

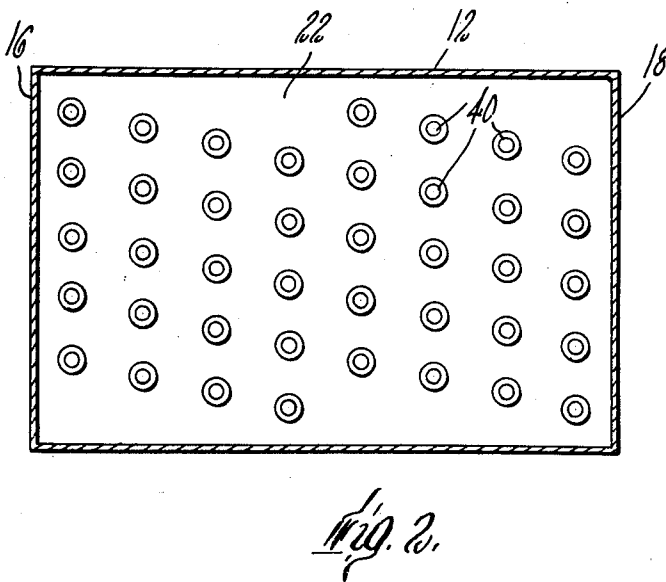
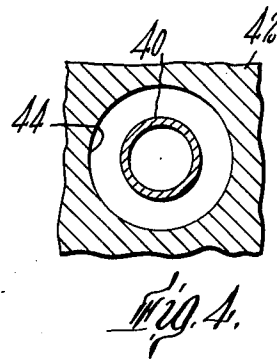
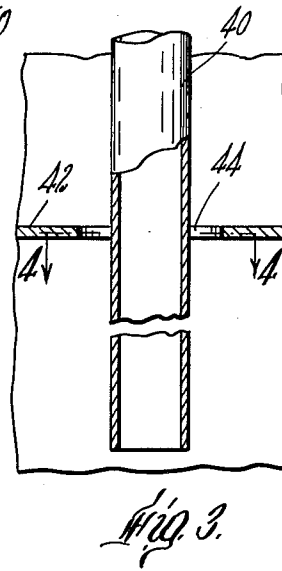
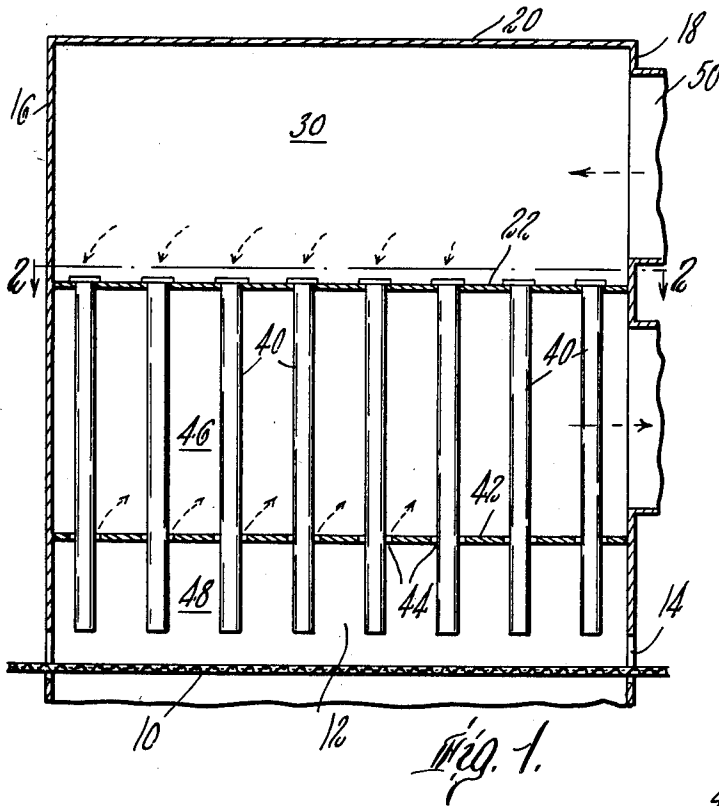
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3,060,595

JET DRYER

Filed June 11, 1959



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3,060,595
JET DRYER

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3 Claims. (Cl. 34-160)

This invention relates to apparatus useful in the treat-
ment of materials with gaseous streams, including par-
ticularly the treatment of continuously fed sheet materials
such as paper and cloth, and more specifically with so-
called jet dryers which utilize high velocity gaseous jets
for such treatment.

