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APPARATUS FOR CONTINUOUS DRYING OF POWDERY OR GRANULAR MATERIALS IN A HIGH-FREQUENCY FIELD

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FIG. 1

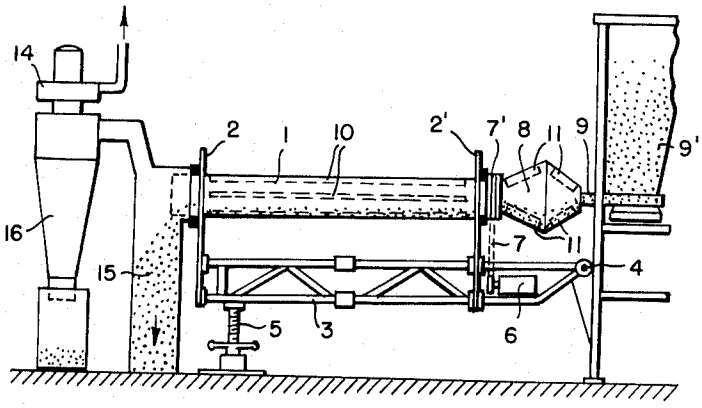


FIG. 2

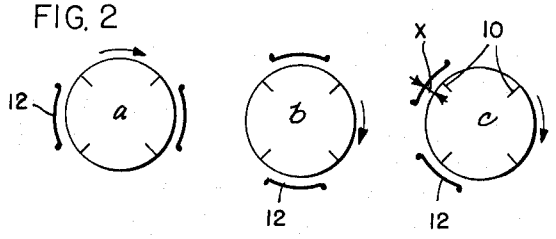
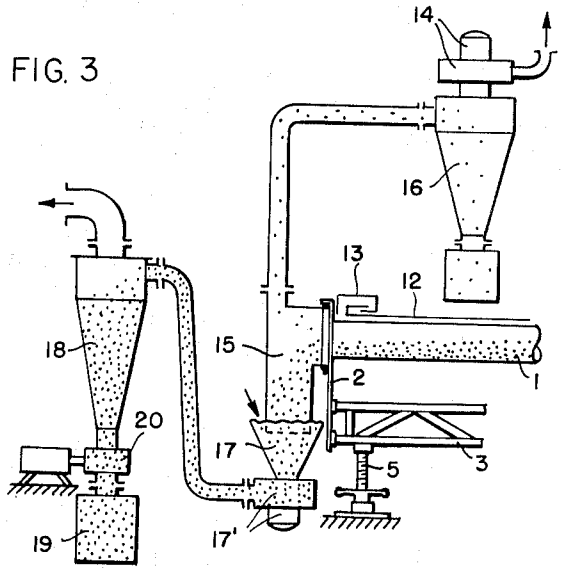


FIG. 3



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APPARATUS FOR CONTINUOUS DRYING OF POWDERY OR GRANULAR MATERIALS IN A HIGH-FREQUENCY FIELD

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This invention relates in general to high frequency drying equipment. More specifically, the invention relates to a tubular dryer comprising a tube made of insulating material, a feeder drum connected to and rotated with the tube, and adjustable electrodes.

It is already known to introduce finely granular to powdery materials continuously or batchwise into a high frequency field which is present in a closed treatment chamber or above a moving belt. It is only possible however to dry satisfactory finely granular material having a moisture content of less than 1 to 3% in thin layers because it is not possible sufficiently to agitate the material and at the same time to draw off the evaporated moisture sufficiently completely.

Batchwise chamber drying is not suitable for large amounts of material. In continuous belt-type dryers additional equipment, such as vanes or agitating means, is necessary for example to turn the material over repeatedly. The high technical expenditure, and also the means and measures necessary for controlling the belt movement and the throughput, as well as for shielding the dust, have hitherto prevented wide application of belt-type high frequency dryers. Furthermore belt-type drying plants can usually only be constructed as stationary plants. This means that they cannot be rapidly made available at centres of a diverse production, especially of chemical substances.

We have now found that the high frequency drying of moist powdery or granular materials having a moisture content of up to 50% can be carried out with low expenditure but nevertheless with high throughput capacity in relation to the power requirement, down to residual moisture contents of 0.1% or less by using as the treatment chamber a tube of insulating material which is horizontal or slightly inclined and which rotates between the high frequency electrodes and through which the material to be dried can be passed in a constant direction.

