

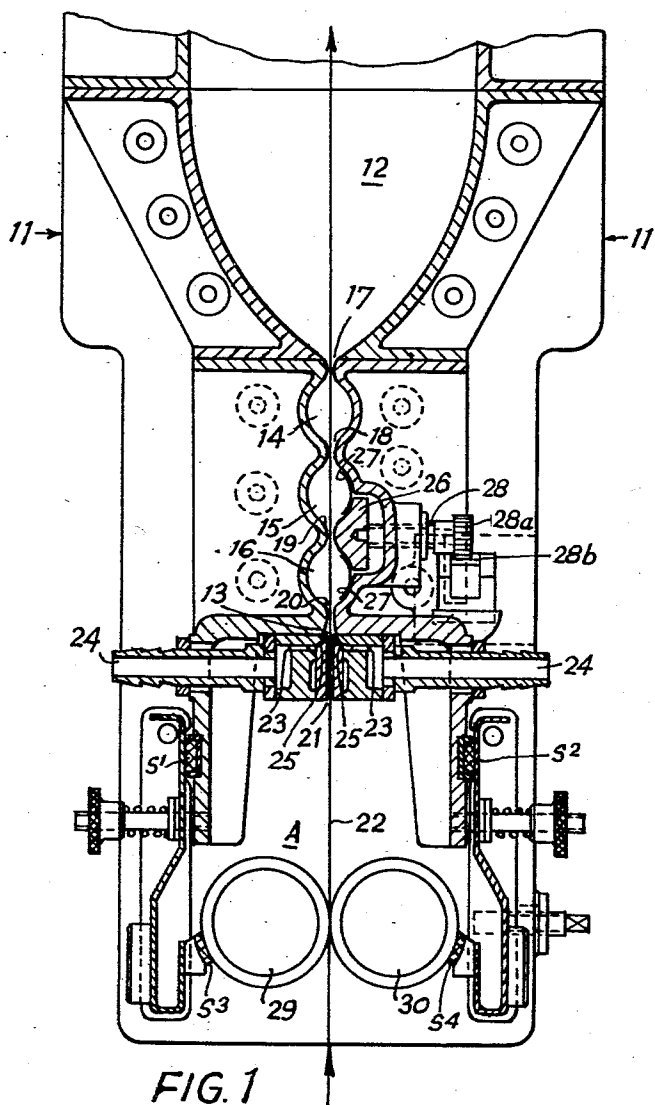
Sept. 11, 1962

J. DOLEMAN
HEAT TREATMENT OF FILAMENTS, FIBRES, THREADS, FILMS
AND SHEET MATERIAL

3,052,989

Filed May 5, 1959

3 Sheets-Sheet 1



INVENTOR:
JACK DOLEMAN
by

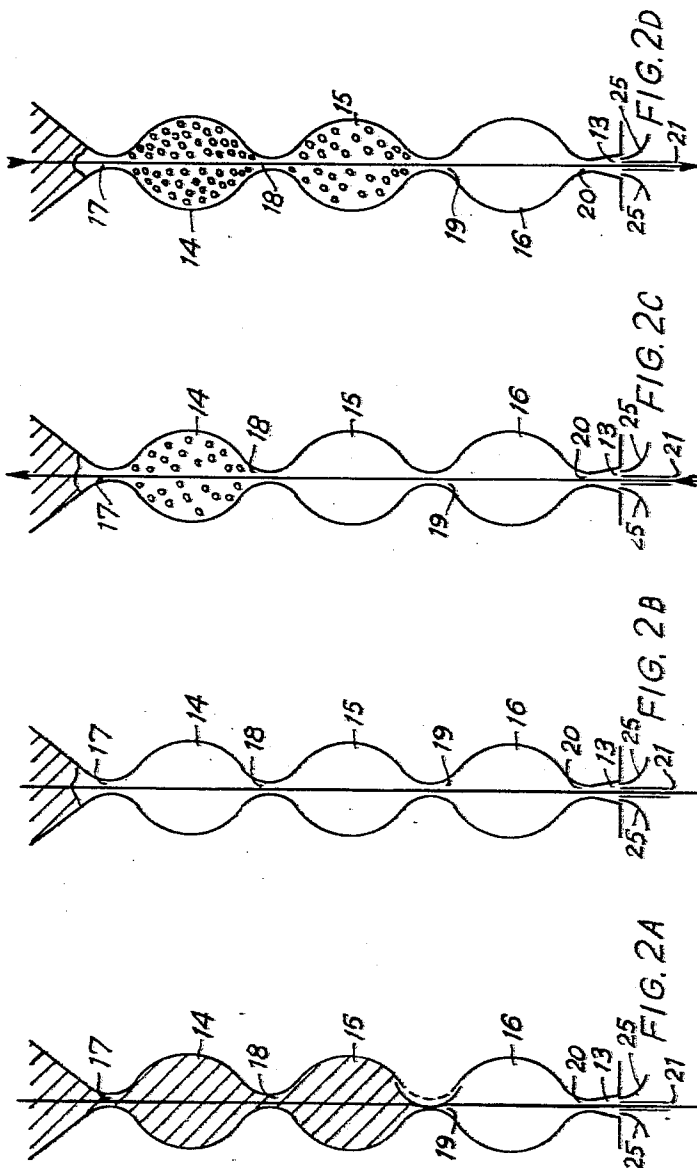
