

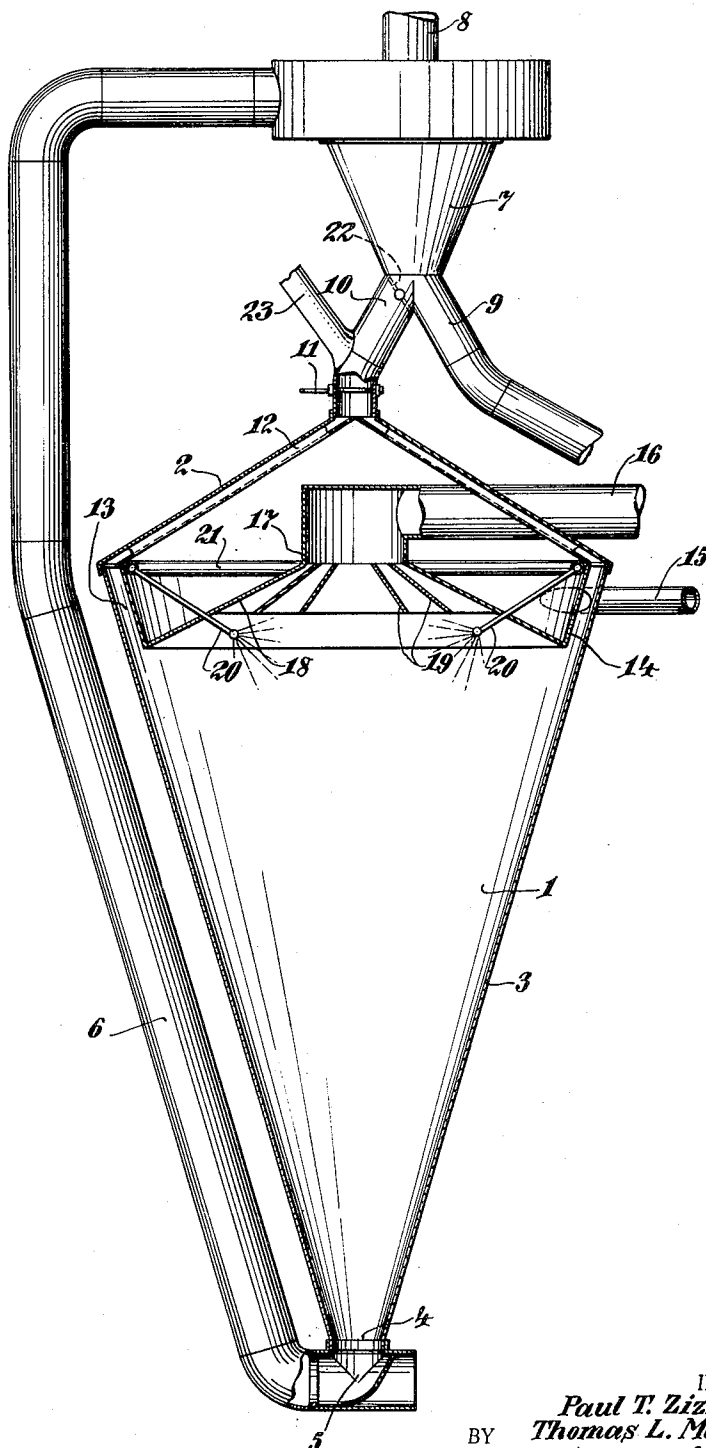
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P. T. ZIZINIA ET AL

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PROCESS AND APPARATUS FOR SPRAY DRYING

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INVENTORS
*Paul T. Zizinia and
Thomas L. McKenna,*
BY *Hoguet, Kary & Campbell,*
Their ATTORNEYS

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PROCESS AND APPARATUS FOR SPRAY DRYING

Paul T. Ziznia, Belmar, and Thomas L. McKenna,
Newark, N. J., assignors to Spray Dryer Laboratory Corporation, Jersey City, N. J., a corporation of New Jersey

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This invention relates to a process and apparatus for spray-drying solid-containing liquids or slurries and has particular reference to the prevention of adhesion of the dried or partly dried particles to the walls and internal surfaces of the drying chamber during the spray-drying operation.