According to a further feature of the invention, the electrodes are capable of being inclined independently from each other with respect to the axis of rotation of the tube, so that the material to be dried can be treated intermittently without the electric data of the high-freqeuncy generator having to be changed. The inclination and speed of the rotating tube may be regulatable in order to adjust the rate of flow of the material to be treated. For feeding the material a feeder drum is provided which is fitted with baffles which make possible a sufficiently uniform charging of the rotating tube.

Further features of the invention will be evident from the following description given with reference to the accompanying drawings, in which FIGURE 1 is a diagrammatic elevation of one embodiment of apparatus according to this invention, FIGURE 2 shows diagrammatic sectional elevations of tubes and electrodes, and FIGURE 3 is a diagrammatic elevation of part of a second embodiment of apparatus according to this invention.

The treatment chamber for the material to be dried consists of a circular tube **1**. The tube extends through apertures in two bearing plates **2** and **2'** and is rotatably

mounted at the points of support, preferably in roller bearings. The bearing plates **2** and **2'** are in turn secured to a frame **3** suspended at one end from a hinge **4**. The other end of the frame is supported on a threaded spindle **5** to allow for raising and lowering the delivery end of the tube **1** mounted above the frame **3**. By turning the spindle **5**, the tube **1** may be brought from the horizontal position into any inclined position within a range of about 0° to 15° so that the flow rate of the material being dried in the tube may be varied. Mounted on the frame **3** is a motor **6** whose shaft effects rotation of the tube **1** through a belt **7** and pulley **7'**. Motor **6** may be provided with means for continuous variation of speed so that the flow rate of the material being treated may also be varied by means of this variable speed. The feed-in end of the tube **1** carries a feeder drum **8** having a larger diameter than the tube **1** and consisting substantially of two superposed conical casings. The free end of an inlet chute **9** of a hopper **9'** projects into the outer free opening of the feeder drum **8** and feeds the material to be treated to the tube **1**.

A mixture of polyester and glass fibers has proved particularly suitable as the insulating material. To ensure intense mixing and agitation of the material in the tube **1**, it is advantageous to provide baffles **10** on the inner face of the tube. The baffles **10** may be made with or without interruptions and lie on generating lines of the tube parallel to the axis of rotation or inclined thereto. In the latter case, the baffles may be arranged in spiral fashion. When the tube **1** is prepared from a mixture of polyester and glass fibers, the baffles **10** may be integral therewith; in other cases they may be secured subsequently. Provided inside the feeder drum **8** are fillets, preferably inclined, or curved blades **11**, which serve to agitate the material to be treated and feed it positively, and are arranged and shaped like the blades in the drum of a concrete mixing machine. It is also advantageous to line the inner face of the tube **1** and the feeder drum **8** including the baffles **10** and the fillets or blades **11** with a polytetrafluoroethylene sheet or a compound sheet of glass fiber reinforced polytetrafluoroethylene. The moist material to be treated then has less tendency to adhere to the inner face of the feeder drum and the treatment chamber. It is then agitated and conveyed better and more completely. Instead of lining the feed and treatment sections for the moist material, it is also possible to apply polytetrafluoroethylene coating.

The arrangement of the electrodes **12** for producing the high freqeuncy field at the rotating tube **1** is shown in FIGURES 2 and 3. The electrodes **12** are spaced from the outer surface of the tube by a distance x and curved according to the diameter of the tube. They are supported at both ends by arms **13** of insulating material which can be screwed to the bearing plates **2** and **2'** at any angular position and distance from each other by means of a multiplicity of tapped holes in the bearing plates **2** and **2'**. Three different angular positions of the electrodes **12** which produce different drying effects and different electrical field strengths in the treatment zone are shown at *a*, *b* and *c* in FIGURE 2. The electrodes may furthermore be adjusted to any other angular position relative to the axis of rotation of the tube **1** in an approximate range of 30° to 180°. The arms **13** carrying the electrodes **12** may also be so connected with the bearing plates **2** and **2'** that the distance x between the electrodes and the outer surface of the tube **1** may be varied within certain limits.

