Sept. 20, 1960 W. D. KOHLINS ET AL 2,953,199

HORIZONTAL SPRAY DRYER

Filed Feb. 19, 1957 2 Sheets-Sheet 1

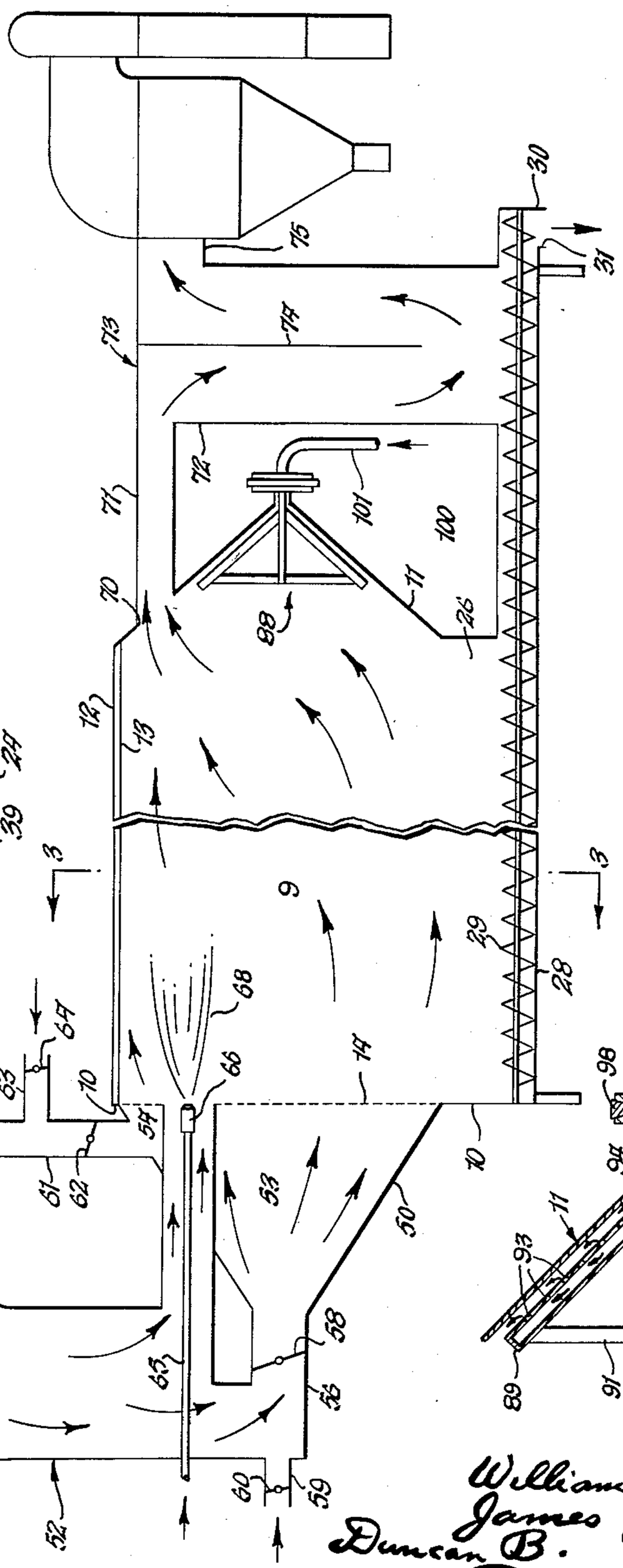


Fig. 1.

Fig. 2.

INVENTORS
William D. Kohlins
James G. Moore
Duncan B. Montgomery
by Popp and Sommer
ATTORNEYS.

Sept. 20, 1960 W. D. KOHLINS ET AL 2,953,199

HORIZONTAL SPRAY DRYER

Filed Feb. 19, 1957 2 Sheets-Sheet 2

Fig. 3.

