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[11] 3,906,130
[45] Sept. 16, 1975

[54] NON-WOVEN AND PERFORATED TEXTILE FABRICS MADE FROM CONTINUOUS SYNTHETIC FIBER, AND A PROCESS FOR THE MANUFACTURE OF SAME

[75] Inventors: **Takashi Tsurumi; Shuichi Emori; Kiyokazu Daigoh; Takemi Ikegami; Tutomu Kaneko,** all of Nobeoka, Japan

[73] Assignee: **Asahi Kasei Kogyo Kabushiki Kaisha,** Osaka, Japan

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[30] **Foreign Application Priority Data**

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[52] **U.S. Cl.** **428/131;** 428/296; 428/369
[51] **Int. Cl.**[2] **D04H 3/05;** D04H 3/14
[58] **Field of Search** .... 161/47, 57, 58, 59, 70, 161/71, 72, 73, 80, 109, 110, 111, 112, 116, 125, 129, 130, 152, 153, 154, 164, 168, 169, 173; 264/178 F

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Primary Examiner—George F. Lesmes
Assistant Examiner—Alan T. McDonald
Attorney, Agent, or Firm—Armstrong, Nikaido & Wegner

[57] **ABSTRACT**

A perforated non-woven textile web is prepared from continuously extruded filaments. The filaments are formed into a web which has alternately arranged, continuous filaments of relatively linear portions which are physically cross linked at various portions along the filament lengths. The filaments also have finely folded portions along their length and the web also has projections and perforations in and on its surface. The web is arranged in such a manner that the filament and finely folded portions are entangled with each other at each of the projections to provide a reinforced latticework structure.