It is a main object of the invention to provide a gaseous
treatment apparatus wherein impingement of gases may
be accomplished simultaneously over a wide area of mate-
rial to be treated while exposing all sections of the mate-
rial to substantially uniform volumes of gas and while
maintaining the impinging velocity so high that the tem-
perature differential between the gas and any single limited
area of the material is maintained as high as possible
consistent with the maximum permissible gas temperature
input.

To this end, the apparatus of this invention is designed
to avoid transverse exhaust of the spent gases present in
constructions such as that shown in Dungler Patent No.
2,594,299. In such constructions uniform drying is diffi-
cult and practically impossible at high velocities because
outer sections of the web being dried are exposed to
greater quantities of air per second than the center of
the web because the volume of air moving transversely
of the web to the exhaust at each side of the apparatus
increases outwardly from the center of the dryer to both
sides, as the air from the side jets is added to the air
exhausting from the center jets. This results in edge dry-
ing—i.e., the center of the web is not dried as rapidly
as its edges.

According to this invention, the gases are not exhausted
across, but rather are exhausted in a direction perpen-
dicularly away from the surface of the material being
treated.

Several advantages accrue. First, the number of jets
may be increased indefinitely in any direction without
affecting the drying characteristics within any existing jet
area. Second, avoidance of transverse exhaust gas flow
permits, by proper design of the spaces between the
nozzles, an abrupt loss of velocity insuring that any
benefits arising from the kinetic energy of the gas will be
procured at or near the drying surface where the kinetic
energy is dissipated. Lastly, the exhaust ports may be
readily so designed that after great loss of velocity, the
air may still be exhausted at the identical rate at which
it is introduced, and preferably at velocities great enough
to permit utilization of an exhaust suction chamber of
reasonable size leading through a closed return circuit
containing a reheating unit.

In short, it is an object of this invention to handle each
nozzle as an individual unit, so to speak, and to handle
every nozzle in the same manner as every other nozzle,
so that cumulatively uniformity of drying results regard-
less of the number or extent of the nozzles and edge-
drying (i.e., overdrying at the edges) is avoided. Inso-
far as possible, this includes providing, in the preferred
form, a separate exhaust adapted to handle the total
volume of air emanating from each separate nozzle.

These and other advantages and objects of the inven-
tion will be discussed in more detail in connection with
a description of the accompanying drawings wherein:

FIG. 1 is a vertical cross-sectional view of a treating
apparatus embodying the invention;

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FIG. 2 is a plan view taken along the line 2—2 of
FIG. 1;

FIG. 3 is an enlarged cross-sectional detail taken of a
portion of FIG. 1, with a part broken away; and

FIG. 4 is a cross-sectional view taken along the line
4—4 of FIG. 3.

In the embodiments shown, the treating chamber is in
a form wherein a conveyor belt 10 which may be travel-
ing continuously conveys materials through an inlet into
the chamber 12, through the chamber and out an outlet
14. The remainder of the apparatus in this embodiment
takes the form of a hood which includes side walls 16
and 18 and a top wall 20. An intermediate internal wall
22 forms the bottom wall of a pressure plenum chamber
30. Leading through the bottom wall 22 of the pressure
chamber 30 are a series of spaced tubes which constitute
the nozzles of the dryer. These nozzles 40 extend down-
wardly so that their orifices lie in a single plane spaced
a short distance above the conveyor belt 10.

A lower partition wall 42 extends horizontally across
the chamber at a certain distance above the single plane
of the jet orifices which distance will be more fully de-
scribed hereinafter. Suffice it to say for the moment that
the wall 42 defines with the side walls and the inter-
mediate wall 22 a suction plenum chamber 46.