Fredrick Brittenfeld
Attorney

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INVENTOR:
JACK DOLEMAN
by

Frederick Breitenfeld
Attorney

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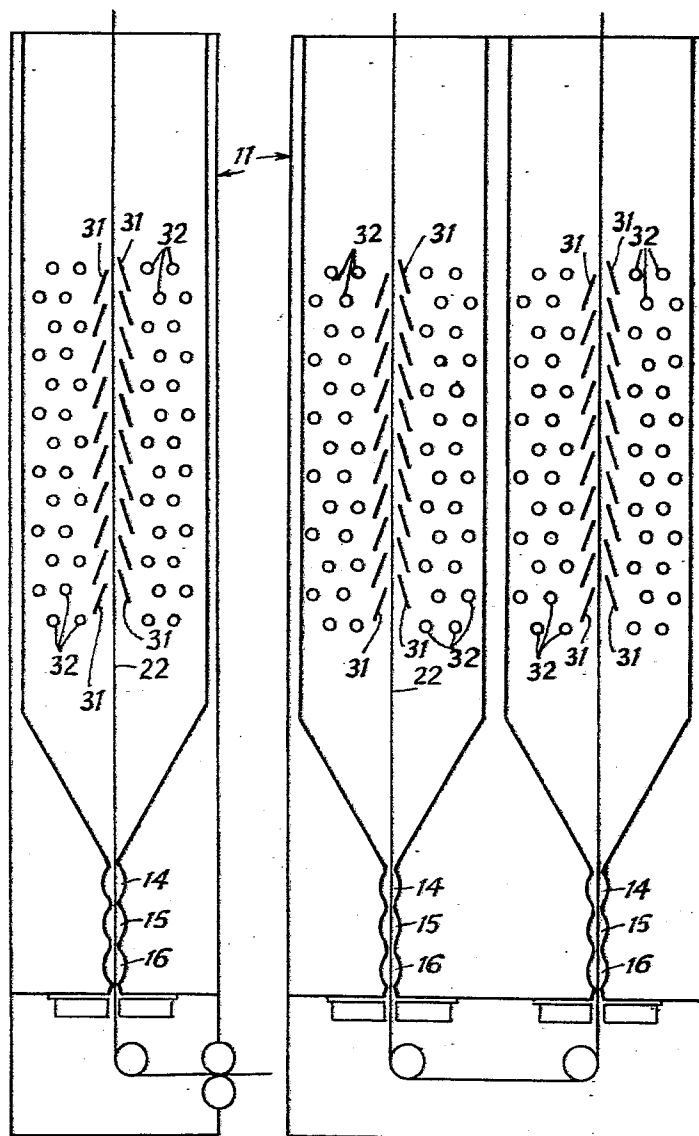


