United States Patent

Weightman

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[54] **MANUFACTURE OF NON-WOVEN FIBROUS WEBS**

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[52] **U.S. Cl.** **19/163**
[51] **Int. Cl.** **D04h 11/04**
[58] **Field of Search** 19/163, 155, 156, 156.3; 156/369–377; 226/95–97

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[57] **ABSTRACT**

A process for making a substantially uniform web comprising traversing fiber or filament depositing means across a moving conveyor under conditions defined by the formula $y = 2x(t+z)$ where y is the total effective width of web deposited by the fiber or filament depositing means measured in the direction of travel of the conveyor, x is the speed of the conveyor, t is the turn round time of the fiber or filament depositing means, x is the traverse time of the fiber or filament depositing means and n is any whole number.

2 Claims, 8 Drawing Figures

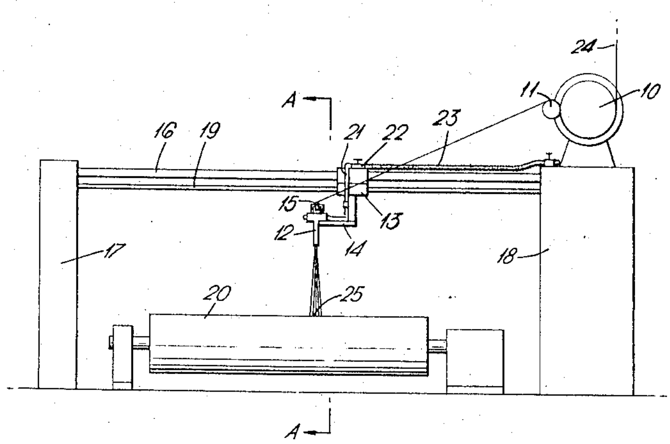


Fig.1.

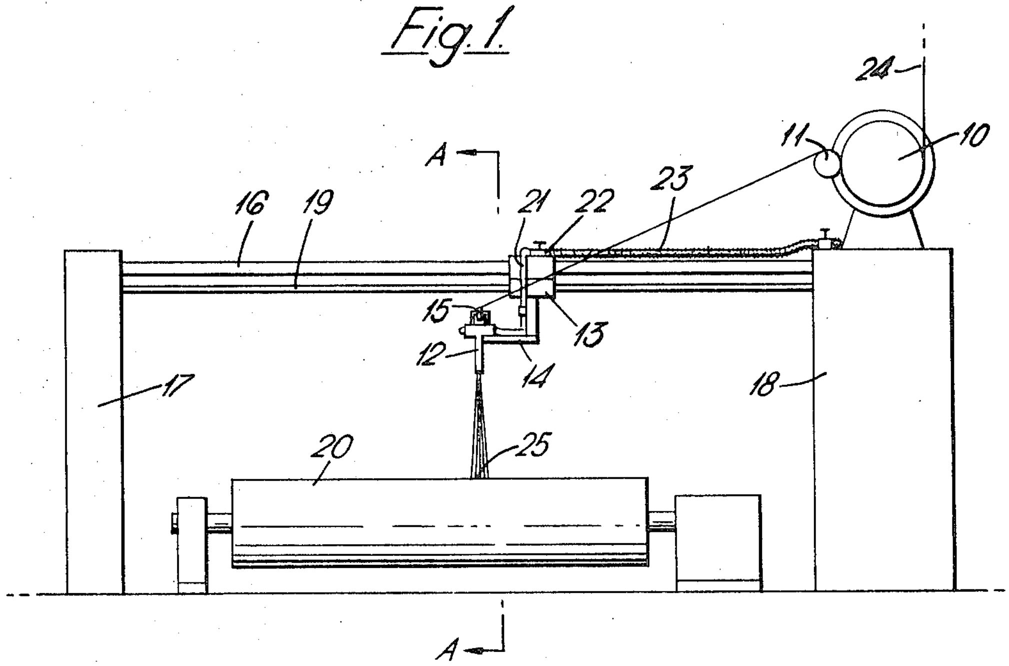
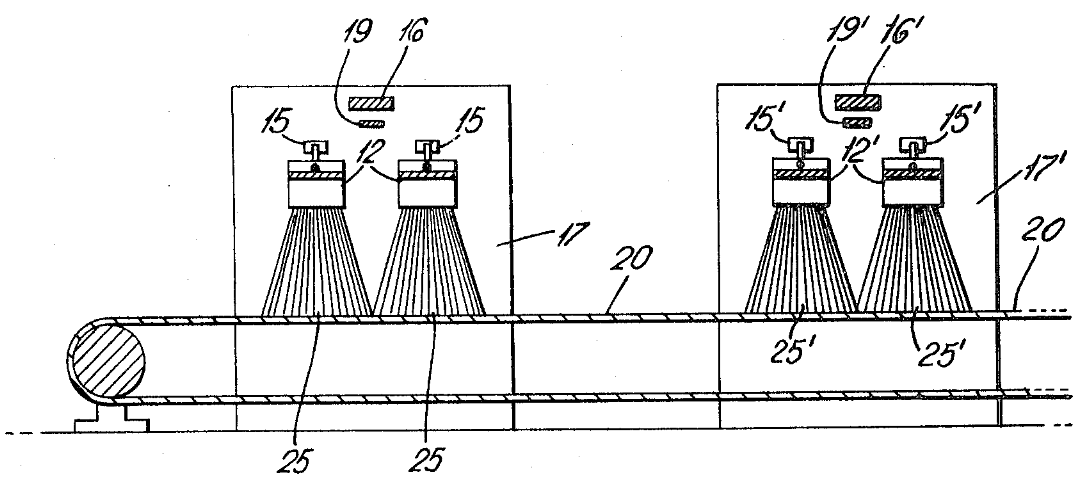


