March 23, 1937. A. J. SACKETT 2,074,673

MIXING MACHINE

Filed Aug. 10, 1933. 3 Sheets-Sheet 1

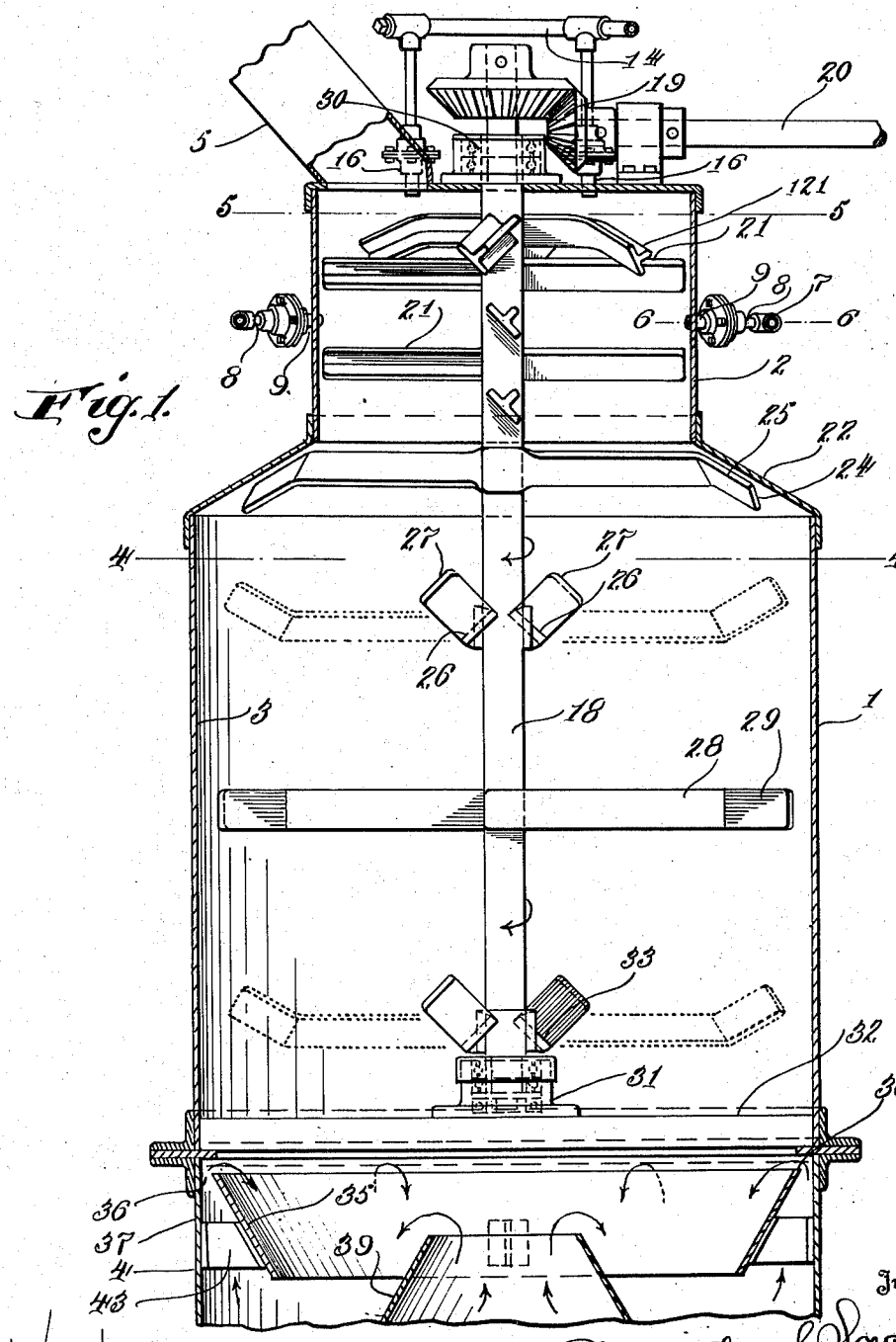


Fig. 1.

Witnesses:

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March 23, 1937. A. J. SACKETT 2,074,673