FIG. 3

FIG. 4

INVENTOR:
JACK DOLEMAN
by

Frederick Breitenfeld
Attorney

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3,052,989

HEAT TREATMENT OF FILAMENTS, FIBRES, THREADS, FILMS AND SHEET MATERIAL

Jack Doleman, Cheadle Hulme, England, assignor, by mesne assignments, to The Cotton Silk and Man-Made Fibres Research Association

Filed May 5, 1959, Ser. No. 811,166

Claims priority, application Great Britain May 6, 1958
7 Claims. (Cl. 34-57)

This invention concerns the treatment of filaments, fibres, threads, films and sheet material in the unwoven or woven, knitted or likewise fabricated form (hereinafter and in the claiming clauses hereof called "the material under treatment"). The treatment may be the drying, dyeing, or resin baking of the material, or any other operation for which the present apparatus may prove useful.

We have described in the specifications of our prior Patent No. 2,785,478 and our co-pending applications Serial Nos. 547,681, filed October 11, 1955 and 639,480, filed February 11, 1957, now Patent 2,971,242, means and methods of passing the material under treatment into and out of and through and heating the same in a bed of solid discrete particles, while subjecting the bed to an upward gaseous current, the size and weight of the particles and the velocity and nature of the current and the disposition of the material under treatment being so chosen that the forces exerted by the current on the particles are sufficient to counterbalance the gravitational force on free particles and to expand the bed thus allowing movement of the particles but is insufficient to convert the whole bed into a unidirectional stream of particles. The said movement of the particles in the bed may be random or include those analogous to convection or circulatory flow in a liquid, that is to say, localised upward movement of particles may occur in a zone or zones of the bed, for example in zones adjacent to the material under treatment, and localised downward movement of particles may occur in another zone or zones of the bed and these localised movements may vary in position and/or direction but the current must not be such as to substitute for these random or convective or circulatory movements a unidirectional flow of the particles of the whole bed. A bed of solid discrete particles subjected to and expanded by such an upward gaseous current in the manner described is herein called "a fluidised bed."

It is necessary to provide sealing means to prevent loss of particles from the fluidised bed in those applications of the fluidised bed to the materials under treatment wherein the said material enters or leaves the fluidised bed otherwise than from the top of the bed. The present invention is concerned with such arrangements and has for its object to improve such sealing means and in particular to minimise the tension in the material under treatment in those cases where the said material leaves through the base and to overcome difficulties which arise at the exit from the fluidised bed in such cases in the manner hereinafter mentioned.

In the complete specification of our co-pending application Serial No. 670,957, filed July 10, 1957, now Patent 2,938,276, we have described and claimed a method of passing the material under treatment into or out of a fluidised bed as herein defined which is characterised by the step of passing the same through an aperture in the base of a fluidised bed container, and at the same time directing a gas upwardly through or past the upper end of the aperture at a sufficiently high velocity substantially to preclude leakage of particles from the inside of the container therethrough. We have found when practising the method described and claimed in the complete specification of our last-mentioned co-pending application

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with the material under treatment passed upwardly into the fluidised bed through an aperture in the base of the container for the fluidised bed that leakage of the particles of the bed downwardly through the aperture may be precluded without the use of excessively high velocities and pressure in the upwardly directed gas stream which passes through or past the upper end of the aperture through which the material under treatment enters the bed. In one embodiment described in the said specification Serial No. 670,957 no more than 7 to 15 lbs. per square inch pressure is sufficient to ensure a substantial sealing effect with the fabric passing upwardly through the aperture.

