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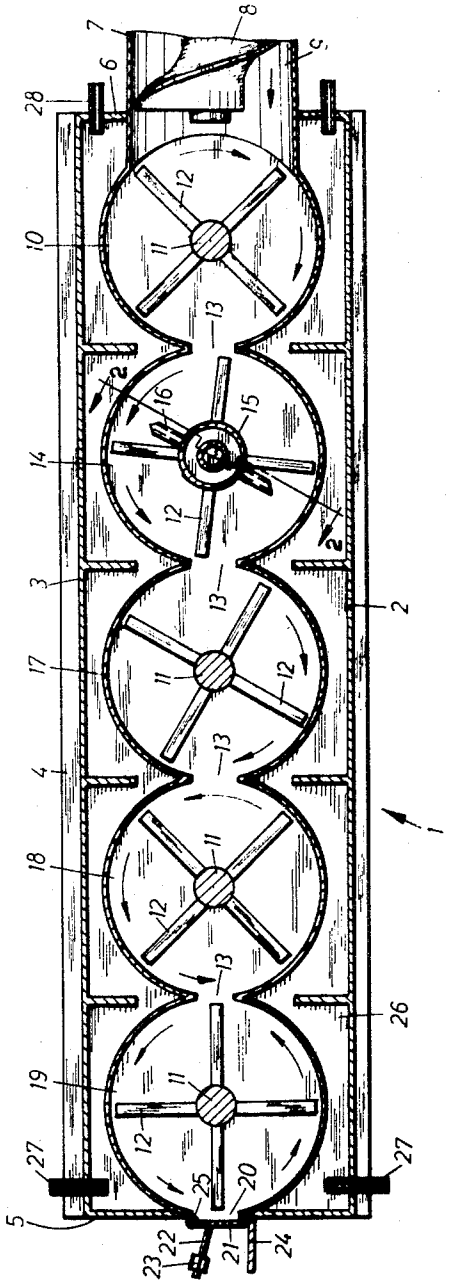
PROCESS OF AND APPARATUS FOR WETTING BULK MATERIALS