A tubular dryer having the features of the present invention and the design data given hereinafter, has been tested out. The tube used was a glass fiber reinforced polyester tube having a length of 3000 mm., a diameter of 280

mm. and a wall thickness of 1 mm. The inside of this tube was provided with four baffles having rectangular cross-section of 2 x 60 mm. The tube was rotated at a speed of about 40 to 50 r.p.m. between two plate electrodes each having a surface area of 200 x 2000 mm., the plates being slightly curved in cross-section. The space between the electrodes at the diametric position with respect to the axis of rotation was 320 mm. To withdraw the evaporated moisture from the interior of the tube, a suction fan **14** was provided at the delivery end of the tube, the fan having the following performance data: air throughput 200 m.^{3}/hour, pressure 200 mm. water column.

A high frequency drying plant which comprises a tubular dryer according to this invention as its essential part also comprises the following other parts. In the simplest case, the delivery end of the tube **1** is located above a receptacle **15** for the dried material. In addition to the suction fan **14** for withdrawing steam and maintaining a slightly reduced pressure in the treatment zone, it is also possible to provide at the top of the receptacle **15** a cyclone **16** or a similar separator which advantageously forms a single unit with the fan **14** (FIGURE 1). In this way, any material treated in the high frequency drying zone which is sucked away with the mixture of steam and air is collected in the separator. This feature is especially advantageous when the materials to be dried are dusty and toxic.

FIGURE 3 shows diagrammatically another arrangement at the delivery end of the tube **1**. In the case of products being dried which conglomerate during the drying process and which after the treatment must be reduced to the original grain size, it is advantageous to suck the material being treated from the receptacle **15** down through a funnel **17** and a blower **17'**, to reduce its size and to separate it from the air in a further separator **18**. The lower end of this separator **18** is in communication through a rotary air lock **20** with a receptacle **19**. The fan **14** in this case is again attached to the upper end of the receptacle **15** and provided with a separator **16**. Air sucked in by blower **17'** to convey the material is not withdrawn from the tube **1** in this case, but is drawn in from the atmosphere through the funnel **17** so that the discharged material is cooled at the same time. With such an arrangement heat sensitive material, which must be free from conglomerates when processed further, may be discharged and bagged direct from the storage container **19**.

We claim:

1. Apparatus for the continuous drying of a powdery or granular material in a high frequency field comprising:

a drying and conveying cylindrical tube essentially composed of insulating material and mounted in a horizontal to an inclined position for rotation about its longitudinal axis;

means to rotate said tube and continuously convey the material to be dried therethrough in a constant direction from the inlet end of said tube to the outlet end;

a feeder drum of greater diameter than said tube and provided with baffles on the inner surface thereof, said drum being rotatably mounted around said longitudinal axis in conjunction with said tube and adapted to continuously charge the material to be dried at a uniform rate into the inlet end of said tube;

means to recover the dried material at the outlet end of said tube; and

a pair of opposing high frequency electrodes adjustably mounted in positions adjacent the outer circumferential surface of said rotating tube such that said electrodes can be adjustably disposed from each other by an angle of from about 30° to 180° with reference to the longitudinal axis of rotation of said tube.

2. Apparatus for the continuous drying of a powdery or granular material in a high frequency field comprising:

a drying and conveying cylindrical tube essentially composed of insulating material and mounted in a horizontal to an inclined position for rotation about its longitudinal axis;

means to rotate said tube and continuously convey the material to be dried therethrough in a constant direction from the inlet end of said tube to the outlet end;

a feeder drum rotatably mounted around said longitudinal axis in conjunction with said tube and formed substantially as a double truncated cone tapering outwardly from the inlet end of said cylindrical tube to the superimposed bases of the double cone, which bases have a diameter larger than the diameter of said tube, and then tapering inwardly to provide a feed opening in said drum, said drum being provided with projecting baffles on the inner surface thereof running obliquely to the axis of said drum and adapted to continuously charge the material to be dried at a uniform rate into the inlet end of said tube;

means to recover the dried material from the outlet end of said tube; and

a pair of opposing high frequency electrodes adjustably mounted in positions adjacent the outer circumferential surface of said roating tube such that said electrodes can be adjustably disposed from each other by an angle of from about 30° to 180° with reference to the longitudinal axis of rotation of said tube.

3. Apparatus for the continuous drying of a powdery or granular material in a high frequency field comprising:

a drying and conveying cylindrical tube essentially composed of insulating material and mounted for rotation about its longitudinal axis in plates attached to a supporting frame, said frame being hinged at one end for movement of said tube from a horizontal to inclined position;

means to adjust the inclination of said frame and tube and means to rotate said tube for continuous conveyance of material to be dried through said tube in a constant direction from the inlet end of said tube to the outlet end;

means to continuously feed the material to be dried at a uniform rate into said inlet end of said tube and means to recover the dried material from the outlet end of said tube; and

a pair of opposing high frequency electrodes adjustably mounted at either end to said plates in positions adjacent the outer circumferential surface of said rotating tube such that said electrodes can be adjustably disposed from each other by an angle of from about 30° to 180° with reference to the longitudinal axis of rotation of said tube and also such that said electrodes can be adjustably disposed at varying distances from the outer circumferential surface of said tube.