MIXING MACHINE

Filed Aug. 10, 1933 3 Sheets-Sheet 2

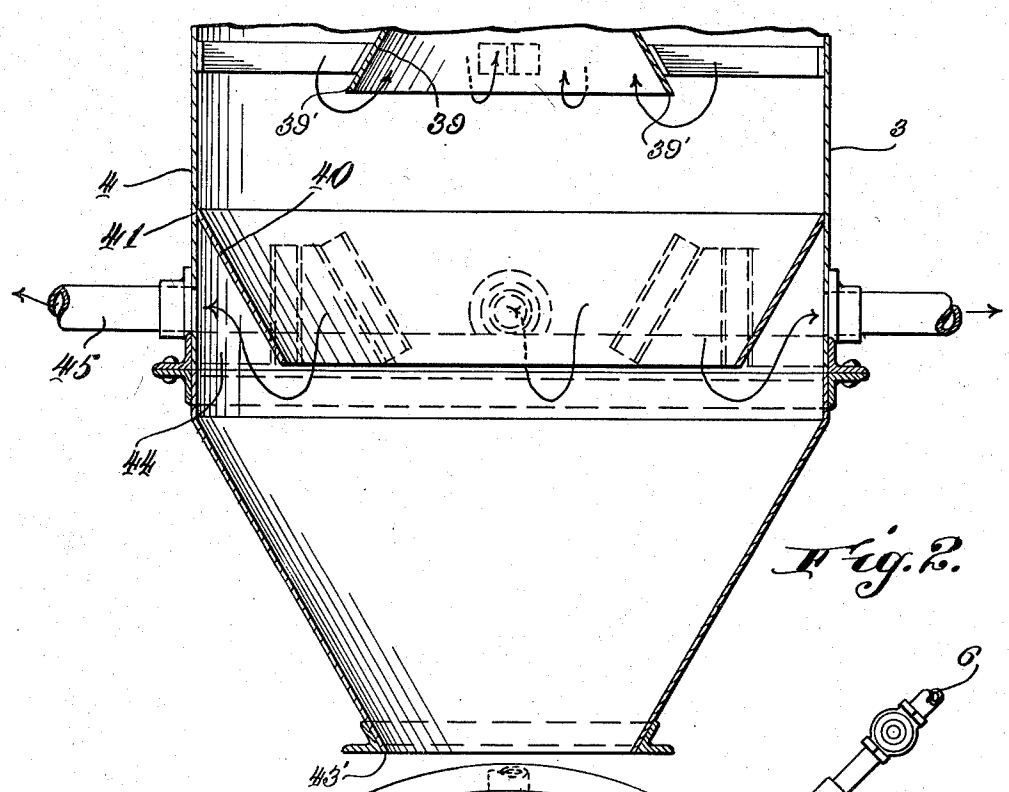


Fig. 2.

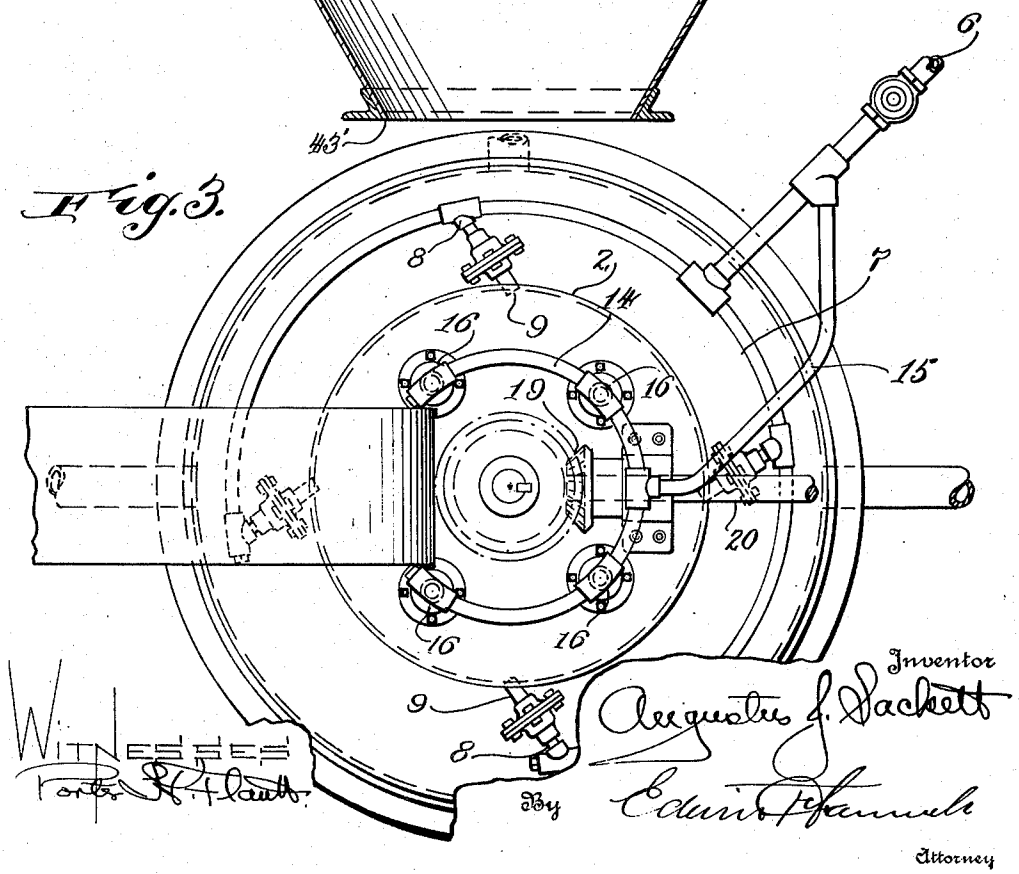


Fig. 3.

