

Oct. 3, 1961

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3,002,289

APPARATUS FOR COOLING FINELY DIVIDED MATERIAL

Filed Feb. 15, 1957

5 Sheets-Sheet 1

FIG. 1

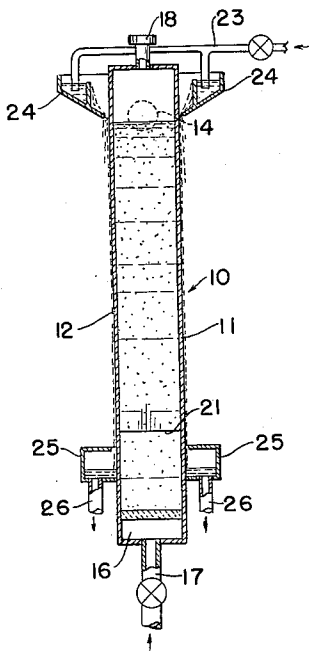


FIG. 2

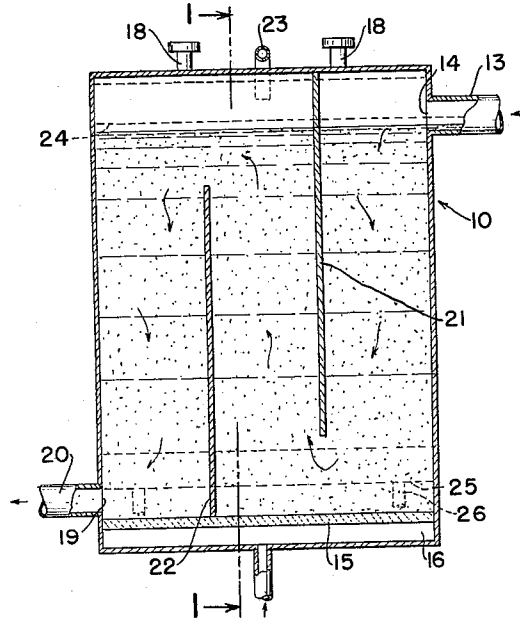


FIG. 3

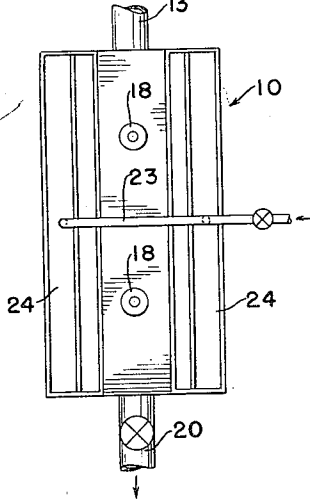
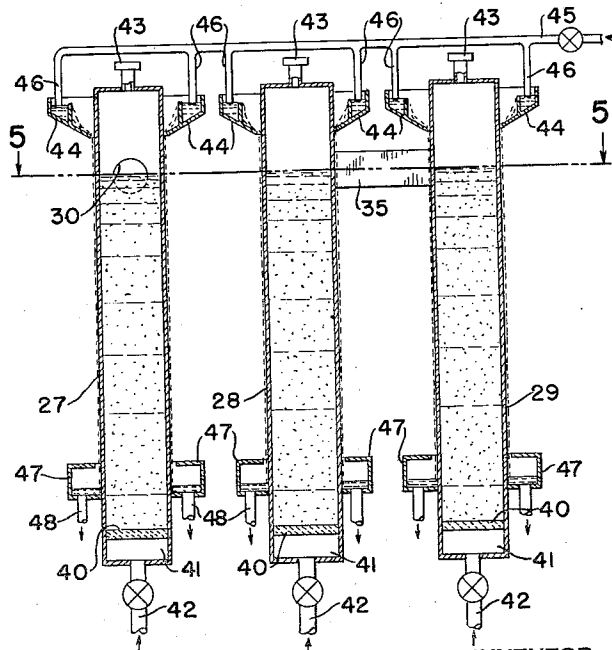


