March 13, 1973 M. BALLAS ET AL 3,720,253

EGG WHITE SPRAY DRYING APPARATUS AND METHOD

Filed April 2, 1971 3 Sheets-Sheet 1

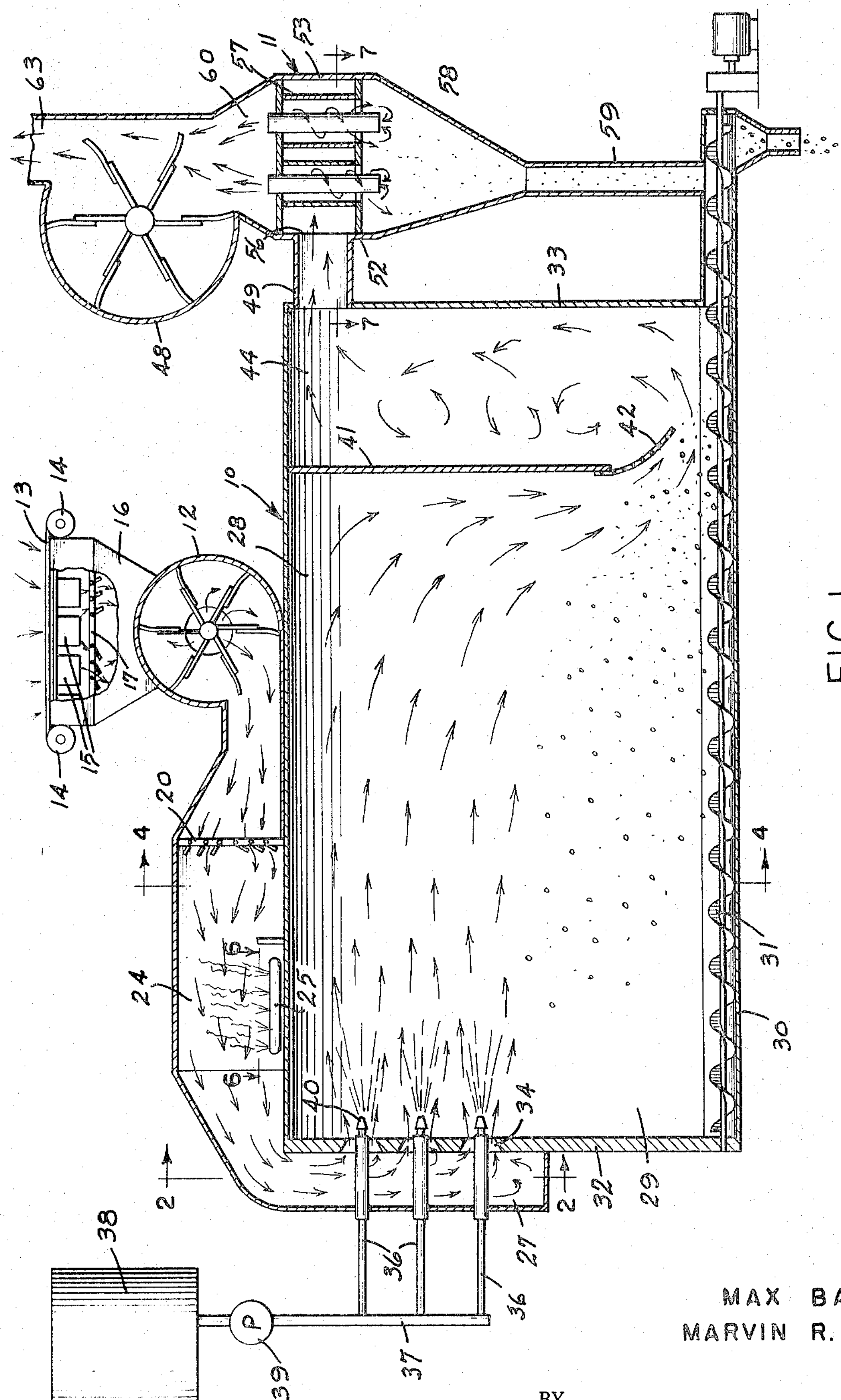


FIG. I

INVENTORS
MAX BALLAS
MARVIN R. PAINTER

BY A. Yates Dowell & A. Yates Dowell
ATTORNEYS