Witnesses

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MIXING MACHINE

Filed Aug. 10, 1933 3 Sheets-Sheet 3

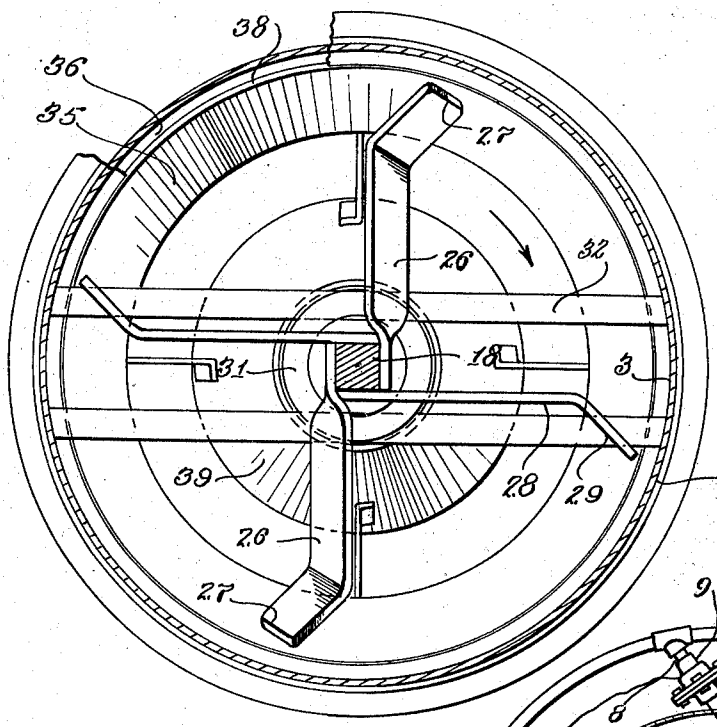


Fig. 4.

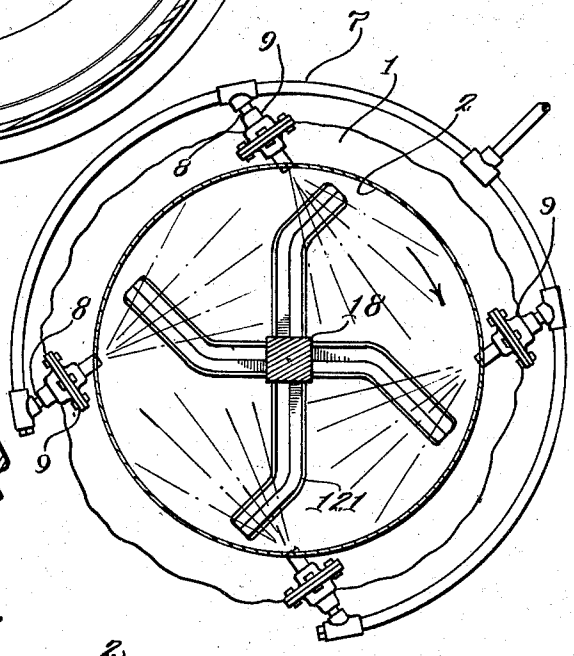
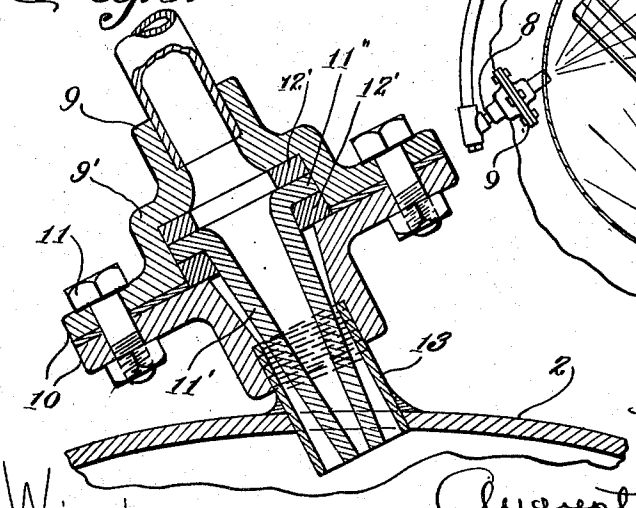


Fig. 5.

Fig. 6.



Witnesses

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Patented Mar. 23, 1937 2,074,673

UNITED STATES PATENT OFFICE

2,074,673

MIXING MACHINE

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Application August 10, 1933, Serial No. 684,475

13 Claims. (Cl. 259—8)

The invention relates to a machine for mixing dry and solid comminuted materials with fluids, the machine of the invention having been used particularly in the manufacture of fertilizers for mixing ammonia which may be presented in various forms as anhydrous ammonia, uria liquid and the like, with super-phosphate in comminuted or powdered form. When the ingredients are thus chosen and fed to the machine and mixed as hereinafter described, the ammonia enters into chemical combination with the phosphate producing ammoniated superphosphate.

The object of the invention is to provide an improved continuously operating mixing machine of this nature whereby a uniform mixture of the dry materials and acid is obtained, giving a resulting combined product of uniform standard properties containing the resulting chemical combination of ammonia and acidulated phosphate rock in the desired predetermined uniform proportions and without perceptible loss of the gaseous ingredient.

Prior to the development of the present machine and similar machines by this inventor, this dry mixing of these ingredients in such a machine has not been accomplished in a commercial way.

