

Sept. 20, 1938.

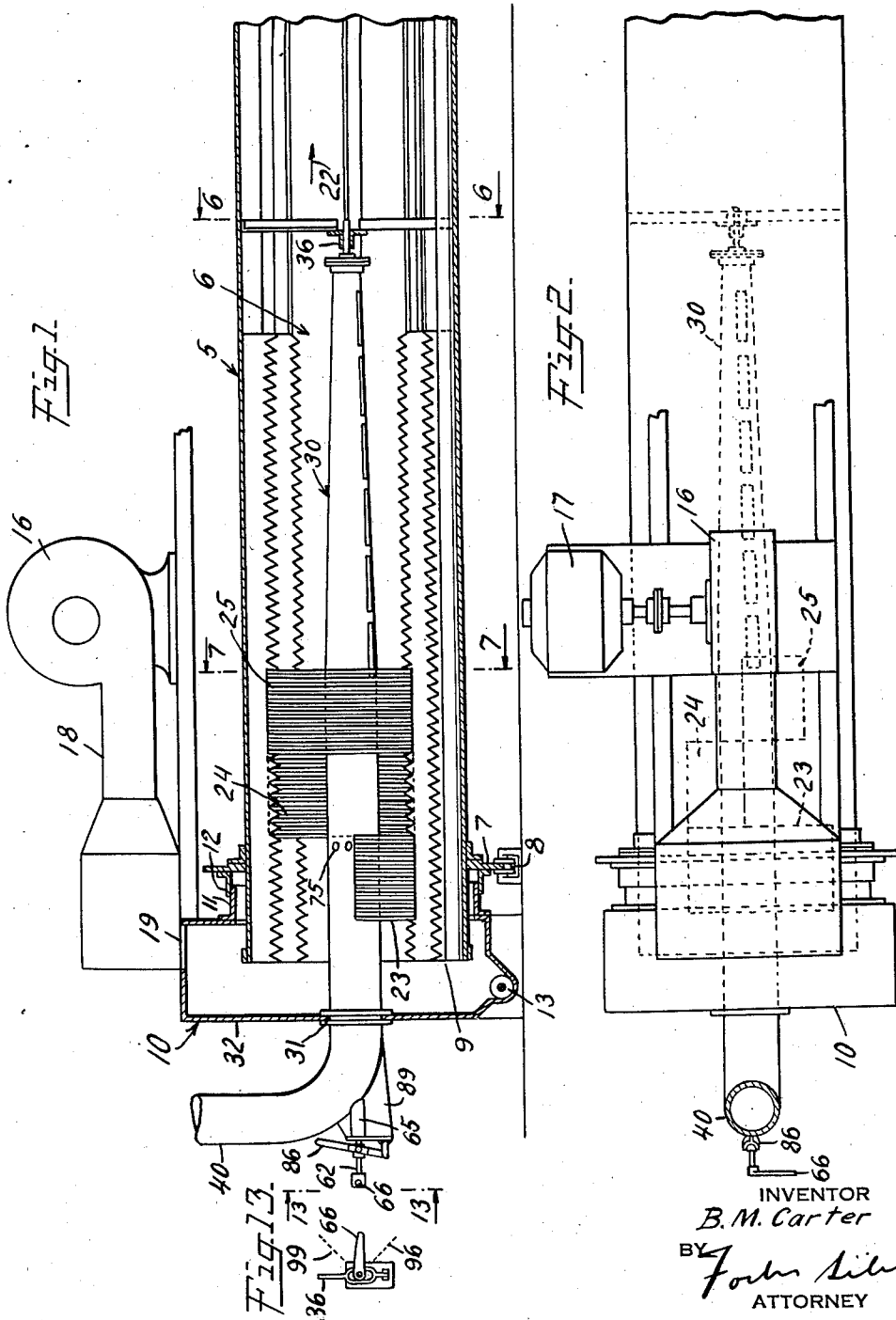
B. M. CARTER

2,130,731

APPARATUS FOR TREATING MATERIAL

Original Filed Jan. 3, 1933

2 Sheets-Sheet 1



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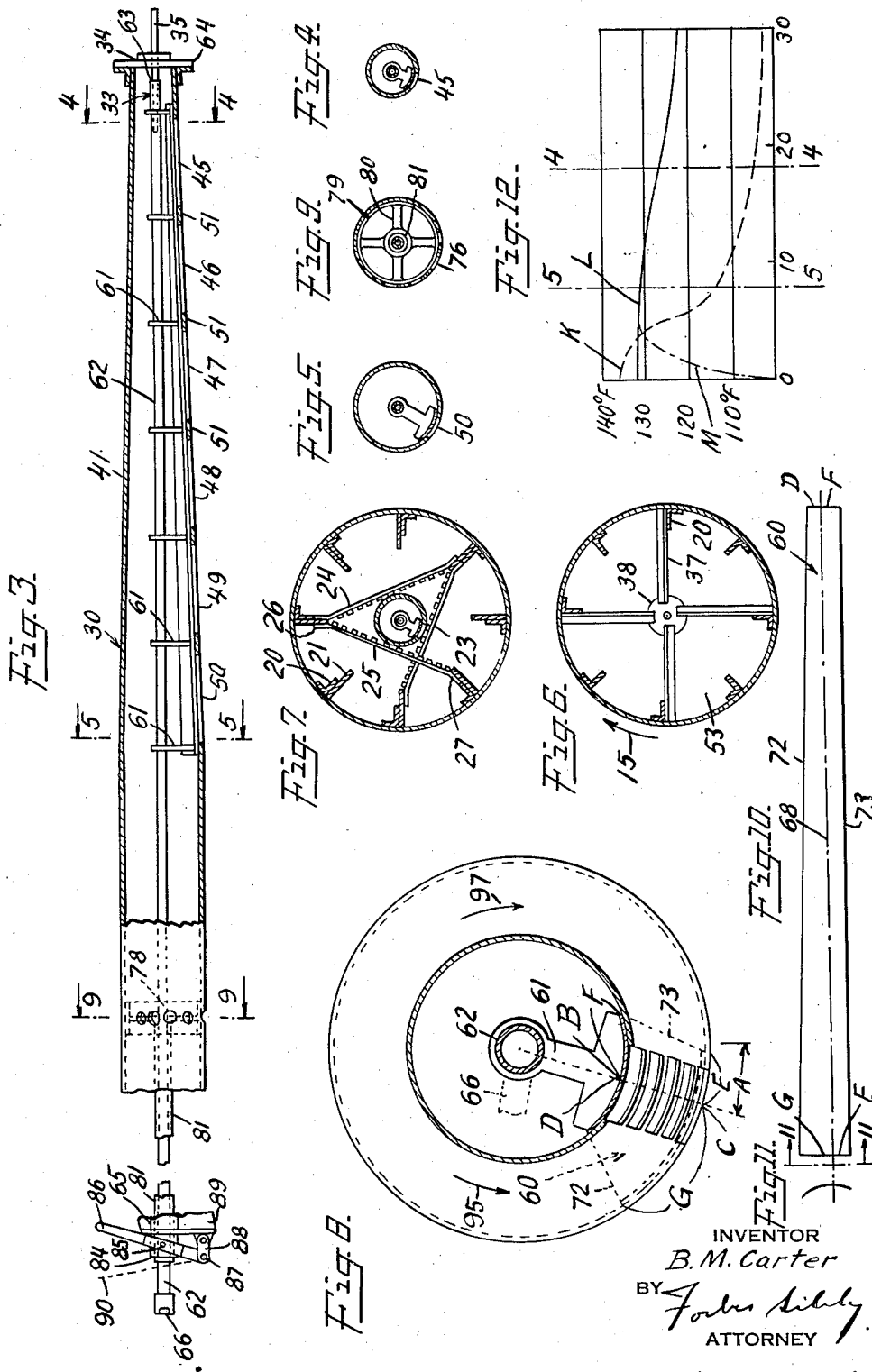
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UNITED STATES PATENT OFFICE

2,130,731

APPARATUS FOR TREATING MATERIAL

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Original application January 3, 1933, Serial No.
649,786. Divided and this application April 28,
1937, Serial No. 139,478

9 Claims. (Cl. 34-6)

This application is a division of my co-pending application Serial No. 649,786, filed January 3, 1933.

This invention relates to apparatus for drying materials, and is especially directed to apparatus for drying salts and similar substances which are subject to softening or liquefaction at relatively low temperatures, and thus must be dried at temperatures below the softening point.

In the more specific aspects, the invention is primarily directed to rotary drum or cylinder drying apparatus. Drying material in such apparatus has been heretofore proposed. In prior operations, it has been customary to continuously pass the material to be dried through an elongated rotary drum against a countercurrent flow of heated drying medium such as air. Because of the low melting point of the salts or similar materials being dried, it is necessary in practical operations that the highest temperature of the drying air be relatively low, i. e., considerably less than the softening point of the material. In countercurrent drying, the nature of the operation is such that the temperature of the heated drying air is greatest at the air inlet-salt outlet end of the drying zone or chamber. The temperature of the heated drying air decreases as the air current passes through the drying zone, and is at a minimum at the point where the air leaves the salt inlet-air outlet end of the drying zone. Hence, the moisture-carrying capacity of the air current is at a minimum as the air stream leaves the drying chamber. Accordingly, the moisture-carrying capacity of the air as it is discharged from the drier, together with other factors, limits the production of dry material by a single unit of apparatus.