Filed Jan. 4, 1968 3 Sheets-Sheet 1

Fig. 1



PROCESS OF AND APPARATUS FOR WETTING BULK MATERIALS

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Fig. 2

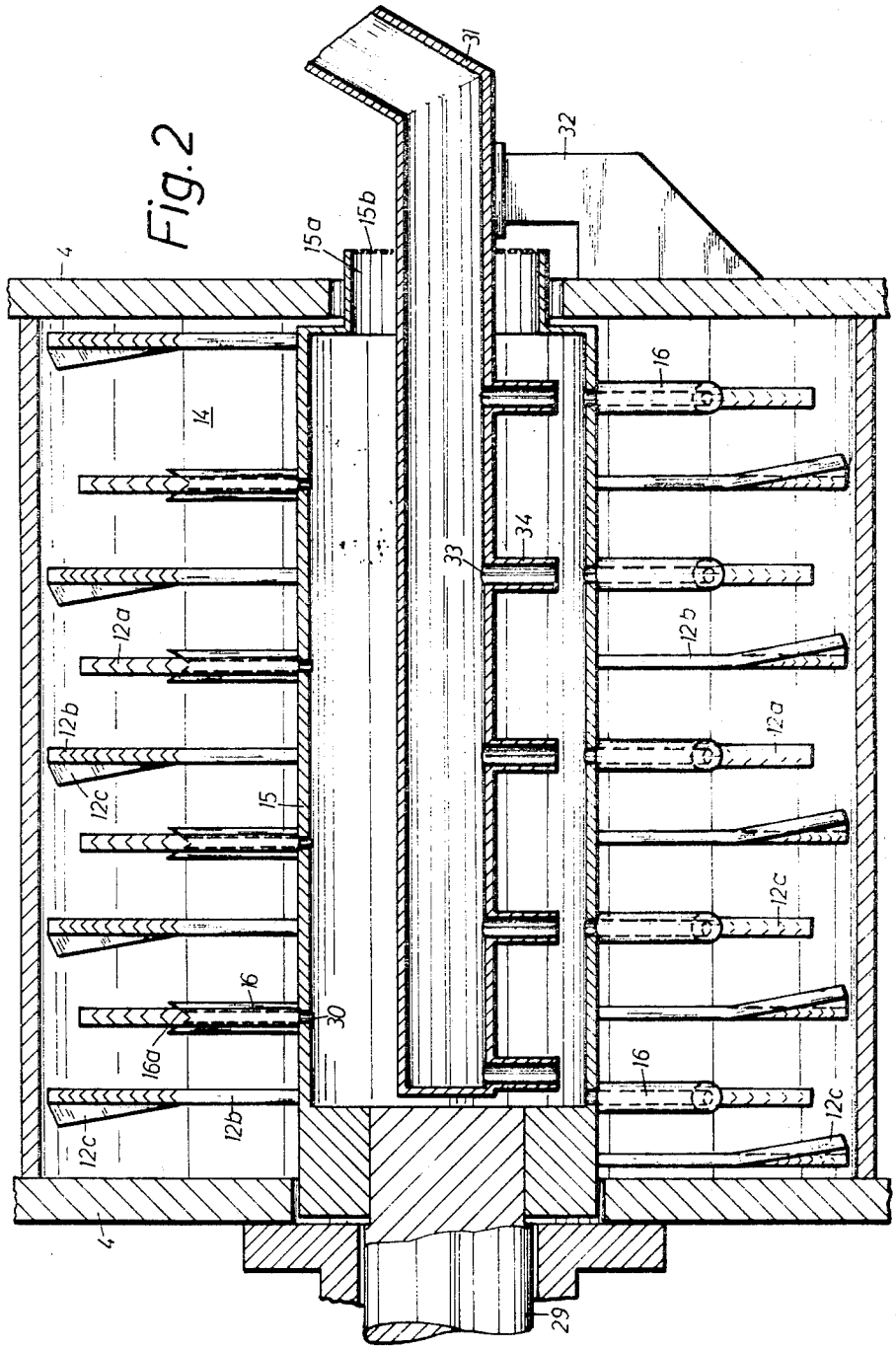

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Fig. 3

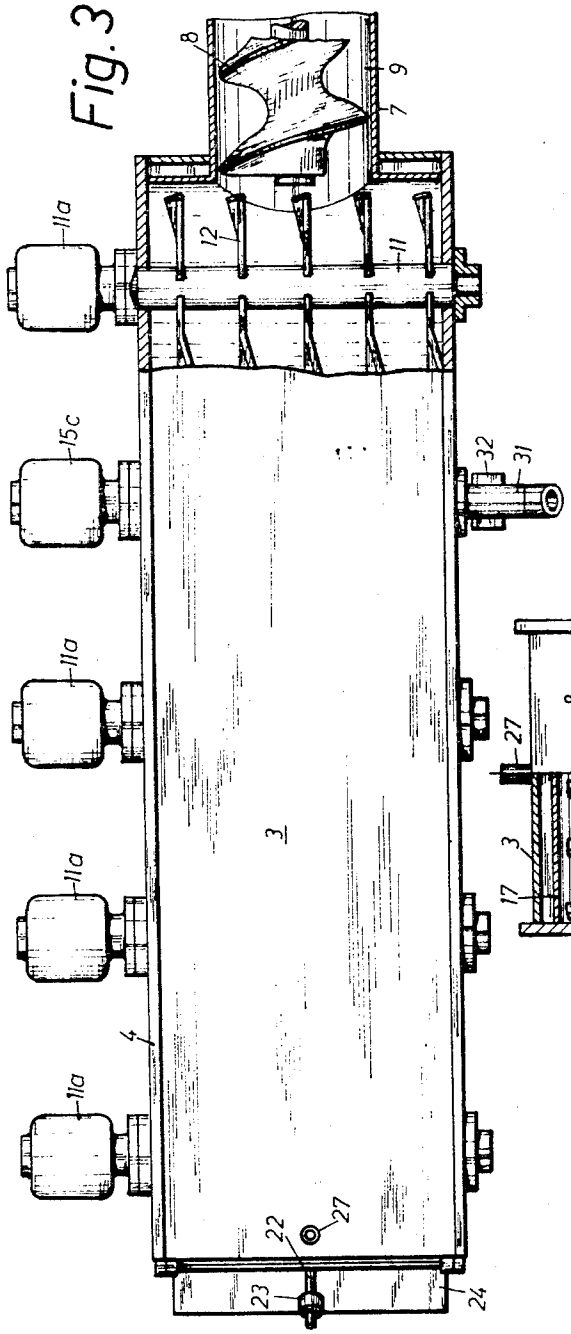
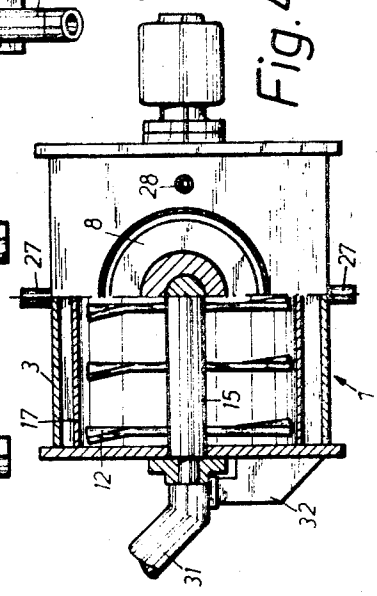