2 Claims, 20 Drawing Figures

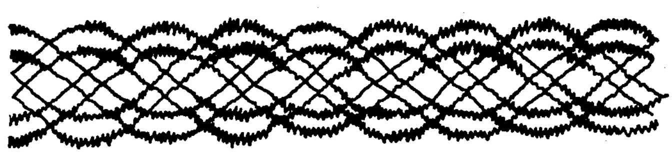


FIG. 1a

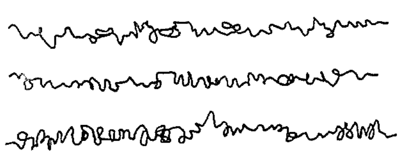


FIG. 1b

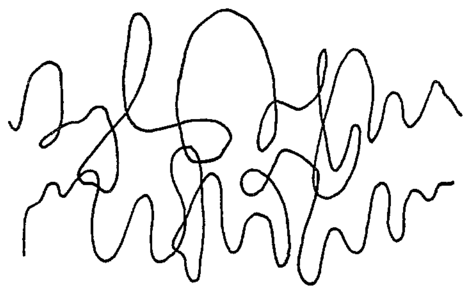


FIG. 2a

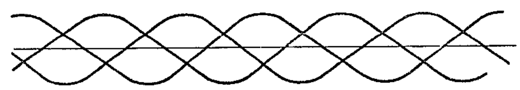


FIG. 2b

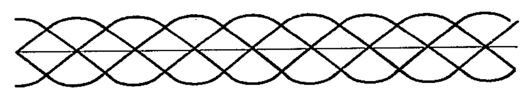


FIG. 2c

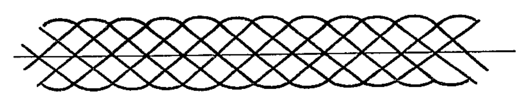


FIG. 3

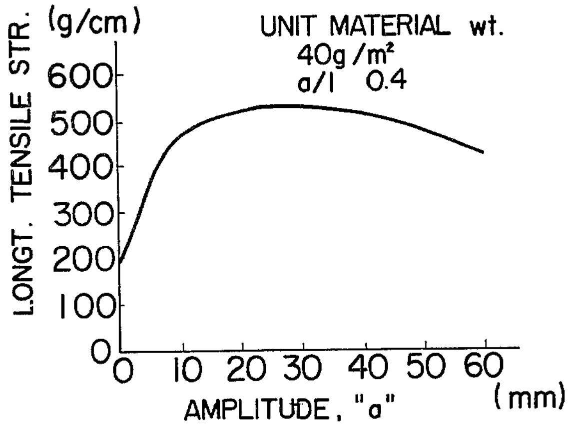


FIG. 4

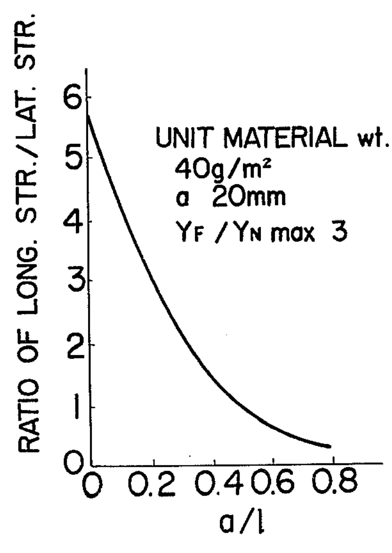
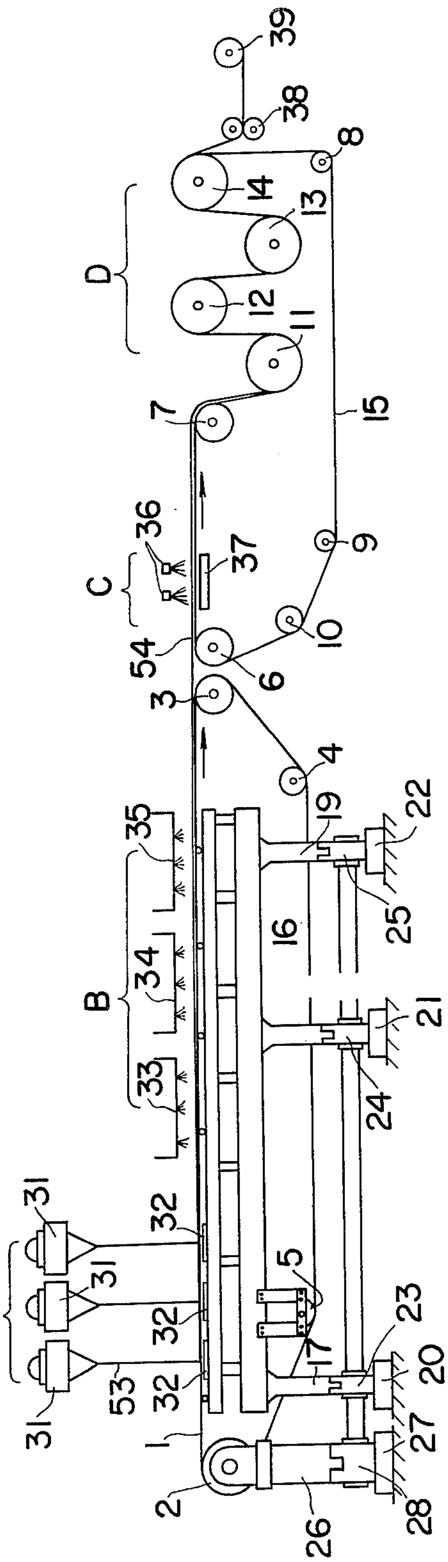