EGG WHITE SPRAY DRYING APPARATUS AND METHOD

Filed April 2, 1971 3 Sheets-Sheet 2

FIG. 4

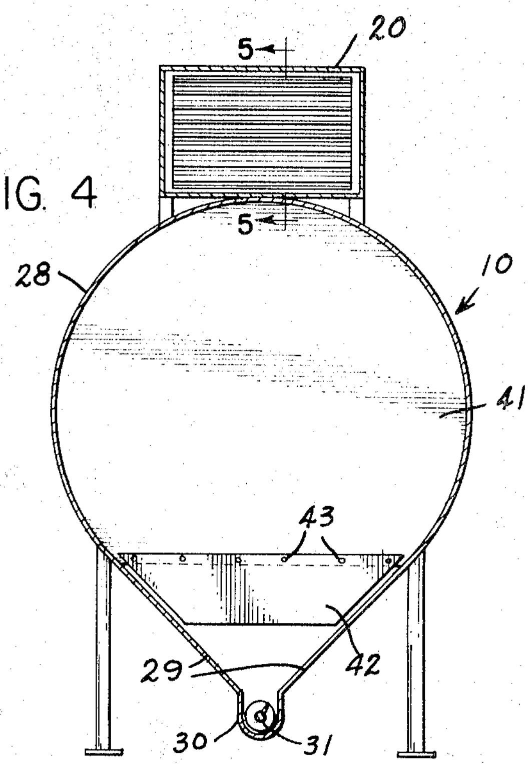
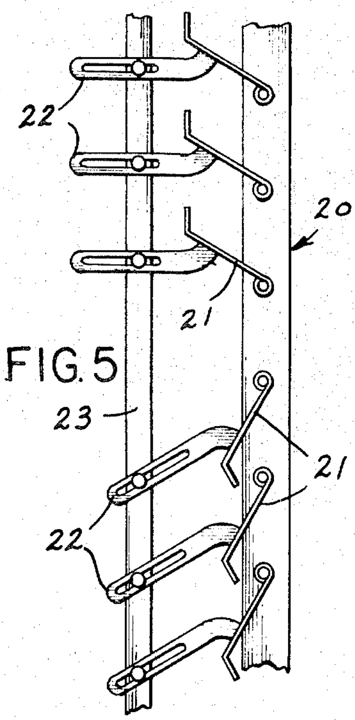


FIG. 5



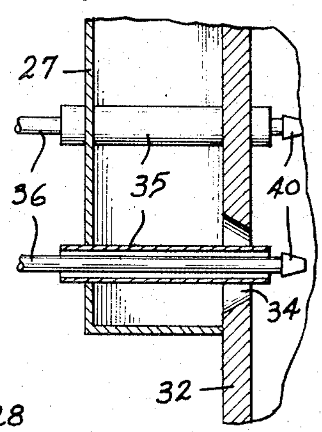
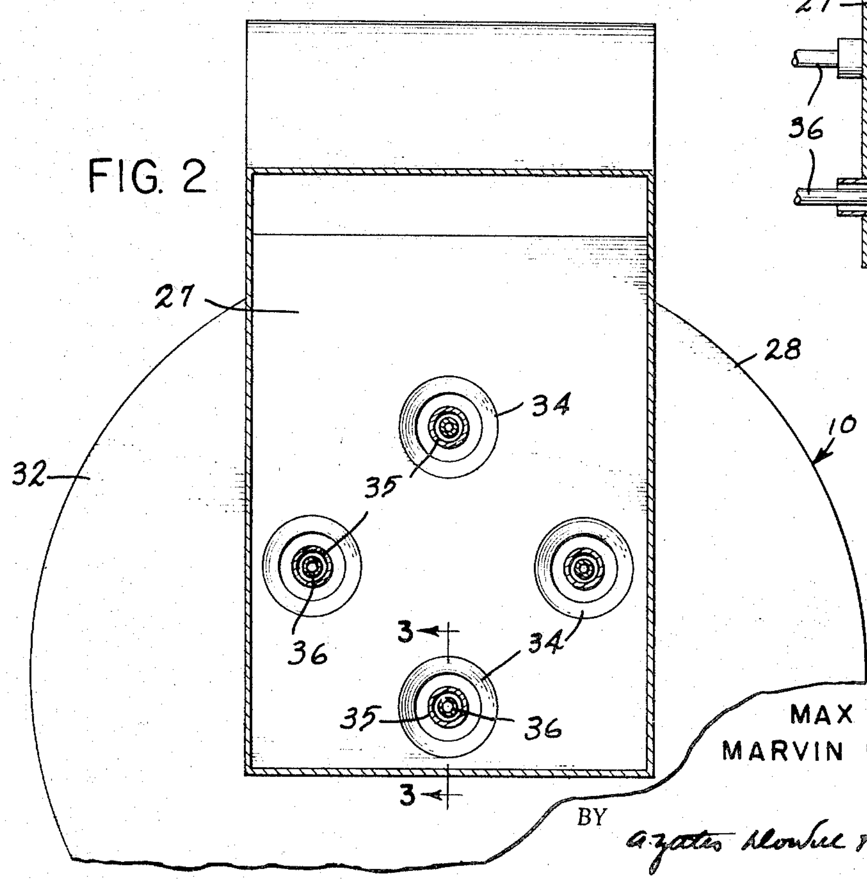