An important feature of the mixing process accomplished by this machine consists in maintaining the particles of dry material in suspension in the space enclosed within the apparatus in which they are circulated by means of rapidly moving beaters or flights so that they remain suspended for a considerable period relative to the time required to propel them directly through the machine and distributing these particles in an atmosphere impregnated with the gaseous liquid which is likewise agitated.

In the operation of the present machine the flights or vanes are moved continuously in rotation and both the gaseous liquid and the comminuted solid are moved downwardly through the machine, the solid being influenced in its motion by gravity as the mixing process progresses, but the motion of the solid and fluid in their passage through the machine is retarded and converted to a lateral or rotary motion and at times to an upward motion and, or a motion in an inclined direction to such a degree that the progress of the solid particles through the apparatus in the preferred form as illustrated occupies a period which may be a half minute or more, the distance travelled in the general direction in which the solid particles which in the machine shown is downwardly, being about fourteen or fifteen feet. The dimensions of the machine are, however, not regarded as an essential element and while the machine is shown in upright position, its angle may be changed, changing the general direction of the path of the materials.

In the accompanying drawings I have illustrated an apparatus embodying the features of the invention in the preferred form in which it has been developed.

In the drawings:

Figure 1 is a fragmentary vertical section through the apparatus, the lower portion of the apparatus being removed for convenience of illustration.

Figure 2 is a corresponding view of the lower portion of the apparatus substantially continuous with Figure 1.

Figure 3 is a top plan view of the apparatus.

Figure 4 is a horizontal section on line 4, 4 in Figure 1.

Figure 5 is a horizontal section on line 5, 5 in Figure 1.

Figure 6 is a sectional view on line 6, 6 in Figure 1.

Referring to the drawings by numerals, each of which is used to indicate the same or similar parts in the different figures, the apparatus as shown comprises a suitable casing or enclosure 1 which is preferably of circular cross section so that it is in a general way substantially cylindrical to conform to the circular path of the flights or agitators which are consequently driven in rotation. Some of these flights serve the purpose of conveyors, as well as beaters. The casing 1 may be considered as comprising an upper section or drum 2, a middle section 3 known as a combustion or combining chamber 3 in which a considerable degree of heat is generated due to the combination of the ingredients, the temperature being preferably maintained around 150 degrees F. in the mixture of the ingredients referred to; and the construction also includes a lower dry mixing or recovery chamber 4 in which the particles of dry materials, part or all of which have been combined with the gaseous or fluid materials are further combined and mixed, and the portions of fluid which have not been combined with the solid which is a very small proportion as one or two percent of the reagent introduced, are recovered and returned into contact with the dry materials further back in the mixing path to be combined therewith.

Referring more particularly to the construction shown, the apparatus is provided at the top with an intake pipe or supply passage 5 which is

inclined downwardly and enters the top drum 2 at the top of the same. Any type of feed which conforms to the conditions presented may be used. The apparatus also includes means for introducing the liquid reagent comprising a supply pipe 6 adapted to be connected to a supply of liquid reagent under pressure. This supply pipe 6 is shown as connected to a pipe ring 7 surrounding the top drum 2 from which the nipples 8 are shown leading inwardly, the nozzles 9 being connected thereto and arranged to direct the fluid into the upper section 2 in any suitable manner and at any preferred angle. In the form shown the nozzles are arranged on lines tangential to a circle at the center which may be about 9 inches in diameter. The material is preferably projected into the apparatus in the form of the invention shown in the direction of rotation of the conveyor flights. These nozzles in Figure 6 are preferably constructed with an outer casing 9' made in two parts, having a flanged connection 10, the flanges being drawn together by bolts 11. Within the casing is a flanged tip 11' having the flange at its rear end held between each by packing 12' in the casing and compressed by bolts 11. The tips are threaded, each of them, into one of four short tubes 13 seated in the wall of the casing section 2 and correspondingly threaded, so that the nozzles can be changed and the proportion of the feed of liquid reagent to the dry material maintained, the nozzles or the nipples being for this purpose changed to conform to the pressure at which the gaseous reagent is supplied, and to the rate of feed of the solid. It is of interest that both the feed of the solid comminuted material and the fluid are continuous as is, likewise, the operation of the blades or flights so the mixing operation is continuous, resulting in a continuous supply of the combined material or product.

The construction also includes a nozzle ring 14 above the drum 2 and preferably concentric therewith, this ring is connected to the supply by a pipe 15 and has connected thereto four downwardly disposed nozzles 16 which are preferably similar to the nozzles 9 and likewise interchangeable. In the form of the invention illustrated, there are four of the nozzles 9 and four of the nozzles 16 arranged to project the gaseous reagent into the drum 2 at the top. These are not primarily for use simultaneously, either set being used separately to conform to conditions, the upper set being used when and if there is any tendency of the fluid to work up the dry feed pipe or supply 5; or the two sets may be used together or selectively as desired.