FIG. 4



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FIG. 5

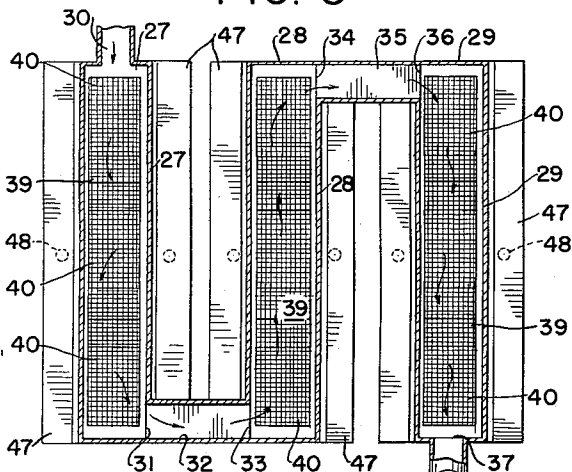


FIG. 8

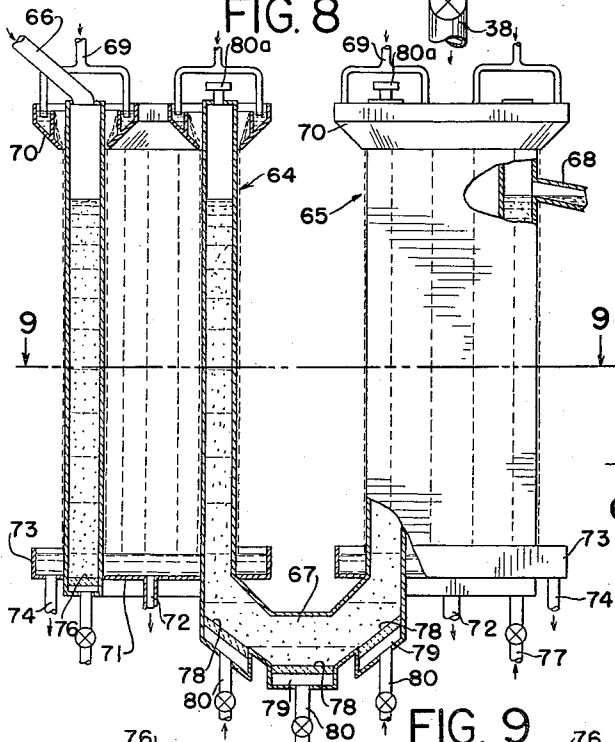


FIG. 9

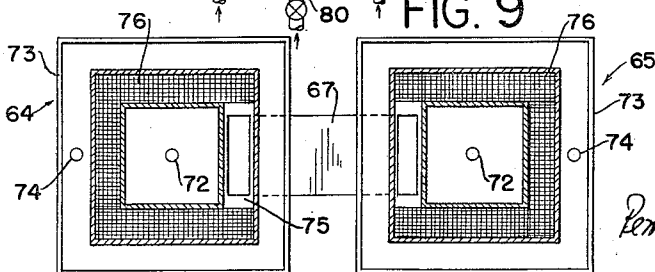


FIG. 6

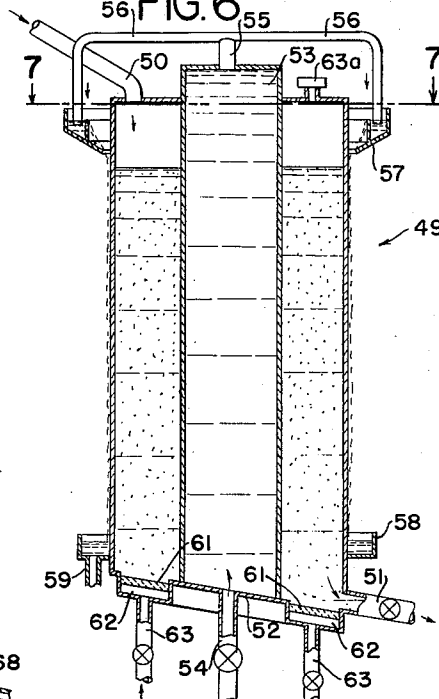
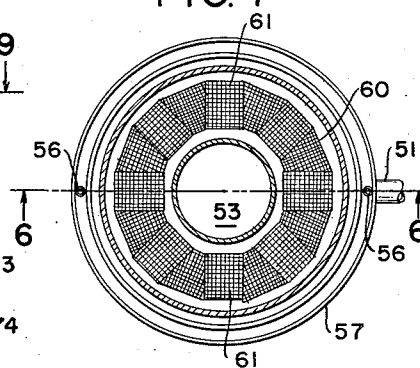