FIG. 3

FIG. 2



INVENTORS
MAX BALLAS
MARVIN R. PAINTER

BY
ATTORNEYS

FIG. 7

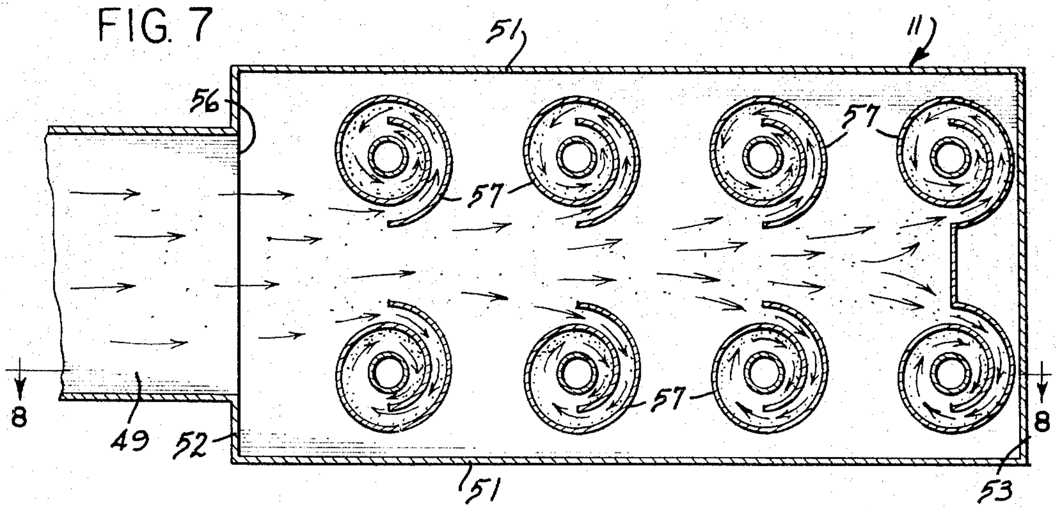
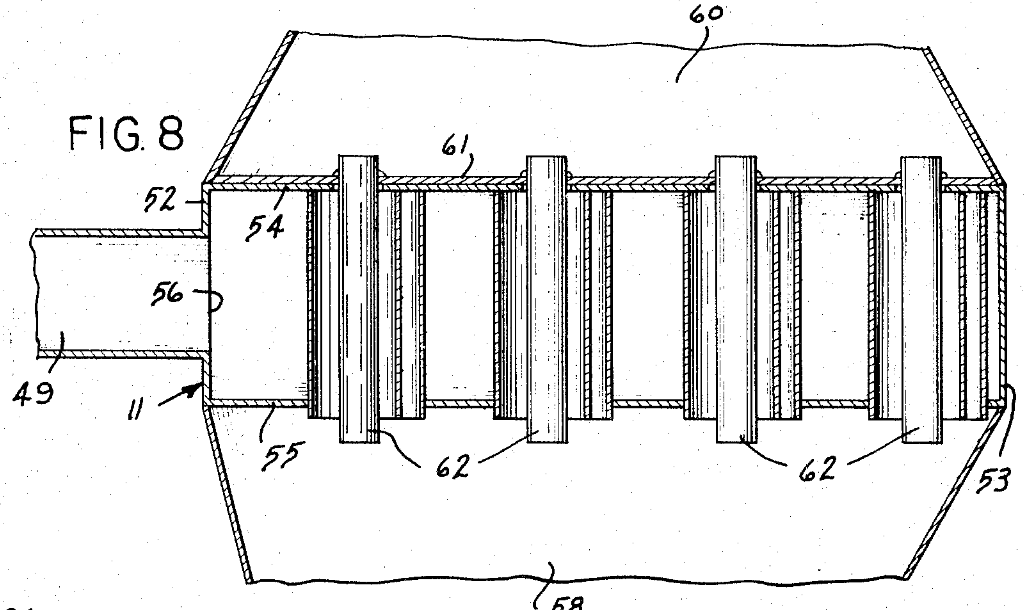


FIG. 8



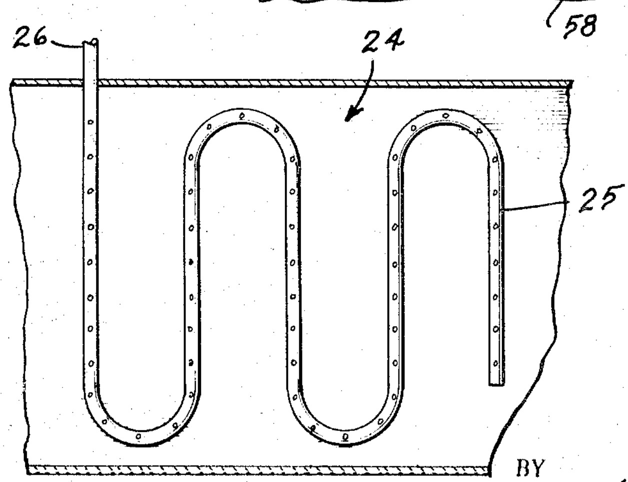


FIG. 6

INVENTORS
MAX BALLAS
MARVIN R. PAINTER

BY

ATTORNEYS

United States Patent Office

3,720,253
Patented Mar. 13, 1973

3,720,253

EGG WHITE SPRAY DRYING APPARATUS AND METHOD

Max Ballas and Marvin R. Painter, Zanesville, Ohio, assignors to Ballas Egg Products Corporation, Zanesville, Ohio