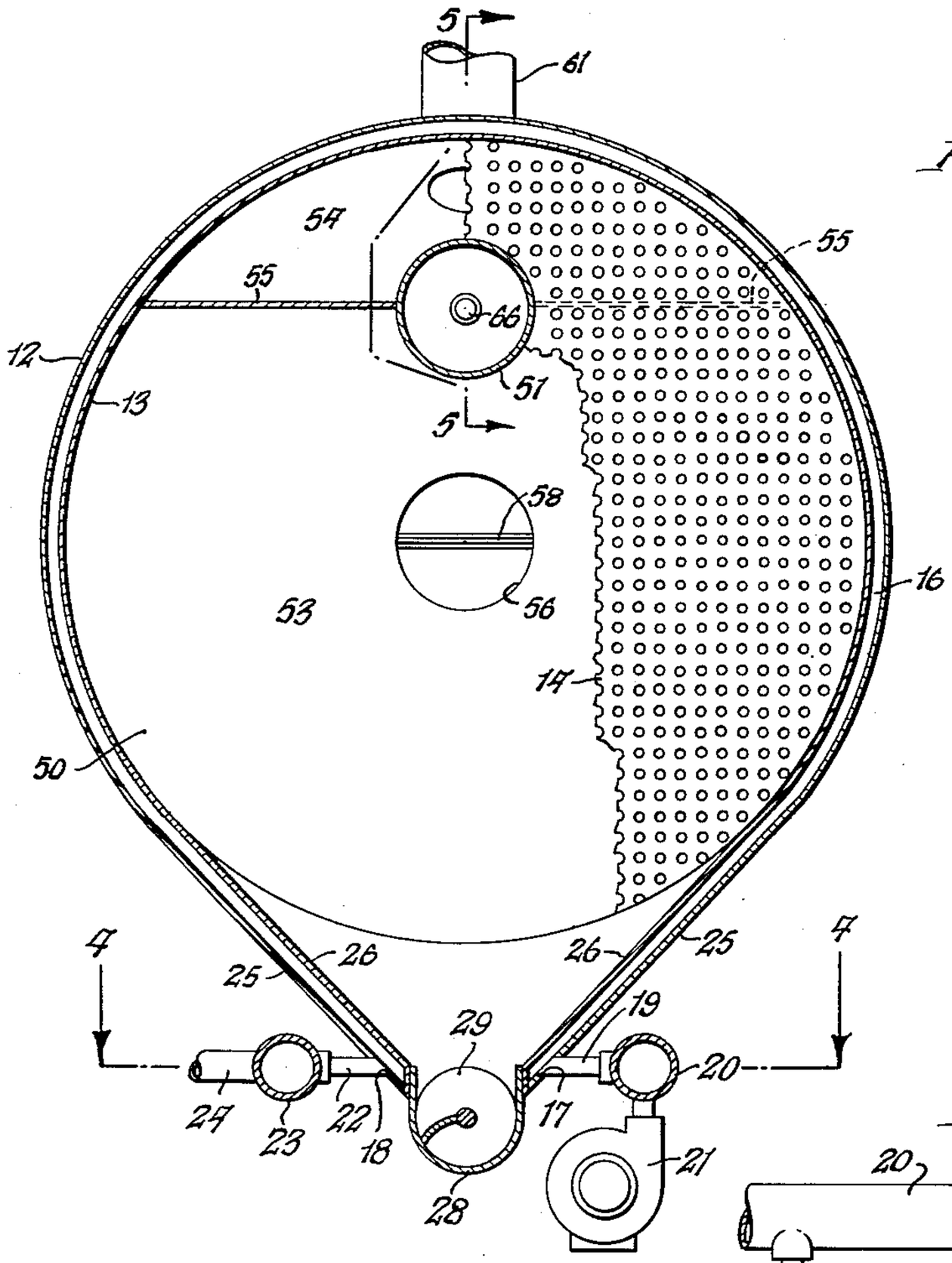


Fig. 4.

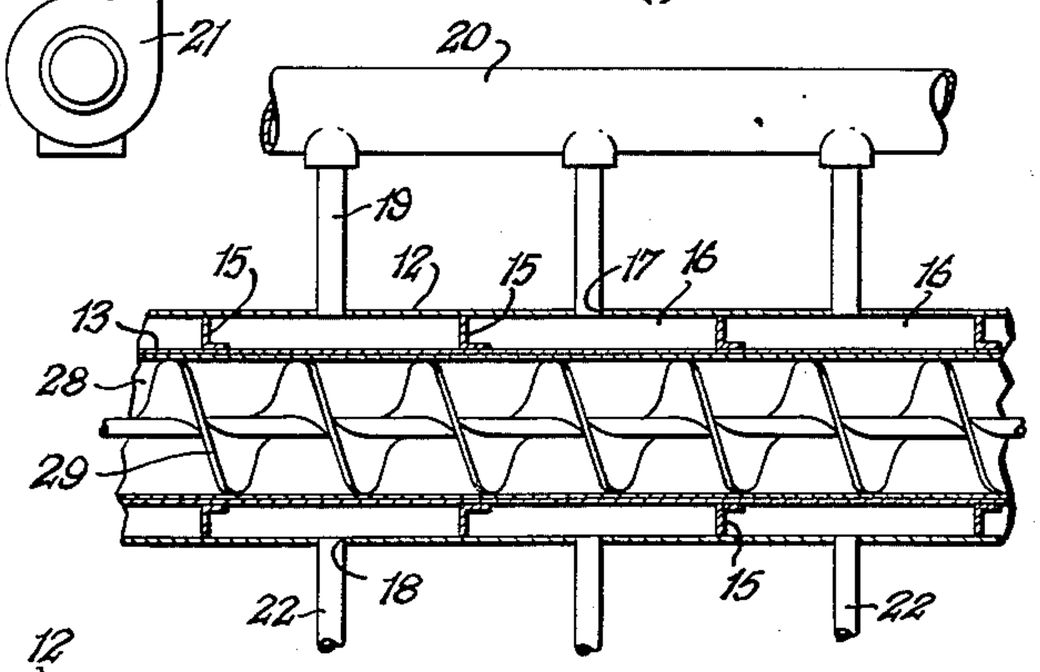
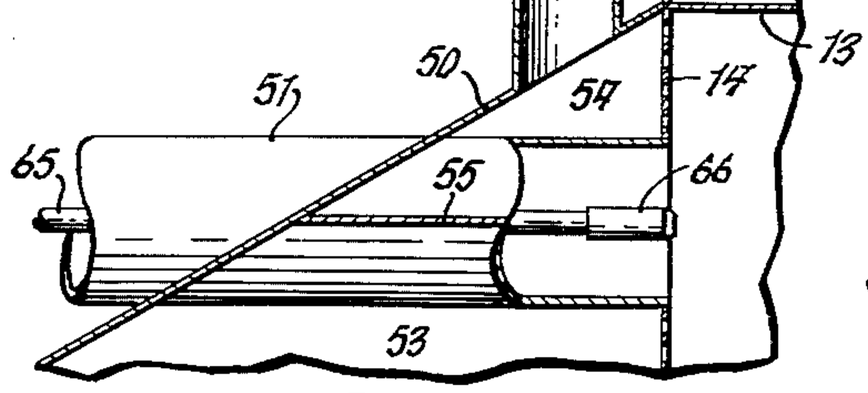