FIG. 7



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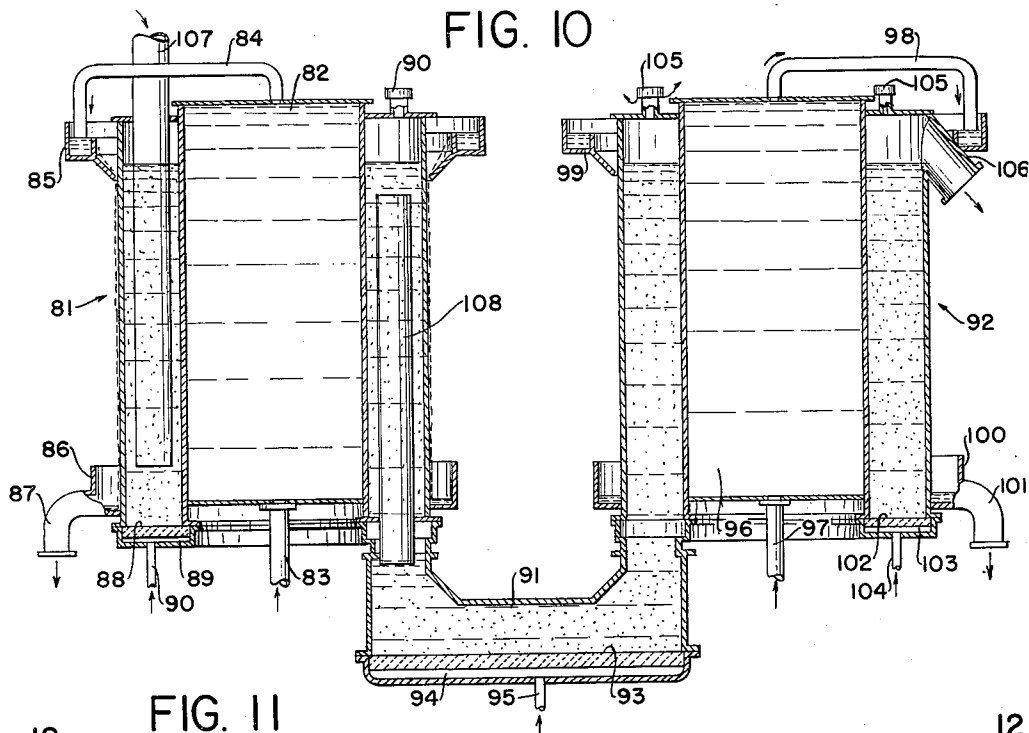
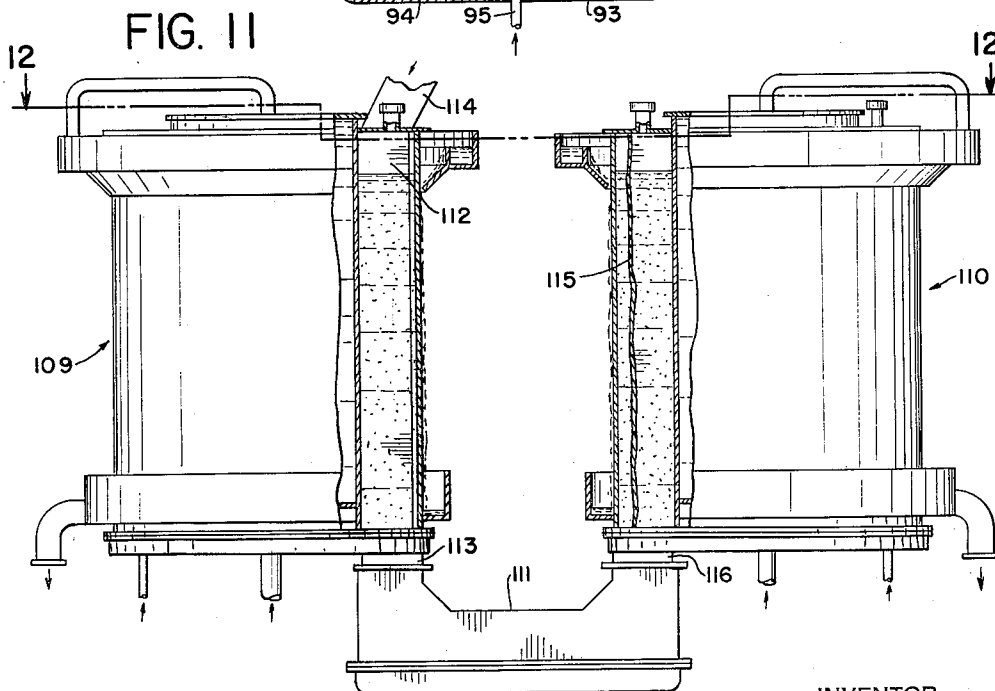
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FIG. 12