Filed Apr. 2, 1971, Ser. No. 130,696
Int. Cl. B01d 1/24
U.S. Cl. 159—4 F 7 Claims

ABSTRACT OF THE DISCLOSURE

Apparatus for spray drying egg whites in a moving stream of air and recovering substantially all of the product from the air stream. The apparatus includes drying and separating chambers in communication with each other and in which a differential air pressure is employed to assist in drying the egg whites, as well as separating substantially all of the dried egg whites from the air stream.

BACKGROUND OF THE INVENTION

(1) Field of the invention

This invention relates generally to the drying and preserving of various products including foods of different kinds and relates specifically to the spray drying of egg albumin or whites and to the method and apparatus by which the egg whites are dried in a stream of heated air and subsequently substantially all of the egg white product is removed from such stream of air.

(2) Description of the prior art

Heretofore many products have been dried or dehydrated to preserve the same over long periods of time, as well as to facilitate the shipping and storage of the products. In general, air drying of wet material has been divided into three major categories, namely, flash drying, spray drying, and fluid-bed drying. In flash drying systems, particulate solids are dropped from a conveyor into a rapidly moving stream of hot gases having air velocities on the order of 4,000 to 6,000 feet per minute. The air in the stream is heated to a temperature of 500° to 1,000° F. which normally dries the product in less than ten seconds. The solids usually are separated from the gas in a cyclone and a bag filter may be used for final clean-up of the gas stream before exhausting to the atmosphere. However, there is a limit of 60% to 70% moisture that can be handled in flash driers.

Spray driers may be considered a modification of a flash drier; however, the product being dried is atomized before being introduced into the moving air stream. Spray driers normally are used for materials in which the moisture content exceeds 80% or in which the solids are dissolved. The liquid product may be atomized to a spray by a rotating disk, a high pressure nozzle or a two-fluid nozzle. Pressure atomization uses pressure between 100 and 7,000 p.s.i.g. to force liquid through a nozzle and usually the pressure is between 300 and 4,000 p.s.i.g.

As in flash driers, spray driers normally operate at temperatures of 500° to 1,000° F. and generally the material is dried within three to ten seconds. Spray driers have one distinct advantage over other types of driers in that they tend to form the drying particles into spheroids. Since the hot inlet gas impinges on the droplets as soon as the droplets leave the atomizer, a film is formed on the first dried surface of the droplets. This film bursts as enclosed moisture escapes.

In fluid-bed driers, a bed of particulate solids is suspended and agitated by a vertically rising stream of gas in which each particle of solid material is surrounded by

the gas. Relative velocity of the gas and solid particles is high although the gas velocity itself is relatively low. Heat is transferred by a combination of conduction and convection and by the travel of the solid particles.

Referring again to spray driers, most products are entrained or suspended in a liquid carrier and the solids are substantially heavier than air. The heavier particulate matter can be air dried using a relatively high temperature stream of air after which the solids normally are separated in a cyclone type operator. This type of structure is disclosed in the patent to Kohlins et al. 2,953,199 and operates satisfactorily in cases where the particulate solids are substantially heavier than air.

Some efforts have been made to spray dry products such as milk, whole eggs, coffee, and other similar products having relatively light weight, which are suspended in an aqueous solution. The apertures for spray drying this type of material normally has included a bag type collector for collecting fine lightweight particulate matter from the air stream before the air is exhausted to the atmosphere. This type of apparatus is disclosed in the patent to Walker 2,957,519. The use of a bag type collector is objectionable since in large scale operations the bags soon become clogged with fine particulate matter which reduces the efficiency of the bags and requires that the system be shut down until the fine particulate can be removed from the bag collectors. Depending upon the material being dried, it may be necessary to shut down the system at least once in every 8 to 24 hours for cleaning the bags. However, such bags have heretofore been necessary in order to avoid loss of a significant quantity of the product.