We have found that when the fabric is passed downwardly through the said aperture there is a marked tendency for particles of the bed to pass downwardly into the said aperture and to jam therein unless substantially higher pressures are employed. Such higher pressures are quite simply determined by mere trial but their use involves the disadvantage that substantially more energy is required to force the gas through the aperture and upwardly through the fluidised bed and there is increased disturbance of the fluidising effect of the gas in the zone adjacent the aperture.

The use of lower pressures, while accompanied by the use of less energy for forcing the gas up through the system, and less disturbance nevertheless involves considerable risk of the material jamming with its attendant increase in tension in the material under treatment, or even of breakage.

The discovery on which the present invention is based is that the velocity of the entering gas and its pressure may be reduced without substantial downward loss of particles of the fluidised bed if the material under treatment is caused to leave and the gas required for fluidising the bed is caused to enter the base of the container of the fluidised bed through a succession of apertures or throats forming parts of an expansion chamber or series of expansion chambers.

The fact that the pressure required to drive the fluidising gases into and through the fluidised bed is not increased by the use of a series of apertures but may in fact be reduced and that a reduced velocity may be effectively employed to prevent any substantial downward loss of particles is surprising and we have been unable to ascertain the precise technical explanation of this surprising result.

According to the present invention a method of passing a filament, fibre, thread, or sheet material in the unwoven or woven, knitted or likewise fabricated form downwardly out of a fluidised bed as herein defined, is characterised in that the material under treatment passes from the container for the fluidised bed and the fluidising gas passes to the said container through a succession of throats forming part of an expansion chamber or series of expansion chambers. By the term "throat" herein and in the claiming clauses hereof we mean a circular or a long narrow aperture through which the material under treatment and the fluidising gas surrounding the said material may pass into or out of an expansion chamber and by the term "expansion chamber" we likewise mean a space through which the material under treatment may pass on its way from the container for the fluidised bed and into which the gas passing through the throat may expand.

Considerable variation is possible in the numbers and shape of the throats and expansion chambers and of their relative widths with varying degrees of improvement in the reduction of tension in the material under treatment and in the energy required for fluidising the bed but a progressive reduction in the widths or cross-sectional area of the throats has been found to be particularly

effective if the wider throat or that of greater area is placed nearest to and the narrowest throat or throat of least area is placed farther or farthest from the container for the fluidised bed.

The invention does not however reside in any precise dimensions of throats or expansion chamber or chambers or in the relative proportions thereof but in the use of a plurality of throats in combination with one or more expansion chambers in the manner and for the purpose herein described. The dimensions and relative proportions best suited to any particular material or range of materials under treatment may be determined by simple trial by reference to the embodiments herein described once the said combination and its manner and purpose as herein described are known.

Preferably there should be provided in the fluidised bed vertically above the expansion chamber system means for controlling the particle movement adjacent the material under treatment, which means impedes the horizontal or substantially horizontal movement of masses of particles towards or away from the said material while permitting convectional or circulatory movement of particles to continue between zones adjacent the said material under treatment and other parts of the fluidised bed.

The invention also comprises within its scope apparatus suitable for the passage of a filament, fibre, thread or sheet material in the unwoven or woven, knitted or likewise fabricated form downwardly out of a container for a fluidised bed as herein defined, including, between the bed containing portion of the container and the gas inlet thereto, one or more expansion chambers, each disposed between throats and a means of supplying gas under pressure in such manner that a stream of gas surrounding the material under treatment may pass upwardly in succession through the said throats and expansion chamber or chambers into the said bed-containing portion for the purpose of fluidising a bed of particles. One or more of the said throats may be constructed in the manner more particularly described in the complete specification of our co-pending application Serial No. 670,957 or a throat may be combined with jets or slits therein described. In an alternative embodiment additional supplies of gas may be introduced into the expansion chamber or chambers thus increasing the volume of gas passing through the higher throat or throats. It is desirable also to provide particle movement controlling means adjacent to the path of the said material under treatment, above the expansion chamber system, and capable of impeding the horizontal movement of masses of particles, in a fluidised bed of particles of overall diameter not less than 100 microns and preferably not more than 1,000 microns, towards or away from the said path while permitting convectional or circulatory movement of particles between zones adjacent to the said path and other parts of the fluidised bed when the apparatus is in operation. We prefer beds formed from particles of between 400 and 700 microns.