The nozzles extend through the wall 42 through over-
size apertures 44, which, in the form shown, comprise
the exhaust ports leading back into the suction chamber.
In the form shown these are circular holes in the wall
42 but their dimensions are carefully chosen as will be
hereinafter described, though their shape and locations
in the wall 42 may be varied.

For the purposes of discussion the area or zone be-
tween the conveyor belt and the plane of the nozzle
orifices will be referred to as the web treatment area.
The passages between the nozzles and extending from
the top of the web treatment zone to the partition wall
42 will be referred to as the expansion chamber, indicated
by reference 48.

For further purposes of discussion, and as shown in
FIG. 2, a description will be given of a 40-nozzle chamber
wherein, as shown in FIG. 2, the nozzles in each suc-
cessive row are offset or staggered so that the nozzle cen-
ters are spaced laterally in successive rows by a distance equal
to the diameter of the bores of the tubes.

If the outside diameter of each tube is $\frac{5}{8}$ inch, they
can, for example be spaced at a distance of $1\frac{1}{4}$ inches
from the conveyor or at least from the material to be
treated when it is placed on the conveyor.

Assuming that the cross-sectional area of the bore of
each tube is in square feet 0.001669, the total bore area
of the entire 40 tubes will be 0.06676 square foot. The
entire length of the chamber in the form shown is, say
2 ft. and the width of the belt is 1.0937 ft., so that the
cross-sectional area of the web under treatment in square
feet is 2.1875.

With the $\frac{5}{8}$ inch outside diameter tubes the partition
wall is provided with apertures each of which is $1\frac{1}{8}$
inches in diameter equivalent in square feet to 0.00690
which deducting the displacement of each $\frac{5}{8}$ inch diam-
eter tube through the center leaves the exhaust ports each
with an area in square feet of 0.00476 and a total area
of 40×0.00476 or 0.1904 sq. ft.

The cross-sectional area of the expansion chamber as
previously defined is therefore the area of web treatment
(2.1875 sq. ft.) minus the displacement of 40 $\frac{5}{8}$ inch
diameter tubes or 2.1021 sq. ft.

The ratio of the jet tube blast area to the web treat-
ment area is thus

$$\frac{0.06676}{2.1875}$$

or 3.05% plus or minus. The ratio in percent of the exhaust areas to the web treatment area is thus $.00476 \times 40$ (0.1904) divided by 2.1875 or 8.69% plus or minus. If the jet discharge velocity is, for example 8000 f.p.m., each jet will emit $8000 \times .001669$ sq. ft. per minute or 13.352 c.f.m. and 40 jets will emit 534 c.f.m.

The velocities at other points in the apparatus may be ascertained from the equation

$$V = \frac{Q}{A}$$

when V is the velocity in feet per minute, A is the cross-sectional area in sq. ft. and Q is the cubic feet per minute, the 534 c.f.m. remaining constant throughout the apparatus.

Calculations show that with wall 42 spaced $5\frac{1}{4}$ " above the conveyor so that the nozzles project 4" below the wall, the velocity through exhaust ports of these dimensions, with a nozzle emission velocity of 8000 f.p.m. will be about 2800 f.p.m. and the velocity in the expansion chamber will be no greater than about 250 f.p.m. The depth of the expansion chamber is of importance in my construction from the standpoint that as the air approaches each exhaust port there is an induced suction approach velocity which is, I believe, controlled by the equation

$$V = \frac{Q}{0.75(10X^2 + A)}$$

where V equals the center line velocity in f.p.m.; X equals the distance from the orifice in feet; Q represents cubic feet per minute and A equals the area of the orifice in square feet.

Thus a velocity of 2800 f.p.m. through the exhaust port will cause a velocity of 810 f.p.m. at a distance of $\frac{1}{2}$ inch below the port, of 400 f.p.m. at a distance of $\frac{3}{4}$ inch below the port and velocities of 238 f.p.m. at a distance of 1 inch below the port. It is desirable therefore, and for best results essential, to have the expansion chamber of such a height that the influence of the suction approach velocity does not interfere with the purposes of the expansion chamber. In other words, sufficient expansion chamber or deceleration height should be provided to secure the desired minimum expansion chamber velocity, before the air velocity is subjected to increase due to the suction approach velocity. Otherwise, the effective height of the expansion chamber will be limited by the suction velocity contour lines. Hence no contour line having a suction approach velocity greater than the desired minimum expansion chamber velocity should extend so far towards the web being treated as to unduly limit the height of the effective expansion chamber area and thus prevent attainment of the desired minimum expansion chamber velocity.