The invention aims principally to provide apparatus for drying salts and similar materials of such construction that the output of a unit of given size may be largely increased. A further understanding of the objects and advantages of the invention may be had from a consideration of the following description taken in connection with the accompanying drawings, in which

Fig. 1 is a vertical, longitudinal section of one end of the dryer, showing in elevation an axially disposed gas distributing pipe;

Fig. 2 is a plan view of the apparatus;

Fig. 3 is an enlarged, longitudinal vertical section of the gas distributing pipe;

Fig. 4 is a transverse section on line 4-4 of Fig. 3;

Fig. 5 is a transverse section on the line 5-5 of Fig. 3;

Fig. 6 is a transverse section on line 6-6 of Fig. 1;

Fig. 7 is a similar transverse section on line 7-7 of Fig. 1;

Fig. 8 is an enlarged view, partly in section, of that portion of the gas distributing pipe between sections 4-4 and 5-5, Fig. 3;

Fig. 9 is a transverse section on line 9-9 of Fig. 3;

Fig. 10 is a developed plan of a damper in the gas distributing pipe;

Fig. 11 is an end elevation of the damper taken on the line 11-11 of Fig. 10;

Fig. 12 shows temperature curves, the purpose of which will be hereinafter noted, and

Fig. 13 is an elevation taken approximately on the line 13-13 of Fig. 1.

Referring to Fig. 1 of the drawings, the reference numeral 5 indicates one end of a cylindrical drum providing a drying chamber 6. The drum carries several longitudinally spaced, circumferential tires 7 resting in supporting rollers 8. The end of the drier, not shown, has mounted thereon an annular gear meshing with a drive pinion through which the drum is rotated from a source of power. The salt outlet end 9 of the drum projects into a fixed housing 10 into the bottom of which material is continuously discharged from the drum. One vertical side wall of the housing 10 has attached thereto a circular flange 11 engaging a flange 12 carried by the tire 7, flanges 11 and 12 forming a substantially gas-tight joint between the rotary drum and the fixed housing 10. Material may be continuously withdrawn from the housing by a screw conveyor 13.

The opposite end of the drum, the salt inlet-air outlet end, not shown in the drawings, extends into a fixed housing similar to housing 10, having an outlet pipe for discharging moisture-laden air from the apparatus. Such fixed housing is also equipped with conventional means for continuously feeding material into the salt inlet end of the rotary drum. As is customary in apparatus of this type, the salt inlet end of the cylinder is elevated slightly to facilitate movement of material gradually toward the salt discharge end in fixed housing 10. The drum is rotated in the direction of the arrow 15 in Fig. 6.

Reference numeral 16, Figs. 1 and 2, indicates a blower, driven by motor 17, the pressure side of the blower being connected through conduit 18 and opening 19 with the interior of housing 10. In operation, drying medium, such as heated air, is fed into the salt discharge end 9 of the drum from the housing 10, passes through drying

chamber 6 countercurrent to the direction of movement of the salt, and flows from the salt inlet end of the drum into a fixed housing similar to housing 10, from which the air is eventually discharged to the atmosphere.

As shown in Figs. 1 and 7, projecting from the inner face of the cylinder 5 are longitudinal angle irons 20 to which are attached serrated plates 21, shown in elevation in Fig. 1. In the particular embodiment of the apparatus described, the serrated plates extend longitudinally about half the length of the drum, and, during rotation of the latter, carry material being dried toward the top of the drying chamber 6 and shower the material into the current of hot air passing through the drier in the direction of the arrow 22 (Fig. 1). Mounted in the drum, in staggered relation, near the salt discharge end are baffles or grilles 23, 24 and 25 shown in side and end elevations in Figs. 1 and 7 respectively. The baffles are screen-like frames, connected at longitudinal edges 26 and 27 with adjacent serrated plates 21. The baffles prevent lumps from passing through with dry salt, and effect a more thorough cascading of fine, nearly dried material than is secured by the serrated angles. At these grilles, the nearly dry salt is effectively showered through the drying atmosphere in a manner which could not be effected at the opposite end of the kiln where the salt is wet.