The apparatus as shown also comprises a central shaft 18 which may be driven by bevelled gears 19, one on the shaft 18 and the other on the driving shaft 20 to rotate at a convenient speed which in the preferred form is approximately 150 R. P. M. This shaft is provided within the upper drum 2 with a suitable number of blades or flights 21. In the form of the invention shown in Figure 1 there are five of these blades or flights 21, all of which are inclined upwardly and forwardly in the direction of rotation so that they tend to project the material both gaseous and solid, downwardly into the combustion chamber or combining chamber 3, serving also to maintain the material in circulation, to distribute it uniformly over the area or space within the drum. Figure 5 shows flights 121 which, in addition to being inclined as in Figure 1 to project the material downwardly, are turned forwardly at their ends to turn the material inwardly toward the center and to give additional circulating and mixing of the solid and fluid reagent.

The middle drum or combustion or combining chamber 3 is preferably of somewhat larger cross section than the upper drum 2 and as shown it is connected to the upper drum by a downwardly and outwardly inclined wall 22, forming a frusto conical portion within which is a mixing flight or beater 24 attached to the shaft and projecting outward radially therefrom as do the flights 21, in the upper drum Figure 1. The two blades of this beater are upwardly and forwardly inclined to give the material a downward acceleration and the outer ends of the beater arms or flights at 25 are further turned forwardly in the direction of rotation to turn the material at the sides inwardly and prevent the material, which is slightly moistened by the partly liquid gaseous reagent, from accumulating on the walls of the chamber.

Spaced downwardly below the flight or beater 24 at the top of the chamber 3 is a second flight or beater 26 also secured to the shaft and projecting outwardly therefrom in a direction which is generally radial, the blades being inclined downwardly and forwardly in the direction of rotation which it may be noted in the form of the machine shown is clockwise so as to have a tendency to throw the material up contrary to the direction in which it is propelled by the flights 21 and 24. This flight or beater 26 in the preferred form of the invention shown also has its outer ends at 27, turned forwardly in the direction of rotation to turn the material inwardly to prevent accumulation of the dry or partially mixed material on the walls due to centrifugal force or other agency. The ends thus inclined also tend to propel the material upwardly and inwardly at an angle of approximately 45° with the vertical. Spaced downwardly below the beater member or flight 26 I have shown a beater member 28 which may be referred to as a fan in that the blades or arms which project outwardly radially or substantially so on each side of the shaft are preferably in a vertical plane or in a plane parallel to or including the axis of the shaft so that they may have no tendency to move the material up or down, but give it a rotary impulse only, whereas the members 24 and 26 give it a downward and an upward impulse respectively, as well as a rotary impulse. This flight or beater 28 in the preferred form also has its outer ends at 29 deflected forwardly in the direction of rotation, said end portions having their forward faces substantially flat and lying in planes approximately parallel to the axis of rotation of the blades so as to turn the material inwardly and prevent accumulation on the walls.

The shaft 18 is shown as mounted in suitable bearings 30, 31 at the top and bottom, the latter being supported on a strut or cross bar 32 or other frame within the chamber 3 and just above this bearing in the bottom of the chamber 3 is still another flight or beater 33. This is preferably arranged with its forward edges turned downwardly so that it tends to raise the material against the force of gravity and the impulse imparted to it by the beaters or flights 21 and 24. The outer ends of vane or beater 32 are turned upwardly and forwardly to turn the material inwardly and prevent accumulation of the material on the side walls.

Below the combustion or combining chamber 3 and at the top of the recovery and dry mixing chamber 4 I have shown a frustoconical short funnel like deflector member 35. This is suitably suspended from the side walls of the chamber 4, being of downwardly reducing cross section and having its top at 36, which is of the larger diameter, spaced inwardly from the outer wall 37, providing a clearance space 38. At the center and projecting upwardly into the frustoconical deflector 35 is a second frustoconical deflector 39 of upwardly reducing taper, the bottom edge 39', which is the large diameter of the frustum being spaced well inwardly from the walls of the recovery and dry mixing chamber 4. Spaced downwardly from the bottom of the second deflector 39 is still another frustoconical deflector 40 of downwardly reducing taper. This is secured at its upper edges at 41 to the inner wall of the chamber 4, which it preferably contacts.

As the material is dropped from the rotating flights, it passes downwardly through the deflector 35, being turned somewhat inwardly by this deflector and outwardly by the deflector 39, a small portion of it passing through the center of the deflector 39. The motion of the material on the path described creates a down draft within the mixer with a consequent vacuum in the space 43 between the wall of the chamber 4 and the deflector 35 so that any of the gas which is contained in this mixture tends to be drawn upwardly into this space and the motion of the material, together with the lightness of the gas, causes it to pass through the opening 38 between the top wall of the deflector and the wall of the chamber, returning it to the combustion or combining chamber 3 in contact with the solid material with which it is thus finally combined, being there recovered and returned. This recovery and return of the reagent may be otherwise accomplished according to the purpose and intent of the invention.

The space 44 between the wall of the chamber 4 and the deflector 40 is connected to the outside by the vent pipes 45 for the discharge of air and steam at this time, the content of ammonia or other gaseous reagent has been in the operation thus described so thoroughly mixed and combined with the dry material that in the practical and satisfactory operation of the apparatus its presence cannot be detected at this point. If, by any chance, the presence of any chemical in the atmosphere is detected, it may be taken as indicating that an excess of this chemical is being provided or that for some reason the normal operation of this machine is not taking place.