Fig. 5.



INVENTORS.
William D. Kohlins
James J. Moore
Duncan B. Montgomery
by Popp and Sommer
ATTORNEYS

United States Patent Office

2,953,199

Patented Sept. 20, 1960

2,953,199

HORIZONTAL SPRAY DRYER

William D. Kohlins, Eggertsville, James G. Moore, Buffalo, and Duncan B. Montgomery, West Seneca, N.Y., assignors to Blaw-Knox Company, Pittsburgh, Pa., a corporation of Delaware

Filed Feb. 19, 1957, Ser. No. 641,187

8 Claims. (Cl. 159—4)

This invention relates to a horizontal spray dryer and is illustrated as embodied in such a dryer for the production of instant coffee in the form of hollow spheres, such form being desirable to provide the desired aroma and to reduce the hygroscopicity of the dried coffee. However, the dryer forming the subject of the present invention is not, of course, limited to any particular product and can be used to dry any liquids capable of being spray dried.

This application is a continuation in part of our copending application for horizontal spray dryer, Serial Number 590,046, filed January 7, 1956, now abandoned.

An important object of the present invention is to produce materials like dried instant coffee in the form of dense walled spheres so as to provide the desired aroma and to reduce hygroscopicity.

Another object is to provide a horizontal spray dryer in which undried material does not come into contact with the dryer walls but travels in suspension through the drying chamber until dry with the dried material settling to the bottom of the drying chamber where it is continuously removed.

Another object is to separately control the form of the spray of liquid to be dried, to rapidly shock or inflate the liquid particles into spheres, this being accomplished by introducing a primary stream of heated air at relatively high velocity directly around the spray nozzle.

Another object is to provide such a horizontal spray dryer in which, following the inflation of the droplets into spheres by said primary stream of air, the spheres are permitted to dry more slowly as they settle to the bottom of the dryer, this being accomplished by the introduction of a secondary stream of air below the primary stream of air and greater in cross sectional area.

Another object is to provide for the control of the relative volume of the streams of primary and secondary air to obtain a product of the desired quality with a minimum expenditure of heat and power.

Another object is to provide for the control of the relative temperatures of the streams of primary and secondary air to provide a product of the desired quality with a minimum expenditure of heat and power.

Another object is to provide a horizontal spray dryer of minimum length by positioning the spray nozzle near the top of the drying chamber so that the material falls through the greater part of the height of the drying chamber while drying.

Another object is to prevent the material being dried from contacting the inside of the dryer before being dried and particularly in the upper part thereof, this being effected by the introduction of a third stream of air to isolate the upper part of the dryer from the spray.

Another object is to provide such third stream of air in minimum volume so as to avoid the heating and handling an unnecessarily large overall volume of air.

Another object is to introduce such third stream of air in such manner as to destroy the aspirating effect of the spray and which aspirating effect tends to produce a large

eddy or backflow which in turn tends to carry undried droplets against the inside of the dryer.

Another object of the invention is to provide for the adjustment of the volume of the third stream of air so isolating the upper part of the dryer from droplets in relation to the volume of the primary and secondary streams of air.

Another object is to provide for the regulation of temperature of said third stream of air in relation to said primary and secondary streams of air.