The drying of egg whites has always been a difficult task since the solid particulate matter suspended in the liquid constitutes only from 10% to 13% of the total weight, and the fine particulate solids are only slightly heavier than air and therefore tend to remain in suspension. In conventional air drying systems using a centrigugal separator, as much as 10% of the egg whites are lost to atmosphere. Bag type separators have reduced the loss to 2% to 3%; however, the fine particulate solids trapped by the bags are subjected to heat for extended periods of of time and such heat causes discoloration as well as deterioration of the albumin or egg white which affects the whipping properties. Therefore, even though the fine particulate egg white solids are not lost to atmosphere, the quality and marketable value of the egg white solids trapped by the bag separators are substantially reduced. Also since the weight of the solid particulate matter of egg whites is substantially less than the weight of similar products, such as milk, whole eggs, and the like, considerably more of the fine particulate solids remain entrained in the air and are trapped within the bag separators; accordingly the frequency of interruption of the systems for cleaning the air bags is greatly increased.

From an economic point of view, it requires approximately 8.38 pounds of liquid egg white to produce one pound of dried egg white and prime dried egg white sells for $1.25 to $1.50 per pound. Dried egg whites which are discolored or otherwise affected by heat sell for a fraction of the cost of prime egg whites. A conventional shipping container filled with dried egg white weighs approximately 150 pounds. If it requires 10% more liquid egg white to fill the container, as in conventional centrifugal separators, this results in a direct loss of $18 to $23 per container plus many indirect costs such as air purification apparatus to prevent the egg white dust from polluting the atmosphere of the neighborhood. Bag type separators reduce the direct loss to $3.00 to $4.50 per container for prime dried egg white; however, the quantity of prime dried egg white is reduced. Also, indirect costs are raised considerably due to non-productive down time during which the bags are being cleaned.

SUMMARY OF THE INVENTION

The present invention is an egg white spray drying apparatus and process in which the egg whites are atomized and sprayed into a moving stream of heated in which the air is maintained under a partial negative pressure to assist in removing moisture from the product. The atomized egg whites are sprayed into a drying chamber where the heavier particles of solid particulate matter fall by gravity to the bottom of the chamber where they can be removed by a conveyor such as a continuously operated screw type auger. Adjacent the opposite end of the drying chamber, the air stream is directed downwardly toward the screw conveyor by a baffle. At the bottom of the baffle, the air stream flow is reversed and passes through an opening of reduced size so that the momentum of most of the particles of solid matter will be thrown toward the conveyor. In passing through the restricted opening, the velocity of the air is accelerated and enters a larger compartment where the air stream slows down and creates a multiplicity of eddy currents, particularly along the fringes of the air stream. The air then is drawn through a relatively small separating chamber having a plurality of scroll type structures having central air tubes extending therethrough. The scrolls or centrifugal separators cause the velocity of the air to be accelerated which creates a vortex that tends to throw the fine particulate solid matter to the outside of the scroll while simultaneously drawing the air downwardly. As the air and particulate matter are discharged from the bottom of the scroll, the relatively clean air in the center of the vortex is caused to change direction and is drawn upwardly through the central tubes, while the particulate matter falls by gravity into a hopper where it is discharged. The clean air is discharged to atmosphere. The system includes a relatively small fan for forcing heated air into the drying chamber and a larger fan for withdrawing air from the drying chamber and through the centrifugal separtaor.

BRIEF DESCRIPTION OF THE DRAWINGS

FIG. 1 is a longitudinal section illustrating one application of the invention.

FIG. 2 is an enlarged section on the line 2—2 of FIG. 1.

FIG. 3 is a section on the line 3—3 of FIG. 2.

FIG. 4 is a section on the line 4—4 of FIG. 1.

FIG. 5 is an enlarged fragmentary section on the line 5—5 of FIG. 4.

FIG. 6 is an enlarged section on the line 6—6 of FIG. 1.

FIG. 7 is an enlarged section on the line 7—7 of FIG. 1.

FIG. 8 is a section on the line 8—8 of FIG. 7.

DESCRIPTION OF THE PREFERRED EMBODIMENT

With continued reference to the drawings, the albumin or egg white spray drying aypparatus of the present invention includes a drying chamber **10** and a separating chamber **11**. In order to dry the egg white product, a fan **12** is mounted on top of the drying chamber **10** and such fan draws air through a fine filter **13** mounted on rollers **14** in such a manner that the filter material in the stream is renewed as desired by the unrolling of a supply roll onto a takeup roll so that the filter is replaced.

Filter **13** removes larger impurities from the air and in order to remove the smaller impurities, one or more bag-type cloth filters **15** of relatively thick felt or other material are located adjacent to the filter **13**. Air passing through the cloth filters **15** is confined within a hopper **16** in which a louvered partition **17** is disposed. The louvers of the partition **17** are adjustable to vary the resistance and direction of air flow. The fan **12** may be of a desired size and operated at a desired speed. However, a fan having a diameter of 30 inches which is rotated at

approximately 1000 r.p.m. to produce a velocity of approximately 2400 feet per minute has been found satisfactory.