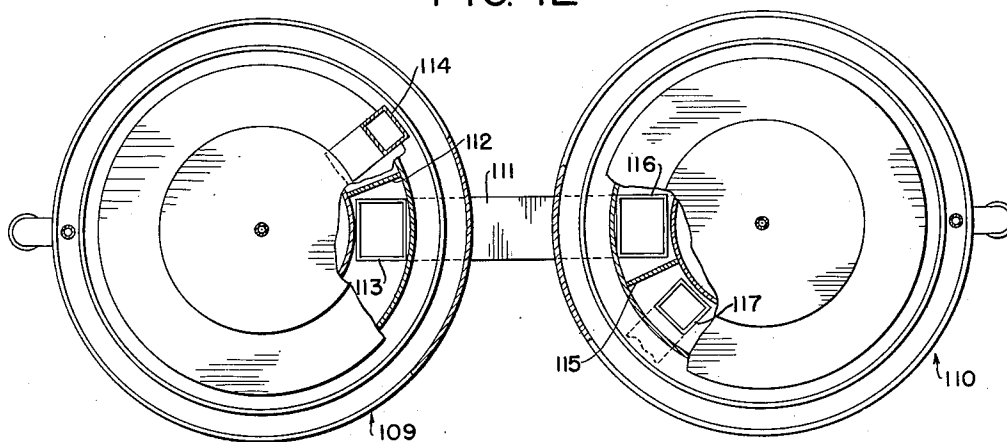
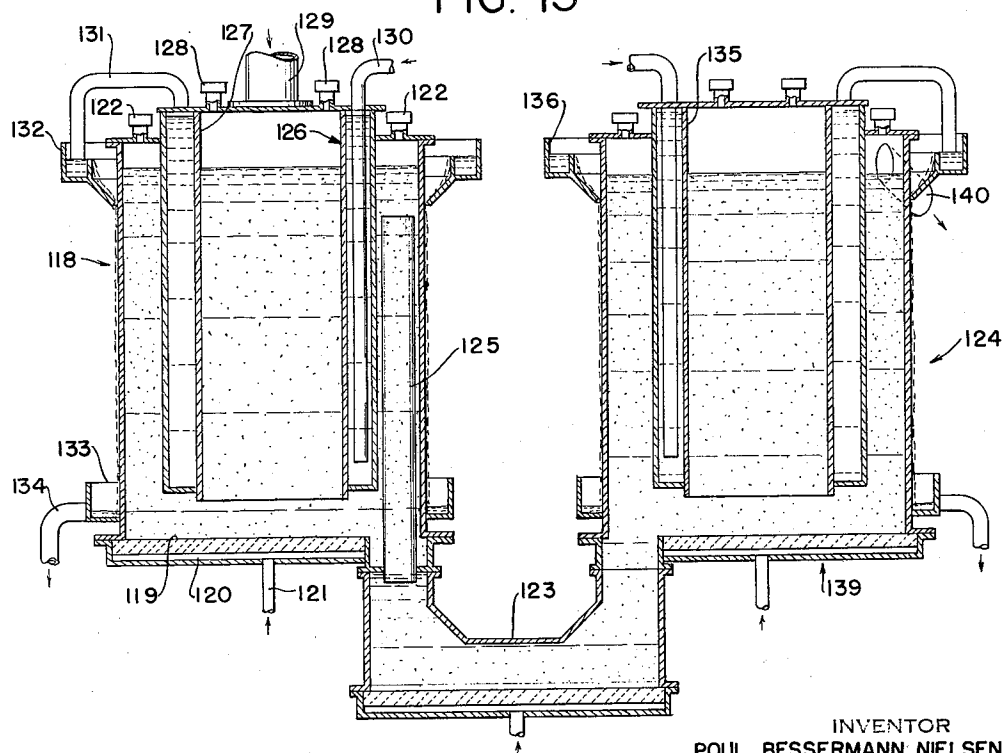


FIG. 13



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FIG. 14

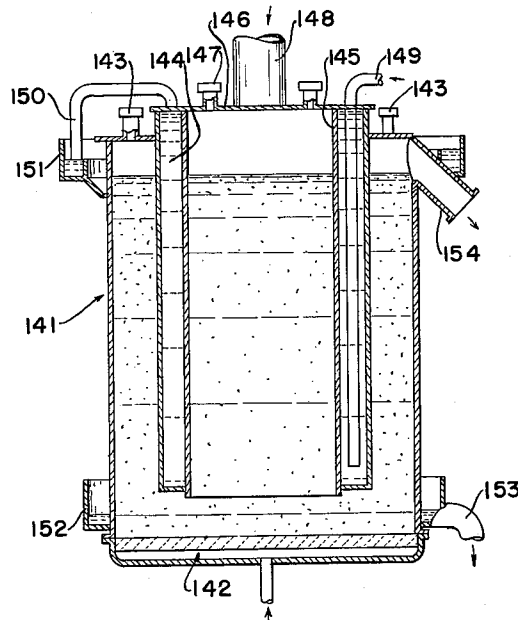
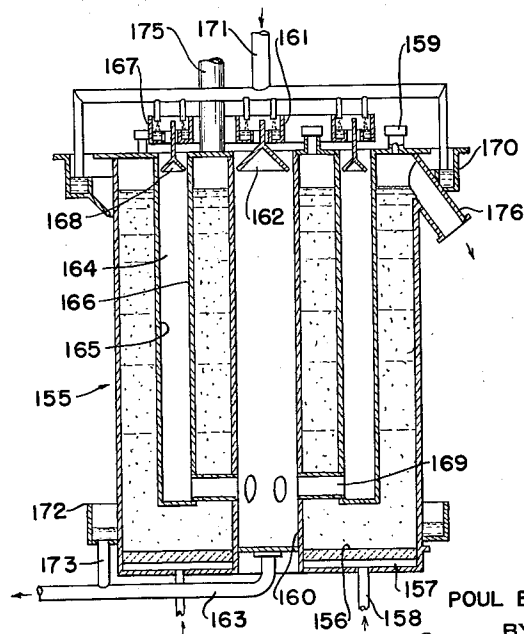


FIG. 15



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6 Claims. (Cl. 34—57)

This invention relates to apparatus for cooling powdered materials capable of being rendered fluent by air diffused through them, examples of such materials being ground cement, cement raw materials, alumina, coal dust, etc. More particularly, the invention is concerned with a novel apparatus for cooling materials of the type referred to, which is of simple inexpensive construction, is efficient and reliable in operation, has no moving parts, and requires little attention in use. The apparatus occupies little ground area and it can be constructed for use in a space of limited height.

