Aug. 9, 1932. M. D. BROADFIELD 1,870,278

ACIDULATING UNIT

Filed Jan. 4, 1930 2 Sheets-Sheet 1

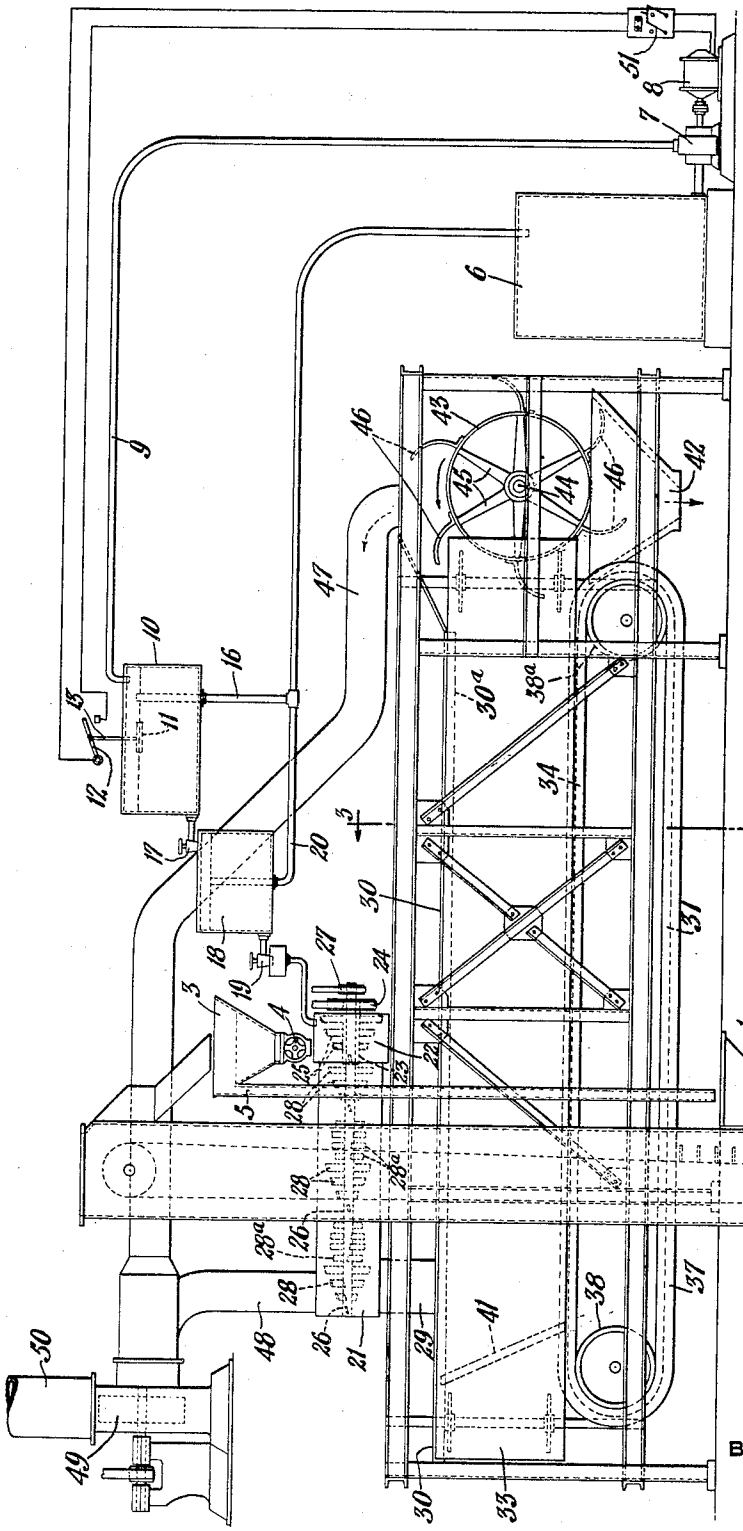


Fig. 1.

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Fig. 2.