Fig.2.



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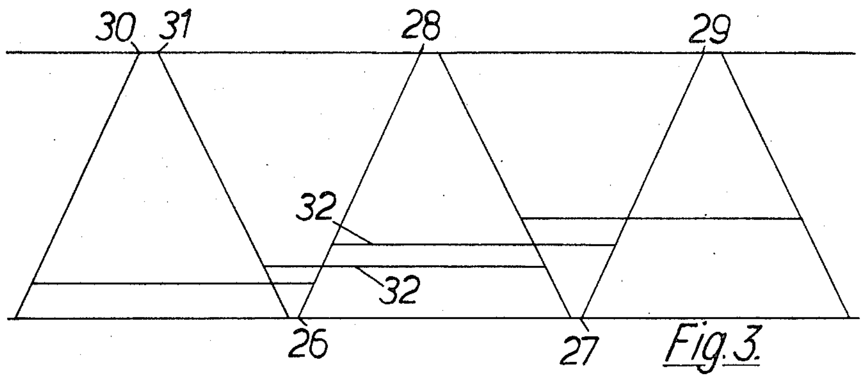

Fig. 3.

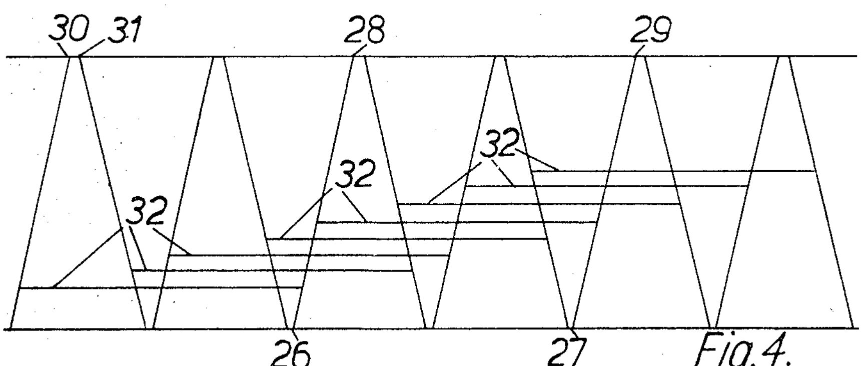

Fig. 4.

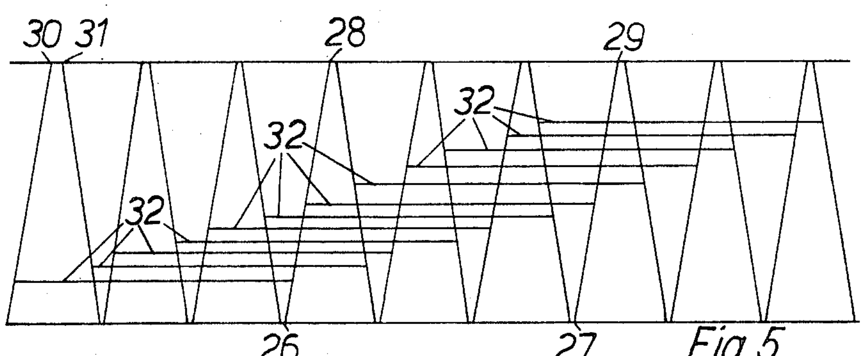

Fig. 5.