Another object is to provide such third stream of air and the primary stream of air in a form which is free from large eddies or swirls and which jointly progress as an internally stable body the full length of the spray dryer, this being accomplished by introducing these streams of air through multi-orifice screens at the wet end of the dryer.

Another object is to effectively isolate said three streams of air from one another prior to their simultaneous discharge into the drying chamber.

Another object is to provide such a horizontal spray dryer in which walls of the drying chamber are cooled to reduce the tendency of solids to stick to the walls of the drying chamber.

Another object is to employ at least a part of the air used in cooling the shell of the drying chamber as preheated air supplied to the main air heater from which heated air is supplied to the drying chamber.

Another object is to provide inlet and outlet blowers which can be balanced to provide any required negative operating pressure within the drying chamber to suit the particular material being dried.

Other objects and advantages of the invention will be apparent from the following description and drawings in which:

Fig. 1 is a longitudinal vertical sectional view through a spray dryer embodying the present invention, parts being shown in elevation.

Fig. 2 is an enlarged fragmentary view similar to Fig. 1 and showing, in section, the rotary air sweep for the end wall at the dry end of the spray dryer.

Fig. 3 is an enlarged vertical transverse section taken on line **3—3**, Fig. 1.

Fig. 4 is a fragmentary horizontal sectional view taken on line **4—4**, Fig. 3.

Fig. 5 is a fragmentary enlarged sectional view similar to Fig. 1 and taken on line **5—5**, Fig. 3, to illustrate the form of a baffle used in conjunction with the delivery of the air streams.

The horizontal spray dryer of the present invention has a horizontal drying chamber **9** formed by a pair of sheet metal end heads **10** and **11** connected to each other by an outer shell **12** and a conforming inner shell **13**. The end head **11** is at the dry end of the dryer and is preferably of outwardly converging conical form while the end head **10** is provided with a large circular opening closed by a vertical screen **14**.

The inner and outer shells are secured in spaced relation to each other by a plurality of ribs **15** which, as best shown in Fig. 4, are interposed between the inner and outer shells **12** and **13** and can be secured to each of these shells in any suitable manner as by welding. As best shown in Fig. 4, these vertical ribs **15** are horizontally spaced, preferably at uniform intervals, to provide a series of vertical air passages **16**.

These air passages are for the circulation of ambient air to cool the inner shell **13** and for this purpose, at one side of the dryer, the shell **12** is provided with an air inlet opening **17** for each of the passages **16** and on the opposite side of the dryer, this outer shell **12** is provided with an outlet opening **18** for the opposite end of each of the passages **16**. Each inlet opening **17** connects

with a branch 19 of a manifold 20 which is supplied with ambient air under pressure from a blower 21. Each outlet opening 18 connects with a branch 22 of a manifold 23 which discharges into an outlet line 24 as hereinafter described.

The shells 12 and 13 have semicylindrical top portions but the lower portions of these shells are respectively in the form of substantially straight walls 25 and 26 which converge downwardly to form a hopper discharging into a trough 28 which extends the full length of the dryer. The trough 28 has a semicylindrical bottom and houses a conveyor screw 29, one end of which can be suitably journalled in the end head 10 and the other end of which is journalled in an end head 30 for the trough 28, this end of the trough 28 being its discharge end and having a downwardly directed discharge spout 31.

The air discharge line 24, as best shown in Fig. 1, connects with the scroll 35 of a main fan or blower 36, the shell of this fan having an air inlet 38 leading to the center of a bladed fan wheel 39 which discharges ambient air drawn in from the inlet 38 through the outlet 40 of the fan housing. This fan is preferably arranged above the shells 12, 13 and discharges into the shell 41 of a heater 42.

While any suitable form of heater can be employed, it is shown as being in the form of a direct fired combustion heater having, within the shell 41, branch pipes 43 from a gas supply line 44 and these branches carrying a plurality of burners 45 which burn flames 46 in the air stream passing through the heater casing 41 so as to heat this air. If, of course, the product being dried is not compatible with products of combustion, a different type of heater would be used.

The screened or dry end of the dryer is shown as enclosed by a conical end head 50 the large rim of which is joined to the end head 10 at its opening for the screen 14 so as to form a continuation of this end head and to provide a plenum chamber for the hot air discharged from the heater 42. A horizontal air inlet pipe 51 for the primary stream of drying air extends through the upper part of the conical end head 50 and also through the upper part of the screen 14. This horizontal air pipe is supplied with heated air from the outlet end 52 of the heater shell 41. The space around this primary air pipe 51 within the conical end head 50 is divided into two chambers 53 and 54 by a pair of horizontal partitions 55 which extend horizontally from the primary air supply pipe 51 and are bounded by this pipe, the shell 50 and the screen 14.