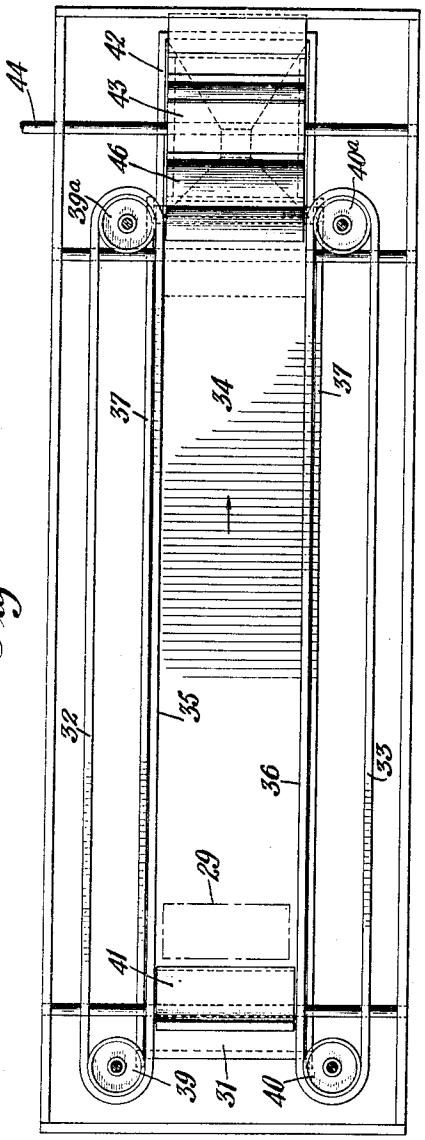


Fig. 3.

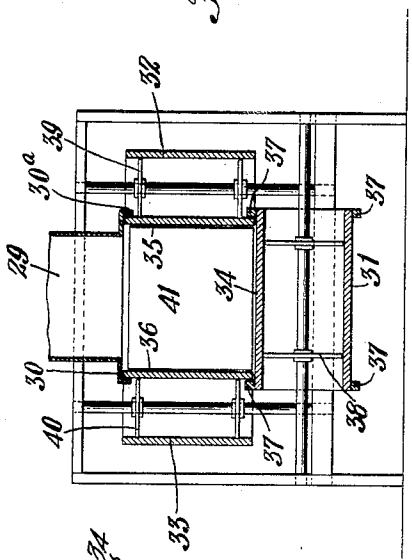


Fig. 4

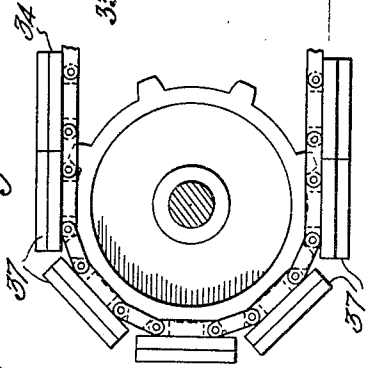
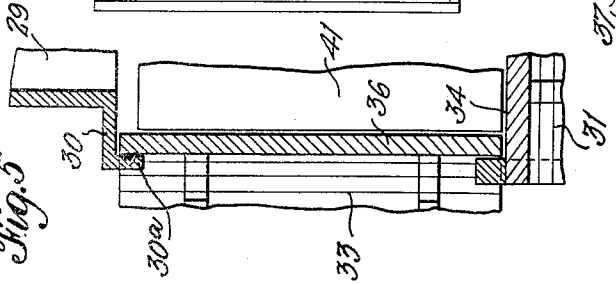


Fig. 5



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UNITED STATES PATENT OFFICE

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ACIDULATING UNIT

Application filed January 4, 1930. Serial No. 418,455.

This invention relates to the acidulation of phosphate rock with sulphuric acid to produce superphosphates and more particularly to an apparatus and method for mixing the reacting materials and for curing the mixture.