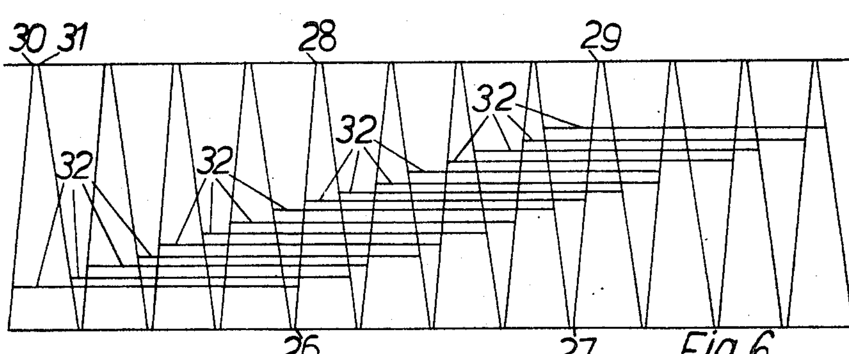

Fig. 6.

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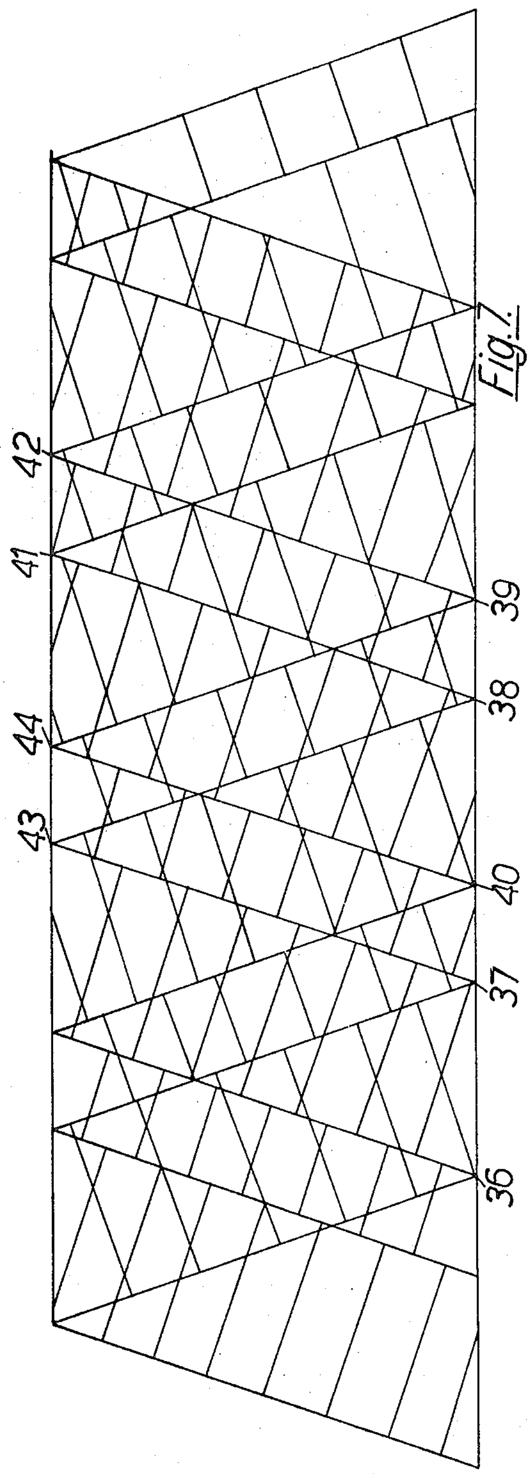

Fig. 7.