FIG. 5



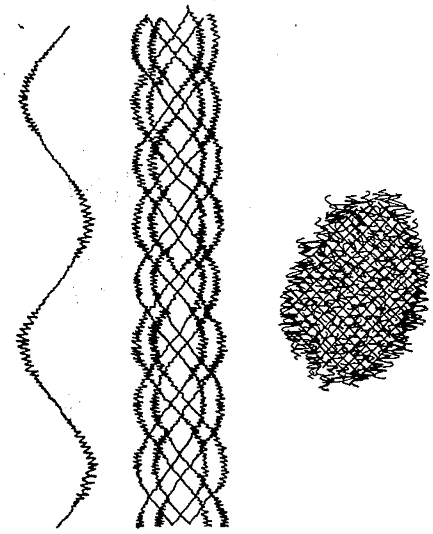


FIG. 7a

FIG. 7b

FIG. 7c

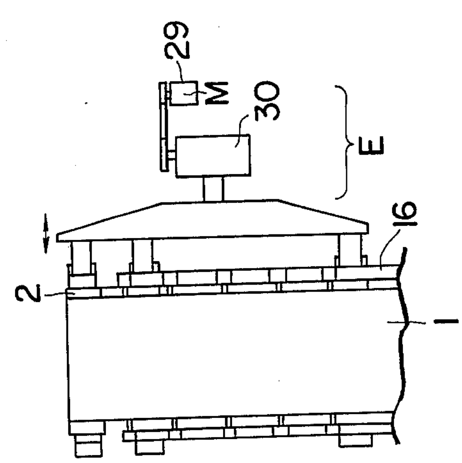


FIG. 6

FIG. 8a

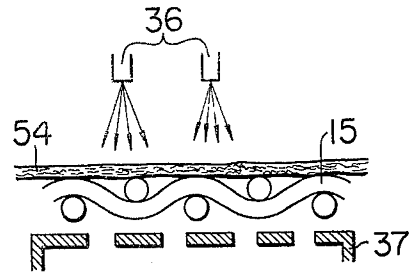


FIG. 8b

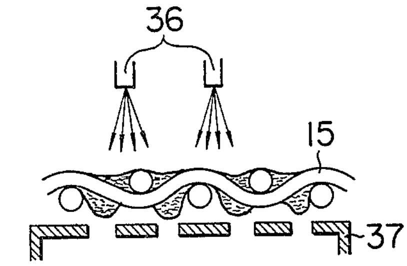


FIG. 9

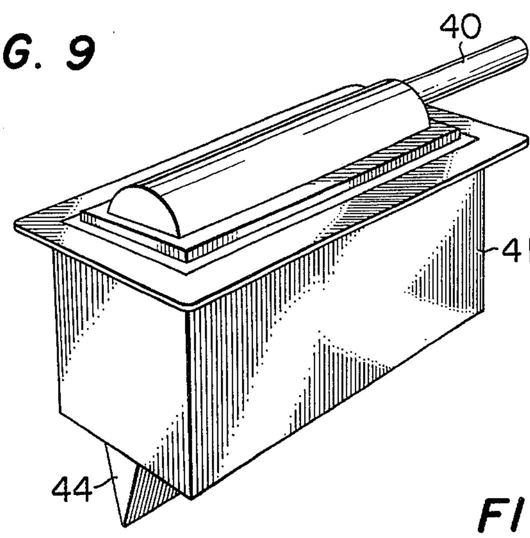


FIG. 10

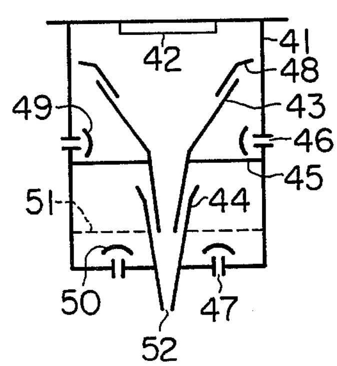


FIG. 11

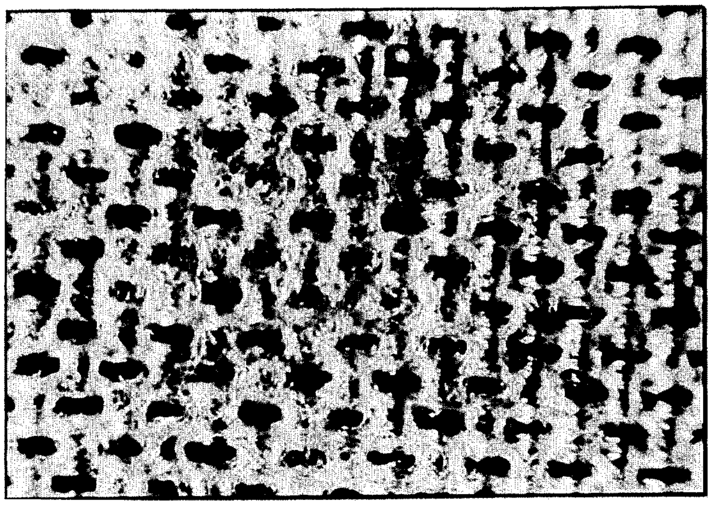


FIG. 12

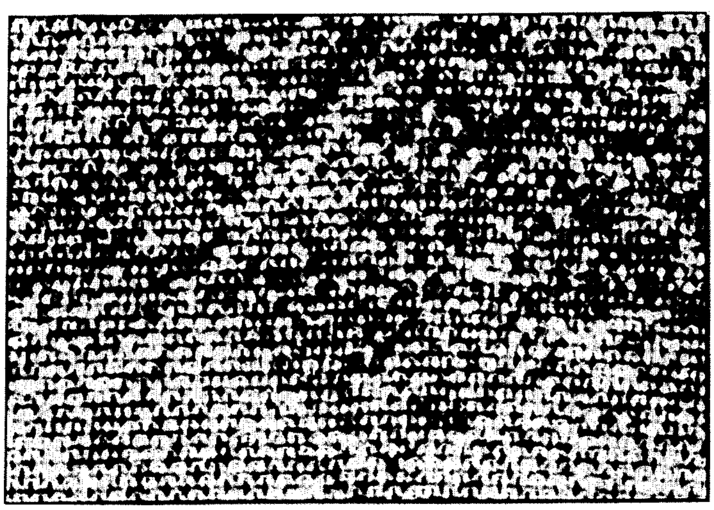
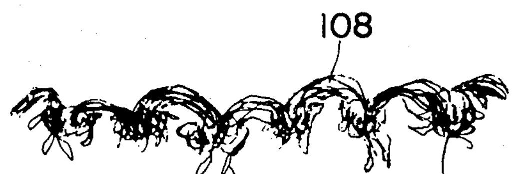


FIG. 13

FIG. 14



NON-WOVEN AND PERFORATED TEXTILE FABRICS MADE FROM CONTINUOUS SYNTHETIC FIBER, AND A PROCESS FOR THE MANUFACTURE OF SAME

This invention relates to improved non-woven and perforated textile fabrics made from continuous synthetic fiber filaments, representing superior strength and hand touch and a process for the manufacture of same.