In the production of superphosphates a measured quantity of ground phosphate rock is mixed with a measured quantity of sulphuric acid and the resulting acidulated phosphate rock powder is allowed to stand for a period of time sufficient to cure the "green" superphosphate.

In mixing the powdered rock and acid, it has been the custom to measure the acid and the powdered rock manually and to pour the acid into the powdered rock in a mixing pan. This type of mixing results in uneven reacting throughout the mass and the gush of sulphuric acid charged into the mixing pan causes the formation of a considerable quantity of the rock dust into nodules or pellets. The acid will not penetrate into these pellets and as a result a considerable quantity of insoluble material will remain with the superphosphate resulting from the reaction.

By mixing the materials in this manner the first powder or dust will come into contact with strong acid and will become overacidulated. This will result in a weakening of the remaining acid and the rest of the dust will be underacidulated. Furthermore, this type of mixing is unsatisfactory because of the difficulty in accurately measuring the quantities of acid and of rock dust to be mixed. Such inaccuracy also results in an under- or an over-acidulation on the material, with a resultant inferior product.

In following the prior practice, it is also necessary that the materials be kept in a fairly liquid mass. To accomplish this, diluted sulphuric acid must be used and because of this the speed of the acidulation step is greatly reduced. Also, in using such diluted acid, the coarser rock dust will not be acidulated and the percentage of insoluble material will be greatly increased.

The customary practice is to place successive charges of this green, acidulated rock powder in the den and, after the den has been filled by these successive charges, to allow it to stand for a certain period for the purpose of curing it. It is apparent that in following this procedure the last portion of the material to be charged into the den will be insufficiently cured in the period of time required to cure the first portion.

It is an object of my invention to avoid these difficulties and to provide an apparatus and method by which an improved product of uniform quality may be produced. It is a further object of my invention to provide means for thoroughly and quickly mixing accurately measured quantities of phosphate rock and acid, and for subjecting such mixture to accurately controlled curing. Another object of my invention is to provide means for continuously moving the mixture through the curing den and toward a cutter adapted to disintegrate the mass at the completion of the curing step. Other objects will become apparent.

In describing my invention, reference will be made to the drawings in which Fig. 1 represents a diagrammatical representation in elevation of my improved apparatus. Fig. 2 is a plan view of the curing den and the cutter. Fig. 3 is a section taken on line 3—3 of Fig. 1. Figure 4 is a fractional detail view of one end portion of the bottom slat belt and Figure 5 is a fractional detail view of one side of the den.

Referring to the drawings, the numeral 1 represents a storage hopper in which a quantity of powdered phosphate rock is stored. This powdered rock is conveyed by means of an elevator 2 and is dumped into the supply hopper 3. The material is withdrawn from the hopper 3 by a measuring feeder 4, having pockets shaped to continuously remove a measured quantity of the powdered rock as the feeder is rotated at a constant speed. These pockets may be positioned spirally around the core of the feeder to provide for the continuous feed of the powdered rock to the mixer. For instance, if four pockets are used, as shown in the drawings, each of the pockets may extend spirally around a quarter of the peripheral surface of the core. The rate of feed may be controlled by regulating

the speed of rotation of the feeder or by maintaining this speed constant and inserting fillers in the pockets of the feeder to regulate their sizes. The material is conveyed to the hopper 3 by the elevator 2 at a rate slightly higher than that of the withdrawal of the powdered rock by the feeder 4 and the excess is returned to the storage hopper 1 through the dust chute 5.

The acid to be supplied to the system is stored in the tank 6 and is pumped through the pump 7, operated by the electric motor 8, and through the line 9 to the acid supply tank 10. This supply tank is provided with an ordinary float-operated level control illustrated by the float 11 adapted to operate the contact bar 12, through the rod 13, to open and close the electric circuit connected with the motor 8, as the level of the acid in the tank reaches its maximum and minimum levels, respectively. An overflow pipe 16 permits any excess acid to return to the tank 6. The acid flows from the supply tank 10 through the valve 17 into the acid measuring tank 18. Acid is withdrawn from the tank 18 at a constant rate through the measuring valve 19, the head of liquid in the tank being maintained constant by feeding the incoming acid through the valve 17 at a rate slightly higher than the rate of withdrawal of the acid through the valve 19. The excess acid is returned to the storage tank 6 through the overflow pipe 20. A removable orifice, of suitable diameter, may be inserted in the outlet of the valve 19 to regulate the quantity of acid fed to the mixer under the constant head of the liquid in the tank 18. This method of measuring the acid is described in greater detail in my application Serial No. 290,452, filed July 5, 1928.