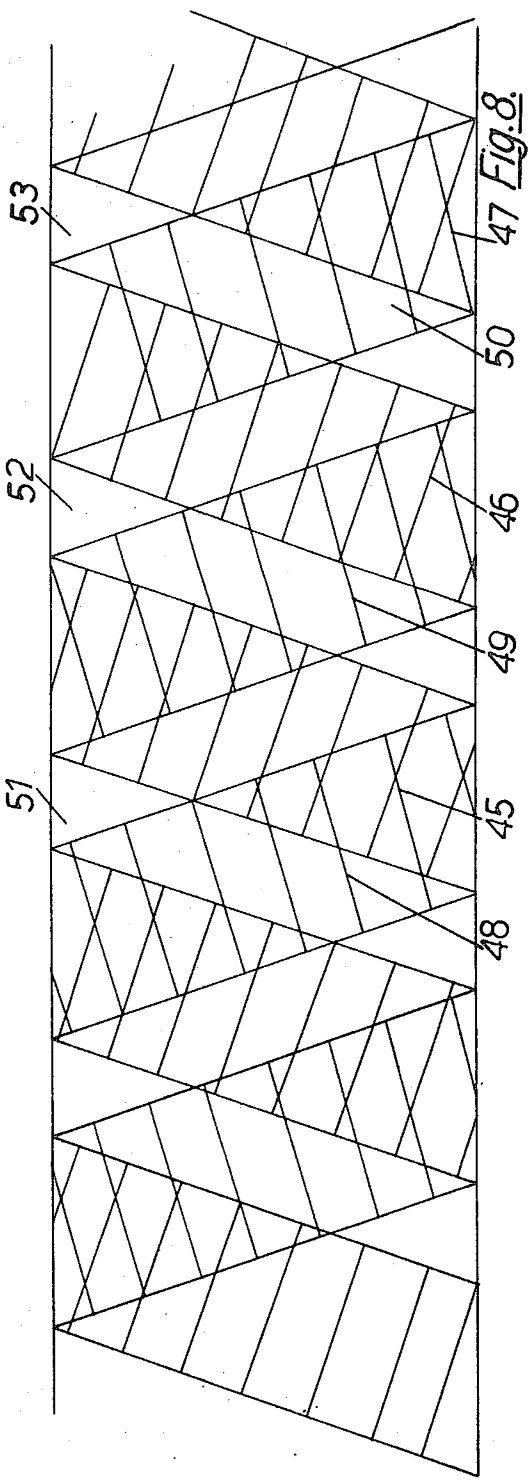

Fig. 8.

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MANUFACTURE OF NON-WOVEN FIBROUS WEBS

The invention relates to methods of producing non-woven fibrous webs and in particular relates to methods of depositing fibers or filaments to form webs using a traversing technique.

Methods for forming fibrous webs by forwarding fibers or filaments from a supply source, for example a hopper of staple fibers, a creel of bobbins or a filament spinning machine, and depositing them on a moving collecting surface are well known, the methods generally involving the use of rotating rolls or air streams to transport and deposit the fibers or filaments. Such transporting and depositing devices have mainly been located in stationary positions opposite the moving collecting surface. In order to obtain uniform webs having an overall width greater than that produced by a single depositing device, it has been necessary to arrange a number of devices side-by-side, ensure each device deposits a uniform and similar array of fibers and filaments, position each device carefully and make use of complicated jointing techniques to ensure the correct degree of overlap. Such precautions demand great care and skill and have not been wholly successful. Even in cases where it has proved possible to deposit reasonably uniform webs in this way there still remain serious disadvantages in that failure of the fiber or filament supply to one of the depositing devices will create an unacceptable discontinuity along the length of the web and in that the webs produced by stationary depositing devices have little coherency and are difficult to handle without disturbing the fiber or filament distribution.

It has been proposed to overcome some of the aforesaid disadvantages by traversing depositing means across the width of the moving collecting surface. Such methods have hitherto proved unsatisfactory because of the difficulty of choosing traverse operating conditions which give a web of uniform weight per unit area, the methods generally producing areas where very few or no fibers or filaments have been deposited and other areas where, for instance, double thicknesses have been deposited.

We have now discovered a method of operating a depositing means traverse system which will produce a web of uniform weight per unit area and accordingly the present invention, in one of its aspects, comprises a method of forming a fibrous web on an advancing collecting surface which comprises traversing fiber or filament depositing means in a reciprocating manner across a collecting surface in directions transverse to the direction of movement of said collecting surface so that $y = 2xn\ (t + z)$ where Y is the total effective width of web deposited by the depositing means measured in the direction of travel of the collecting means, x is the speed of the collecting surface, t is the turn-around time of the depositing means, z is the traverse time of the depositing means and n is any positive integer. The turn round time, t, may be constant or it may be a function of traverse time, z, depending on the design of the traverse mechanism.

The depositing devices may be traversed across the collecting surface by for instance mechanical, pneumatic or hydraulic means or by means of a linear induction motor, and the fact that any such traversing means takes a finite time to reverse its direction is one of the reasons for the inclusion of the term t in the formula relating to the method of the present invention. Thus the turn-round time t is the time elapsing from the moment when the depositing devices start to decelerate having travelled across the width of the collecting means to the moment when the depositing devices cease to accelerate when travelling in the opposite direction. The depositing devices may continue to function during the turn round time but the web will be non-uniform and may be conveniently removed by edge trimming. The only limitation concerning the type of traverse used is that it should travel substantially uniformly across the collecting surface.

In the most simple case in which a single depositing device is used, y is taken as the effective width of the web deposited by that device measured in the direction of travel of the collecting means. This effective width is dependent on the total width of web produced by the device and the distribution of fibers or filaments in the web, which in turn depend on the type and design of the depositing device. If the distribution is substantially uniform then the effective width is equal to the total width but if the distribution is non-uniform then the effective width is equal to some function of the total width depending upon the actual shape of the distribution.