Recently, non-woven textile fabrics have attracted large public attraction, since these modern type of textile products represent a grave future prospect. From this reason, textile manufacturers have performed vast and various developments and investigations on and into this kind of new type fabrics, regardless of their manufacturing origin of synthetic, regenerated or natural fibers, and miracle and charming products thereof have already appeared on the market. These non-woven textile products represent peculiar and superior respective characteristics. As an example, spun-bond products made from synthetic fibers have such characteristics as low cost and high tensile strength and are highly suitable for use as industrial materials, interior decorative materials and the like, and they have already acquired public acceptance. On the other hand, the dry- or wet-manufactured non-woven fabrics from rayon short fibers pulp fibers and the like have found their wide use as disposable materials, sanitary materials, wiping and the like materials.

In consideration of the aforementioned general situation of the non-woven fabrics, it is the main object of the present invention to provide a substantially improved non-woven fabric having superior strength as well as hand touch and the like characteristics, especially suitable for use as the disposable material for sanitary, wiping, clothing and the like purposes.

A further object of the present invention is to provide a suitable process for the preparation of such improved non-woven fabric as above.

It is highly desirable for the above kind of various purposes, especially for the sanitary fibrous material, to provide the following performances:

1. it must be prepared from a material having a superior moisture-absorbing ability comparable to that of cellulose.
2. it must represent a high value of tensile strength which is not subjected to appreciable reduction even when wetted.
3. it must not contain any harmful substance to human bodies, such as oiling, glueing and/or the like agent.
4. it does not contain liably separating-off short length fibers and thus, it should preferably be prepared from continuous filaments.
5. it must be manufactured at low cost.

According to our knowledge, such non-woven fabrics as satisfying all the aforementioned superior characteristics have not yet been realized. As an example, although certain kind of the synthetic fiber-made spunbond non-woven fabrics may have the several favorable characteristics, as mentioned above at items 2 – 5, those prepared from the material having superior moisture-absorbing performance comparable to that of cellulose as mentioned at the above first item 1 have not yet been realized. Conversely, the non-woven fabrics prepared either in the wet or dry manufacturing process by the use of rayon staples, cotton fibers or the like may satisfy the above first item 1, those desirous characteristics mentioned at the above items 2, 3 and 4 can not be satisfied.

A still further and more specific object of the present invention is to provide a remarkable non-woven fabric capable of representing all the aforementioned characteristics at item 1 – 5, and a process for the manufacture of same.

The non-woven fabric according to this invention represents the following features:

1. it is manufactured from highly favorable moisture-absorbing fibrous material as obtainable by the wet-spinning process of cuprammonium rayon, viscose rayon and the like fibers.
2. it is composed of continuous filaments and capable of being manufactured by the process which is directly combined with the spinning process.
3. the filaments are intimately and strongly interwound with each other without use of bonding agent, providing nevertheless high values of dry- and wet tensile strength.
4. it is composed of a number of continuous filaments having relatively linear parts which are physically cross-linked with each other, so as to represent generally a multiple and composite latticework, said filaments being formed into a web which represents an infinite number of projections distributed geometrically over the whole surface of the web and the filaments being united with each other at these projections and by such filament portions as having a high degree of freedom so as to provide high values of dry- and wet tensile strength of the web.
5. the provision of the aforementioned projections provides an appreciable bulkiness and a soft hand touch.
6. the non-woven web represents a substantially geometrically arranged perforations and the filaments are bonded together at a number of points substantially in the point-contact manner, thereby representing bilateral flexibility.

The process according to this invention for the manufacture of the above mentioned novel non-woven web may be carried out in the following manner.