Air discharged from the fan **12** passes through a louvered partition **20**. As illustrated in FIG. 5, the partition **20** includes a plurality of louvers **21** swingably mounted on the partition and each of such louvers has a link **22** connected to an operating arm **23**. As illustrated, certain of the louvers **21** are angled upwardly and other louvers are angled downwardly to control the direction and movement of the air flow from the fan **12**. Downward movement of the operating arm moves the lower louvers toward closed position and simultaneously moves the upper louvers toward open position. Upward movement of the operating arm reverses the positions of the upper and lower louvers so that the direction of air stream from the fan **12** can be controlled without restricting the air flow.

Air passing through the partition **20** enters a heating chamber **24** having a heater **25** therein. The heater **25** may be of a desired size and configuration and heated by gas, electricity or other source of energy which is sufficient to heat the air passing through the heating chamber **24** to a temperature of approximately 225° F. and normally does not exceed 250° F. As illustrated in FIG. 6, the heater is a gas flame burner arranged in a serpentine path and connected to a supply pipe **26** for introducing gas under pressure into the heater **25**. From the heating chamber **24**, the heated air is forced under pressure from the fan **12** into a plenum chamber **27** at one end of the drying chamber **10**.

The drying chamber **10** includes a semicylindrical upper portion **28** connected to downwardly tapering walls **29** which terminate at a trough **30** in which a conveyor such as a screw-type auger **31** is located. Opposite ends of the drying chamber are closed by the end walls **32** and **33**. The end wall **32** is provided with one or more openings **34** providing communication between the plenum chamber **27** and the interior of the drying chamber **10** to permit heated air from the plenum chamber to flow into the drying chamber. A sleeve **35** has one end mounted centrally of each of the openings **34** and such sleeves extend through the plenum chamber **27** to the exterior.

A liquid egg white supply pipe **36** extends through each of the sleeves **35** and is connected to a header **37** which in turn is connected to a reservoir **38** having a supply of liquid egg whites therein. A pump **39** is provided for forcing the liquid egg whites under pressure through the header **37** and the supply pipe **36**. An atomizing nozzle **40** is mounted on the end of each of the supply pipes **36** within the drying chamber **10** and arranged so that liquid egg white is atomized and sprayed into the drying chamber. Heated air from the plenum chamber **27** flows through the openings **34** and entirely surrounds each of the nozzles **40** so that the air impinges on the atomized liquid egg whites and causes the droplets to dry within a period of one to two seconds.

Due to the atomization of the liquid egg whites and the spraying of the same into the heated air, a film forms around each spheroidal droplet and such film bursts as enclosed moisture escapes and results in flufly particulate matter. Even though heated air is flowing into the drying chamber under pressure, a negative pressure or partial vacuum is maintained within the drying chamber in a manner which will be described later to assist in the drying process. The heavier dried particulate matter falls almost immediately onto the tapered walls **29** of the drying chamber from which it slides downwardly into the trough **30** and is discharged from the drying chamber by the auger **31**. If desired, the tapered walls **29** may be vibrated by a conventional vibrator (not shown) to assist in the downward sliding of the particulate matter into the trough.

Spaced inwardly from the end wall **33** of the drying chamber is a fixed imperforate partition or baffle **41** having a configuration complementary to the interior of such chamber. The baffle **41** is connected to the upper portion **28** and extends downwardly a short distance along the tapering walls **29**. To the lower end of the baffle **41** is connected an apron **42** of rubber or other semi-flexible material mounted in any desired manner, as by fasteners **43**. The apron **42** extends downwardly to a position spaced from the auger **31**.

Air from the main portion of the drying chamber **10** is drawn beneath the baffle **41** and apron **42** into a compartment **44** between the partition **41** and the end wall **33**.

In order to draw air into the compartment **44**, a relatively large fan **48** is provided in the separating chamber **11**. The fan is of an appropriate size and operating characteristics, although a 33 inch fan driven at a speed of approximately 1450 r.p..m. and moving the air at a velocity of approximately 3845 feet per minute has been satisfactory. Since the exhaust fan **48** operates at a higher capacity than the inlet fan, a negative pressure or partial vacuum is created within the drying chamber.

Due to the differential pressures between the main drying chamber and the compartment **44**, the apron **42** curves rearwardly and creates a reduced throat through which air from the main drying chamber passes. This creates a venturi effect which causes the velocity of the air to be accelerated through the reduced throat. As illustrated in FIG. 1, this causes air currents within the main drying chamber to move down the baffle **41** and through the throat, after which the direction of air flow is sharply changed and caused to flow upwardly. The momentum of the particulate dried egg whites suspended in the air tends to cause such particulate matter to keep moving in a straight line downwardly until it is received within the trough **30**. At this point most of the dried egg white has been removed from suspension in the air stream; however, some of the fine particulate matter having a weight only slightly greater than air remains in suspension.