Fig. 4



United States Patent Office 3,466,015
Patented Sept. 9, 1969

3,466,015

PROCESS OF AND APPARATUS FOR WETTING BULK MATERIALS

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Filed Jan. 4, 1968, Ser. No. 695,676
Claims priority, application Germany, Jan. 11, 1967, L 55,478
Int. Cl. B01f 15/00, 7/04
U.S. Cl. 259—9 13 Claims

ABSTRACT OF THE DISCLOSURE

A process of and apparatus for wetting bulk materials capable of trickling movement by treating them in a multi-chamber apparatus having a rotatable knife head in each chamber at least one of them being in a hollow shaft through which the wetting liquid is introduced.

The invention relates to the wetting of bulk materials. The invention is particularly, but not exclusively, applicable to the glue-coating of dry materials capable of trickling movement such as pulverulent and/or very fine-fibre or fine-grain materials. Liquid, such as glue, is continuously added to a flow of material to which a turbulent movement is imparted for mixing purposes.

In various branches of industry it is necessary for liquids to be uniformly added to highly absorbent, and generally powdered, dry materials; one example is the chipboard industry. Recently, in the production of chipboards, grinding dust or very fine chips have been used as a covering layer for the boards. A binding agent such as glue with between 12 and 20% by weight of solid resin constituents is added to this covering layer material. The glue liquid used usually consists of about 50% (by weight) of water and about 50% (by weight) of solid resin since in this way a relatively fine division can be achieved, such as is desirable.

Known apparatus for covering grinding dust or very fine chips with glue are chip gluing mixers in which the chip material is circulated in a mixing container by rotating mixing tools without substantial friction on one another. The glue is sprayed through a plurality of two-component nozzles as an air-glue mixture on to the material to be wetted in the upper portion of the mixing container which can be for example elevated or provided with outward bulges. However, the glue distribution is not satisfactory, since owing to non-uniform distribution of liquid and binding agent and accretions falling off the mixing tools, more or less large agglomerates form in the mixing material and these agglomerates harden very quickly. In order to eliminate such mixing defects as much as possible, rotating teasing rollers or similar tools have been arranged in the gluing mixers, but owing to the large quantity of material in the mixing container only a proportion of the agglomerates can be taken-up and opened before they harden.

The mix must, therefore, after glue application, be homogenized in separate machines if it is desired to avoid having glue spots in the finished products. Such subsequent homogenization, however, is generally not satisfactory since, by this time, the mixed material has already solidified the glue by absorbing its water content to such an extent that the glue can no longer be opened-out.

The known homogenizing machines and gluing mixers are also expensive and the mixers, and particularly their two-component nozzles, are very liable to develop faults in operation when dealing with fine to powdered material.

An object of the present invention is to provide a process and apparatus with which it is possible for even very fine dry materials to be uniformly wetted without subsequent treatment whilst avoiding agglomeration, for example with a glue liquor with a degree of fineness and a uniformity such as has not been satisfactorily possible hitherto.

Other objects of the present invention and advantages thereof will become apparent as the description proceeds.

Accordingly, the invention provides a process for the wetting of bulk materials capable of trickling movement, wherein a liquid is continuously added to the flow of material subjected to turbulent movement for mixing purposes, the dry material being introduced continuously in succession into a plurality of mixing stations in each of which a stirring action takes place and the liquid being added to the material in the mixing station before the last station or at least one of them. The mixing stations have the effect of loosening-up the material, uniformly providing it with wetting liquid and then mixing it uniformly. The mixing achieved is substantially better than is achieved with the hitherto known gluing mixers, the knife-type mixing tools having the additional advantage that they open-up old agglomerations in the mix and, despite the addition of liquid, prevent the formation of new agglomerations until the mix is in the desired state.