Additional quantities of heated drying medium are fed into the drum through an axially disposed, longitudinal distributing pipe 30 shown in elevation in Fig. 1, and in enlarged section in Fig. 3. The inlet end of pipe 30 is fixedly supported at 31 in outer side wall 32 of the housing 10. Pipe 30 is cylindrical from wall 32 to section 5-5 in Fig. 3. From this point, pipe 30 tapers uniformly toward the small end 33, which is closed off by a circular disk 34. Rigidly connected to and extending through disk 34 is a stub shaft 35, the outer end of which passes through a bearing 36 supported by a spider, the arms 37 of which are riveted at the outer ends to angle irons 20 and at the inner ends to the circular flange 38 of the bearing 36. Hence, the small end of the fixed pipe 30 is maintained in position by bearing 36. The gaseous drying medium, such as air, is fed into pipe 30 from an inlet conduit 40. The top side of pipe 30 may advantageously be covered with insulating material, such as asbestos, to prevent overheating and possible melting of salt material falling on top of the pipe during rotation of the drum.

The tapered portion 41 of the air pipe 30, between transverse sections 4-4 and 5-5, is provided on the lower side with a plurality of elongated openings 45, 46, 47, 48, 49, and 50 of uniform length and width. The openings are separated by the short sections 51 left uncut to avoid weakening of the pipe. In effect, all of the openings together may be considered as constituting a single elongated slot in the underside of tapered section 41. As noted, the drum rotates in the direction of the arrow 15 in Fig. 6, and accordingly the shell, in conjunction with angles 20 and plates 21, tends to carry material upwardly through the left half 53 (Fig. 6) of drying chamber 6. In order to cause air entering the drying chamber 6 through openings 45-50 to be directed toward the salt being dried, the longitudinal center line of openings 45-50 is displaced circumferentially from the vertical a distance equal to an angle A as indicated particularly in Fig. 8, and also in Figs. 4 and 5.

Angle A may for example be about 20°. The openings are therefore off the vertical center in the direction of rotation of the cylinder so that the hot air is directed toward the surface of the bed of salt at a point at which the bed is of substantial depth.

The passage of air through openings 45-50 is controlled by an eccentric damper indicated generally by reference numeral 60, and shown in Fig. 10 in plan. In Fig. 10, the damper is curved upwardly out of the plane of the paper as will be seen from Fig. 11. The curvature of the damper is such that the convex surface conforms with the inner surface of tapered section 41 of the air pipe 30. The damper is rigidly connected through hangers 61 to a longitudinally extending pipe 62, the inner end 63 of which fits over and may oscillate about the inner end of fixed stub shaft 35. The opposite end of pipe 62 is rotatably supported in a fixed bearing 65 shown in Figs. 1 and 3. Keyed to the outer end of pipe 62 is an operating handle 66 (Fig. 13) and since the inner end of the pipe is rotatably carried by stub shaft 35 and the outer end of the pipe is rotatably supported in bearing 65, the position of the damper 60 relative to the openings 45-50 may be controlled by manipulation of handle 66.

Referring to Fig. 10, line 68 represents the center line or crest of the damper. When the latter is positioned to close all openings 45-50, as shown in the large section Fig. 8, line 68 coincides with the longitudinal center of openings 45-50 indicated by the dotted line between points B and C (Fig. 8). In the particular damper illustrated, although specific dimensions are immaterial, dimension D (Fig. 10) is slightly less than dimension E (measurements being taken from the center line 68 on the convex surface to edges 72 and 73). Dimension F is greater than dimension E, and dimension G is somewhat less than twice dimension F. Thus as shown in Fig. 10, edges 72 and 73 are disposed in different angular relation with respect to center line 68, that is, the taper of edge 72 with respect to line 68 is sharper than the taper of edge 73 with respect to center line 68. When the damper is in place in pipe 30 and adjusted so that all openings 45-50 are closed, longitudinal edges 72 and 73 and transverse edges represented by dimensions D, F, E, and G occupy the positions shown in Fig. 8.

The gas distributing pipe 30 is also provided at 75 (Fig. 1) with a plurality of openings 76 shown in section in Fig. 9. Openings 76 are to the right of the vertical (Fig. 9) and are arranged similarly to openings 45-50 so that hot gas entering the drum through openings 76 is directed into the body of salt being carried upwardly in the direction of the arrow 15 of Fig. 6. Openings 76 are controlled by a longitudinally sliding damper 78 (Fig. 3) comprising a ring 79 carried by spider arms 80, the inner ends of which are connected to a sliding sleeve 81 extending outwardly through bearing 65 (Fig. 1). Attached to the outer end of sleeve 81 is a lug 84 (Fig. 3) to which is pivotally connected at 85 an operating handle 86 one end of which is pivoted at 87 to the end of a link 88 pivoted to a fixed bracket 89, shown more clearly in Fig. 1. By this construction, it will be seen that movement of the handle 86 from the position shown in full lines in Fig. 3 to the dotted line 90 effects longitudinal movement of damper ring 79 away from openings 76.