Spray-drying apparatus usually consists of a drying chamber through which is passed a current of heated drying air into which is atomized the solid-containing liquid or slurry, so that intimate contact between the drying air and the minute solid-containing globules is effected with the result that the globules are dehydrated. Means for separating the resulting dry powder from the moisture-laden drying air is provided, either in the drying chamber itself or apart therefrom.

A major handicap to the continuous operation of spray-drying apparatus is the tendency of a large proportion of the dried and partly dried powder to adhere to the walls of the drying chamber. This condition may arise with any material, but it is especially acute when the material has a low normal melting point or is particularly sensitive to heat when freshly spray-dried, causing the surface of the particles to soften or remain soft, so that the particles are sufficiently sticky to adhere to the walls of the drying chamber.

One method of reducing the adhesion of the dried or partly dried powder to the walls of the drying chamber, etc., is to provide secondary zones of cold air in the drying chamber, which quickly chill the dried or partially dried solids as they leave the hot drying zone and thus surface-hardens them so that the tendency to stickiness is reduced. Examples of such an arrangement are illustrated in Patent No. 1,634,640, issued July 5, 1927, to Paul T. Ziznia. With this arrangement the dried material may be conducted through the drying chamber, the connecting ducts and the collecting devices without prohibitive loss, but even with this arrangement there is a wasteful dusting of the finer particles on the walls of the drying chamber and other parts of the apparatus. This thin layer of the finer particles burns after its moisture content has evaporated and causes fire as well as spoiling of the entire mass. Various expedients, such as scrapers, brushers, blowers, chains and the like have been employed in an effort to reduce this objectionable adhesion of the particles to the walls of the drying chamber, but have met with indifferent success. Furthermore, mechanical devices

such as scrapers, brushers, blowers, chains or the like are only useful where inorganic and non-sticky products are being spray-dried but with products that are sticky when hot, the cold air zone arrangement has proven heretofore to be the most effective method of reducing this objectionable adhesion of the particles to the chamber walls.

However, the employment of cold air zones necessitates the introduction of cold air to the extent of one-third to two-thirds of the total air volume, with the result that the temperature of the drying air is considerably reduced with a consequent reduction of its dehydrating properties, and, inasmuch as the cold air zone produces an abrupt change in temperature, the drying operation is terminated abruptly at a point where it might be desirable to continue the application of heat in certain instances and with certain products, to obtain special desired results. Consequently, in order to obtain a satisfactory degree of dehydration before chilling in the cold air zone, it has been necessary to operate with high initial temperatures or with a wastefully large supply of hot air, together with a finer degree of atomization or a larger drying chamber to secure the requisite degree of intimate contact with the hot air before chilling. These expedients, in addition to their manifest disadvantages, introduce many variables, with the result that there is considerable uncertainty as to the finished product with regard to residual moisture and physical structure, and injury is caused to the finished product because of the high operating temperatures, so that the difficulties of operation of a process which is normally somewhat critical are magnified.

In accordance with the present invention, a process and apparatus for spray-drying are provided which dispense with the necessity of providing a cold air zone and permit the natural dehydrating process to progress normally and continuously with normal operating temperatures and with normal volumes of air, without the objection that the particles adhere to the walls of the drying chamber, whether or not such adhesion would be due normally to stickiness, to dusting of the finer particles, or to softening of the surfaces of the particles due to the material of which they are formed or the heat in the drying chamber.

The invention comprises the provision of a scouring sheet of finely-divided dry material, preferably previously spray-dried powder of the same material as that which is to be spray-dried.