According to another aspect of the invention, there is provided an apparatus for carrying out the mixing and homogenizing process comprising a plurality of small mixing and homogenizing chambers connected to one another through apertures and arranged in succession to one another, and a mixing and homogenizing tool is rotatable in each chamber to stir the material therein, the tool in at least one chamber being mounted on a hollow shaft provided with apertures through which liquid can flow.

The shaft of the first and/or second knife head is provided with a plurality of knives or knife-like mixing tools distributed along its length and is conveniently a hollow shaft with radial bores. The bores can be extended externally by small tubes. When liquid glue is introduced into the hollow shaft as it rotates at a high speed, for instance by means of an electromotor, the glue is distributed as a film on the inner wall of the hollow shaft. As a result, small quantities of liquid are continuously projected through the radial bores into the mixing and homogenizing chamber in which it is introduced into the material being mixed which is being whirled about the chamber. The material preferably rotates as a ring of material adjacent the chamber wall. If the radial bores of the hollow shaft are extended outwardly by small tubes, the liquid distribution is substantially improved owing to the increased peripheral speeds of the outlet apertures, so that the liquid impinges substantially in the form of a mist on the inner side of the loose ring of material being mixed, and penetrates therein. Since the ring of material is continuously sliced-up by a plurality of obliquely set knives rotating at a high speed, for instance by means of an electro-motor connected with the shaft carrying the knives, and is turned over at the same time, the particles of material are continually rubbing against one another and pass on any excess glue which they have received to neighbouring particles which have received less glue, before the glue has lost its ability to spread owing to the water content being absorbed into the dry material being mixed.

After the addition of the glue, the mixture must also pass through further chambers with knife heads in order to continue the mixing operation as long as possible. Only

when the material being mixed has almost completely absorbed the water content of the glue and the mixture is almost dry again and therefore capable of trickling movement, can the material issue from the apparatus. In order not to have the material passing too quickly through the chambers, which are connected to one another by apertures, it is expedient to make some or all of these successive knife heads rotate in the opposite sense and, if appropriate, also to make the individual knife heads rotate at different peripheral speeds or rotational speeds.

In one embodiment of the invention, five mixing and homogenizing chambers are arranged one behind the other. Each cylindrical chamber has a diameter of 250 mm. and a length of 250 mm. The knife head in the first chamber after the feed worm rotates at a peripheral speed of about 16 metres per second by means of a suitable drive means such as an electro-motor. The dry material introduced in this chamber is distributed over the appropriate working width. Agglomerations present in the material are opened-up. In the adjoining second chamber the liquid is added to the material being mixed. Here, by way of a suitable drive means, the knife head rotates at a peripheral speed of about 32 metres per second for better distribution of the liquid. In the third and fourth chambers the knife heads rotate at a peripheral speed of about 16 metres per second, again by way of a suitable drive means. The knife head in the last chamber has a relatively low peripheral speed of only about 8.5 metres per second, i.e. the drive means connected with the shaft carrying said knives is driven at a lower speed. The discharge of the mixed material from this last mixing and homogenizing chamber is restricted by a weight-loaded swingable gate so that this chamber operates with a greater degree of fullness than the preceding chambers. In this way, the degree of fullness necessary in the preceding chambers is maintained and the time of dwell of the material in the entire apparatus is prolonged so that the wetted material can absorb the liquid more deeply in order to prevent agglomerations forming during and after the mixing operation.

It is also advantageous to arrange the mixing tools in each chamber in such a manner that they sweep over the entire peripheral surface and are so set that, alternately from chamber to chamber, 60 to 90% of the material is conveyed in the axial sense e.g. towards the left and 10 to 40% towards the right, so that the material passes through the apparatus along a zigzag course as seen in plan view.

This apparatus serves, for example, to apply glue to very fine chips with an output of 500 to 700 kilograms per hour. With the addition of 30% by weight liquid glue (solid resin content 50% by weight) the material issues from the apparatus mixed in a satisfactory uniform manner and in an agglomeration-free condition capable of trickling. For higher outputs per hour, the mixing and homogenizing chambers must be appropriately enlarged. If necessary, the chambers can be capable of being cooled in order to dissipate friction and reaction heat and/or heatable in order to accelerate reaction.