The mixer 21 includes a cylindrical casing and may have a section 22 of enlarged diameter at its inlet end. Within the enlarged portion of this casing, there is positioned a hollow shaft 23 which is rotated by a pulley 24 fixed thereto.

The paddles 25 are fixed to the periphery of the shaft 23 at an angle to the axis of the shaft and are arranged in spiral paths extending in counterclockwise direction around the periphery of the shaft. A second shaft 26, passing through the hollow shaft 23, is rotated by the pulley 27 fixed to its end. Groups of paddles 28 and 28*a* are fixed to the shaft 26. The groups of paddles designated as 28 are positioned similarly to the paddles 25 and so that a clockwise rotation of the shaft 26 will advance the mixture toward the outlet end of the mixer. The groups of paddles indicated as 28*a* are arranged in spiral lines extending in a clockwise direction around the periphery of the shaft 26. The latter groups of paddles serve to retard the mixture in its progress through the mixer, in order that a sufficient and thorough mixing may be had before the material is discharged. An automatic scraper may be operated periodically within the casing of the mixer to clean off the superphosphate adhering thereto.

No claim is made in this application to the above apparatus or the operation carried on therein, since these features are being claimed in my copending application Serial No. 511,473, filed January 27, 1931.

An outlet 29 is provided at the end of the mixer 21, by which the mixed material may be conveyed to the curing den. The curing den is positioned below the mixer 21 and comprises three endless slat belts 31, 32 and 33. The upper surface 34 of the belt 31 is adapted to move in a horizontal plane from left to right as viewed in Figs. 1 and 2. The belts 32 and 33 are positioned above the edges of the belt 31 with their inner surfaces 35 and 36, respectively, adapted to move in vertical planes from left to right as viewed in Fig. 2.

The belt 31 is wide enough to extend beyond the inner surfaces of the belts 32 and 33 and has at its edges upwardly projecting blocks 37, which serve as guides for the lower edges of the surfaces 35 and 36. The belts 31, 32 and 33 extend around and are driven by the pulleys 38 and 38*a*, 39 and 39*a*, 40 and 40*a*, respectively.

A fixed baffle plate or bulk head 41 is positioned at the receiving end of the den to prevent the material supplied to the den through the outlet 29 from being spilled over the end of the moving belt 31.

A cutter is positioned over the hopper 42 at the delivery end of the den. This cutter comprises a drum 43, supported upon a horizontal axle 44 through spiders 45, which are fixed to the axle. The curved blades 46 are fixed to the periphery of the drum 43 in such positions that a counterclockwise rotation of the drum will pass them through the end portion of the curing den in cutting position.

The upper edges of the inner surfaces 35 and 36 of the belts 32 and 33 are connected by a cover 30, adapted to prevent the escape of fumes evolved during the curing. The outer edges of the cover 30 project downwardly, as indicated at 30*a*, to provide guides for the upper edges of the vertical belts. A tapered guide bar may extend across the inner side of the upper end of each of the slats of the belts 32 and 33, and these bars may fit into correspondingly tapered grooves upon the inner sides of the projections 30*a*. These bars and grooves prevent the escape of gas between the moving belts and the stationary top and they may be lubricated to provide frictionless guides for the upper portions of the surfaces 35 and 36. The cutter and the adjacent end portion of the den are enclosed to confine the fumes liberated at this point.