This dried powder, after being separated from the drying air, is reintroduced into the drying chamber at any suitable point and is caused to flow by gravity, accelerated by a small blast of air if desired, continuously over the walls of the drying chamber, thereby effecting a thorough scouring action for dislodging any particles which have adhered to the walls and reducing or preventing the tendency of other particles to adhere to the walls by providing a mobile shield between the walls and the drying particles. As occasional larger-sized, freshly spray-dried particles penetrate the powder sheet and adhere to the hot walls of the drying chamber they are quickly removed by the scouring action of the powder sheet. Also, the freshly spray-dried particles admix with the previously spray-dried particles of the powder sheet so that agglomeration of the former is prevented and the rate of dehydration is reduced, with the result that solidification takes place while the moisture content of the product is relatively high, which is a desirable condition with some products.

In order that the powder sheet be sufficiently dense to inhibit passage of the drying material therethrough and sufficiently heavy to provide an efficient scouring action, its volume is preferably considerably in excess of the volume of the drying material passing through the chamber. Also, in order to augment this scouring action toward the bottom of the chamber, where the tendency toward adhesion of the particles is normally more pronounced, and in order to increase the degree of admixture at the bottom of the chamber to prevent agglomeration and retard the rate of dehydration after formation of the particles, the chamber is preferably formed in a conical shape with the walls converging toward the outlet at the bottom, so that the powder sheet grows progressively denser and heavier. The incline of the walls is relatively steep so that the speed of movement of the powder sheet is not inconsiderable and yet it is sufficiently slow to provide the intimate contact with the walls which is a necessary prerequisite to a thorough scouring action. The propelling air is preferably introduced tangentially so as to impart a spiral motion to the powder sheet.

It will be seen that with this simple arrangement, spray-drying apparatus of average size can be employed without increasing the normal volume of air materially or without the necessity of heating the drying air to abnormally high initial temperatures to compensate for the chilling effect of a cold air zone, and without requiring mechanical expedients for keeping the walls of the drying chamber free of the dried or partially dried particles. Furthermore, in repeatedly passing through the drying chamber, the powder-sheet particles themselves are reheated and remain hot and when admixed with the freshly spray-dried particles, impart their heat thereto so that not only may the rate of dehydration of the fresh particles be reduced, but their cooling time may be prolonged so as to effect desired results. Accordingly, with this new arrangement, the variables are few and more readily controlled, so that the residual moisture in the finished particles and their size and physical structure may be readily and accurately predetermined and regulated.

For a more complete understanding of the invention, reference may be had to the accompanying drawing in which numeral 1 designates a drying chamber which is closed at the top 2

and is conical in shape with smooth, steeply inclined walls 3 converging at the bottom 4 toward the exit opening 5 into duct 6 leading to the powder collector 7 of conventional form and having the air exhaust duct 8.

The outlet of the spray-dried material from collector 7 is divided, one branch, 9, leading to storage or the like and the other branch, 10, leading through control gate 11 to a plurality of distributing ducts 12 arranged radially under the top 2 of the drying chamber, and discharging into an annular space 13 formed at the upper end of the drying chamber 1 between the sloping wall 3 and the circular distributing plate 14. The size, number and spacing of the distributing ducts 12 are variable according to requirements. A plurality of tubes 15 of relatively small size, connected to a source of air under pressure, not shown, discharge tangentially into the annular space 13, the plate 14 being so shaped as to direct the air spirally downwardly over the surface of the walls 3. This air may be of high or low velocity and may be hot, cold or any desired temperature, depending upon requirements. Although the spiral distribution of this air is preferred, the tubes may discharge radially into the annular space instead of tangentially, or at any intermediate horizontal or vertical angle, also depending upon requirements.

Located in the upper part of drying chamber 1 and connected by duct 16 to a suitable air heater and blower combination, not shown, is an air distributing head 17 discharging into a conical hood 18 provided with diverging vanes 19 for distributing the heated drying air uniformly throughout the drying chamber 1. The hood 18 is joined to the lower edge of plate 14.