Beneath the deflector 40 the casing 1 is of downwardly reducing taper at 42, terminating at its lower end in an opening 43' which is preferably square, beneath which may be placed a suitable bin or box or other container to receive the finished product.

In the operation of the machine comminuted dry material as phosphate rock or other material to be mixed with gaseous, or if desired, liquid reagent, is introduced through the pipe 5 or other conveyor into the drum 2 at the top, being fed continuously by any preferred type of dry feeding apparatus. The gaseous or liquid reagent is injected by way of the nozzles 9 and 16 or in any other suitable or preferred manner, giving a continuous feed in the desired proportion to the feed of dry material, the fluid reagent being presented to the nozzles under pressure or delivered to them in any suitable manner as by pumping. While the fluid reagent which has been used is liquid under pressures which would be employed and turns to a gas at atmospheric pressure or thereabouts when introduced into the apparatus, it will be understood that other fluids may be used.

In the drum 2 the flights or blades 21 which in the form of the invention shown rotate clockwise, have the effect of distributing both materials uniformly throughout the drum and projecting them downwardly into the combustion or combining chamber 3 in the preferred form to throw the material toward the center to prevent accumulation on the walls. It will be noted in this connection that the blades 21 are shown as of T shaped cross section, having backwardly projecting fins 21' which are mainly effective in re-inforcing and stiffening the blades, and in Figure 5 the blades are bent at the ends, which not only turns the material inwardly, but deflects it at an angle between the vertical and horizontal. The speed of rotation at which the apparatus has been operated is from approximately 125 to 150 R. P. M., but any convenient speed may be employed, and part of the blades may give the material an upward impulse.

The arrangement of the flights as already described in the combining or combustion chamber 3, is of particular interest in that it not only provides continuous intimate mixing and continuous uniform contact of the fluid reagent with the dry material, but circulates these constituents of the final product in such a manner that the solid particles are suspended in the atmosphere within the combustion or combining chamber 3 for a relatively prolonged period which in the form of the invention shown is approximately 25 or 30 times the period which would be required for passing them through the chamber, by projecting them downwardly by gravity or otherwise or in a direction deflected from the horizontal if this were considered advisable or found more convenient. In this way the reagent is maintained in uniform and constantly changing contact with the particles of the solid material for a period amply sufficient to attain uniform and substantially complete combination of the reagent with the dry material. In this connection, it should be understood that while the preferred portion of this apparatus is upright or as shown it may be tipped or inclined at any desired angle.

When the dry material on leaving the chamber 3 comes in contact with the deflectors 35, 39, 40, it is deflected by successive steps inwardly and then outwardly and then inwardly whereby the dry materials are further completely mixed to avoid stratification and segregation of portions of different strengths and to complete the distribution of the particles in such a way that the resulting mixture is absolutely uniform so far as can be determined by any conceivable test and these deflectors have the further important effect of creating a slight vacuum in the space 43 between the deflector 35 and the wall of the chamber 4 or otherwise, causing the fumes of the reagent, if any, that remain unmixed to rise into this annular space whence, due to their relatively low specific gravity and to the vacuum or over said opening or eddy currents resulting from the motion of the material, they pass upwardly through the opening 38 into further contact with the circulating particles of dry materials whereby such re-

agent is recovered and combined with the solid material.

Outside of the lower deflector 40 leading from the annular space 44 are the vent pipes 45 which carry off the steam or other vapors resulting from the mixing process, it being understood that a considerable temperature is attained in the chamber 4 due to the chemical combination of the reagent with the solid. This temperature in the practice of the invention has been ascertained as about 150° F. and this is found to be a favorable temperature for the combination of the reagents and solids which have been used. These or other materials may be combined at different temperatures. The mixed material discharged at the opening 43 at the bottom into the bin or container are found to be completely combined in the form of a substantially dry comminuted product of the desired properties and of the highest commercial quality. It is of importance that the feed of dry and fluid materials and the mixing operation, as well as the delivery of the mixed combined material or product, are continuous.

I have thus described a machine for mixing solid and gaseous reagents, the description being specific and in detail, in order that the manner of constructing, applying, operating and using the invention may be fully understood; however, the specific terms herein are used descriptively rather than in a limiting sense, the scope of the invention being defined in the claims.

What I claim as new and desire to secure by Letters Patent is:

1. The method of mixing gaseous and vaporous reagents and comminuted solid materials which consists in feeding the materials continuously to the locus of mixing which is completely enclosed but provided with a feed and discharge passage, the feed passage being at the top and the locus of mixing and the discharge passage at the bottom, so that the solid materials move downwardly due to gravity, maintaining the solid material in comminuted form in suspension in an atmosphere of the reagent and circulating the solid in contact with the reagent, and imparting an upward motion to the solid particles at certain points in said locus the general tendency of the particles being downward to the point of delivery, thus maintaining the comminuted particles in circulation in contact with the reagent for a period largely in excess of the period required to project the solid particles from the point of feeding to the point of delivery in the absence of such circulation and maintaining a continuous delivery of the mixed materials from the locus of mixing.