The chamber 53 is supplied with hot air from the outlet end 52 of the heater shell 41 through a horizontal duct 56 preferably at the center of the conical end head 50. This hot air, which forms the stream of secondary air for drying the coffee, is under control of a damper 58 which can be manually adjusted. The temperature of this secondary air supplied from the duct 56 to the chamber 53 can be regulated by bleeding in a regulated quantity of ambient air from an inlet duct 59 to the duct 56. The amount of ambient air so admitted as the secondary air can be under control of a damper 60 which can be regulated by hand.

Hot air is supplied from the outlet end 52 of the heater casing 41 to the chamber 54 through a duct 61 under control of a damper 62 which can be manually operated. The temperature of this stream of air can be regulated by bleeding in a regulated amount of cool ambient air from a duct 63. The amount of ambient air so admitted can be under control of a damper 64 which can be adjusted manually.

The liquid to be dried is supplied under pressure to a horizontal pipe 65 which extends coaxially through the horizontal duct 51 for the primary air. This pipe terminates in a spray nozzle 66 which discharges a spray 68 of droplets into the spray chamber 9 from immediately adjacent the outlet of the primary air pipe 51. The spray

68 is generated at the discharge end of the duct 51 for the primary air so that the droplets are shocked or rapidly inflated into spheres with a consequent rapid reduction in the water content of the droplets, the spheres being then subjected to produce dense walls, to the slower drying action while descending, under the influence of gravity, through the secondary stream of drying air emerging through the multi-orifice screen 14 from the chamber 53.

The air escapes from the drying chamber 9 through an outlet opening 70 in the upper part of its conical end wall 11 at the dry end of the dryer. This outlet opening communicates with a horizontal duct 71 which discharges this air into the upper part of the shell 72 of a first separator 73. This separator 73 is shown as having an internal vertical partition 74 which is arranged transversely of the air flow and connects with the top and side walls of the separator shell 72 but terminates a substantial distance above the bottom wall thereof. Accordingly, the air entering the separator 73 from the horizontal duct 71 is first deflected downwardly and then horizontally and then upwardly and then is again deflected horizontally in passing out through the upper discharge duct 75 of the separator 73. With these abrupt changes in direction, the greater part of any solids in the air entering the separator 73 are deflected against the partition 74 and the walls of the shell 72 and settle downwardly into the trough 28 which is common to this separator 73 as well as to the shell 13 of the dryer. The partition 74 preferably can be adjustable as to position and can be agitated, the specific features of the separator 73 forming no part of the present invention.

The duct 75 discharges into a second separator 78 which can be of any suitable form to remove any remaining solids from the air stream. It is shown as being of the centrifugal type having a conical bottom 79 leading to a discharge 80 for the solids and having its air outlet 81 connected with the inlet of a centrifugal fan or blower 82 which discharges the air through a duct 83. It will be seen that the effects of the exhaust blower 82, the blower 36 and preheated air blower 21 are cumulative in moving air through the apparatus and that these can be adjusted or balanced to provide any desired negative pressure within the drying chamber 9. It will further be seen that this negative pressure serves to draw cool ambient air in through the ducts 59 and 63, under control of the dampers 60 and 64, to reduce the temperature of the corresponding streams of air.

An air sweep, indicated generally at 88, is used to prevent the accumulation of solids on the conical end wall 11 at the dry end of the drying chamber. This air sweep is shown as having a hollow body in the form of two angularly disposed arms 89 radiating from a tubular hub 90. The arms 89 are coaxial with the conical end head 11 and their angularity is such as to conform to the conical end head. The free ends of these arms can be braced by a cross brace or arms 91 which can connect with a cap 92 at the inner end of the tubular hub 90. This hub is journalled concentrically in the end head 11 of the drying chamber 9 and the arms 89 of the sweep are provided with a plurality of perforations 93 through which streams of air are discharged against the inner face of the conical end head 11 for the purpose of cooling the same to prevent the accumulation of solid material thereon. The tubular hub 90 of the rotary sweep 88 is journalled in a bearing bushing 94 suitably supported in the apex of the end head 11 of the drying chamber. A pulley 96 having a drive belt 98 is fast to the outer end of the tubular hub 90 and it will be noted from Fig. 1 that this pulley is arranged in a space 100 between the end head 11 of the drying chamber 9 and the primary separator 73. Also located in this space 100 is a conduit 101 through which air is forced into the tubular hub 90 for distributon by the rotary sweep 88 against the end head 11 of the drying chamber.

Operation

It will be assumed that the liquid to be dried is instant coffee having in the order of 28% to 50% solids to be dried in the form of dense walled spheres having a moisture content not exceeding about 3%. It will also be assumed that the dry bulb temperature of the ambient air is in the order of 80° Fahrenheit and the wet bulb temperature of the ambient air is in the order of 66° Fahrenheit so that the relative humidity is 49%.