The depositing devices may be pairs of nip rolls or baffle plates which generally produce an approximately rectangular distribution. We have found, especially when depositing continuous filaments, that air ejectors are most useful. Such air ejectors, depending upon their design, may, when stationary, deposit circular, elliptical or rectangular shaped webs and for each type of ejector it is necessary to determine the distribution of filaments in the webs produced and then the effective widths. Rectangular shaped webs produced from rectangular slot-type ejectors are normally substantially uniform across their width and generally the effective width is substantially the same as the total width. Circular and elliptical shaped webs however such as are produced from ejectors of say circular cross-section usually have a non-uniform distribution of filaments across their widths. Such distributions often approximate to Gaussian distributions and in this case the effective width should be taken as the Half-Peak Width.

Once the effective width, y, of the single depositing device is found, the following procedure is adopted to calculate the conditions which will give a product having uniform thickness or weight per unit area. The throughput of fibers or filaments through the depositing device will be known, as will the weight per unit area of product required. The width of the product will also be known and depends on the length of traverse of the depositing device. From these fixed parameters the conveyor speed, x, is readily calculated. The values of y and x are substituted in the equation representing the conditions for uniform weight per unit area, $y = 2xn\ (t + z)$ and the values of $2\ (t + z)$, the traverse cycle time, are found for $n = 1, 2, 3$, etc.

For all integral values of n, a uniform product is obtained having constant weight per unit area, and the number of layers of web deposited at any position in the web will be given by $2n$. Thus if $n = 1$, all parts of the conveyor surface will be covered twice, and if $n = 3$ all parts of the conveyor surface will be covered six times by an individual web having a weight per unit area equal to one third of that deposited when $n = 1$.

The value of n may be chosen to give a pattern of covers most suited to a particular end-use, but frequently only a limited number of choices of n will be available because of traverse machinery speed limitations.

Often, however, the use of a single depositing device is undesirable, because of the undesirably low collecting surface speeds, x, and throuputs associated therewith and, in an attempt to increase productivity, undesirably high traverse speeds may result. A number of depositing devices can be used to increase throughput and preferably each individual depositing device gives a uniform cover by conforming to the equation $y = 2nx\ (t + z)$. The use of more than one depositing device provides an opportunity for conveyor speed to be increased. The resulting web will be composed of a number of superimposed uniform webs.

If the effective widths, y, of the several depositing devices are substantially similar, the several depositing devices may conveniently be attached to a single traversing device aligned in a direction parallel to the direction of motion of the collecting surface. Since each device is individually producing uniform cover the spacing of the devices along the traversing device is not important provided that the depositing devices do not interfere with each other.

When the conveyor speed is increased as a result of provision of a plurality of depositing devices in order to increase the rate of production of a web of desired weight, it frequently happens that the preferred condition of operation, in which each depositing device gives uniform cover, is unattainable because of the excessively high traverse speeds required to satisfy the condition $y = 2nx\ (t + z)$. In such cases, it becomes necessary to group a number of depositing devices together in such a manner that the group itself produces a uniform web by obeying the relationship $Y = 2nx\ (t + z)$, where Y is the effective width deposited by the group of depositing devices measured in the direction of advance of the collecting means.

The devices are spaced apart within the group so that the total effective width Y of the group is the sum of the effective widths y_1, y_2, y_3, etc. of the webs produced by each of the devices working in conjunction.

The individual depositing devices forming the group may be grouped directly adjacent to each other and traversed together at spacing depending upon their effective widths y_1, y_2, y_3, etc., or may be spaced apart along the length of the collecting surface and traversed together or oppositely depending on their spacing. This latter spacing will again be critically dependant on the effective widths y_1, y_2, y_3, etc., of the webs produced by the several depositing devices and will be such as to eventually build up a continuous total effective width Y.

The throughput of the process can be still further increased by having a plurality of groups of depositing devices, each group producing a uniform web.

The invention therefore provides a means of producing a uniform web from one or more individual depositing devices each giving individually a uniform web by obeying the relationship $y = 2nx\ (t + z)$, or one or more groups of depositing devices, each group individually giving a uniform web by obeying the relationship $Y = 2nx\ (t + z)$.

The arrangement of depositing devices is a matter of choice although where possible each device should preferably give uniform cover. In such processes it is of course highly desirable that a uniform product be obtained at all times, including during involuntary failure of one or more of the depositing devices. The means of achieving such a uniformity of product during involuntary failures of a number of depositing devices is an important aspect of the invention, and is now described.