The apparatus of the invention comprises a chamber or tower of a height much greater than either of its transverse dimensions and having walls of substantial area, which are made of heat-conducting material and are maintained at a temperature lower than that of the material to be cooled. The tower has an inlet and an outlet for the material so disposed as to insure that the material travels along a long path in passing through the tower and the length of the path may be increased by suitable baffle means, such as partitions attached alternately to the top and bottom walls and extending part way to the opposite wall. The cooling of the heat-conducting walls may be effected in any desired way and sprinkling means directing water jets upon the walls near the upper ends thereof are satisfactory.

The passage of the material through the tower is facilitated by introducing air into the material to aerate it and cause it to flow with turbulence, so that all particles of the material are brought close to or into contact with the heat-conducting walls. The aeration is effected by providing the bottom of the tower with porous plates of a total area not substantially less than the cross-section of the tower and air under pressure is admitted to plenum chambers closed at the top by the plates and escapes upwardly through plates into the material. The air passing up through the body of material causes it to seethe and flow through the chamber with the desired turbulence, so that rapid and uniform cooling results.

In some forms of the new apparatus, more than one tower is employed and, in such constructions, the several towers are constructed and connected to provide the longest path of travel for the material. When two towers are used, the towers have a connection at their lower ends for the passage of the material and one tower has an inlet at its upper end and the other has an outlet similarly located. With this arrangement, the levels of the fluidized material in the two towers are the same, so that both towers take an equal part in the cooling action.

The cooling of the heat-conducting walls of the tower or towers of the apparatus may be effected in various ways other than by sprinkling so as to insure best use of the cooling medium and the towers may be constructed in such manner that each tower has more than two walls confining the material and abstracting heat therefrom.

For a better understanding of the invention, reference may be made to the accompanying drawings, in which FIG. 1 is a vertical sectional view of one form of the apparatus on the line 1—1 of FIG. 2;

FIG. 2 is a vertical section view through the apparatus at right angles to FIG. 1;

FIG. 3 is a top plan view of the apparatus shown in FIGS. 1 and 2;

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FIG. 4 is a vertical sectional view of a form of the apparatus having a plurality of towers connected in series;

FIG. 5 is a sectional view on the line 5—5 of FIG. 4;

FIG. 6 is a vertical sectional view on the line 6—6 of

FIG. 7 of a form of the apparatus having an annular tower;

FIG. 7 is a horizontal sectional view on the line 7—7 of FIG. 6;

FIG. 8 is a view, partly in vertical section and partly in elevation, of a modified form of the apparatus including two hollow towers;

FIG. 9 is a sectional view on the line 9—9 of FIG. 8;

FIG. 10 is a vertical sectional view of another modified form of the apparatus;

FIG. 11 is a vertical sectional view of another modified form of the apparatus;

FIG. 12 is a sectional view on the line 12—12 of FIG. 11; and

FIGS. 13, 14, and 15 are vertical sectional views of other modified forms of the apparatus.

The form of the apparatus of the invention shown in FIG. 1 comprises a chamber or tower 10, which is oblong in cross-section and has relatively wide side walls 11, 12 made of heat-conducting material, such as sheet iron. The powdered material to be cooled is supplied to the tower through a pipe 13 leading to an inlet opening 14, which is preferably formed in one end wall near the top of the tower. Within the tower, the material is supported upon a floor 15, which lies slightly above the bottom of the tower and forms the top of a plenum chamber 16, to which air is supplied through a valved pipe 17. The floor 15 is made wholly or in part of porous fluidizing plates, so that air supplied to chamber 16 may pass upward through the plates and into the material within the tower to render the material fluent and to cause it to seethe and flow with turbulence. The air escaping from the material issues from the tower through vents 18 at the top of the tower and the cooled material is discharged through an outlet opening 19 formed in the other end wall near its bottom with the material conducted away from the opening through a valved pipe 20.

In its passage through the tower from the inlet 13 to the outlet 19, the material may be caused to travel along a tortuous path, as, for example, by means including a baffle 21 extending downwardly through the tower from the top and lying in front of inlet 13. The baffle 21 terminates above the floor 15 and a second baffle 22 rises from the floor between baffle 21 and the outlet opening and terminates short of the top of the tower. The baffles thus cause the material entering the inlet to pass downward and beneath baffle 21, after which the material rises between the baffles and then passes over the top of baffle 22 and downward along the outer side of baffle 22 to the outlet.

The material is cooled in its travel through the tower by means of a cooling medium, which may be water directed against the wide side walls of the tower. The water is supplied by a valved pipe 23 to troughs 24 extending across the side walls near their upper ends and constructed to discharge water against the side walls. The water is collected in troughs 25 extending across the side walls near their lower ends and the water is led from troughs 25 by pipes 26.