Gas removal flues 47 and 48, leading from

the portion of the enclosure about the cutter and from the casing for the mixer 21, respectively, are connected to the inlet side of the suction fan 49. By this means the fumes liberated in the mixing, curing and cutting operations may be withdrawn and expelled through the flue 50.

In carrying out the process in my apparatus, the electric switch 51 is closed and sulphuric acid of the desired strength is pumped to the supply tank 10. The elevator 2 and the feeder 4 are then operated to supply the desired amount of powdered phosphate rock to the mixer 21. A suitable orifice is inserted in the outlet of the valve 19 and the valves 17 and 19 are opened in order to continuously supply the exact quantity of acid necessary to react with the measured amount of powdered rock being continuously supplied by the feeder 4. The shafts 23 and 26 are rotated in clockwise directions. I prefer to operate the shaft 23 at a higher speed than the shaft 26 and the enlargement of the section 22 of the container for the mixer is such that the mixture is retained in that sect on until a thorough mixing is accomplished. The paddles 25 serve to mix the materials and to convey them into the second section of the container. The paddles 28 mix and advance the mass while the paddles 28*a*, being positioned at a reverse angle, mix and retard the movement of the materials. The speeds of rotation of the shafts 23 and 26 and the detailed arrangement of the paddles 25, 28 and 28*a* may be such that the mixing of the powdered rock and acid is completed by the time the mass reaches the outlet 29.

The slat belts 31, 32 and 33 are driven so that each of the surfaces 34, 35 and 36 move at the same constant speed toward the cutter and at such a rate of speed that the curing of each portion of the green acidulated rock, delivered through the outlet 29, will have been completed by the time that portion reaches the cutter. The cutter is rotated in a counterclockwise direction, as viewed in Fig. 1, and at such a speed relative to the curing den so that the desired degree of disintegration may be obtained and the disintegrated mass will be conveyed to the hopper 42, from which they may be disposed of as desired. The drum 43 and the blades 46 should be so positioned that during the cutting of the material in the den, which den may be filled substantially to the top of the belts 32 and 33, such material will be supported by the belt 31 so as to prevent the caving-in or sloughing-off of the cured material.

The measuring devices described will assure a constant and continuous supply to the mixer of the exact quantities of the reacting materials required by the formula. The enlargement of one or more sections of the casing for the mixer will cause the materials to be retained in such sections for a greater period of time, and this construction, together with the conveying, mixing and baffling paddles will provide for the complete mixing of the reacting materials and the constant supply of the mixed materials to the curing den. This complete mixing of the ingredients assures the reaction of all of the acid with the powdered rock in the proper proportions, with the result that a larger quantity of available superphosphates will be produced with less moisture and free acid. By using the more concentrated acid, a higher temperature will result from the heat of reaction and a greater quantity of moisture will be eliminated as vapor.

The traveling curing den permits the continuous operation of the system and results in a uniformly cured product. It is apparent that my apparatus may also be operated continuously while the material in the traveling den is being advanced by successive intermittent movements of the belts.

The several elements of the complete acidulating unit which have been described are illustrative of suitable means for accomplishing the desired results, but these may be varied to meet the particular conditions under which the operation is to be performed. Although I have described only one embodiment of my invention, it is apparent that many modifications thereof may be made and it is not intended to hereby limit it to the particular procedure or apparatus described.

What I claim is:

1. A den for conveying plastic materials comprising a bottom endless belt and two side endless belts positioned so that the lower edges of the opposed surfaces of the side belts are above the opposite edge portions of the surface of the bottom belt, and means carried by said bottom belt for preventing outward movement of the lower edges of the opposed surfaces of the side belts, said belts being actuated to provide surfaces moving substantially together in the same direction.

2. A den for conveying plastic materials comprising a bottom endless belt and two side endless belts each positioned so that the lower edges of the opposed surfaces of the side belts are above the opposite edge portions of the bottom belt, said belts being actuated to provide surfaces moving substantially together in the same direction, means for guiding the lower edges of the opposed surfaces of said side belt to prevent outward movement thereof relative to the bottom belt, and a cover for said den, said cover providing guides for preventing outward movement of the upper edges of the opposed surfaces of the side belts.