In all cases, the involuntary failure of a number of depositing devices will result in a reduction in the overall weight per unit area of the web. In order to restore the web to its former weight per unit area it is necessary to reduce the speed of the collecting surface, x, to a new value x^*. However, in the majority of cases the change of x to x^* will result in uniformity of product being lost, since the new relationship $y = 2nx^*\ (t + z)$ in which n is an integer, will only rarely be satisfied. It will be seen therefore that it will also be necessary to change the values of effective width, y, or to change the traverse time and/or turn around time $(z + t)$, or a combination of y and $(z + t)$, to re-establish an integral value for n.

For example, suppose that there are q groups of depositing devices, each group containing p depositing devices and each group individually producing a uniform web and having an effective width, Y. Then each group must be obeying the relationship $y = 2nx\ (t + z)$. The conveyor speed, x, has been chosen to give a product having a desired weight per unit area with all $q{\cdot}p$ depositing devices functioning. Now supposing that in one group, s depositing devices fail. Since it is the group as a whole which produces a uniform cover it will be necessary to deliberately fail the remaining $(p - s)$ devices in that group in order to be able to regain the uniform product. Hence on failure of any s devices in a group, the number of devices lost due to inadvertant and deliberate failure will be p. If the s devices are not all in the same group it will be necessary to fail $r{\cdot}p$. devices where r is the number of groups affected.

Now for a given weight per unit area the speed of the collecting surface is proportional to the number of devices. Therefore, we have

Before failure: $x\alpha - pq$

After failure: $x\alpha - (pq - pr)$

$$\therefore\ X^* = \left(\frac{q-r}{q}\right)x$$

Thus in order to re-establish the former weight per unit area it is necessary to reduce the conveyor speed by $x(r/q)$ where r is the number of groups failed and q is the total number of groups.

In order to re-establish uniformity the equation $Y = 2nx^*\ (t + z)$ must be satisfied. Hence the value Y or $(t + z)$ or a combination thereof must be changed to restore an integral value to n. It may occasionally happen that n has an integral value after alteration of x to x^*, the condition being that $q/(q-r)$. n is an integer. However in the vast majority of cases it is necessary to alter the effective width, Y or the traverse and/or a turn round time $(z + t)$. It is impractible to alter the effective width, Y since this depends on design and type of depositing device and upon the number of devices in the group. Accordingly in practical cases it is $(z + t)$ which is altered and this is considered below.

Let it be necessary to alter $(z + t)$ to T in order to satisfy the relationship $Y = 2n^*x^*T^*$ where n is an integer

Before failure $Y = 2\ nx\ (z+t)$

After failure $Y = 2\ n^*x^*T$

$\therefore\ nx\ (z+t) = n^*x^*T$

but

$$x^* = \left(\frac{q-r}{q}\right)x$$

$$\therefore\ (z+t) = \frac{n^*}{n}\left(\frac{q-r}{q}\right)T$$

$$T = \frac{n^*}{n}\frac{(z-t)}{(q-r)}q$$

In all cases it will be found that $n = n^*$ or n^* can be made to equal n. So

$$T = \frac{(z+t)}{q-r}q$$

The value of $(z + t)$ can be altered by altering (i) the traverse time, z, (ii) the turn round time, t and (iii) both traverse time and turn round time. In case (i) z is altered to z^*, so

$$z^* + t = \frac{(z+t)}{q-r}q$$

or

$$z^* = \frac{zq + tr}{q-r}$$

in case (*ii*) t is altered to t^*, so

$$z + t^* = \frac{(z+t)}{q-r}q$$

$$t^* = \frac{tq - zr}{q-r}$$

and in case (*iii*). $(z+t)$ is altered to $(z+t)^*$

$$(z+t)^* = \frac{q}{q-r}\ (z+t)$$

Should it be desired to retain the term, $(z + t)$, at a constant value, then it is necessary, in addition to reducing the conveyor speed to

$$\left(\frac{q-r}{q}\right)x$$

to reduce the effective width to

$$\left(\frac{q-r}{q}\right)Y$$

to maintain uniformity of web weight per unit area.

By such a procedure, a web of uniform density is maintained, although of course the structure and number of overlaid laps are altered.

It is therefore necessary to deliberately fail a number of depositing devices so that remaining groups each give uniform cover and to adjust conveyor speed, and traverse time or effective width to maintain production of a uniform web, as described above. However, if a minimum weight of web only is required and the number of failed depositing devices is small compared with the total number of depositing devices, then the remaining depositing devices might conveniently be permitted to continue functioning to produce a web with slightly varying weight along its length.