2. The method of combining continuously dry comminuted solid and gaseous and vaporous reagents which consists in presenting the solid material and the fluid reagent to and projecting them continuously along a predetermined enclosed path in an atmosphere containing the fluid reagent distributed throughout said path, circulating the solid and fluid in lateral relation to said path and to a limited extent in directions substantially opposed to the general direction of the passage of said material, thus maintaining the solid in suspension in contact with the reagent for a period largely in excess of that required to project it along said path and thereby obtaining a complete and uniform mixture of the reagent with the solid, thus utilizing and combining with the solid with substantial completeness the supply of reagent presented to the material.

3. The method of combining comminuted solid and gaseous and vaporous reagent which consists in presenting the solid material and the fluid reagents to and projecting them continuously along a predetermined enclosed path in an atmosphere containing the fluid reagent distributed through and along said path circulaing the solid and fluid in angular relation to said path and to a limited extent in directions substantially opposed to the general direction of the passage of said material, thus maintaining the solid in suspension in contact with the fluid reagent for a period largely in excess of that required to project it along said path and thereby obtaining a complete and uniform mixture of the reagent with the solid, thus utilizing and combining with the solid with substantial completeness the supply of reagent presented to the material.

4. A machine for mixing gaseous and vaporous reagents and comminuted solid materials, comprising an upright casing, means for introducing continuously the dry material at the top of said casing, means for injecting the reagent continuously adjacent the point of entrance of the dry material, a series of flights within the casing adjacent the point of entrance of said materials, means for operating the flights to project the materials downwardly through the casing and to distribute them uniformly, a combining chamber included in said casing below said flights, which serve to advance the materials into said combining chamber, said combining chamber having therein a second series of flights, means for operating said flights to distribute the solid particles and the fluid reagent uniformly in contact with each other part of said flights being shaped and operated to move said particles oppositely to the general direction of progress to retard the passage of the solid particles by projecting them for short distances upwardly, the solid and fluid moving downwardly through the combining chamber being retained therein and being circulated continuously in substantially uniform contact with each other to the end that complete combination as of the reagent and the solid particles is attained, and means for delivering the combined materials continuously from said combining chamber.

5. A machine for the continuous mixing of gaseous and vaporous reagents and comminuted solid materials, comprising a casing, means for introducing the solid material continuously, means for injecting the reagent in conformity with the introduction of solid material adjacent the point of entrance of the solid material, a series of blades within the casing adjacent the point of entrance of said materials, means for operating the blades to project the materials forwardly and continuously through the casing and to distribute and circulate them, a combining chamber included in said casing beyond said blades which serve to advance the continuous materials into said combining chamber, said combining chamber having therein a series of blades inclined at different and opposite angles to their direction of motion, means for operating said blades to distribute the solid particles and the fluid reagent uniformly in contact with each other and to retard the passage of the solid particles and reagent through the combining chamber, retaining them therein and circulating them in substantially uniform contact with each other to the end that complete combination of the reagent and the solid particles is attained, and means for delivering the

combined materials continuously from said combining chamber.

6. A machine for the continuous mixing of gaseous and vaporous reagents and dry comminuted solid materials, comprising an upright casing, means for introducing the solid material continuously, means for injecting the fluid material in conformity with the introduction of solid material adjacent the point of entrance of the solid material, a combining chamber included in said casing, the materials being passed downwardly through said combining chamber said chamber having therein a series of blades to project the solid materials for short distances in directions opposed to the general direction of the passage of said material inclined at opposite angles to the direction of motion, means for operating said blades to distribute the solid particles and the reagents uniformly in contact with each other and to retard the passage of the solid particles and fluid through the combining chamber, retaining them therein and circulating them in substantially uniform contact with each other to the end that complete combination of the reagent and the solid particles is attained, and means for delivering the combined materials continuously from said combining chamber, said delivery means including means for further mixing the solid materials and means for returning any unmixed reagent to the combining chamber.

7. In a machine for the continuous mixing of comminuted solid and gaseous and vaporous reagents a drum, means for leading the comminuted solid thereto, means for injecting reagent into the drum, means for feeding the materials through the drum and mixing them therein and a chamber connected to said drum to receive the materials and reagents therefrom, a plurality of sets of beater blades operating in said chamber blades, means for moving said blades, the blades of said respective sets being oppositely inclined to the direction of motion part of said sets serving to advance and the other part of said sets serving to retard the materials and to distribute them through the chamber and maintain them in suspension to the end that the mixing operation is completed while the solid materials are retained in suspension in the atmosphere within the chamber which is open oppositely to the drum, for delivering the solids when thus combined with the reagent from the beater chamber, and means for further mixing the solid thus combined with the reagent comprising oppositely inclined baffles, one of such baffles providing a space for the accumulation of any unmixed reagent a pipe leading therefrom whereby the reagent is recovered and returned to the mixing operation.