Extending through hood 18 into chamber 1 is a plurality of inwardly-directed atomizers 20 supplied by a header 21 for spraying the solid-containing liquid or slurry in finely-divided form into the hot air stream issuing from distributing head 17. The number, spacing and size of the atomizers 20 may be varied according to requirements.

In operation, the solid-containing liquid or slurry is sprayed by atomizers 20 into the hot air stream issuing from distributing head 17, so that the minute globules are surrounded by the hot air and are dehydrated while passing through the chamber 1 toward the bottom 4 to be discharged through opening 5 into duct 6, in which they are conveyed by the drying air to the separator 7, where the solids are separated from the moisture-laden air, which is exhausted through 8. This process is described in general in aforementioned Patent No. 1,634,640.

A predetermined proportion of the dried powder collecting in collector 7 is utilized to form the powder sheet and an amount substantially equal to the quantity of fresh powder being continuously produced is withdrawn through duct 9 and conveyed to storage, or the like. The powder sheet material flows through duct 10 and gate 11, which is opened the proper degree, so that the fluent powder flows by gravity through radial distributing ducts 12 into annular space 13, where it is propelled in a circular direction by the air issuing tangentially from tubes 15 to flow downwardly over the inclined walls 3 of the drying chamber 1 in a spiral direction. Plate 14 deflects this propelling air smoothly over the surface of the walls 3, so that the powder is distributed uniformly in its downward spiral path, its natural gravity flow being augmented by the

propelling air. This propelling air is insufficient in volume to disturb the proper air-liquid ratio, so that the control of the spray-drying operation remains easy and accurate. The propelling air may be any desired temperature, and may be directed one of several ways to impart a selected direction to the powder.

The powder-sheet thus formed and consisting of previously spray-dried material and therefore relatively stable and insensitive to heat and moisture, accordingly flows over the walls 3 in intimate contact therewith to produce an effective scouring action, which not only scours any particles from the walls that succeed in penetrating the sheet, but also prevents the drying powder from adhering to the walls 3 by forming a shield therefor. Because the walls 3 are steep, the flow of the powder forming the sheet is relatively rapid to provide efficient scouring and yet is not so rapid as to preclude the necessary intimate contact of the particles with the walls 3. Also, because the walls 3 converge downwardly the powder sheet becomes progressively denser toward the bottom of the drying chamber where greater scouring is necessary because the adhering tendency is greater.

In the event that the surfaces of the freshly spray-dried particles are moist and therefore sticky, or the particles are formed of a material which even when dried remains sticky while hot, the powder sheet is helpful to prevent agglomeration of these sticky particles because the dried particles forming the sheet insert themselves between and thus separate the sticky particles and promote surface hardening of the individual particles. This admixture with the previously spray-dried particles may be availed of to reduce the rate of dehydration of the freshly spray-dried particles, so that their moisture content can be definitely controlled. Furthermore, the additional previously-dried fluent material enables the entire mass to travel freely through and around the bends of the exit 5 and duct 6 and continues to aid the particles to harden, so that by the time they reach the separator 7 they are stabilized and ready for reintroduction into the drying chamber 1 to form the powder sheet. This intimate admixture of the freshly spray-dried material with the previously spray-dried powder provides an important means of control of the physical characteristics of certain materials heretofore difficult or impossible to spray-dry. The volume and temperature of the powder sheet, of the propelling air, and the control of heat radiation from the drying chamber and duct surfaces afford a certain measure of control of the temperature of the recirculating powder sheet.

It is evident that the fresh spray-dried powder thus may be exposed for a considerable time to conditions which may be varied to suit individual requirements and to produce results not hitherto attained. It is possible, for instance, to employ a low temperature powder sheet whose action is purely one of mechanical protection, so that the spray-dried powder is collected in a final form not different from that resulting from the instantaneous drying exposure at the atomizers; or the temperature of the recirculating powder sheet may be so adjusted as to provide an extended drying time under moderated conditions. Perhaps the most important of the secondary effects obtainable by the control of temperature and time of exposure in the recirculating powder sheet is the tempering or stabilizing brought about in certain normally crystalline

materials which issue from conventional spray-dryers in an unstable form induced by the rapidity of dehydration.

