1 within the limits of adjustment of the partition 4 is provided with a circumferential series of elongated openings 18 which communicate with an annular chamber divided by means of the circular sizing screen 19 into two annular chambers 20, 21. The portions of the openings 18 which are beyond the limits of the partition 4 are normally covered by liners 22, 23, of different widths measured longitudinally of the mill. The liners 22 in the chamber 5 may be of the same thickness as the liners 23 in the chamber 6, or they

may be of different thicknesses as disclosed, the liners 22, 23 as well as the balls 10, 11 being insertible and removable through manholes in the shell 1, such holes having been omitted from the drawing on account of the customary provision thereof in mills of this type. The chamber 16 adjacent the holdback screen 13 communicates directly with the annular chamber 20 through the openings 18 so that material delivered through the screen 13 passes directly through the openings 18 to the interior of the circular sizing screen 19. Reject collecting plates 24 located within the chamber 20 are adapted to collect material which cannot pass through the sizing screen 19 and to deliver this oversize into return conduits 25 leading from the chamber 20 into the coarse grinding chamber 5 of the mill. The chamber 21 located exteriorly of the sizing screen 19 is provided with collecting plates 26 which collect the fines passing through the sizing screen 19 and deliver these fines into the conduits 27 leading from the chamber 2 into the fine grinding chamber 6 of the mill. The conduits 25, 27, are located within the chamber 16 adjacent the wall 15, and do not interfere with the passage of material through the holdback screen 13. The material passing through the conduits 27 is fed to the chamber 6 through the opening 30 in the wall 15 and the finished product delivered from this chamber 6 is delivered to the elevating plates 12 through the discharge screen 29.

In carrying out the process of this invention, the partition 4 is first located somewhere within the limits of the openings 18 and the chambers 5, 6, are filled substantially up to the mill axis with comminuting balls 10, 11. The mill is then rotated and the feed of material through the trunnion 70 is gradually increased until the requisite fineness of discharge product does not exceed that necessary for standard cement.

The next step is to balance the mill, that is, place the several chambers in condition to grind the material passing therethrough with maximum efficiency. In the present invention this is done by adjusting the partition 4, without any sacrifice from the condition of maximum capacity.

The condition of the material at the end of the coarse grinding chamber is then determined by removing a sample through a manhole or from a chamber 20, 21 and by subsequent screen analysis. If the material here is found from prior practice to be too fine for maximum efficiency of this chamber, the quantity of large balls 10 is reduced and the partition 4 moved toward the feed end of the mill, the level of the balls 10 being maintained constant. Due to this shifting of the partition 4 toward the feed end of the mill, the quantity of small balls 11 in the finishing chamber 6 must be increased in order to compensate for the increase in the length of this chamber 6 and yet maintain constant the level of the balls 11. The mill is then given a test run and the condition of the final discharge is again noted. On account of the increase in the quantity of small grinding bodies 11, the material discharged from the chamber 6 will be finer than necessary, and the feed to the mill is gradually increased to a point where the material discharged from chamber 6 will be only enough coarser so as to be of the required fineness. The condition of the material at the discharge end of the coarse grinding chamber 5 is then again noted. If it is then found from prior practice to be too coarse for maximum efficiency of this chamber, the chamber is lengthened by moving the partition 4 toward the discharge end of the mill and correspondingly increasing the quantity of large balls 10. The resulting increase in large grinding bodies will now deliver the material to the finishing chamber 6 finer than before so that the final product will be too fine and the feed may be increased. Adjustment of the partition 4 is continued until a point is reached where a maximum discharge of material at the proper fineness results. It will be noted that during these adjustments, the charge of grinding balls is maintained substantially at the centerline of the mill by insertion or removal of balls 10, 11 through the manholes, and the power required to operate the mill will be substantially constant. Upon reaching the maximum capacity, the horse power hours per barrel, which is the accepted standard of determining the efficiency of a mill, will be the lowest, that is, the maximum efficiency will have been attained.

While the drawings disclose the use of a partition 4 of special construction, it will be noted that such special construction is not necessary in carrying out the present invention, and that an ordinary partition consisting of a perforated diaphragm may be employed.