Since the compartment **44** is substantially larger in volume than the throat, the velocity of the air decreases and creates a multiplicity of eddy currents which permit additional fine particulate matter to fall out of suspension. At the upper end of the compartment **44**, an air duct **49** is provided which connects the drying chamber **10** with the separating chamber **11**. Since the air duct is substantially smaller than the compartment **44**, the velocity of the air drawn through the duct is again accelerated.

The separating chamber **11** includes side walls **51** and end walls **52** and **53** connected by top and bottom walls **54** and **55**. The end wall **52** has an opening **56** providing communication with the air duct **49**. A plurality of scrolls or helical walls **57** are connected to the top wall **54** and extend downwardly through the bottom wall **55** into a collection hopper **58** with a discharge tube **59** connecting the hopper **58** with the housing of the auger **31**. A plenum chamber **60** is located above the top wall **54** of the separating chamber **11** and such plenum chamber includes a bottom wall **61** in which a plurality of tubular member **62** are mounted. The tubular members **62** pass through the bottom wall **61** and extend downwardly through the separating chamber with one of the tubular members being disposed within the central portion of each of the scrolls **57**. The lower ends of the tubular members are located exteriorly of the scrolls. The exhaust fan **48** is located in the upper portion of the plenum chamber **60** and is adapted to draw air through the tubular members **62**.

As illustrated in FIGS. 1 and 7, the velocity of the air in the air duct **49** is accelerated and since the tubular members **62** extend through the scrolls, the air with fine particulate matter suspended therein is directed into the scrolls **57**. Due to the configuration of the scrolls, a vortex is provided which causes the fine particulate matter to move to the exterior of the vortex by centrifugal force as the air is moving around the scrolls and downwardly. When the air is discharged from the bottom of the scrolls, the fine particulate matter is thrown out of suspension while the relatively clean air in the center of the vortex is caused to reverse direction and more upwardly through

the interior of the tubular members **62** into the plenum chamber **60**. The fine particulate matter falls through the collection hopper and discharge tube, while the clean air is exhausted by the fan **48** to the atmosphere through a stack **63**. The temperature of the air being exhausted normally is approximately 125° F. and seldom is above 150° F.

In the operation of the device, the inlet fan **12** draws atmospheric air through the filters **13** and **15** and forces such air through the heating chamber **24** where the temperature of the air is elevated to approximately 225° F., after which the heated air is discharged into the plenum chamber **27**. The heated air is forced through openings **34** in the end wall of the drying chamber **10** by the pressure of the inlet fan **12** as well as the partial vacuum or negative pressure created within the drying chamber by the outlet fan **48**. As the heated air is being introduced into the drying chamber, liquid egg whites are atomized and sprayed through nozzles **40** into the flowing stream of heated air which causes the droplets of liquid egg white to be dried within a matter of one or two seconds. The heavier particles of dried egg white fall by gravity to the trough **30** at the bottom of the drying chamber where they are discharged by the auger **31**. The air within the drying chamber is withdrawn through a throat beneath the baffle **41** and apron **42** and the direction of air flow is abruptly changed so that some of the particulate matter still in suspension is thrown out of suspension as the air enters the compartment **44** at the end of the drying chamber.

From compartment **44** the air is accelerated and drawn through the air duct **49** into the separating chamber **11**. The air is drawn into the scrolls **57** which creates a vortex so that the particulate matter still in suspension is thrown against the walls of the scrolls by centrifugal action until the particulate matter is discharged from the scrolls. The direction of flow of the clean air in the center of the vortex is reversed so that as soon as the particulate matter is thrown out of suspension, clean air is drawn upwardly through the tubular member **62** into the plenum chamber **60** by the exhaust fan **48** and is exhausted to atmosphere. The particulate matter thrown out of suspension within the vortex falls by gravity into the collection hopper **58** where it is discharged into the auger **31** for packaging and shipment.

In one specific application of the above apparatus and process, operation was continuous for approximately 130 hours at peak efficiency without any clogging of the apparatus. After 130 hours the supply of liquid egg white material was exhausted and for this reason the operation ceased. During the entire operation in excess of 99½% of the dried egg whites were recovered in prime condition. Due to the relatively low temperatures involved, as well as the speed of drying, and the rate of movement of the dried egg white product through the system, all of the egg white product was treated without undesirable side effects. The product was removed continuously from the drying chamber so that it required less than a minute between the time the liquid egg white was sprayed into the chamber and the time the dried egg white product was discharged from the chamber. The product discharged was not of an uncomfortable temperature to the human hand.