The volume of the powder constituting the powder sheet is in excess of the spray-dried powder forming in the chamber 1 as the result of the spray-drying operation. Preferably, the volume of the reintroduced spray-dried powder is several times that of the freshly spray-dried powder moving concurrently therewith through the chamber 1. For example, a ratio of ten parts of previously spray-dried powder to one part of freshly spray-dried powder produces a very effective scouring action and has the additional advantage that the admixing of the previously spray-dried powder with one-tenth the volume of the fresh powder produces a more stable and non-sensitive powder. The selection of the proper ratio of previously spray-dried powder constituting the powder sheet to the fresh powder depends upon the material which is being spray-dried. The combined previously spray-dried and freshly spray-dried powder is preferably separated after each passage through the apparatus from the moisture-laden air in the separator 7 for reintroduction into the chamber 1 in the proper quantity as controlled by gate 11, after an amount substantially equal to the quantity of powder being continuously produced in chamber 1 is withdrawn through duct 9. This arrangement permits exact control of the volume of the powder sheet.

The use of the powder-sheet enables the total volume of the air handled to be considerably reduced and the drying time considerably prolonged throughout the entire spray-drying system. This, of course, considerably reduces the heat requirements. Instead of the actual drying time being confined to a part only of the drying chamber alone, as must be the case where the cold air zones are used, the use of the powder-sheet permits the drying action to continue from the moment the liquid is atomized, through the entire length of the drying chamber, through the connecting duct and during the entire time that the powder is circulated around the interior of the collector and until finally discharged from the collector.

In addition, a determined amount of this same powder while still hot is reintroduced as the powder-sheet into the drying chamber whereby the drying time is still further prolonged. Obviously, this considerably increases the drying time and consequently it is feasible to evaporate with the same quantity of drying air and heat a larger quantity of liquid, because the freshly spray-dried powder need not necessarily be instantaneously dried to completeness, but in a partly dried condition may be permitted to admix with the powder-sheet and there progress and continue its drying action until finally discharged from the powder collector. The extra drying time accorded by this method is at least two or three times that usually provided with cold air induction, because in that arrangement only a portion of the drying chamber itself is available and actually utilized for the drying.

Omission of the cold air zones prevents sudden reduction of the temperature of the drying air and sudden chilling of the hot, freshly spray-dried particles. By keeping the freshly spray-dried product in the still hot and partly humidified drying air, which is possible by the use of the powder-sheet, the partly solidified particles are prevented from prematurely hardening and

are retained for a considerable time in that condition, i. e., they remain soft and partly molten for a longer time and are thereby enabled to become stabilized. This action is augmented by the powder-sheet which causes all of the spray-dried product to pass several times through the entire spray-drying system, thereby considerably lengthening the time of exposure of the spray-dried product to the hot air.

This lengthened exposure affords sufficient time for many particles to become stabilized and since this exposure to the heat may be regulated as required, sufficient time may be allowed to various materials to permit the particles to become entirely stabilized in the normal process of operation of the powder-sheet. With many materials the initial drying does not completely dehydrate the product, which also causes the product to be sensitive. The admixture effected in operation of the powder-sheet, and the extended drying time accorded thereby, allow the product to become completely dried and permit control of the requisite drying time to accomplish the desired results.

The terms "stable" and "unstable" used herein are employed to compare certain characteristics, particularly the degree of sensitiveness to heat and humidity, of some spray-dried products as produced by the methods heretofore known and applied, with similar improved characteristics, notably a relative insensitiveness to similar atmospheric conditions, possessed by the same products when spray-processed with the aid of the novel continuously protective and drying time extending powder-sheet herein disclosed. In the normal spray-drying operation, the dehydration is so extremely rapid and complete that it often causes a solidifying of the solid constituents of each spray-dried particle before such constituents can assume their normal alignment in each particle and results in an unstable product. This rapid solidifying forces each such spray-dried particle into a strained condition of unstable equilibrium.