8. In an apparatus for the continuous mixing of comminuted solid materials and gaseous and vaporous reagent a casing and means for feeding the comminuted solid thereto and means for injecting the gaseous or vaporous reagent into said casing at the top, rotary beater blades therein inclined forwardly and downwardly in the direction of rotation and other rotary blades therein beneath the first mentioned beater blades and inclined upwardly and backwardly as to the direction of rotation whereby the solid and gaseous reagent is uniformly distributed and retarded in its advance through the casing, allowing a period during which the dry material is suspended in the casing by the operation of the blades, which period is sufficient for the complete mixing and combining of the materials, the casing being open at the bottom for the continuous discharge of the mixed material.

9. In an apparatus for mixing dry comminuted solid materials and gaseous and vaporous reagents a receiving drum, a mixing drum and means for feeding the comminuted solid to the receiving drum and means for injecting the fluid reagent into said receiving drum, rotary beater blades in the receiving drum inclined forwardly and downwardly in the direction of rotation and other rotary blades beneath the first said blades in the mixing drum and inclined upwardly and backwardly as to the direction of rotation whereby the material is uniformly distributed and retarded in its advance through the combining chamber, allowing a period during which the dry material is suspended in the mixing drum by the operation of the blades, which period is sufficient for the complete mixing and combining of the materials, and stationary deflectors for further mixing the dry materials, some of the blades having their ends turned forwardly in the direction of rotation said end portions having substantially flat forward surfaces approaching parallelism to the axis of rotation to turn the material toward the center and prevent accumulation of material on the walls.

10. The method of mixing gaseous and vaporous reagents and comminuted solid materials which consists in feeding the solid comminuted materials and reagent continuously to the locus of mixing which is completely enclosed but provided with a feed and discharge passage, the feed passage being at the top of the locus of mixing and the discharge passage at the bottom, so that the solid materials move downwardly due to gravity, maintaining the solid material in comminuted form in suspension in an atmosphere of the reagent and circulating the solid in contact with the reagent imparting an upward motion to the solid particles at certain points in said locus the general tendency of the particles being downward to the point of delivery, thus maintaining the comminuted particles in circulation in contact with the reagent for a period largely in excess of the period required to project the solid particles from the point of feeding to the point of delivery in the absence of such circulation and maintaining a continuous delivery of the mixed materials from the locus of mixing, maintaining a vacuum due to the flow of the solid material near the point of delivery and utilizing the vacuum to return the uncombined gaseous and vaporous reagent into contact with the solid particles.

11. In a machine for the continuous mixing of comminuted solid and gaseous and vaporous reagent a drum, continuously operating means for leading the comminuted solid thereto, means for injecting fluid reagent into the drum, continuously operating means for feeding the materials through the drum and mixing them therein a chamber connected to the drum to receive the materials and reagents therefrom and a plurality of sets of inclined beater blades in said chamber and means for operating said blades, part of them to advance the materials and to distribute them through the chamber and the remainder, to propel the materials backwardly a relatively short distance toward said drum and maintain them in suspension to the end that the mixing operation is completed while the solid materials are retained in suspension, the chamber being open opposite the drum for continuously delivering the solids when thus combined with the reagent from the beater chamber, and means comprising

baffles inclined to the direction of motion of the material utilizing the vacuum due to the velocity of the materials, for recovering the uncombined reagent and returning it to the path of the material, the entire apparatus being closed except the feed and discharge.

12. In a machine for the continuous mixing of comminuted solid and gaseous and vaporous reagents a drum, continuously operating means for leading the comminuted solid thereto, means for injecting fluid reagent into the drum, means for feeding the materials through the drum and mixing them therein a chamber connected to the drum to receive the materials and reagents therefrom and a plurality of sets of inclined beater blades in said chamber and means for operating said blades continuously, part of them to advance the materials and to distribute them through the chamber and the remainder, to propel the materials backwardly a relatively short distance toward said drum and maintain them in suspension to the end that the mixing operation is completed while the solid materials are retained in suspension, the chamber being open opposite the drum for continuously delivering the solids when thus combined with the reagent from the beater chamber, and vacuum means operated by the material as it advances for recovering the uncombined reagent and returning it into contact with the comminuted solid, and means for further mixing the solids, said means for returning the agent being combined with said further mixing means, the entire apparatus being closed except the feed and discharge.

13. In an apparatus for the continuous mixing of comminuted solid materials and gaseous and vaporous reagents a receiving drum and a mixing drum connected by a passage to the receiving drum to receive the material therefrom, means for feeding the comminuted solid to the receiving drum continuously, means for injecting the reagent into said drum, rotary beater blades in the receiving drum inclined forwardly and upwardly in the direction of rotation to feed the material through the receiving drum and beneath the same other rotary blades in the mixing drum inclined upwardly and backwardly as to the direction of rotation whereby the material is uniformly distributed and retarded in its advance through the mixing drum, allowing a period during which the comminuted material is suspended in the mixing drum by the operation of the blades, which period is sufficient for the complete mixing and combining of the materials, and deflectors for further mixing the comminuted materials, one of said deflectors being inclined downwardly and inwardly from the wall of the drum providing a chamber with a back draught for trapping the reagent and means in connection therewith for returning the unmixed reagent to the mixing drum, the entire apparatus except for the feed and discharge being closed.

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