The form of the apparatus shown in FIGS. 4 and 5 includes three towers 27, 28, 29 lying side by side. The towers are generally of the construction illustrated in FIG. 1, although those illustrated are not provided with baffles corresponding to baffles 21, 22. The tower 27 has an inlet 30 for material in one end wall near the top thereof and an outlet 31 for the material through a side wall near the lower end thereof and adjacent the other end wall. The outlet 31 is connected by a pipe 32 to an

inlet 33 in the side wall of tower 28 near the bottom of that wall and adjacent an end wall. The tower 28 has a material outlet 34 in its other side wall near the top thereof and adjacent the other end wall. The outlet 34 is connected by a pipe 35 to an inlet 36 in the side wall of tower 29 near the top thereof and adjacent an end wall and the tower 29 has a material outlet 37 in its other end wall near the bottom thereof. A valved pipe 38 leads from outlet 37 to conduct away the cooled material. Each of the towers 27, 28, 29 has a false bottom or floor 39 made wholly or in part of porous aerating plates 40 and forming the top of a plenum chamber 41. Air is supplied to the chamber 41 beneath the floor in each tower through a valved pipe 42 and air traveling upward through plates 40 and the material in the towers fluidizes the material and escapes through air vents 43 at the top of the towers.

Each tower is provided with cooling means, and, for this purpose, troughs 44 are mounted on the towers to extend across the wide side walls thereof near their upper ends. The troughs are supplied with water through a valved pipe 45 having branches 46 leading into the troughs and the troughs are constructed to discharge water against the side walls of the towers. Water traveling down the walls is collected in troughs 47 extending across the side walls of the towers near their lower ends and the water is carried away from troughs 47 through pipes 48.

In the operation of the cooling apparatus shown in FIGS. 4 and 5, the hot material is supplied to tower 27 through inlet 30 and is aerated by air entering the material through the aerating plates 40. The material travels through the tower to the material outlet 31 and then passes through pipe 32 and enters the bottom of tower 28 through the inlet 33. The material rises in tower 28 to the outlet 34, from which it enters pipe 35, and the material travels through the pipe and enters tower 29 through inlet 36. The material passes downward through tower 29 to issue through the outlet 37 and be led away through pipe 38. In its travel through the towers, the material flows with turbulence and is cooled by heat transfer through the wide side walls of the towers.

The apparatus shown in FIG. 6 comprises a tower 49, which is of annular cross-section with inner and outer cylindrical walls made of sheet iron or like heat-conducting material. The material to be cooled is supplied to the tower through a pipe 50 leading into the top of the tower and the material issues through an outlet opening 51, which is formed in the outer cylindrical wall of the tower and diametrically disposed in relation to the inlet. The space inside the inner cylindrical wall of the tower is closed at the bottom by a plate 52 to form a chamber 53, to which cooling water is supplied through a valved pipe 54, and the inner wall of the tower extends upwardly above the top and is covered to close the upper end of chamber 53. The water escapes from chamber 53 through an outlet pipe 55 with branches 56 and the branches discharge the water into a circular trough 57, which surrounds the tower near its upper end and is constructed to discharge the water upon the outer surface of the tower. The water flowing down the outside of the tower enters a circular trough 58 and is led away through a discharge pipe 59.

The bottom of the annular chamber of the tower is provided with a floor 60, which lies at an angle to the vertical with its lowest part near the material outlet 51. The floor is formed wholly or in part of porous aerating plates 61 and beneath the plates is a plenum chamber 62, to which air for aeration purposes is supplied through valved pipes 63, the air escaping through one or more vents 63a.

In the operation of the apparatus shown in FIGS. 6 and 7, material supplied to the tower enters the annular interior thereof through the inlet pipe 50 and is aerated and becomes fluent. The fluent material travels downwardly in turbulent flow through the chamber and to the

outlet 51 and the material is cooled in its passage through the tower by giving up heat through the inner and outer heat-conducting walls of the tower.

The apparatus shown in FIGS. 8 and 9 includes a pair of towers 64, 65, which are of hollow form. The towers may be annular in cross-section or formed as inner and outer hollow squares, the latter construction being shown. The material to be cooled is supplied through a pipe 66, which leads to an inlet at the top of one side of tower 64 and the tower has an outlet from the bottom of the opposite side, from which a pipe 67 leads to an inlet at the bottom of one of the sides of tower 65. The material issues from the tower 65 through an outlet in the opposite side wall near the top thereof and the cooled material is conducted away through a pipe 68.

In its travel through tower 64, the material is cooled by water, which travels down along the outer surfaces of the inner and outer walls of the tower. The water is supplied by pipes 69 to troughs 70, which extend along the inner and outer walls of the towers near their upper ends. The space defined by the inner walls of each tower is closed at the bottom by a plate 71, upon which the water discharged against the inner walls of the towers collects to be led off through a pipe 72. The water discharged against the outer walls of the towers collects in a trough 73 surrounding each tower and is led off through a pipe 74.

The bottom of each tower is formed with a floor 75 made wholly or in part of porous aerating plates 76 and there is a plenum chamber beneath the floor, to which air for aerating purposes is supplied through a valved pipe 77. The duct 67 connecting the outlet of tower 64 and the inlet of tower 65 is provided with aerating plates 78 forming the tops of chambers 79, to which air is supplied through valved pipes 80, the air escaping through one or more vents 80a.