The above procedure is also applied in the case of inadvertant failure of depositing devices, each of which individually produces a uniform web. This case is a specific example of that described above, in which the number of depositing devices in a group giving a uniform web is one. Hence there is no necessity to fail deliberately any depositing devices.

The method of production of a uniform web before and after failure of a number of depositing devices may conveniently be automated by use of failure detecting devices and automatic switching to change the collecting speed, x, and the speed of traverse of the depositing devices in a conventional manner.

The value of n chosen will depend upon the weight required for the final web, the coherency desired in the final web, magnitude desired for the throughput from each depositing device, the traverse speed and the conveyor speed and is generally chosen to give the best compromise between these factors.

The collecting surface itself may conveniently be a foraminous conveyor belt but the actual nature of the belt will depend on the nature of the depositing devices used and may be a drum or flat imperforated surface.

The invention will now be described in more detail with reference to the accompanying drawings of which:

FIG. 1 shows an end view of a continuous filament web depositing apparatus;

FIG. 2 shows a section taken along the line A – A of FIG. 1;

FIGS. 3 – 6 show diagrammatically the construction of webs formed by a single fiber or filament depositing device giving uniform cover in different modes of operation according to the invention;

FIG. 7 shows diagrammatically the construction of a web formed by two fiber or filament depositing devices having differing effective widths acting in conjunction to produce a uniform web;

FIG. 8 shows diagrammatically the construction of a non-uniform web produced by the failure of one of the depositing devices used to produce the web of FIG. 7.

Referring to the drawings in more detail, FIGS. 1 and 2 show views of apparatus in which two rectangular air ejectors are traversed together. The apparatus consists of a pair of forwarding rolls **10** mounted in tandem and a pair of smaller rolls **11** forming nips with the rolls **10**, two air ejectors **12** spaced apart a specified distance affixed to a mounting block **13** by angle iron **14** and having mounted thereon banding devices **15**, a runner bar **16**, along which the mounting block **13** slides, supported by frameworks **17** and **18**, a driving chain **19** affixed to the mounting block **13** and supported at its ends by sprocket means (not shown) mounted in frameworks **17** and **18**, the sprocket means being driven via electromagnetic clutches by driving motors (not shown) mounted in frameworks **17** and **18** so that the mounting block **13** is traversed back and forth along the runner bar **16**, and a foraminous conveyor belt **20** situated between frameworks **17** and **18** so that it travels in a direction at right angles to that of the mounting block. The ejectors **12** are fed with high pressure air via pipes **21**, connected through valves **22** mounted on block **13** to extensible hose **23**.

In practice two continuous filament threadlines **24**, taken from a spinning head (not shown), pass around the forwarding rolls **10** through the nips formed by rolls **10** and **11** and are entrained into air ejectors **12** via banding devices **15**. The air ejectors **12** deposit the continuous filaments on the conveyor belt **20** in the form of webs **25** which just overlap to form a continuous uniform width equal to the total effective width of web as hereinbefore defined. The conveyor speed, the traverse time and the turn round time are adjusted in accordance with the formula $y = 2xn\ (t + z)$ and the apparatus run to produce a uniform continuous filament web. The apparatus may include a plurality of depositing means disposed along the length of conveyor belt **20** as illustrated in FIG. **2** wherein primed reference numerals designate a second group of depositing elements.

FIGS. **3** to **6** show diagrammatic plan view of webs formed by a single fiber or filament depositing device giving uniform cover in different modes of operation according to the invention. FIG. **3** shows the pattern of web produced with $n = 1$, and FIGS. **4**, **5** and **6** show the patterns with $n = 2$, 3 and 4 respectively. In all of these figures the effective width of web deposited is the same and is indicated by the distance between points **26** and **27**. Points **28** and **29** indicate the position of web deposition after a single traverse of the depositing device across the collecting surface from the position indicated by points **26** and **27**, assuming that the collecting surface is moving from right to left in the figures. The effect of a finite turn round time for the traversing depositing devices is shown by the gap between points **30** and **31** on the web.

Lines **32** in FIGS. **3** – **6** indicate widths of web deposited in any traverse and the number of lines **32** crossing any particular portion of the web indicates the number of covers constituting that portion of the web. It is seen that between initial and final traverses the webs produced are uniform, having a number of covers equal to $2n$. Other depositing devices may be used also operating in according to the invention to superimpose their uniform webs on the uniform base web and may be spaced at any points above the collecting surface.