The means for supplying gas should be so arranged that the gas flows up between the sides of the throats and the material under treatment and, in the case of film or sheet material, the volume of gas supplied to one side of the material should be substantially equal to the volumes supplied to the other side. The velocity should be adjusted to prevent any substantial downward leakage of particles from the fluidised bed past the lowermost throat or aperture. Since the total volume of gas will be determined within limits by the dimensions of the fluidised bed and the nature of the particles, the adjustment of velocity for the purpose of preventing leakage will in general require to be effected by suitably proportioning the width of throat in relation to the number of throats and expansion chambers employed. The cross-sectional area of the throats must of course be sufficient at the gas velocity requisite to prevent leakage, to pass

sufficient gas to fluidise the bed of particles in the container.

Means may be provided for temporarily closing at least one of the throats.

In order to obtain improved results we have found it better to arrange that the walls of the expansion chambers and the throat portions are in the form of smooth curves blending one into the other. A convenient and useful number of expansion chambers is three.

When the material to be treated is in the form of film or sheet material or consists of a row of filaments, fibres or threads, the expansion chamber system through which the material passes should have a uniform vertical cross-section in parallel planes transverse to the film or sheet or to the row of filaments, fibres or threads, whilst if the material consists of a single filament, fibre or thread the expansion chamber system should be circular at any horizontal cross-section. Each throat, in the case of the treatment of film or sheet material or of a row of filaments, fibres or threads should present an elongated aperture, while in the case of a filament, fibre or thread of substantially circular section, the throat will be a convergent, then divergent, circular orifice.

The invention is particularly useful when embodied in a container for a fluidised bed in combination with feed and withdrawal means for the material to be passed directly through the bed in a downward direction in a single pass. Another useful embodiment consists of a fluid bed container having two means for passing the material, at least one of which is constructed in accordance with the invention and which are mounted side by side, in combination with a device for guiding material which has passed downwardly through one said means, for upward passage through the other said means. Alternatively, two fluidised beds may be used, the material under treatment passing downwardly through the one bed and upwardly through the other bed. It is also possible to pass the material under treatment through a succession of beds.

The invention will now be described further, by way of example, with reference to the accompanying drawings, in which:

FIG. 1 is a diagrammatic sectional view of the lower part of a container for a fluidised bed;

FIGS. 2A, 2B, 2C and 2D are diagrams illustrating the treatment of cloth in the container of FIG. 1;

FIG. 3 is a diagram illustrating "single pass" treatment of material, and

FIG. 4 is a diagram illustrating "double pass" treatment of material.

Referring mainly to FIG. 1 a container 11 for a fluidised bed has a portion 12 for the bed proper which container is connected to an aperture 13 in the base of the container by three expansion chambers 14, 15, 16 spaced in vertical succession. Between the uppermost chamber 14 and the bed portion 12 of the container 11 a throat 17 is formed which extends across the whole bed to define a restricted passage.

A throat 18 between the uppermost chamber 14 and the middle chamber 15 is of similar extent to the first throat 17 but is more restricted.

A throat 19 between chambers 15, 16 is of similar extent, but again is more restricted than the throat 18.