1. Spinning liquor is extruded from a large number of spinning orifices arranged generally in a rectangular or elongated ellipse, into a coagulation liquid bath and the extruded filaments are led to flow downwardly together with the bath liquid for coagulation and regeneration and the thus coagulated filaments are led out from an outlet opening having an elongated slit and opening at the lower end of the coagulation bath, together with the bath liquid, and then the filaments are caused to make free-dropping under the influence of gravity force and in such state that the filaments groups is totally enveloped by the outgoing and down-flowing coagulation bath liquid curtain.
2. More than three spinning units of the above kind are so arranged in series with each other at a predetermined mutual distance in the direction of travel of a pervious conveyor and above the latter that the major axis of each of the rectangular hexahederal spinning part of the unit crosses, when observed from above thereof, at tight angles to the conveyor arranged directly below the spinning units at a cer-

tain predetermined vertical distance therefrom and laterally thereto.

3. The pervious conveyor while it advances at a certain predetermined travel speed is caused to oscillate laterally and generally so that the cast-on continuous filaments from each of the spinning units describe respective and parallel sinusoidal curves thereon. In this case, all the sinusoidal curves from the spinning units are overlapped one filament/-group after another filament group and at a predetermined off-phase relationship by arranging the spinning units in the corresponding series way relative to the conveyor.

4. When the impinging velocity of the filaments against the travelling conveyor is assumed to be V_F; the travelling velocity of the conveyor to be v_N and the lateral oscillation velocity of the conveyor as measured at the origin of the oscillation to be $\nu_{N\,.\,max}$ (it becoming maximum by the resultant of V_F with the lateral velocity) and by varying V_F and v_N or by varying the lateral oscillating velocity, the following relation is established:

$$1 \leq V_F/V_{N\,.\,max} < 5$$

for at least three spinning units; and

$$V_F/v_N < 3$$

for at least one spinning units.

5. At a downstream point from the filament impinging points, the thus formed filament web on the same conveyor or upon transferred therefrom onto a further and different conveyor is showered directly with liquid jets and from directly above the filament web.

In this way, a non-woven filament web having the aforementioned unique characteristics can be manufactured in a successful way.

In the following, the invention will be described more in detail by reference to the accompanying drawings, in which:

FIG. **1** at 1*a* and 1*b* represents in a modelized form the conventional depositing manner of continuous filaments on a travelling conveyor as spun according to the wet funnel spinning process and to the synthetic fiber spun-bond process, respectively.

FIG. **2** at 2*a*, 2*b* and 2*c* represents in modelized forms, several filaments interwinding modes when realized by three, four and six continuous filaments as funnel-spun and impinged on a travelling and at the same time laterally oscillating pervious conveyor, respectively.

FIG. **3** is a chart showing the longitudinal tensile strength of the web as spun and impinged on a longitudinal travelling and laterally oscillating conveyor as obtainable with variation of the conveyor oscillation amplitude.

FIG. **4** is a chart showing a ratio of tensile strengths, as measured longitudinally and laterally of the web when the oscillation amplitude is set to a constant while the ratio of: oscillation amplitude to half wave length is varied.

FIG. **5** is a schematic view illustrative of several successive steps of the manufacturing process according to this invention.

FIG. **6** is a schematic plan view of a mechanism employable in the present invention for subjecting the travelling pervious conveyor to a lateral oscillation movement.

FIG. **7** at *a*, *b* and *c* show several modes of combined curve arrangement performed by one and four continuous filaments on a longitudinally travelling and laterally oscillating conveyor and a web structure by a large number of filaments, having been illustrated in highly modelized forms.

FIG. **8** at *a* and *b* are schematically illustrating views for the explanation of a web-perforation step employed in the process according to the present invention, the web structure being shown at a before the step and *b* after the step, respectively, for easy comparison.

FIG. **9** is a schematic perspective view of an elongated rectangular spinning unit employable in the process according to this invention.

FIG. **10** is a schematic cross-section of the spinning unit shown in FIG. **9**.

FIG. **11** is a representation of a microscopic photograph of a part of the upper of front surface of a non-woven web prepared by the process according to this invention.

FIG. **12** is a similar view to FIG. **11**, illustrative of part of the rear surface of the same web.

FIG. **13** is a schematic enlarged plan view of the non-woven fabric according to this invention.

FIG. **14** is a sectional view taken substantially along a section line A — A' shown in FIG. **13**.

When a filament is deposited from a funnel spinning unit onto a travelling pervious conveyor and when the filament velocity is higher than the conveyor speed, it is fixedly cast thereto as shown at a of FIG. **1**. In this figure, three parallel filaments are shown in parallel for easy comparison. The lateral amplitude is highly irregular and rather limited.

In the case of the filament prepared by the spun-bond process, the filaments can be deposited on the conveyor in a still highly irregular manner, showing a high variety of lateral deviation. The difference between the both shown at *a* and *b*, respectively in FIG. **1** may be attributed to the difference in the kind of the medium employed, or more specifically, the liquid in the former and the gaseous medium in the latter.