The above relations may be further expressed as a desire on my part to have the total cross-sectional area of the orifices in a ratio to the total cross-sectional area of the expansion chamber which is as small as possible consistent with maintaining the overall compactness of the device. In general this will mean that expressed percentage-wise such ratio should be from $1\frac{1}{2}$ to about 6%, being

$$\frac{.06676}{2.1208}$$

or 3.15% in the illustrative apparatus. On the other hand, the percent of the cross-sectional areas of the exhaust ports based upon the total web treatment area may run from about $1\frac{1}{2}$ % to as high as 18%, depending upon the permissible size of the suction chamber 46, being

$$\frac{0.00476 \times 40}{2.1875}$$

or 8.69% in the illustrative device.

The extent to which the nozzles extend beyond the partition wall 42 controls the height of the web treating area. In general, as the nozzles are lengthened, the expansion chamber is increased in height, other dimensions being constant; with the minimum expansion chamber velocity thus decreasing. However, depending upon the distance between wall 42 and the web being treated, the nozzle may extend from wall 42 as little as 25 percent of that distance.

The pressure plenum chamber 30 and the suction chamber 46 are provided respectively with an inlet 50 from the fan and an outlet 52 to the fan of equal cross-sectional area. As shown, both chambers are so dimensioned that the inlet 50 will supply gas at uniform rates to all 40 nozzles and the outlet pipe 52 will draw uniformly from all 40 exhaust ports 44, in accordance with known principles.

It should be understood that it is not essential that the nozzle orifices lie in a horizontal plane nor that they extend downwardly as distinguished from horizontally or upwardly. The entire unit may thus be turned about a horizontal axis or otherwise tipped so that the plane of the orifices will be parallel to any plane which constitutes the path of the material being treated.

What is claimed is:

1. Apparatus for gaseous treatment of a material comprising a casing having a plane wall forming a partition, said wall being perforated to define a plurality of spaced apertures forming exhaust ports lying in the plane of said wall, said apertures having a total area substantially less than the total area of said partition within said casing, a series of straight parallel tubes extending through said wall away from said plane and terminating at and having orifices lying in a common plane spaced from but parallel to the plane of said exhaust ports for directing gaseous streams issuing from said orifices at a predetermined uniform velocity onto a material presented in opposition to said orifices, the space within said casing between said planes being obstructed solely by said tubes and forming an expansion chamber, having a depth equivalent to the distance between said planes and a transverse cross-sectional area which is uniform throughout its depth, into which the gases in said streams pass after they impinge on said material and through which they rise with velocities substantially reduced from said orifice velocity before they reach the suction velocity contour lines of said exhaust ports.

2. Apparatus as claimed in claim 1 wherein said casing has an inlet and an opposed aligned outlet adapted to permit a material to be treated to be passed into, through and out of said casing along a plane path parallel to the plane of said orifices and wherein said tubes extend from the plane of said partition towards said path at least 25% of the distance between said partition and said path, whereby the depth of said chamber is at least 25% of said distance.

3. Apparatus as claimed in claim 1 wherein said tubes extend generally perpendicularly through the apertures in said wall and are spaced from the walls of said apertures to define with the walls of the apertures the exhaust ports in said wall.

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UNITED STATES PATENT OFFICE
CERTIFICATE OF CORRECTION

Patent No. 3,060,595

October 30, 1962

William P. Dapses

It is hereby certified that error appears in the above numbered patent requiring correction and that the said Letters Patent should read as corrected below.

Column 2, lines 46, 57, and 60, for "5/6", each occurrence, read -- 5/8 --.

Signed and sealed this 30th day of April 1963.

(SEAL)

Attest:

ERNEST W. SWIDER
Attesting Officer

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Commissioner of Patents