The invention may be employed in practice substantially as follows:

As noted, the invention is directed particularly to apparatus for drying material subject to softening or liquefaction at relatively low temperatures, and hence should be dried at temperatures below the softening point. For convenience and by way of illustration, the operation of apparatus of the invention will be described in connection with the drying of trisodium phosphate, a salt containing considerable quantity of water of crystallization. It is to be understood, however, that the apparatus of the invention is applicable for use not only to the drying of salts containing water of crystallization, but to the drying or treatment of any material from which water or other vaporous constituents must be evaporated at temperatures below that at which liquefaction or incipient fusion of the material treated would take place.

In customary commercial practice, trisodium phosphate crystals, containing 12 molecules of water, are first separated from the mother liquor by means of a filter, and may be washed with water to remove mother liquor ordinarily retained by the dewatered crystals. For example, after the water wash, one well-known type of centrifugal filter delivers a product containing from 5% to 8% free water. Initial dewatering of the crystal slurry and the apparatus employed constitute no part of this invention.

To meet certain trade requirements on trisodium phosphate crystals, for example, all free water and a small amount of the water of crystallization must be removed from the centrifuged salt so that the dried product will contain the equivalent of not less than about 101.5% of $\text{Na}_3\text{PO}_4 \cdot 12\text{H}_2\text{O}$ and such water is removed by exposure of the wet salt to a heated gaseous drying medium such as hot air. Heretofore, drying has been accomplished in operations involving counter-current flow of salt and hot air through a rotary drum, the hot air initially introduced into the drier at the salt discharge end being heated to the desired temperatures by any convenient means. In such operations, involving countercurrent flow of salt and drying air, the amount of salt which may be dried in any given apparatus is dependent upon the difference in water content between the air entering the salt outlet end and leaving the salt inlet end of the drier. Furthermore, the output of such a drier per unit of time is more or less dependent upon atmospheric conditions, the capacity being less in summer than in winter on account of the higher temperature and the humidity of the atmosphere in warm weather.

The basic features of the process aspects of the invention may be more clearly understood from a brief consideration of some of the fundamental principles involved. In summer in the temperate zone, temperatures of about 80° F. and relative humidity of about 70% frequently prevail. Under these conditions, atmospheric air contains about 7.6 grains of water per cubic foot. On heating, the volume increases, and the moisture carrying capacity is raised so that such air on heating to 100° F. contains about 7.4 grains of water per cubic foot, and has a relative humidity of about 38%. On further heating to, say, 120° F., such air, as introduced into the salt outlet end of the drier, would contain about 7.1 grains of water per cubic foot and the relative humidity decreases to about 21%. Since in practical operation, complete equilibrium is not ob-

tained, the humidity of the heated air discharged from the salt inlet end of the drier decreases as the temperature increases. Thus, air leaving the salt inlet end of the drier at about 100° F. and relative humidity of about 60% would carry about 11.6 grains of water per cubic foot, or about 4.2 grains per cubic foot in excess of entering atmospheric air heated to about 100° F., having a relative humidity of about 38% and containing about 7.4 grains of water per cubic foot. Further, air leaving the salt inlet end of the drier at about 120° F. and a relative humidity of about 50% would carry about 17.2 grains of water per cubic foot, or about 10.1 grains per cubic foot in excess of entering atmospheric air heated to about 120° F., having a relative humidity of about 21% and containing about 7.1 grains of water per cubic foot. Accordingly, a given volume of air leaving the drier at about 120° F. and about 50% relative humidity would dry more than twice the amount of wet salt that would be dried by the same amount of air leaving the drier at about 100° F. and about 60% relative humidity.

It will be understood the output per unit of time of a drier of a given size is determined by quantity of air employed, moisture content of such air, and the temperature to which the air is heated prior to introduction to the drier. The initial moisture content of the air is determined by atmospheric conditions, and is not subject to control, unless the air is previously conditioned by refrigeration, drying, etc. The remaining two controllable factors are also subject to limitation. The volume of drying air employed cannot be in excess of that at which it would tend to carry the material out of the drier in suspension, and on the other hand, the temperature of the drying air cannot be raised above that at which the materials being treated would be deleteriously affected.

In the present description of the operation of the process, it is to be understood the reference to specific temperatures, volumes of drying air, and dimensions of the drier are illustrative, and are mentioned only to facilitate description of one embodiment of the invention.

Pure trisodium phosphate crystals melt at about 170° F., but the commercial salt may not generally be exposed to temperatures in excess of about 140° F. without creating a sticky condition that produces undesirable caking. Thus, in practice it is not desirable to allow the maximum temperature of the drying air to exceed about 135° F. In prior practice, it has been customary to pass the salt continuously through a rotary drum in contact with a stream of air flowing countercurrent through the drier, the temperature of the drying air introduced into the salt outlet end of the drier being about 135° F.