The sudden chilling, caused by the induction of cold air in the cold air zone method, causes the partly solidified particles to set in such strained condition of unstable equilibrium that the normal alignment of the constituents in each particle is prevented, and the stabilization of each spray-dried particle is inhibited. This strained condition of unstable equilibrium persists and each spray-dried particle is thereby rendered extremely sensitive to humidity and/or heat. The powder sheet overcomes this instability and sensitiveness of the freshly spray-dried powder by increasing the time for solidification and results in more stable particles having a desired high moisture content.

While a preferred method and apparatus have been illustrated and described herein, the invention is not limited thereby, but is susceptible to changes in form and detail within its scope. For example, it is not essential that the powder-sheet be formed of the same material as the freshly spray-dried particles but may be other material introduced from pipe 23 connected to pipe 10, which may be wholly or partially disconnected from drying chamber 1 by means of valve 22, depending upon requirements. This other sheet-forming material may be mixed or agglomerated with the freshly spray-dried material or be separated therefrom by screening, winnowing, or the like. Also, the fines may be separated from the larger spray-dried particles by screening through

a 70-80 mesh screen, or the like, depending on the material, and these fines utilized to form the powder sheet which has the added advantage that the fine particles of the sheet may be caused to agglomerate with the freshly spray-dried particles and thus reduce the quantity of fines and increase the average size of the finished particles. Furthermore, the drying chamber need not be conical but may have any other desired shape, the powder-sheet need not be directed concurrently with the spray but may flow counter thereto, and the powder constituting it may be introduced at any level with respect to the spray nozzles, i. e., either above, below, or at the level of the nozzles, depending on the level where adhesion to the walls begins.

We claim:

1. A process of spray-drying, which comprises spraying the material to be dried into the drying chamber, and continuously flowing finely-divided relatively dryer material over the wall of the chamber to prevent adhesion of the freshly dried material to the wall.

2. A process of spray-drying, which comprises spraying the material to be dried into the drying chamber, and flowing a sheet of finely-divided relatively dryer material over the wall of the chamber, said material moving in the direction of the spray and forming a shield between the spray and the wall.

3. A process of spray-drying, which comprises spraying the material to be dried into the drying chamber, and directing finely-divided relatively dryer material in a converging sheet around the wall of the chamber to form a shield between the spray and the wall of the chamber.

4. A process of spray-drying, which comprises spraying the material to be dried into the drying chamber, and directing finely-divided relatively dryer material over the wall of the chamber in the form of a spirally-moving sheet.

5. A process of spray-drying, which comprises spraying the material to be dried into the drying chamber, and continuously reintroducing previously spray-dried material into the chamber in the form of a fluent layer on the surface of the wall of the chamber to prevent adhesion of the fresh material to the walls.

6. A process of spray-drying, which comprises spraying the material to be dried into the drying chamber, and continuously reintroducing previously spray-dried material into the chamber over the walls thereof for preventing contact between the freshly spray-dried material and the wall and for admixture with the freshly spray-dried material.

7. In spray-drying apparatus of the class described, the combination of a chamber, means for introducing the material to be dried in a finely-divided condition into said chamber, and means for flowing finely-divided relatively dryer material over the walls of the chamber to prevent adhesion of the freshly spray-dried material to the walls.

8. In spray-drying apparatus of the class described, the combination of a chamber in which the treatment of the material takes place, means for passing a current of heated gas through the chamber, means for introducing the said material into the current of gas in a finely divided condition, and means for introducing an extraneous finely-divided solid substance over the wall of the chamber to prevent adhesion of the freshly dried material to the wall of the chamber.