One embodiment of the invention is illustrated diagrammatically in the accompanying drawings, wherein:

FIGURE 1 is a longitudinal sectional view through mixing and homogenizing chambers and a feed worm conveyor of an apparatus for wetting and homogenizing fine bulk materials and

FIGURE 2 is a cross-section through a mixing and homogenizing chamber taken on the line 2—2 of FIGURE 1.

FIGURE 3 is a top-view with partly opened mixing chamber of the apparatus of FIGURE 1.

FIGURE 4 is a lateral view of the apparatus of FIGURE 1 with partly opened mixing chamber and conveyor screw casing.

The apparatus illustrated comprises a housing **1** with a lower wall **2** and an upper wall **3**, connected to one another by side walls **4**. The housing **1** is closed by end walls **5** and **6**.

The end wall **6** has a central aperture in the end wall **6** through which a tube **7** extends into the housing. A worm conveyor **8** is rotatable in the tube **7** by means of a motor not shown, connected to the conveyor shaft. The conveyor screw **8** introduces bulk material into the apparatus in the direction indicated by the arrow **9**. The speed of the worm **8** is infinitely variable by means of a suitable gear not shown and presses the material into a first, approximately cylindrical, mixing and homogenizing chamber **10**. This chamber **10** has a concentric shaft **11** of a knife head or other mixing tool which is provided with sharp-edged knives **12** or mixing tool arms distributed over its length. The shaft **11** is connected with an electromotor **11***a*. The knife head **12** or other tool distributes the introduced material uniformly over the length of the chamber **10** or the width of the housing **1**.

The material to be mixed is forced from the chamber **10** into a further cylindrical mixing and homogenizing chamber **14** through a radial aperture **13**. The axis of the chamber **14** is parallel to that of the chamber **10**. A hollow shaft **15** which carries knife-like mixing tools **12** is mounted concentrically in this chamber **14** and is connected with the electro-motor **15***c*. The shaft **15** also carries small tubes **16** which project radially outwards and which are each arranged behind one of the tools **12** which, advantageously, have relatively short arms **12***a* in the direction of rotation of the shaft. These small tubes **16** are used for introducing liquid into the material situated in the chamber **14**. The chamber **14** is followed by further chambers **17**, **18**, and **19** which are each connected to one another by means of an aperture **13**. A shaft **11** is arranged in each of these chambers connected with electromotors **11***a*. Each shaft **11** has arms for mixing tools **12**, the arrows shown in the drawing indicating that these mixing tools in some cases rotate in opposite senses.

The last chamber **19** is provided with a discharge aperture **20** which can be closed or throttled by a gate **21**. A displaceable, but fixable, weight **23** is mounted on a bar **22** on the outer side of the gate **21**, so that the resistance of the gate **21** to the pressure of material exerted on it from the inside of the chamber **19** can be adjusted. The quantity of material forced out of the chamber **19** is adjustable by varying the magnitude of this resistance. The material is discharged over a plate **24** through a discharge shaft (not shown) or on to a conveyor (also not shown). The gate **21** can pivot outwards about a hinge **25**.

Owing to the adjustable gate **21**, the material accumulates in the last chamber **19** so that in all the preceding chambers the desired degree of fullness in each case can be maintained despite continuous operation. A further acumulation of material in the mixing chambers is caused by the fact that the knife head rotating in the last chamber **19** rotates in the same direction as the knife head in the previous chamber **18**, whereby the material circulated in the last chamber **19** opposes the passage of material through the preceding chambers. In the same sense, the material can also be made to accumulate in one of the preceding chambers or in several chambers in succession.

A hollow space is formed between the chambers **10**, **14**, **17**, **18** and **19** and the walls **2**, **3**, **4**, **5** and **6** of the housing **1**. This hollow space can be used to receive a heating or cooling medium. For this purpose, inlet pipes **27** and outlet pipes **28** are provided in the housing **1**.