It has been found that in prior practice, e. g. where wet salt and drying air pass countercurrent through the drier, the temperature of the drying air drops off rapidly, in the first one-third of the length of the drying chamber, and thereafter remains substantially constant until the air leaves the salt inlet end of the drier. In Fig. 12, the abscissa represents the length of the drying chamber, and the ordinate represents the temperature of the drying air. Dotted curve K approximately indicates the temperature conditions existing in the drier when operated in accordance with prior practice. From this curve, it will be seen that while passing through approximately the first third of the drier, the temperature drops from approximately 135° F. to say

about 110–112° F., and thereafter, during the subsequent two-thirds of passage through the drier, the temperature of the drying air decreases gradually to about 100° F., at which temperature the drying air passes out of contact with the wet salt being fed into the salt inlet end of the drier.

In accordance with the present invention, operations are conducted so that the temperature of the drying air leaving the drier is considerably raised, thus largely increasing the water carrying capacity of the drying air at the time of last contact with wet salt. By means of the present method and apparatus, conditions in the drying chamber may be so controlled that the temperature of the air leaving the drier may be regulated as desired within certain limits. From a consideration of the temperature curve K of Fig. 12, it will be seen that if properly regulated quantities of drying gas, heated to proper temperatures, are introduced into the drier beginning at points beyond approximately the first third of the drier (measuring from the salt outlet end), the temperature of the drying atmosphere in the subsequent two-thirds of the drying chamber may be raised, and the water carrying capacity of the drying air, as discharged from the salt inlet end of the drier, largely increased. In the present invention, such temperature control in the drier may be had by introducing heated gas into the drying chamber 6 through the gas distributing pipe 30, by suitable regulation of dampers 60 and 78.

In the apparatus illustrated, it may be assumed for example, drum 5 is about 30 feet long. The taper of pipe 30 begins at section 5–5, Fig. 3, about 7 feet from the salt outlet end 9 of the drum, and at a point which is indicated by a corresponding line 5–5 on Fig. 12. As the temperature of the drying air has dropped materially at about line 5–5 (Fig. 12), to accomplish the purposes of the invention, controlled quantities of air heated to proper temperatures are introduced into the drying chamber through one or more of the openings 45–50 of pipe 30. It is noted, section line 4–4 (Fig. 3), corresponds approximately with line 4–4 on Fig. 12. The particular portion of the drier, between lines 5–5 and 4–4 (Fig. 12) into which hot gas from pipe 30 is introduced is selected by manipulation of the damper 60.

In Fig. 8, the damper is shown in such position that all openings 45–50 are closed. It will be recalled from the foregoing description that edges 72 and 73 are pitched oppositely and at different angles with respect to center line 68 of damper 60.

Referring to Fig. 8, it will be seen that movement of damper 60 in the direction of the arrow 95, first uncovers a portion or the whole of opening 45 nearest the small end of tapered section 41. Thus, a comparatively short downward movement of handle 66 (Fig. 13) uncovers the opening 45, and admits heated air from the pipe 30 into the interior of the drum at the point at which opening 45 is positioned. Because of the relatively sharp pitch of edge 72, with respect to center line 68 of the damper 60, it will be seen that continued movement of damper 60 in the direction of the arrow 95 successively uncovers openings 45–50 in the order named, until when the handle 66 is in the position of the dotted line 96 (Fig. 13), all openings 45–50 are uncovered, and because of the taper of pipe 30 substantially equal quantities of air pass through each opening into the drum. Thus, when it is desired to introduce air into parts of chamber 6 nearer the salt inlet end

than salt outlet end 9, handle 66 is moved downwardly, and as many of the openings as necessary may be uncovered, and additional hot gas admitted to selected portions of the drum.

In other situations arising in practice, it may be desirable to introduce additional hot gas only or initially in portions of the drying chamber nearer the salt discharge end of the drum. This may be accomplished by raising handle 66 which causes movement of damper 60 in the direction of the arrow 97 in Fig. 8. As edge E of the damper is shorter than edge F, it will be seen that such movement of the damper first uncovers the opening 50 adjacent the section line 5–5 of Fig. 3. On account of the pitch of edge 73, with respect to center line 68 of damper 60, further movement of the damper in the direction of the arrow 97 uncovers opening 50–45 progressively in the order named. When handle 66 is in the position of dotted line 99, all openings are uncovered, and air enters drying chamber 6 in the same manner as noted above where the damper was fully opened by downward movement of handle 66.