3. A den for conveying plastic materials comprising a bottom endless belt and two side endless belts actuated to provide surfaces moving substantially together in the same direction and positioned so that the surface of

one of said side belts is above each edge portion of the bottom belt, and guide means for preventing outward movement of said surfaces of the side belts relative to the bottom belt, a cover adapted to fit over the upper edges of the inner surfaces of the side belts and having depending edges adapted to extend downwardly beyond said inner surface, and means for sealing the aperture between the upper portions of the inner surfaces of the side belts and the depending edges of the cover.

4. A den for conveying plastic materials comprising a bottom slat belt and two side slat belts, each belt being made up of slats adapted to contact with adjacent slats in the same belt, said side belts being positioned so that a lower edge of each belt is above and within an edge of the surface of the bottom belt, guide blocks carried by each of the slats of the bottom belt and positioned to prevent outward movement of the bottom portions of the side belts relative to the bottom belt, said belts being actuated to move substantially together in the same direction.

5. A den for conveying plastic materials comprising a bottom slat belt and two side slat belts each made up of slats in contact with adjacent slats in the same belt, said side belts being positioned so that a lower edge of each side belt is above and within an edge of the upper surface of the bottom belt, guide blocks on each of said slats to prevent outward movement of the side belts relative to the bottom belt, a cover adapted to fit over the upper edges of said side belts and having depending portions extending downwardly outside of the inner surfaces of the side belts, a tapered guide bar fixed to each of said slats and adapted to move in notches cut in the depending portions of said cover.

6. A den for conveying plastic materials comprising a laterally rigid bottom belt and two laterally rigid side belts actuated to move in the same direction as the bottom belt and positioned in respect to the bottom belt so as to form a movable den having a closed bottom, and means for sealing the spaces between the adjacent portions of the side and bottom belts.

7. A den for conveying plastic materials comprising a bottom belt and two side belts actuated to move in the same direction as the bottom belt and positioned with respect to the bottom belt so as to form a movable den having a closed bottom, means for sealing the spaces between the adjacent portions of the side and bottom belts, a cover, and means for sealing the spaces between the adjacent portions of the side belts and the cover.

8. A den for conveying plastic materials comprising an endless bottom belt made up of slats and two endless side belts made up of slats, each positioned so that the lower edges of the opposed surfaces of the side belts are above the opposite edge portions of the upper surface of the bottom belt, and means for sealing the spaces between the slats of the side and bottom belts to form a den having a closed bottom.

9. A den for conveying materials comprising a laterally rigid bottom belt and two laterally rigid side belts actuated to move in the same direction as the bottom belt and positioned in respect to the bottom belt so as to form a moving den having a closed bottom, and means carried by said bottom belt for sealing the spaces between the adjacent portions of the side and bottom belts.

10. A den for conveying materials comprising a bottom slat belt and two side slat belts actuated to move in the same direction as the bottom belt and positioned in respect to the bottom belt so as to form a movable den having a closed bottom, and blocks carried by slats of said belts for sealing the spaces between the adjacent slats of the side and bottom belts.

11. A den for conveying materials comprising a bottom slat belt and two side slat belts actuated to move in the same direction as the bottom belt and positioned in respect to the bottom belt so as to form a movable den having a closed bottom, means for sealing the spaces between the adjacent portions of the side and bottom belts and a baffle at the inlet end of said den to prevent discharge of the material at that end.

12. In an apparatus of the class described, a bottom slat belt and two side slat belts actuated to move in the same direction and positioned in respect to the bottom belt so as to form a movable den having a closed bottom, means for sealing the spaces between the adjacent portions of the side and bottom belts, and a cutter at the discharge end of said belts, said cutter being positioned and shaped so that the cutting edge passes completely through the material while the latter is supported upon the bottom belt.

In testimony whereof, I have signed my name to this specification this 2nd day of January, 1930.

MACK D. BROADFIELD.