In the operation of the apparatus shown in FIGS. 8 and 9, the material entering the top of tower 64 is aerated and travels with turbulent flow through the tower to the bottom outlet, the material being cooled in such movement by giving up heat through the inner and outer walls of the tower to the cooling medium. The material issuing from the tower is conducted through passage 67 into the bottom of tower 65, in which the material travels upwardly with turbulent flow to the outlet and is carried away through pipe 68. In its travel through tower 65, the material is further reduced in temperature by heat transfer through the side walls of the tower.

The apparatus shown in FIG. 10 comprises a cooling tower 81 annular in form and generally similar to that shown in FIG. 6. The space within the inner cylindrical wall of the tower is closed at the top and bottom to form a chamber 82, to the lower end of which the cooling water is supplied through a pipe 83 to escape at the upper end through a pipe 84 discharging into a trough 85 encircling the upper end of the tower and discharging jets upon the outer cylindrical wall of the chamber. The water collects in a trough 86 encircling the tower near its lower end and is led off through a pipe 87.

The tower is provided at its bottom with porous plates 88 forming the top of a plenum chamber 89 supplied with air under pressure for aerating purposes, the air escaping through one or more top vents 90. The interior of the tower is connected at its lower end by a passage 91 to the lower end of a similar tower 92 and the bottom 93 of the passage is porous and forms the top of a plenum chamber 94 supplied with air for aeration through a pipe 95. The tower 92 has an internal cooling chamber 96 supplied with water through a pipe 97 and escaping at the top of the chamber through a pipe 98 leading to a trough 99 encircling the tower near its upper end and discharging jets of water upon its outer surface. The water is collected at the lower end of the tower in a trough 100 and led off through a pipe 101. The tower 92 has porous plates 102 at its bottom, which form the

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top of a plenum chamber 103 supplied with air under pressure through a pipe 104, the air escaping through one or more vents 105. The material entering the bottom of the tower through passage 91 escapes through an outlet 106 leading from the tower.

In order to insure a long travel of the material through the apparatus, the material is supplied to tower 81 through an inlet pipe 107, which enters the tower through its top at a point diametrically opposite the connection of passage 91 to the tower and terminates a short distance above the bottom of the tower. The material then leaves tower 81 through an outlet pipe 108, which is connected to one end of passage 91 and extends upward into tower 81 to terminate a short distance from the top thereof. The travel of the material through tower 92 is prolonged by placing the outlet 106 near the top of the tower and in diametrical relation to the connection of passage 91 to the tower.

The operation of the apparatus of FIG. 10 is similar to that of FIGS. 8 and 9, but an increased cooling effect is obtained by the use of the inlet and outlet pipes 107 and 108.

The apparatus of FIGS. 11 and 12 is similar to apparatus of FIG. 10, except that the inlet and outlet pipes 107, 108 are not employed and the travel of the material through the towers 109, 110 is prolonged in different manner. The towers are connected at their lower ends by an aerating passage 111, which is similar to the passage 91, and tower 109 has a vertical partition 112 lying at one side of the inlet 113 into the passage 111. The tube 114 supplies material to tower 109 through the top of the tower and close to and on the side of the partition 112 opposite to the outlet 113. The tower 110 has a vertical partition 115 at one side of and close to the connection 116 of passage 111 to the tower and the tower has an outlet 117 leading from its interior near its upper end and on the side of partition 115 opposite to the connection 116.

The apparatus shown in FIG. 13 includes a tower 118 having a bottom 119 formed of porous plates closing the top of a plenum chamber 120 supplied with air for aeration through a pipe 121, the air escaping through vents 122. The tower is connected by an aerating passage 123 to a similar tower 124 and the passage has an inlet tube 125 extending upwardly from the passage into tower 118. An annular cooling chamber 126 extends into tower 118 through its top and the space within the inner cylindrical wall 127 of the chamber is open at the bottom and has a closed top with vents 128 and a material inlet pipe 129. Cooling water enters the cooling chamber through an inlet pipe 130 extending through the top of the chamber and terminating near its lower end and the water is led away from the top of the chamber through a pipe 131 to a trough 132 encircling the upper end of the tower and discharging the water in jets against the outer surface of the tower. The water is collected in a trough 133 encircling the tower near its lower end and led away through a pipe 134.

The tower 124 contains an annular cooling chamber 135 similar in all respects to the chamber 126 and is cooled externally by water, which has passed through the chamber and is directed against the outer wall of the tower from a trough 136. The tower is provided at its bottom with aerating means generally designated 139 and has an outlet pipe 140 leading from the tower near its upper end and at a point diametrically opposite its connection to the passage 123.

The operation of the apparatus of FIG. 13 is similar to that of the apparatus of FIG. 10, but a greater cooling action is obtained in that the cooling chambers 126 and 135 have surfaces in contact with the material, which are of greater area than the corresponding surfaces of chambers 82 and 96.