FIGURE 2 shows on a larger scale the mounting of the knife head with the hollow shaft for the introduction of the wetting liquid. The hollow shaft **15** is connected with the electro-motor **15***c* and is mounted at one end in an overhung fashion on a stub shaft **29** and has mixing tool arms distributed at its outer periphery and is several rows over the length of the hollow shaft **15**. These arms are advantageously somewhat shortened knife-type arms **12***a*. Tools **12***b* follow these arms in the direction of rotation and extend almost to the peripheral surface of the

chamber and have a widened head **12***c*. Small tubes **16** for spraying-out the wetting liquid are also arranged on the hollow shaft **15**. These small tubes **16** are arranged above bores **30** in the hollow shaft **15** and extend radially outwards. Each small tube **16** is arranged behind a knife-type arm **12***a* and before a following tool arm **12***b*. The upper end of each small tube **16** can be provided with a notch-like cut-out **16***a* which extends in the direction of rotation of the shaft **15**. The tool arms **12***a* arranged in front of the small tubes **16** are longer so that the liquid does not reach the chamber wall.

A fixed feed conduit **31** projects into the hollow shaft **15**, through its open end **15***a*, and serves for introducing the wetting liquid. This conduit **31** is fixed and is supported on a bearing bracket **32** which is arranged at the outer side of one side wall **4**. The underside of the feed conduit **31** is provided with outlet apertures **33** which are followed by small outlet tubes **34**. The wetting liquid from these tubes **34** passes to the inner wall of the hollow shaft **15** and, owing to the rotation of the hollow shaft **15**, is finely divided at the inner wall until it passes through the apertures **30** and the following small tubes **16** into the interior of the cylindrical mixing chamber. In order to prevent the hollow shaft **15** drawing in any dust or foreign bodies with the air, the open end **15***a* is closed by an air filter **15***b*.

What we claim is:

1. In a process for the wetting of bulk materials capable of trickling movement, the steps comprising transferring bulk material through a succession of a plurality of mixing stations in each of which the bulk material in transit is subjected to turbulent stirring; continuously adding a liquid internally of said bulk material while undergoing turbulent movement, said liquid being added to said bulk material in at least one mixing station prior to the final station, and thereafter mixing the bulk material-liquid combination under turbulent movement without further liquid addition.

2. A process according to claim **1**, wherein the mixing and homogenizing operation is repeated in successive stations until the liquid is absorbed by the dry material and the mixture is free of agglomerations and capable of trickling movement.

3. An apparatus for carrying out mixing and homogenizing comprising in combination a plurality of peripherally enclosed individual bulk material stirring chambers arranged in side-by-side relation and connected to one another by material transmitting apertures, material entry means in the first of said chambers, material exit means in the last of said chambers, stirring tool means in each chamber rotatable on an axis disposed transversely to the overall direction of material flow through successive chambers, the tool means in at least one of said chambers being mounted on a hollow shaft, the axis of rotation of which is disposed transversely to the overall direction of material flow, said hollow shaft being provided with apertures through which liquid can flow.

4. An apparatus as claimed in claim **3**, wherein an infinitely variable controlled-feed worm is arranged upstream of the first chamber for the purpose of introducing dry material.

5. An apparatus according to claim **4**, wherein the hollow shaft, or each of them is open at one end and a fixed liquid inlet conduit projects into the shaft.

6. An apparatus according to claim **5**, wherein the liquid throughflow apertures of the hollow shaft, or of each of them are arranged on the hollow shaft to follow knives in the direction of rotation.

7. An apparatus according to claim **6**, wherein the liquid throughflow apertures are extended outside the hollow shaft or shafts by small tubes.

8. An apparatus according to claim **7**, wherein the small liquid tubes are notched, the notches being arranged in the direction of rotation of the shaft.

9. An apparatus according to claim **3**, the hollow shaft or shafts being arranged at right angles to the material flow in each mixing chamber.

10. An apparatus according to claim **3**, wherein the last mixing and homogenizing chamber has an outlet aperture which can be throttled.

11. An apparatus according to claim **3**, wherein the tools are knives some of which are relatively short and other knives are obliquely positioned and are arranged in such a manner that they sweep over the entire inner peripheral surface of the chamber and, from chamber to chamber alternately, convey 60 to 90% of the material being mixed in the axial sense towards one chamber end and 10 to 40% towards the other chamber end.

12. An apparatus according to claim **3**, wherein the tools are knife heads which are driven in opposite directions of rotation.

13. An apparatus according to claim **12**, wherein the tools are knife heads which rotate at different peripheral speeds.

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U.S. Cl. X.R.

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