The lower-most expansion chamber 16 narrows to a throat 20, the size of which is not critical, and will usually be somewhat larger than the other throats 17, 18, 19 thereabove. At the bottom of the container 11 beneath the throat 20 is disposed an assembly substantially in accordance with the invention the subject of our co-pending application Serial No. 670,957 aforesaid, that is to say comprising an aperture 21 and means for diverting a gas upwardly through or past the upper end of the aperture 21 at a sufficiently high velocity substantially to preclude leakage of particles through the aperture 21. The assembly is constructed in two identical halves, one at each side of the path of the fabric 22, and together they define

the narrow aperture 21. Each half extends across the whole width of the container and constitutes a header 23 for pressure air supplied thereto by an air-line 24. Each half also has a slit 25 upwardly and inwardly inclined towards the region above the aperture 21, and through which the pressure air from the air-line 24 is directed. One side wall of the two lower expansion chambers 15, 16 is constituted by a damper 26 and flexible plates 27 carried thereby, and this damper 26 may be adjusted inwardly or outwardly by means of rods 28 operated by screw means or a hydraulic system for example. In the machine being described there are three rods spaced along the container side and each has a pinion 28a engaging a rack 28b which can be operated by external means (not shown) to adjust the dampers. By such adjustment the throat 19 between these two expansion chambers may be closed or opened to the required gap dimension. The purpose and function of this arrangement will be more particularly described hereinafter.

In the embodiment of FIG. 1, a pair of feed rollers 29, 30 are disposed beneath the base of the container 11 to assist in the progression of the fabric 22 through the bed container, and such other and additional feed and guiding means as are necessary will be provided. The rollers 29, 30 also serve to complete the sealing of the airbox A; other sealing members S¹, S², S³, and S⁴ are provided.

Referring now to FIGS. 2A, 2B, 2C and 2D, the operation of the fluid bed container hereinbefore more particularly described will be explained. These figures show diagrammatically the expansion chambers 14, 15, 16, the entrance aperture 21 and the lower part of the bed proper.

The bed particles are Ballotini (glass spheres) grade No. 7, the spheres having diameters lying within the range 520 microns to 600 microns. The air supplied through the two side slits 25 adjacent the aperture 21 is adequate to fluidise the bed proper.

The uppermost throat 17 forms an elongated slit across the width of the container, and the gap dimension is $\frac{3}{32}$ ". The next lowermost slit 18 has a gap dimension of $\frac{1}{8}$ ". The next lowermost slit 19 has a gap dimension which is adjustable in the manner previously described, and is adjusted to a gap dimension $\frac{3}{32}$ " for operation of the bed container. The lowermost throat 20 has a gap dimension of $\frac{3}{32}$ ".

A woven fabric 36 inches wide and approximately .015 inch thick is threaded up through aperture 21, expansion chambers 14, 15, 16, and the bed proper portion of the chamber, and with the throat 19 closed the bed is charged with particles. Thus the particles fill the bed proper containing portion and the two upper expansion chambers.

The fluidising air is switched on, and the throat 19 between the two lowermost expansion chambers opened to its working gap dimension. The air supply is effective to clear the expansion chambers of particles with the fabric stationary. This condition is shown in FIG. 2B. The boundary between the bed proper and the air above the upper expansion chamber is unstable, its profile constantly changing, but there is negligible movement of Ballotini into and out of the expansion chamber system.

FIG. 2C shows the fabric moving upwardly through the slit 21, the expansion chamber system, and the bed proper. Again, the boundary between the bed and air above the uppermost expansion chamber is unstable and of constantly changing profile. In the uppermost expansion chamber, there is movement of particles both in and out of the chamber, and the particles in the chamber are at all times subject of turbulent motion. The two lowermost expansion chambers are substantially free of particles. The fluidising air is supplied at a pressure of 7 to 10 lbs. per square inch.

FIG. 2D shows the fabric passing downwardly through the bed proper, the expansion chamber system, and aperture 21. In this case the boundary between the bed and air above the uppermost expansion chamber is again unstable and of constantly changing profile. In the upper-

most chamber there is a moderate movement of particles both into and out of this chamber, and in the expansion chamber below this there is only a slight movement of particles into and out of the chamber. In each chamber there is turbulent motion of such particles as are within the chamber at any time. The lowermost chamber is substantially free of particles. The fluidising air is supplied at a pressure of 7 to 10 lbs. per square inch.