4. Apparatus for the continuous drying of a powdery or granular material in a high frequency field comprising:

a drying and conveying cylindrical tube essentially composed of a glass fiber reinforced unsaturated polyester resin as an insulating material and mounted in a horizontal to an inclined position for rotation about its longitudinal axis;

means to rotate said tube and continuously convey the material to be dried therethrough in a constant direction from the inlet end of said tube to the outlet end;

a feeder drum of greater diameter than said tube and provided with baffles on the inner surface thereof, said drum being rotatably mounted around said longitudinal axis in conjunction with said tube and adapted to continuously charge the material to be dried at a uniform rate into the inlet end of said tube;

means to recover the dried material at the outlet end of said tube; and

a pair of opposing high frequency electrodes adjustably mounted in positions adjacent the outer circumferential surface of said rotating tube such that said electrodes can be adjustably disposed from each other by an angle of from about 30° to 180° with reference to the longitudinal axis of rotation of said tube.

5. Apparatus for the continuous drying of a powdery or granular material in a high frequency field comprising:

a drying and conveying cylindrical tube essentially composed of insulating material and mounted in a horizontal to an inclined position for rotation about its longitudinal axis;

means to rotate said tube and continuously convey the material to be dried therethrough in a constant direction from the inlet end of said tube to the outlet end;

a feeder drum of greater diameter than said tube and provided with baffles on the inner surface thereof, said drum being rotatably mounted around said longitudinal axis in conjunction with said tube and adapted to continuously charge the material to be dried at a uniform rate into the inlet end of said tube;

a lining on the inner surfaces of said tube and said drum composed of polytetrafluoroethylene;

means to recover the dried material at the outlet end of said tube; and

a pair of opposing high frequency electrodes adjustably mounted in positions adjacent the outer circumferential surface of said rotating tube such that said electrodes can be adjustably disposed from each other by an angle of from about 30° to 180° with reference to the longitudinal axis of rotation of said tube.

6. Apparatus for the continuous drying of a powdery or granular material in a high frequency field comprising:

a drying and conveying cylindrical tube essentially composed of insulating material and mounted in a horizontal to an inclined position for rotation about its longitudinal axis;

means to rotate said tube and continuously convey the material to be dried therethrough in a constant direction from the inlet end of said tube to the outlet end;

a feeder drum of greater diameter than said tube and provided with baffles on the inner surface thereof, said drum being rotatably mounted around said longitudinal axis in conjunction with said tube and adapted to continuously charge the material to be dried at a uniform rate into the inlet end of said tube;

a lining on the inner surfaces of said tube and said drum composed of glass fiber reinforced polytetrafluoroethylene;

means to recover the dried material at the outlet end of said tube; and

a pair of opposing high frequency electrodes adjustably mounted in positions adjacent the outer circumferential surface of said rotating tube such that said electrodes can be adjustably disposed from each other by an angle of from about 30° to 180° with reference to the longitudinal axis of rotation of said tube.

7. Apparatus for the continuous drying of a powdery or granular material in a high frequency field comprising:

a drying and conveying cylindrical tube essentially composed of insulating material and mounted in a horizontal to an inclined position for rotation about its longitudinal axis;

means to rotate said tube and continuously convey the material to be dried therethrough in a constant direction from the inlet end of said tube to the outlet end;

a feeder drum of greater diameter than said tube and provided with baffles on the inner surface thereof, said drum being rotatably mounted around said longitudinal axis in conjunction with said tube and adapted to continuously charge the material to be dried at a uniform rate into the inlet end of said tube;

means to recover the dried material at the outlet end of said tube; and

a pair of opposing high frequency electrodes adjustably mounted in positions adjacent the outer circumferential surface of said rotating tube such that said electrodes can be adjustably disposed from each other by an angle of from about 30° to 180° with reference to the longitudinal axis of rotation of said tube and also such that said electrodes can be adjustably disposed at varying distances from the outer circumferential surface of said tube.

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