The bulk of the ambient air used in the drying chamber **9** is admitted through the inlet **38** of the blower **36** which discharges into the casing **41** of the heater. A second stream of ambient air which is, however, preheated, is also admitted to the scroll **35** of the fan **36**, this being supplied from the inlet of a blower **21**, Fig. 3. This last blower draws in ambient air and discharges it into the manifold **20** from which it flows out through the branches **19**. Each branch **19** connects, Figs. 3 and 4, with one end of a passage **16** formed between the inner and outer shells **13**, **12** of the drying chamber **9** by the ribs **15**. In passing through these passages **16** the ambient air cools the inner shell **13** so as to reduce the tendency for incompletely dried or thermoplastic materials to adhere to the inside of this inner shell **13**. From the discharge end of the passages **16** the air, now preheated by contact with the inner shell **13**, escapes through the branches **22** of a manifold **23**. From this manifold **23** the preheated air passes through a duct **24** to the scroll **35** of the blower **36**.

In passing through the heater casing **41** the air contacts the flames **46** of the gas burner **42** and is heated to the required temperature, in the order of from about 500° to 550° Fahrenheit, passing thence to the outlet end **52** of the heater shell **41**. This hot air is then divided into three streams before being admitted to the drying chamber **9**.

Of these the primary high velocity stream of air passes from the outlet end **52** of the heater shell **41** through the horizontal duct **51** and discharges directly into the upper part of the drying chamber **9** immediately adjacent the screen **14** which does not, however, extend over the outlet of this horizontal duct **51** to impede this primary stream. This primary stream is from about 25% to 30% of the total volume of air admitted to the drying chamber **9**. Into this stream of hot primary air issuing from the horizontal duct **51** is discharged a spray **68** of fine droplets of the coffee solution or other product being dried. The liquid can advantageously be supplied to the nozzle **66** at a pressure of from about 325 to 400 p.s.i. and at a temperature of from about 105° to 130° Fahrenheit. The contact between these droplets and this primary stream of air shocks or rapidly inflates each droplet into a hollow sphere, the larger proportion of water in the droplet being abstracted during this process by direct evaporation from the droplet into the hot stream of primary air. With a coffee solution having a concentration of about 30% solids discharged from the nozzle **66**, the coffee droplets in the spray **68** are rapidly formed into hollow spheres with a reduction of the moisture content to about 13%.

A secondary stream of heated air passes from the outlet end **52** of the heater shell **41** through the horizontal duct **56** into the chamber **53** within the lower part of the conical end head **50** at the wet end of the dryer. The volume of secondary air so admitted to the chamber **53**, particularly with reference to the volume of the primary air admitted through the horizontal duct **51** is under control of a manual damper **58**. This volume of secondary air can be from about 60 to 70% of the total air used. Also the temperature of the stream of secondary air admitted to the chamber **53** is under control of a manual damper **60** which can be adjusted to bleed in the required amount of cool ambient air to obtain the desired temperature differential between the primary air emerging from **51** and the secondary air entering the

chamber **53**. The temperature of this secondary stream of air approximates the temperature of the primary air stream, namely, in the order of from about 500° to 550° Fahrenheit.

The air temperature in the drying chamber **9** is from about 305° to 330° Fahrenheit.

An important feature resides in the provision of the screen **14** between the secondary air chamber **53** and the spray chamber **9**. The screen is preferably in the form of a perforated plate with many small closely spaced holes so as to create a uniform orifice pressure drop across the entire area of the screen **14** which encloses the chamber **53**. Such a screen prevents any major turbulence in the stream of secondary air entering and flowing through the drying chamber **9** and insures the progress of the stream of secondary air as an internally stable body the full length of the drying chamber **9**.

Following the formation of the hollow spheres in the primary stream of hot air issuing from the horizontal duct **51** these spheres settle by gravity into the stream of hot secondary air flowing through the lower part of the spray chamber **9** and which occupies a much greater cross sectional area of the spray chamber than the primary stream of air. These spheres give up additional moisture to this stream of secondary hot air as they settle toward the bottom of the chamber but at a much slower rate since the hollow spheres rapidly solidify and the moisture is required to escape through the solid skins of these spheres. The length and height of the spray chamber is selected to insure that the spheres are dry, namely, to less than about 3% moisture content by the time they reach the bottom of the spray chamber. In this regard it will be noted that the horizontal duct **51** for the primary stream of hot air and also the nozzle **66** are located well above the horizontal center of the drying chamber **9** and close to the top thereof so as to provide the maximum distance of fall of the hollow spheres to the bottom of this drying chamber.

On reaching the bottom of the drying chamber the spheres are picked up by the screw conveyor **29** and discharged unbroken through the discharge spout **31**.