In the case of the spun-bond process, the cast-on filaments cross with each other over a relatively wide area and the resulted filaments structure may represent a high tensile strength advantageously. In the case of the web spinning process, the filaments may normally be cast on the conveyor, each in a rather elongated and zig-zag shape with rather smaller lateral deviation, thus providing a rather weak structure of the fibrous web. As an example, when each of the filaments is taken out longitudinally from the web structure, it can normally be easily drawn out. In order to avoid such disadvantageous phenomenon by setting the difference between the filament velocity and the conveyor travelling velocity to a smaller possible value, the filaments could be cast on in their nearly linear arrangement on the pervious conveyor. In such case, although the longitudinal tensile strength will become extremely high, the lateral strength may be only smallest.

On the other hand, we have found according to our profound experiments that when the non-woven web formed by the wet-spun continuous filaments of cuprammonium-, viscose rayon and acrylonitrile and cast-on onto a wire net similarly as in the aforementioned way, is showered from upper with liquid jets, a meshedly perforated product can easily be provided. This means such the filaments parts lying on the wires are flushed hydraulically down into the mesh openings of the wire-or gauze net. Therefore, such portions of the previously formed fibrous web which correspond to the wires are subjected to formation of the perforations, while those of the web which have been flushed into the gauze openings will form downwardly projecting projections from the common plane of the web.

According to our practical experiments with the ratio: V_F/v_N broadly varied, it has been found that with the ratio set to higher than 3, there is a remarkable tendency to invite neat and rather sharply defined formation of the perforations of the above kind. The spray nozzles which have been used by us in these perforating experiments were of the flat type having a spraying angle of 40°. The outlet pressure was set to 5 kg/cm^3 with a water delivery rate of 5 lit./min. From this, it has been concluded that for hydraulic rearrangement of the web structure, the constituting filaments must have certain degree of freedom. It was further found, however, that the perforated non-woven web thus prepared represents only small longitudinal and lateral tensile strengths and is, therefore, far from its acceptable condition.

In the progress of our experiments in the above sense, such a thought has been hinted that a perforated non-woven web of high strength may be realized combiningly cast-on of rather linearly arranged filaments parts with rather finely zig-zag-shaped and folded filaments parts at a properly selected ratio and the thus formed web is then subjected to the action of water jet streams. In the thus provided and hydraulically perforated web, the rather linearly arranged filaments parts will provide a skelton-like structure and the rather high freedom filaments parts will entangle the skelton, and thus, the resulted perforated web may represent high tensile strengths in the longitudinal and lateral directions of the web.

When the conveyor is caused to laterally oscillate by means of a cam- or crank mechanism, as an example, while the conveyor is advancing at a certain constant speed of v_N, the overall motion thereof can be expression by the following mathematical equations:

$x = v \cdot n \cdot t$ (the distance x has been taken in the conveyor-advancing direction)

$y = a \cdot \sin 2\pi\, nt$ (the distance y has been taken in the lateral direction)

Then, the respective velocities will be:

$v_x = v_N$

$v_y = 2\,\pi \cdot a \cdot n \cdot \cos 2\,\pi\, nt$

where,

n represents the lateral oscillation cycles/min of the conveyor;

a stands for the amplitude of the oscillation;

l represents ½ wave length of the oscillation;

t represents time in minutes.

The resultant velocity V_N of the longitudinal and lateral velocities of the conveyor will be:

$$V_N^2 = v_N^2 + 4\pi^2 a^2 n^2 \cdot \cos^2 2\pi nt$$

$$= v_N^2 \left(1 + \frac{4\pi^2 a^2 n^2}{v_N} \cos^2 2\pi nt\right)$$

$$= v_N^2 \left\{1 + \left(\pi \frac{a}{1}\right)^2 \cdot \cos^2 2\pi nt\right\}$$

Therefore, the conveyor velocity V_N as measured at the original point of reciprocation will become:

$$V_{N\,.\,max} = v_N \sqrt{1 + \left(\pi \frac{a}{1}\right)^2}$$

and it will be at the peak or valley:

$$V_{N\,.\,min} = v_N$$

Then, the ratio of filament velocity relative to conveyor velocity will be always:

$$\frac{V_F}{V_{N\,.\,max}} < \frac{V_F}{V_{N\,.\,min}} = \frac{V_F}{v_N}$$

Therefore, at the peak or valley, the filament will represent a more accumulation than that appearing at the origin of the reciprocating motion by such factor as:

$$\frac{V_{N\,.\,max}}{v_N} = \sqrt{1 + \left(\pi \frac{a}{1}\right)^2}$$

Or, alternatively, the degree of freedom of the filament at the peak or valley is higher than that appearing at the origin of the reciprocation of the same factor as:

$$\sqrt{1 + \left(\pi \frac{a}{1}\right)^2}$$

Now assuming $V_F/V_{N\,.\,max} = 1$, the value of V_F/v_N will vary as shown in the following Table, with variation of $a/1$.