The adjustment of the partition 4 in the present case is accomplished by interchanging some of the liners 22, 23, access to the interior of the mill for the purpose of interchanging these liners being had through the manholes. The plates 24, 26, must also be changed in order to maintain proper alinement between the portions of the conduits 25, 27, which are within the chambers 20, 21, and those portions within the partition 4. For instance, if it is desired to adjust the partition 4 toward the feed end of the mill a slight amount only, it is necessary only to interchange the liners directly adjacent the partition. If a greater adjustment is desired, the necessary adjustment of lin-

ers to produce the desired degree of adjustment of the partition may readily be made. Ordinarily, the limits of necessary adjustment of the partition 4 will not extend beyond the limits of the openings 18 as disclosed, but it will be apparent that these openings may be made of any length within the limits of the shell 1, sufficient to accommodate the desired degree of adjustment.

In the structure disclosed, the material delivered from the coarse grinding chamber 5 passes through the holdback screen 13 and is precipitated upon the circular sizing screen 19. As the mill rotates in the direction indicated by the arrows in Figs. 3 and 4, the material rolls along the surface of the screen 19, the fines passing through this screen into the chamber 21 and the oversize being eventually precipitated upon the return plates 24 and returned to the coarse grinding compartment 5 through the conduits 25. The fines which pass through the screen 19 are eventually precipitated upon the plates 26 and are delivered into the feed end of the finishing chamber 6 through the openings 30 by means of the conduits 27. This construction of the partition permits efficient removal of the sufficiently reduced material from the coarse grinding chamber 5, thereby avoiding unnecessary fine grinding of the material by the coarse grinders.

It should be understood that it is not desired to limit the present invention to the exact steps of the process described or to the exact details of construction of the apparatus shown and described, for obvious modifications will occur to a person skilled in the art.

It is claimed and desired to secure by Letters Patent,—

1. The method of grinding material in a tube mill provided with primary and secondary grinding chambers, which method consists in grinding the material in said primary chamber and then in said secondary chamber at a normal grinding level, changing the relative volumetric capacities of said chambers and maintaining the normal grinding level therein, and subsequently continuing the grinding operation in said chambers as changed.

2. The method of grinding material in a tube mill provided with primary and secondary grinding chambers, which method consists in grinding the material in said primary chamber and then in said secondary chamber at a normal grinding level, testing the material ground in order to determine the efficiency of operation of the mill, changing the relative volumetric capacities of said chambers in order to improve the efficiency of operation as determined by said test and maintaining the normal grinding level in said chambers, and subsequently continuing the grinding operation in said chambers as changed.

3. The process of apportioning the work done in the several chambers of a combination comminuting mill to produce maximum grinding capacity and efficiency, which comprises producing chambers of arbitrary volumetric grinding capacities, loading one of said chambers to the center line of the mill with coarse grinding bodies, loading another of said chambers to the center line of the mill with fine grinding bodies, admitting material to the mill and operating the mill to comminute the admitted material, ascertaining the condition of the material in the mill, and relatively varying the volumetric grinding capacities of said chambers without altering the level of the charges of grinding bodies and continuing the grinding of the partially ground material in the changed chamber until the required fineness for the discharged material is obtained.

4. In a comminuting mill, a rotary shell, means forming a chamber surrounding and extending longitudinally of said shell, said shell being perforated adjacent said chamber and said perforations extending along the entire length of said chamber measured longitudinally of the mill, a partition adjustable axially of said shell at said perforations, said partition being of less width than the length of said chamber whereby perforated portions of said shell are located beyond said partition, and means for closing the perforations located beyond said partition.

5. In a comminuting mill, a rotary shell, means forming a chamber surrounding said shell, a screen within said chamber, said shell having a plurality of openings extending longitudinally of said shell and located adjacent said chamber, a partition adjustable axially of said shell at said openings, said partition being of less width than the length of said openings, means for closing the portions of said openings projecting beyond said partition, means within said partition for returning rejects from said screen to one of said chambers, and means within said partition for delivering material passing said screen to another of said chambers.

6. In a comminuting mill, a shell, a screening partition adjustable longitudinally of said shell, and means for effecting access to said partition through said shell at the periphery of said partition.

7. In a comminuting mill, a shell, a screening partition adjustable longitudinally of said shell, means forming a chamber surrounding and extending longitudinally of said shell adjacent to the periphery of said partition, and means for effecting access to said partition through said chamber.

8. The method of grinding in a tube mill having primary and secondary chambers,

which method consists in a preliminary grinding until the fineness of the discharged material does not exceed that required, changing the relative volumetric capacities of the chambers while maintaining the constant level of the coacting grinding elements therein, and subsequently continuing the grinding in said changed chambers and increasing the feed until the required fineness of ground material is obtained.

In testimony whereof, the signature of the inventor is affixed hereto.

PAUL C. VAN ZANDT.