We claim:

1. Apparatus for spray drying liquid egg white product comprising an elongated drying chamber having first and second end walls, product removal means in said chamber for removing dried product, a first plenum chamber located adjacent to said first end wall, means for introducing heated air under pressure into said first plenum chamber, aperture means in said first end wall providing communication between said first plenum chamber and said drying chamber, spray nozzle means connected to a supply of liquid egg white product, said nozzle means positioned to pass said product through said aperture means

and to discharge it into said chamber, whereby said product is sprayed from said nozzle means toward said second end wall and heated air is blown through said aperture means in intimate association with said product into said chamber so that the product is dried into powder form and a substantial portion is deposited in said chamber for removal, said second end wall of said chamber being spaced from said first end wall a distance such that in normal operation the product achieves a substantially dry condition before reaching said second end wall, said second end wall having a discharge passageway, an expansion and settling chamber located exteriorly of said second end wall and communicating with said drying chamber through said discharge passageway, said expansion and settling chamber having a cross-section substantially larger than said discharge passageway to reduce the velocity of the air and any entrained product carried thereby after passing through said discharge passageway to permit the settling of a substantial quantity of air entrained product in said expansion and settling chamber, said expansion and settling chamber having a discharge opening, said discharge opening having a cross-section substantially smaller than that of said expansion and settling chamber, a separating chamber communicating with said expansion and settling chamber through said discharge opening, said separating chamber including upper and lower walls, a second plenum chamber located adjacent to said lower wall, a third plenum chamber located adjacent to said upper wall, a plurality of tubular members extending from said third plenum chamber to said second plenum chamber, a scroll disposed about each of said tubular members and providing communication between said separating chamber and said second plenum chamber, blower means connected to said third plenum chamber for drawing air from said second plenum chamber and said separating chamber and causing air entrained product to fall out of suspension in said second plenum chamber, and means for collecting the product from said second plenum chamber.

2. The structure of claim 1 including a flexible baffle disposed across at least a portion of the discharge passageway in said second end wall.

3. The structure of claim 1 in which said drying chamber includes an upper portion and a lower portion, said upper portion being generally semi-cylindrical in cross-section and said lower portion including downwardly and inwardly inclined wall structure.

4. The structure of claim 1 in which said means for introducing heated air into said first plenum chamber includes duct means connected to said plenum chamber, a second blower means located in said duct means for forcing atmospheric air through said duct means, and heater means in said duct means for heating the air therein.

5. In an apparatus for spray drying liquid egg white product having a drying chamber, means for spraying liquid egg white product into said chamber in intimate association with heated air to dry said egg white product into powder form, said drying chamber having discharge means, and a centrifugal separating chamber in communication with the discharge means for separating the entrained product from the air flow: the improvement comprising said centrifugal separating chamber including upper and lower walls, a lower plenum chamber located adjacent to said lower wall, an upper plenum chamber located adjacent to said upper wall, a plurality of tubular members extending from said upper plenum chamber through said separating chamber to said lower plenum

chamber, a scroll disposed about each of said tubular members between the upper and lower walls of said separating chamber and providing communication between said separating chamber and said lower plenum chamber, blower means connected to said upper plenum chamber for drawing air from said lower plenum chamber and said separating chamber and causing air entrained product to fall out of suspension in said lower plenum chamber, and means for collecting the product from said lower plenum chamber.

6. The process of drying and collecting for removal liquid egg white product, comprising spraying the product into a drying chamber in intimate association with heated air so that the product is dried into powder form and a substantial portion is deposited in the chamber for removal,

passing the air and entrained product through a first restricted discharge passageway remotely spaced from the location at which the product is sprayed into the chamber and at the lower portion thereof,

passing the air and entrained product from the first discharge passageway into an expansion and settling chamber of substantially larger cross-section than said discharge passageway whereby a further substantial portion of product in powder form is deposited,

passing the air and entrained unsettled product from the expansion and settling chamber through a second restricted discharge passageway located at a position remote from said first discharge pasageway into a plurality of cyclonic separators disposed along generally vertical axes,

passing all of the air and entrained product from the cyclonic separators downwardly into a lower collection chamber while separating entrained product from the air, and

exhausting the air upwardly through said cyclonic separators.

7. The process of claim 6 in which the heated air is blown into the first chamber by a first blower and withdrawn from the cyclonic separators by a second blower, in which the second blower operates at a higher capacity than said first blower.

References Cited

UNITED STATES PATENTS

2,957,519	10/1960	Walker	159—4 F
2,957,773	10/1960	Toolmin, Jr.	159—4 F
1,886,548	11/1932	Horne et al.	55—348 X
3,082,098	3/1963	Bergquist	99—210
2,953,199	9/1960	Kohlins et al.	159—4 F
2,835,597	5/1958	Barzelay	159—4 F X
2,578,315	12/1951	Parker	34—79 X
2,531,343	11/1950	Patterson	34—82 X
2,730,282	1/1956	Bonner	34—92 X
2,501,979	3/1950	Wood et al.	34—79
890,314	6/1908	Thompson	34—242

FOREIGN PATENTS

1,308,253	9/1962	France	55—346

WILLIAM F. O'DEA, Primary Examiner

W. C. ANDERSON, Assistant Examiner

U.S. Cl. X.R.

34—22, 92, 79; 99—210; 55—348, 349, 449; 159—48 R