The spray **68** has an ejector action upon the air in the drying chamber **9** particularly in tending to produce a backflow of air above the spray. If permitted, such a backflow of air would carry with it some of the droplets or moist spheres and which would deposit both on the inner shell **13** above the spray **68** and also on the area of the screen **14** surrounding this spray. To prevent this result, a third stream of hot air from the outlet end **52** of the heater shell **41** passes through the vertical duct **61** into the chamber **54** formed in the extreme upper part of the conical end head **50** by the pair of horizontal partitions **55** which abut the horizontal primary air duct **51** as best shown in Fig. 3. This third stream of air can be from about 5 to 10% of the total volume of air. This third stream of hot air emerges from the extreme upper end or segment of the perforated screen **14** to proceed, as with the secondary air, without eddies or swirls as an internally stable body above the spray **68** and along the top of the shell **13**. This third stream of hot air effectively prevents any backflow created by the spray **68** and also provides a layer of air which isolates both the upper part of the screen **14** and also the roof of the chamber **9** from contact with the droplets discharged in the spray **68** or the spheres formed from these droplets.

The volume of this third stream of air is preferably held to a minimum since it has no great drying effect and if provided in excess would merely waste heat and result in the handling of an excessive amount of air. Also, the temperature of this air of the third stream is not particularly critical and a substantial amount of cool ambient air can be admitted through the duct **63** under control of the manual damper **64**.

Any materials reaching the end head **11** at the dry end of the dryer are prevented from accumulating thereon

by the rotary sweep **88** which discharges a plurality of streams of cool air from the orifices **93** in its rotating hollow arms **89** directly against the conical end head **11**. These streams serve both to cool this end head and also to dislodge any materials tending to collect on this end head. These materials, of course, fall downwardly to the screw conveyor **29**.

By far the preponderance of the dry product from the drying chamber **9** falls directly into the trough **20** and is immediately conducted away by the conveyor screw **29**. A small amount, however, of dry material will be carried out of the drying chamber **9** with the escaping moist air, this moist air passing into the first separator **73**. The separator can be in the form of a simple fall-out separator having a baffle **74** which requires the leaving air to first pass downwardly and then abruptly upwardly so that the solid particles tend to settle out. Such particles are discharged by the screw **29** through the outlet **31**.

Any remaining solids can be removed from the moist air in any suitable manner depending upon the character of the material and the separation economies involved. A cyclone separator **78** is shown for this purpose, although it will be understood that electronic precipitators or other forms of separators can be employed where required.

Specific examples of the practice of the invention in producing spheres of instant coffee are as follows:

	Example 1	Example 2	Example 3
Air temperature from heater 42 ° F.	520	545	500
Percent solids in feed 65	29	31	31
Temperature of feed 65 ° F.	108	120	126
Pressure of feed 65 p.s.i.	260	400	400
Temperature drying chamber 9 ° F.	325	325	325
Pressure drying chamber 9 p.s.i.	—.2	—.25	—.3
Temperature exhaust 71 ° F.	290	295	290
Final moisture—product percent	1.5	2.4	2.0
Bulk density—product lb./cu. ft.	13.5	12.5	12.5

Average production—2.375 lb./hr. Powder/sq. ft.—cross sectional area

As significant features of the invention it will be noted that the liquid spray **68** is projected concurrently into the primary stream of hot air and the particles therefrom settle into the secondary stream of air flowing below the primary stream of air; the primary air stream is admitted to the upper part of the drying chamber **9** and is of smaller cross sectional size and has a greater velocity than the secondary air stream which occupies the greater part of the cross sectional area of the spray chamber **9**; the secondary air stream emerges from the multi-orifice screen **14** as an internally stable body; the relative volume, temperatures and rate of flow of the air supplied to the primary and secondary streams can be regulated; a third stream of air is projected into the drying chamber **9** above the primary air stream to travel along the top of the drying chamber; this third air stream emerges from the multi-orifice screen **14** as an internally stable moving body; the volume, rate of flow and temperature of the third stream of air, with reference to the primary air stream, can be regulated; and the three air streams are provided by the very simple structure comprising the primary air duct **51**, conical end head **50**, multi-orifice screen **14** and partitions **55**. It will be noted that the depth of the second stream of air from the duct **53** is substantially equal in height and cross section to the height and cross section of the drying chamber **9** and that the nozzle **66** is recessed in the duct **51** thereby to avoid turbulence in this second stream and provide an internally stable or rectilinearly streamlined flow of this second stream.

From the foregoing it will be seen that the present invention provides a horizontal spray dryer achieving the many objectives set forth and is particularly adapted for the production of the dry product in unbroken hollow spheres which are shocked or rapidly inflated from droplets and then dried at a slower rate.