Thus, by moving handle 66 downwardly, air is introduced into the drier first at the small end of the tapered section, and then progressively toward the larger section, if downward movement of handle 66 is continued. On the other hand, by lifting handle 66, air is introduced into the drum first through the opening 50 adjacent section line 5–5 of Fig. 3, and thereafter, on further upward movement of handle 66, through openings progressively nearer the small end of a distributing pipe 30. Accordingly, by adjustment of the position of the damper to suit specific operating conditions, additional quantities of hot drying gas may be introduced into any portion of the drying chamber, and the temperature conditions therein controlled as required. It will be seen that by reason of the difference of pitch of edges 72 and 73 with respect to center line 68 of the damper, all the openings 50–45 may be more rapidly opened or closed by raising handle 66 or lowering the same to the horizontal position, thus in effect using edge 73 as the "working" edge of the damper. On the other hand, downward movement of handle 66 and raising the same to the horizontal position makes edge 72 the working edge, and as the pitch of edge 72 is sharper, with respect to center line 68, the openings 45–50 are uncovered or covered at a less rapid rate. In practice, it has been found generally desirable to admit additional hot drying gas nearer the salt inlet end, say through openings 45, 46 and 47, rather than near the salt outlet end. Thus, handle 66 is manipulated so that edge 72 is employed as the working edge of the damper.

In one particular series of tests, carried out in midsummer over an extended period of time, and at an average atmospheric temperature of about 80° F. and about 70% relative humidity, operations were conducted so that approximately 40 tons of dried trisodium phosphate were produced by the drier in 24 hours, about 10.8% free and combined water having been removed from the wet salt. The total quantity of drying medium employed was about 5,000 cubic feet per minute. About half this volume of air, at temperatures about 131° F., was fed into the drier from the fixed housing 10. An equal volume, consisting of products of combustion from an oil burner, heated to temperatures of about 400° F. was fed into the distributing pipe 30 from pipe 40, and introduced into the drier with all the openings 45–50 un-

covered. The combined volume of gas left the drier at temperatures of about 122° F., the temperature prevailing in the drum being indicated approximately by the curve L, in Fig. 12. In the

above tests, the following results were obtained:

	Feed	Product
	Percent	Percent
$\text{Na}_2\text{PO}_4 \cdot 12\text{H}_2\text{O}$	92.96	103.04
NaOH	1.60	1.25
Na_2CO_3	.78	1.23

By proceeding in accordance with the above, the output of the drier was approximately doubled over operations carried out in a drier of the same size, but built and operated as in the prior practice. It will be seen from Fig. 12, the temperature of the drying medium leaving the drier is about 20° higher than previously obtainable, thus effecting the largely increased capacity of the drier.

By operation of damper 78 controlling openings 76 positioned relatively near the salt discharge end of the drum, additional quantities of hot drying gas may be fed into the drum, if desired, to regulate temperatures in the drying chamber, and to provide for particular operating conditions arising. The construction including damper 78 also permits operation of the process in such manner that the air fed into the drier from the housing 10 may be at temperatures of about 100° F., thus cooling the dried salts, to some extent, just prior to discharge from the drier, such cooling advantageously permitting packaging of the product without caking, and without the use of additional equipment to cool the product prior to packaging.

Where air or other gaseous heating medium is introduced into the drying chamber from housing 10 at lower temperatures of about, say, 100° F., the temperature in the drying chamber just beyond the salt outlet end 9 may be rapidly raised to the desired maximum temperature by opening the damper 78, and permitting admission of hot gases through openings 76. By this operation in conjunction with manipulation of damper 68, a temperature curve in the drier approximating curve M may be obtained, which curve, as will be seen, converges with curve L at a point near the salt outlet end of the drier, the temperatures thereafter approximating those which prevail in instances where the drying air is initially introduced at 131-132° F.

In the above specific example, it will be noted the hot combustion products entering the drier through pipe 30 were heated to temperatures of about 400° F. No particular temperatures for the high temperature gas supply need be employed. Improved results, over prior practice, may be obtained where the hot gases entering through pipe 30 are at any temperature above that of the gas entering the drier from housing 10. The higher the temperature of the gases entering the drier from pipe 30, the higher the temperature of the combined gas stream leaving the salt inlet end of the drier, and accordingly the greater the output of the drier and the efficiency of the drying operation. To obtain substantially improved increase in the drier capacity, the temperature of the gas introduced through pipe 30 should not be less than about, say, 250° F. The upper limit of the temperature of the gas from pipe 30 is controlled by the nature of the material being treated. The temperature of such gas should not be high

enough to raise the temperature of the combined gas stream in the drier sufficient to cause softening or injury to the material being treated. The volume of the combined gas stream in the drier should not be in excess of that at which material would be carried away in suspension.