9. In spray-drying apparatus of the class de-

scribed, the combination of a chamber in which the treatment of the material takes place, means for passing a current of heated gas through the chamber, means for introducing the said material into the current of gas in a finely divided condition, and means for reintroducing previously spray-dried material over the wall of the chamber to prevent adhesion of the fresh material to the wall of the chamber.

10 10. In spray-drying apparatus of the class described, the combination of a chamber having downwardly converging walls, means for passing a current of heated gas downwardly through the chamber, means for spraying the material to be dried into said gaseous current, and means for distributing previously spray-dried material upon the upper portions of the converging walls of the chamber for gravity flow over them to form a scouring sheet for preventing adhesion of the freshly spray-dried particles to the walls of the chamber.

11. In spray-drying apparatus of the class described, the combination of a chamber having downwardly converging walls, means for passing a current of heated gas downwardly through the chamber, means for spraying the material to be dried into said gaseous current, and means for directing finely-divided relatively dryer material in a lateral direction over an elevated point on the surface of the walls of the chamber for gravity flow in a spiral direction over them for scouring adhering freshly spray-dried particles from said walls.

12. In spray-drying apparatus of the class described, the combination of a chamber having downwardly converging walls, means for passing a current of heated gas downwardly through the chamber, means for spraying the material to be dried into said gaseous current, and means for introducing previously spray-dried material into said chamber for admixture with the freshly spray-dried material after the formation of the particles thereof, means for conducting the admixture of the fresh and previously spray-dried material in the presence of the heated drying gas from the drying chamber, and means for separating the material from the gas for reintroduction into the chamber.

13. In spray-drying apparatus of the class described, the combination of a chamber having downwardly converging walls and a bottom opening, means for passing a current of heated gas downwardly through the chamber, means for spraying the material to be dried into said gaseous current, means for distributing previously spray-dried material upon the upper portions of the converging walls of the chamber for gravity flow over them to form a scouring sheet for preventing

adhesion of the freshly spray-dried particles to the walls of the chamber and for admixture with the freshly spray-dried material discharging through the said bottom opening, a collector connected to said bottom opening for separating the mixture of the previously and freshly spray-dried material from the spent drying gas, and a return connection between said collector and the distributing means for reintroducing the spray-dried material into the chamber to form the scouring sheet.

14. A process of spray-drying, which comprises spraying the material to be dried into a drying chamber, separating the relatively fine particles from the resulting spray-dried product outside of the drying chamber, and reintroducing the said fine particles over the wall of the drying chamber for agglomeration with the freshly spray-dried particles.

15. A process of spray-drying, which comprises spraying the material to be dried into a chamber containing heated gas to produce a finely-divided relatively dry material, separating the dried material from the drying gas outside of the drying chamber, and continuously reintroducing at least a portion of the separated material over the wall of the drying chamber for admixture with the freshly dried material and for preventing adhesion of the freshly dried material to the wall of the drying chamber.

16. A process of spray drying, which comprises spraying the material to be dried into a drying chamber, flowing finely-divided relatively dryer material over the wall of the chamber to form a shield between the spray and the wall of the chamber, and directing a blast of gas over the wall of the chamber to aid the flow of the said shield-forming material.

17. A process of spray drying, which comprises spraying the material to be dried into a drying chamber, and propelling with a gas under pressure a layer of finely-divided relatively dryer material over the wall of the chamber to form a shield between the spray and the wall of the chamber.

18. In a spray-drying apparatus of the class described, the combination of a chamber, means for introducing the material to be dried in a finely-divided condition into said chamber, means for flowing finely-divided relatively dryer material over the walls of the chamber to prevent adhesion of the freshly spray-dried material to the walls, and means for directing a blast of gas over the walls of the chamber to aid the flow of the said finely-divided relatively dryer material over the walls of the chamber.

PAUL T. ZIZINIA.
THOS. L. MCKENNA.