We claim:

1. A horizontal spray dryer, comprising a horizontally elongated tubular shell, an end head enclosing each end of said tubular shell, a multi-orifice screen spaced from one end head to provide horizontally a relatively long drying chamber at one side thereof and horizontally a relatively short space at the opposite side thereof, a first horizontal duct extending through said one end head, space and screen and arranged to project a primary stream of gas into said drying chamber and directly and in a substantially straight path toward the other end head, means within said first duct arranged to project a spray of liquid particles into said primary gas stream issuing from said first duct, horizontal partition means bounded by said one end head, screen and first duct and dividing said space into an upper and a lower chamber, means arranged to force gas to said lower chamber to pass through said screen and form a secondary stream of hot gas flowing below and substantially parallel with said primary stream of gas and through which said particles settle, means arranged to heat the gas supplied to said ducts, means arranged to force gas to said upper chamber to pass through said screen and form a third stream of gas flowing above and substantially parallel with said primary stream and isolating the top of said drying chamber and said screen from said particles, and means arranged to exhaust the moist gas from the end of said drying chamber adjacent said other end head.

2. A horizontal spray dryer as set forth in claim 1 wherein said first duct is arranged above the longitudinal center of said shell and said lower chamber is of substantially greater size than said upper chamber.

3. Apparatus for drying liquids into hard, dense walled hollow spheres, comprising a horizontally elongated shell forming a drying chamber, a first horizontal duct having an outlet of much smaller cross sectional size than the cross sectional size of said drying chamber and said outlet being arranged in the upper part of said drying chamber and with said duct arranged to project a first stream of gas horizontally into one end of said shell and in a substantially straight path toward the opposite end thereof, means in said duct arranged to project a spray of said liquid in the form of particles into the center of said first stream of gas concurrently therewith, means heating said first stream of gas before contact with said particles to a temperature to cause said particles to rapidly inflate into incompletely dried hollow spheres, a second duct having an outlet of a size substantially equal in height and cross section to the height and cross section of said drying chamber and with said second duct arranged to project a second stream of hot gas having a depth substantially equal in height and cross section to the height and cross section of said drying chamber horizontally into said one end of said shell below, concurrently and in contact with said first stream of gas, a multi-orifice screen arranged across said outlet for said second duct to provide a rectilinearly stream-lined flow in said second stream of hot gas, said incompletely dried hollow spheres settling through said second stream of hot gas and slowly drying therein to render the walls of said spheres hard and dense, and means at the bottom of said drying chamber to collect and remove the dried hollow spheres therefrom, means arranged to exhaust the moist gas from said opposite end of the shell shell.

4. Apparatus as set forth in claim 3 wherein said heating means are common to said first and second streams and wherein means are provided for applying a cooling medium to the gas passing through said second duct to reduce the temperature of said second stream of gas below the temperature of said first stream of gas.

5. A horizontal spray dryer, comprising a horizontally elongated enclosed shell forming a drying chamber,

means arranged to project a primary stream of gas horizontally into one end of said shell and directly in a substantially straight path toward the opposite end thereof, means at said one end of said shell arranged to project a spray of liquid particles to be dried into said primary gas stream concurrently therewith, means arranged to project an internally stable secondary stream of gas horizontally into said one end of said shell below and substantially parallel with said primary stream of gas and through which secondary stream said particles settle, said upper primary stream being of materially smaller cross sectional size than said lower secondary stream, means arranged to supply said gas under pressure to said projecting means for both said primary and secondary streams, means arranged to heat the gas so supplied, means arranged to project a third stream of gas horizontally along a substantially straight path into said one end of said shell above and substantailly parallel with said primary stream of gas to travel along the top of said drying chamber, and means arranged to exhaust the moist gas from said opposite end of said shell.

6. A horizontal spray dryer as set forth in claim 5 wherein a multi-orifice screen is arranged across the outlet of said means to project a third stream of gas, to effect an orifice pressure drop in the third stream of gas passing therethrough and to render said third stream of gas internally stable.

7. A horizontal spray dryer as set forth in claim 5

wherein damper means are provided for regulating the volume of gas supplied to said third stream with reference to the volume of gas supplied to said primary stream.

8. A horizontal spray dryer as set forth in claim 5 wherein means are provided for regulating the temperature of the gas supplied to said third stream in relation to the temperature of the gas supplied to said primary stream.

References Cited in the file of this patent

UNITED STATES PATENTS

1,138,380	Harris et al.	May 4, 1915
1,157,947	Merrell	Oct. 26, 1915
1,497,201	Wheat	June 10, 1924
1,734,260	La Mont	Nov. 5, 1929
1,782,054	Uhl	Nov. 18, 1930
1,794,978	Pease	Mar. 3, 1931
1,866,769	Harris	July 12, 1932
2,188,506	Hall	Jan. 30, 1940
2,278,473	Musher	Apr. 7, 1942
2,758,927	Chase	Aug. 14, 1956
2,818,917	Vincent	Jan. 7, 1958

FOREIGN PATENTS

377,747	Germany	June 26, 1923
889,439	France	Oct. 1, 1944