It will also be understood any suitable gas may be used for both the high and low temperature supply. Air heated by heat exchange may be employed for either or both low and high temperature supply, and also combustion gases, if sootless, may be utilized for either or both the low and high temperature supply, thus eliminating use of steam heaters previously employed, and thereby effecting economies in cost of heat supplied to the drier.

I claim:

1. Apparatus for treating material comprising a rotary drum forming a treating chamber, means for introducing solid material to be treated into one end of the chamber, means for moving the material through the chamber, means for introducing a primary stream of gas into the opposite end of the chamber, means for passing the gas stream through the chamber countercurrent to the movement of the solid material, a fixed conduit projecting into the chamber from said opposite end and terminating in a tapered section extending longitudinally through a substantial part of the chamber, an elongated slot in the underside of and extending substantially the length of the tapered section of the conduit, a damper in the conduit for closing the slot, said damper having oppositely pitched edges so formed as to close off, on movement of the damper, the whole of the slot or variable portions of either end of the slot, a second opening in the conduit adjacent said opposite end of the chamber, a damper to control said opening, and external means for operating said dampers.

2. Apparatus for treating materials comprising a chamber, means for introducing material to be treated into the chamber, a conduit in the chamber for introducing treating medium, an elongated opening in the conduit and a damper associated with the opening, said damper having oppositely pitched edges so formed as to close off on movement of the damper the whole of the opening or variable portions of either end of the opening.

3. Apparatus for treating material comprising a rotary drum forming a treating chamber, means for introducing solid material to be treated into one end of the chamber, means for moving the material through the chamber, means for introducing a primary stream of gas into the opposite end of the chamber, means for passing the gas stream through the chamber countercurrent to the movement of the solid material, a fixed conduit projecting into the chamber from said opposite end and terminating in a tapered section extending longitudinally through a substantial part of the chamber, an elongated slot in the underside of and extending substantially the length of the tapered section of the conduit, a damper in the conduit for closing the slot, said damper having oppositely pitched edges so formed as to close off, on movement of the damper, the whole of the slot or variable portions of either end of the slot.

4. Apparatus for treating material comprising a chamber, means for introducing material to be treated into the chamber, a conduit in the chamber for introducing treating medium, an opening in the conduit and a damper associated with the

opening, said damper having opposite edges disposed at different angular relation with respect to the intervening center line of the damper and so formed as to close off on movement of the

5 damper the whole of the opening or variable portions of either end of the opening.

5. Apparatus for treating material comprising a chamber, means for introducing material to be treated into the chamber, a conduit in the

10 chamber for introducing treating medium, an opening in the conduit and a damper associated with the opening, said damper having opposite converging edges so formed as to close off on movement of the damper the whole of the opening

15 or variable portions of either end of the opening.

6. Apparatus for treating materials comprising a chamber, means for introducing material to be treated into the chamber, a conduit in the chamber

20 for introducing treating medium, an opening in the conduit and a damper associated with the opening, said damper having oppositely pitched edges so formed as to close off on movement of the damper the whole of the opening or variable

25 portions of either end of the opening.

7. Apparatus for treating material comprising a chamber, means for introducing material to be treated into the chamber, means for passing the material through the chamber, means for

30 passing treating medium through the chamber in contact with the material, a conduit in the chamber, means for introducing additional treating medium into the conduit, an opening in the conduit and a damper associated with the opening,

35 said damper having oppositely pitched edges so formed as to close off on movement of the damper the whole of the opening or variable portions of either end of the opening.

8. Apparatus for treating material comprising

a chamber, means for introducing solid material to be treated into one end of the chamber, means for moving the material through the chamber, means for introducing a primary stream of treating medium into the opposite end of the chamber, means for passing said primary stream through the chamber countercurrent to the movement of the solid material, a conduit projecting into the chamber for introducing further quantities of treating medium, said conduit extending longitudinally through a substantial part of the chamber, an elongated opening in the conduit and a damper associated with the opening, said damper having oppositely pitched edges so formed as to close off on movement of the damper the whole of the opening or a variable portion of either end of the opening.

9. Apparatus for treating material comprising a rotary drum forming a treating chamber, means for introducing solid material to be treated into one end of the chamber, means for moving the material through the chamber, means for introducing a primary stream of gas into the opposite end of the chamber, means for passing the gas stream through the chamber countercurrent to the movement of the solid material, a conduit projecting into the chamber from said opposite end for introducing further quantities of treating medium, said conduit terminating in a tapered section extending longitudinally through a substantial part of the chamber, an opening in the tapered section of the conduit and a damper associated with the opening, said damper having oppositely pitched edges so formed as to close off on movement of the damper, the whole of the opening or a variable portion of either end of the opening.

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