In operation we have found that the material may be progressed satisfactorily and it was particularly noted that when passing the material downwards, we found no serious tendency for the tension in the material to rise unduly because of any jamming of the particles. Nor was there any substantial leakage of particles from the bed.

With reference to the means for closing the throat between the two lowermost expansion chambers, it has been found convenient to arrange that on switching off the supply of fluidising gas to the bed, that the dampers are caused automatically to close the throat, thus preventing escape of particles from the then unfluidised mass through the expansion chamber system and the aperture 21.

FIG. 3 shows diagrammatically a fluidised bed container 11 through which the material 22 for treatment may be travelled in a single pass, leaving the bed at the base thereof and entering the bed through the open top of the container.

Within the container for the bed proper will be disposed louvres 31 as described and claimed in our copending application Serial No. 670,956, and also heaters 32 which may be in the form of tubes carrying electrical resistance elements or tubes supplied from suitable headers with high temperature steam.

FIG. 4 shows a fluid bed container which is in effect a duplication of the container shown in FIG. 3 and enables material to be passed downwardly through one part of the container and then upwardly through another part of the container in a double pass. Again louvres 31 and heater means 32 will normally be provided in the bed portion proper.

I claim:

1. A fluid bed apparatus comprising in combination a container having an outlet aperture in its base, a bed of solid discrete particles in said container, at least one expansion chamber beneath said container, said chamber having an upper and a lower throat, the walls defining said chamber diverging from one of said throats to a point of maximum width of said chamber and converging from that point toward the other of said throats, said upper throat communicating with the aperture in said container, means for directing gas upwardly into said chamber through said lower throat in order to fluidise said bed, said chamber being substantially empty except for a small quantity of fluidised particles therein, and means for moving a continuous length of flexible material downwardly through said container and chamber.

2. A fluid bed apparatus according to claim 1 wherein each of said throats presents an elongated aperture, said apertures all lying in the same plane, and said gas directing means comprises slits disposed immediately adjacent to and on each side of the aperture of said lower throat, said slits being positioned to direct the gas upwardly on each side of the plane in which said apertures lie.

3. A fluid bed apparatus comprising in combination a container having an outlet aperture in its base, a bed of solid discrete particles in said container, three vertically aligned expansion chambers beneath said container, each of said chambers having an upper throat and a lower throat and the walls of each chamber diverging from its lower throat to a point of maximum width of the chamber and converging from that point toward its upper throat, the upper throat of each chamber being the lower throat of the chamber above it and the upper throat of the uppermost chamber communicating with the aperture in said container, means for directing gas upwardly into said chambers through the lower throat of the lowermost

chamber in order to fluidise said bed, and means for moving a continuous length of flexible material downwardly through said container and chambers.

4. A fluid bed apparatus according to claim 3 wherein the cross-sectional areas of said throats excluding the lower throat of the lowermost chamber are unequal, the upper throat of the uppermost chamber having the greatest cross-sectional area and the throat between said lowermost chamber and the intermediate chamber having the smallest cross-sectional area.

5. A fluid bed apparatus according to claim 3 wherein each of said throats presents an elongated aperture, said apertures all lying in the same plane, and said expansion chambers are of uniform vertical cross-section in planes transverse to the plane of said apertures.

6. A fluid bed apparatus according to claim 3 wherein each of said throats presents a circular aperture, said apertures being colinear, and said expansion chambers are of uniform vertical cross-section in any plane containing all of said apertures.

7. An arrangement comprising a pair of fluid bed apparatus as described in claim 3 disposed side by side, and means for moving said material which has passed downwardly through one of said apparatus upwardly through the other of said apparatus.

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