FIG. **7** shows a diagrammatic plan view of a web produced by two depositing devices, one having an effective width equal to twice the other, co-operating to produce a uniform web. For convenience the effect of a finite turn round time has been ignored. Points **36** and **37** indicate the effective width of web deposited by one depositing device and points **38** and **39** indicate the effective width deposited by the second device. The devices are so positioned that they produce a combined effective width equal to the distance between points **36** and **40**.

The devices may be traversed together and arranged side-by-side so that they deposit webs between points **36** and **37** and **37** and **40**, may be traversed together and spaced apart defined distances so that, for instance, one device deposits web between points **36** and **37** and the other device deposits web between points **38** and **39** or may be traversed oppositely to one another so that, for instance, one device deposits web between points **36** and **37** and the other device deposits web between points **43** and **44** or, say, **41** and **42**.

FIG. **8** shows the web produced by the depositing devices employed to manufacture the uniform web of FIG. **7** with the device having the smaller effective width failed. The resulting web is non-uniform having areas **45**, **46**, **47** in which there is double cover, areas **48**, **49**, **50** in which there is single cover and uncovered areas **51**, **52** and **53**.

The invention will be further described by the following Example.

EXAMPLE

Eight air ejector depositing devices having substantially similar effective widths were attached to a common mounting which was traversed above an endless conveyor advancing perpendicularly to the direction of traverse of the depositing devices. The air ejectors were found to give an elliptical distribution of deposited filaments and the effective width of the devices was found to be 25 – 29 cm. The conveyor was arranged to advance 27 cm. in each complete traverse cycle. Continuous filaments of polyhexamethylene adipamide were fed to all of the devices and the throughput was such that a product having a nominal weight of 6 oz./yd.^{2} (about 210 g.m.$^{-2}$) was obtained. Each device thus obeyed the relationship $y = 2x\ (t + z)$, i.e. gave individually substantially uniform cover as shown diagrammatically in FIG. 3 of the accompanying drawings.

Samples of the web measuring 20 × 20 cm. were cut at intervals from the web and their weights measured. The mean weight of twelve 400 $cm.^2$ samples was 8.27 g. and the standard deviation was 0.44.

Further samples measuring 100 × 5 cm. were taken across the web and the mean weight of twelve samples was found to be 10.25 g. The standard deviation was 0.44.

The value of standard deviation was due to the varying effective widths of the depositing devices. When two devices having the same effective width of 27 cm. were used to make a nominal 6 $oz./yd.^2$ (210 $g./m.^2$) web the mean weight of 12 samples measuring 20 × 20 cm. was found to be 8.15 g. and the standard deviation was 0.08.

What I claim is:

1. A method of forming a fibrous web having at least a substantially uniform weight per unit area which comprises traversing a plurality of depositing devices in a reciprocating manner above a continuously advancing collecting means in directions perpendicular to the direction of advance of said collecting means and depositing thereon a web of fibers or filaments such that $y = 2nx\ (t + z)$ where y is the effective width (as herein before defined) of said web deposited by said depositing means measured in the direction of travel of said collecting means; x is the speed at which said collecting means advances; z is the traverse time of said depositing means; t is the turn around time of said depositing means and n is any positive integer and further including reducing said speed of said collecting means, x,on failure of one or more said depositing devices by the fraction obtained by dividing the number of said failed depositing devices by the total number of said devices and simultaneously increasing the total traverse cycle time by the reciprocal of the said fraction.

2. A method of forming fibrous webs having an at least substantially uniform weight per unit area which comprises traversing a plurality of groups of depositing devices in a reciprocating manner above a continuously advancing collecting means in a direction perpendicular to the direction of advance of said collecting means and depositing thereon a web of fibers or filaments such that $y = 2nx\ (z + t)$ where y is the effective width (as hereinbefore defined) of said web deposited by said depositing means measured in the direction of travel of said collecting means; x is the speed at which said collecting means advances; z is the traverse time of said depositing means; t is the turn around time of said depositing means and n is any positive integer formed and said individual depositing devices are so arranged within said groups that the individual webs produced by said individual depositing devices combine with webs formed by other depositing devices within a group to form a uniform web such that $Y = 2nx\ (t + z)$ where Y is the effective width (as hereinbefore defined) of said web deposited by the depositing devices within a single group measured in the direction of travel of said collecting means; x is the speed at which said collecting means advances; z is the traverse time of said depositing means; t is the turn around time of said depositing means and n is any positive integer and further comprising that upon on failure of one or more devices in one group or more groups of devices, the remaining devices functioning in each affected group of devices are deliberately deactivated and the speed of said collecting surface is reduced by the fraction obtained by dividing the number of failed groups of devices by the total number of groups and simultaneously increasing the total traverse cycle time by the reciprocal of the said fraction.

* * * * *