a/1	V_F/v_N
0	1
0.2	1.18
0.4	1.61
0.6	2.13
0.8	2.70
1.0	3.30
1.2	3.90
1.4	4.51
1.6	5.12
2.0	6.36

As it is well supposed from the foregoing analysis and as ascertained by our practical experiments, when a number of filaments are spun by the wet spinning process and impinged by gravity action upon the conveyor which is caused to advance at a constant velocity and subjected to lateral oscillation at the same time, a fibrous non-woven web composed of relatively linearly arranged filaments portions and those which have relatively high degree of freedom, and further that when the thus formed web is subjected to hydraulically perforating action of the kind referred to specifically hereinbefore, an acceptably perforated web product having high longitudinal tensile strength could be realized, as will become more apparent as the description proceeds.

In the spinning stage as an initial step of the process according to this invention, the continuous filaments are arranged in an evenly distributed state enveloped within a liquid curtain and caused to emerge out from an elongated slit-like outlet in such distributed and enveloped state.

At the spinning step, at least three spinning units are employed, the reason therefor residing in the attainment of uniformity in the web appearance as well as web strength. If bearable with somewhat inferior uniformity in the above sense, only two wet spinning units may be utilized within the framework of the present invention.

In FIG. **2** at *a*, *b* and *c*, yarn wave configurations attainable with use of 3, 4 and 6 spinning units are shown. It is most preferable, the sinusoidal wave curves represent each phase lag of $2\pi/n$, when n stands for the number of wet spinning units employed. It should be understood in these diagrams that the wave pattern diagram is shown only in a highly simplified way that each filaments array consisting of, say, 90,000 filaments delivered from each spinning unit is shown only a single line.

The amplitude and frequency of the lateral oscillation given to the pervious conveyor means can be varied within a broad range so as to provide attractive products. However, it should be stressed at this stage that there are the following general principles in this respect:

A. Amplitude "*a*".

With the ratio of $a/1$ fixed and with variation of "*a*", the strength of the web will vary as shown representatively in FIG. **3.** We have obtained non-woven fabrics of sufficient strength by selecting the value of "*a*" within the range of 5 – 50 mm.

B. Number of oscillations.

When the conveyor is caused to travel at a constant travelling velocity, the pitch of the sinusoidal curve of the filament will be varied by variation of the number of oscillations per unit time.

With the value of a "*a*" fixed and with variation of the pitch, a relation as representatively shown in FIG. **4,** can be obtained. As seen from FIG. **4,** a web having longitudinal and lateral strengths well balanced with each other may be produced when the ratio $a/1$ is set to about 0.5. The difference between the longitudinal and lateral tensile strength of the web will become more appreciable, depending upon the degree of deviation of the said ratio from 0.5. Within the framework of the present invention, the value of $a/1$ may be varied within a vast range, depending upon the usage of the final products.

When a number of spinning units are employed, at least three sets thereof should represent the value of ratio: $V_F/V_{N\ .\ max}$ set to 1 – 5. This is from such reason that by the adoption of this measure, the formation of the skeleton of filaments can thereby be assured. With higher value of this ratio than 5, the web can not provide an acceptable strength.

In the present invention, at least one of the adopted number of web spinning units must represent the value of V_F/v_N higher than 3. By adopting this measure, the very presence of filaments parts of high degree of freedom is assured for the realization of mutually intimate interwinding of the filaments.

In order to satisfy the aforementioned various requirements, various combination modes of V_F with $a/1$ may be considered and adopted. Several representative combinations thereof will be shown hereinbelow for better understanding of the invention.

1. Three spinning units were employed. $V_F = 30$ m/min.

$$v_N = 8 \text{ m/min. } a/1 = 1.$$

In this embodiment, each of all the spinning units represents

$$V_F/V_{N\ .\ max} \cong 1.1 \quad V_F/v_N \cong 3.8$$

2. Use of four spinning units.

For three units, $V_F = 30$ m/min. $v_N = 15$ m/min. $a/1 = 0.4$

For the remaining one unit, $V_F = 60$ m/min.