The form of the apparatus shown in FIG. 14 is similar to one of the towers employed in the apparatus of FIG. 13 and includes a tower 141 having an aerating bottom

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142 and top air vents 143. An annular cooling chamber 144 extends into the tower through its top and the space inside the inner cylindrical wall 145 of the chamber is closed by a top 146 having air vents 147 and an opening, to which the material supply pipe 148 leads. Cooling water is introduced into the chamber through a pipe 149, which extends through the top of the chamber and terminates close to its bottom, and the water leaves the chamber through a discharge pipe at its top, which conducts the water into a trough 151 encircling the top of the chamber and constructed to discharge water upon the outer side wall of the tower. The water is collected in a trough 152 encircling the tower near its lower end and having a discharge pipe 153. The material, which enters the tower from pipe 148, travels down through the interior of the annular cooling chamber and then passes up outside the chamber to a discharge pipe 154. As in the construction shown in FIG. 13, the apparatus described has three surfaces, through which heat is taken from the material.

The apparatus shown in FIG. 15 comprises an annular tower 155, which is provided with a floor made of porous plates 156 closing the top of a plenum chamber 157 supplied with air through a pipe 158, and the air traveling upwardly through the chamber escapes through top vents 159. The space defined by the inner cylindrical wall 160 of the tower is closed at the bottom and water from a trough 161 lying above the top of the space is directed by a baffle 162 upon the interior of wall 160 and is led away from the bottom of the space through a pipe 163. An annular cooling chamber 164 open at the top is formed within the tower by concentric walls 165, 166 and an annular water trough 167 is mounted above the top of the chamber and discharges water upon a baffle 168, which causes the water to flow down walls 165, 166. The lower end of the chamber is connected by a plurality of pipes 169 to the space within the inner cylindrical wall 160 of the tower and the water is led off through pipe 163. A trough 170 encircles the tower near its upper end and is supplied with water by a pipe 171, which also supplies water to the troughs 161 and 167. The water from trough 170 is discharged from the trough and flows down the outer cylindrical wall of the tower to be collected in a trough 172, from which the water is led off through a branch pipe 173 connected to pipe 163. The material to be cooled is admitted through a supply pipe 175 into the space defined by the walls 160 and 166 of the cooling chamber and travels downwardly through the space and then upwardly outside wall 165 of the chamber to a discharge pipe 176.

The apparatus shown in FIG. 15 is a development of that shown in FIG. 14, but is more efficient in that it includes four surfaces, through which heat may be abstracted from the material.

While the apparatus has been described as used for cooling powdered materials, it will be apparent that it can be employed in the heating of such materials. When the apparatus is used for heating purposes, the heating medium is caused to travel in contact with the heat-conducting walls of the apparatus and, when appropriate, the walls may be jacketed to confine the medium.

I claim:

1. An apparatus for cooling a hot powdered material, which includes a pair of independent chambers, each being of substantial height in relation to its transverse dimensions and having relatively closely spaced opposed vertical walls of heat-conducting material, one chamber having an inlet for admitting powdered material into the chamber near its upper end and an outlet for discharge of powdered material near its lower end, the other chamber having an inlet for admitting powdered material into the chamber near its lower end and an outlet for discharge of powdered material near its upper end, a connection outside the chambers between the outlet of the first chamber and the inlet of the second, means for causing a

flow of a cooling liquid along the outer surfaces of the heat-conducting walls of the chambers, and means at the bottom of each chamber for introducing air into the powdered material within the chamber to render it fluent.

2. The apparatus of claim 1, which includes means at the bottom of the connection for introducing air into the powdered material traveling through the connection.

3. The apparatus of claim 1, which includes a third chamber, which is of the same construction as the first, a connection between the outlet for powdered material from the second chamber and the inlet for powdered material into the third chamber, means for causing a cooling liquid to flow in contact with the outer surfaces of the heat-conducting walls of the third chamber, and means at the bottom of the third chamber for introducing air into the powdered material within the chamber to render it fluent.

4. An apparatus for cooling a hot powdered material, which includes a pair of independent chambers each defined by inner and outer coaxial heat-conducting walls, one chamber having an inlet for material at its upper end and an outlet for material at its lower end, the second chamber having an inlet for material at its lower end and an outlet for material at its upper end, a connection between the outlet of the first chamber and the inlet of the second, means for causing a cooling liquid to flow over the external surfaces of the inner and outer walls of the chambers, and means at the bottom of the chambers for introducing air into the material to render it fluent.

5. The apparatus of claim 4, in which means disposed between the walls of at least one chamber prolong the travel of the material from the inlet to the outlet.

6. An apparatus for cooling hot powdered material which comprises a pair of chambers each having inner and outer vertical coaxial heat-conducting walls connected at their upper ends, the outer wall extending downward below the inner wall and the inner wall being double and defining an annular cooling chamber, a closure for the upper end of the inner wall, a closure for the lower end of the outer wall, and means for causing a flow of cooling liquid through the annular cooling chamber and along the outer surface of the outer wall, the first chamber having an outlet for material at its lower end and an inlet for material at its upper end leading into the space defined by the inner wall of the annular cooling chamber, the second chamber having an inlet for material at its lower end and an outlet for material at its upper end, a connection between the outlet of the first chamber and the inlet of the second, and means at the bottom of each chamber for introducing air into the material within the chamber to render it fluent.

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