Then, for the three units:

$V_F/V_{N\ .\ max} = 1.25$

$V_F/v_N = 2$

For the remaining one unit: $V_F/v_N = 4$

In the hydraulic perforation step, a punched metallic sheet or web may equally be used in place of the guaze wire net as the pervious conveyor for movingly carrying the fibrous non-woven web, with equal results. As the pervious conveyor arranged directly below the spinning units for casting-on of the corresponding number of continuous filaments, we use preferably an endless plain-woven wire gauze net of 40 – 60 mesh. The cast-on continuous filaments web can be as per se subjected to a hydraulic perforation job by use of a plurality of liquid jets. Or alternatively, the fibrous web may be transfered onto a further pervious conveyor for subjecting it to a hydraulic perforation job. In the latter case, a gauze wire net of 10 – 60 mesh can be advantageously employed.

In place of the plain-woven wire net, any one or any combination of those of triple-woven, twill-woven or the like wire net may equally be used for attaining a correspondingly modified perforation design effect of the final products.

In place of wire net, a perforated non-woven fabric web may also be used.

Most advantageous and preferable liquid medium adapted for the formation of liquid jet streams to be utilized for the execution of the hydraulic perforation job may be water. Its most suitable performance for the fiber rearrangement, easy operability and workability and its highest economy must be taken into account for carrying out the process of the present invention.

As the spray nozzles for use in the present process, various known types may be employed. Circular shower type nozzles and flat shower type one have been used with better results.

The liquid pressure at the oulets of the jet nozzles depends upon the ratios of V_F/v_N and $V_F/V_{N\ .\ max}$ and upon the overall feed rate of the continuous filaments as spun and cast on. With higher values of V_F/v_N and $V_F/V_{N\ .\ max}$ and with smaller feed rate of the continuous filaments, the outlet liquid pressure will become smaller.

The thus prepared perforated non-woven fabric web of the present invention represent geometrically arranged perforations corresponding to the non-perforated substance parts of the net or punched carrier web, and a large number of projections corresponding to the perforations or openings of the carrier web and consisting of entanglements of the related parts of the continuous filaments, and further, stringlike filaments bundle parts connecting said projections with each other.

At each of said projections, high freedom filaments are intimately entangled with low freedom filaments arranged in a latticework skelton, so as to provide a well-organized overall structure of the non-woven web.

In the following, a plurality of processing steps of the manufacturing process of the present invention will be described hereinbelow in detail be reference to FIG. **5.**

In FIG. **5,** numeral **1** represents an endless type wire net conveyor which circulates clockwise therein as shown by a small arrow and by being movably supported by rollers **2, 3, 4** and **5** of which those denoted **2**; **3** may be drive rollers receiving motion from a proper prime mover, not shown.

Above the net conveyor **1** and in proximity to the left-hand end thereof, there are provided a plurality of, herein three, spinning units, generally shown at "A". At intermediate place between the both ends of the conveyor net **1** and directly thereabove, there are provided several scouring units **33 – 35** consisting a scouring stage, generally shown at "B". "C" represents a perforating stage and "D" a drying stage. The perforating stage "C" and the drying stage "D" are related with a further net conveyor **15** which circulates along a number of rolls or cylinders **6 – 14,** of which those denoted **11 – 14** constitute in combination a cylinder dryer machine. In fact, rollers **6**; **7** are of the driving type and the cylinder rolls **11 – 14** are driven from a suitable prime mover, not shown. In this way, the net conveyor **15** can circulate in clockwise direction in FIG. **5,** as shown by a small arrow.

Numeral **16** represents a machine frame carrying the constituent parts of the spinning and scouring stages "A" and "B", said frame **16** being rigidly supported on columns **17 – 19** which are connected pivotably to the upper parts of stationary pillars **23 – 25** rigidly supported on the base blocks **20 – 22,** respectively.

Roller **2** is rotatably mounted on top of a column **26** which is connected at its lower end pivotably to the upper part of a stationary pillar **28** rigidly supported on a base block **27.**

In FIG. **6,** roller **2** and frame **16** are mechanically connected to a mechanical oscillator unit "E". Numeral **29** represents an electric motor, while **30** denotes a casing in which a crank mechanism is contained, although not shown. As may be well supposed, actuation of the motor **29** so as to bring the oscillator unit "E" into operation, will oscillate to and fro, roller **2,** net conveyor **1** and frame **16** horizontally in FIG. **6** in unison.

In FIG. **5,** numeral **31** represents three spinning units **31,** each funnel thereof having a horizontally elongated rectangular shape, as may be well supposed from joint consideration of FIGS. **9 – 10.** Each of these spinning funnels has its major axis directing in the lateral direction relative to the travelling net conveyor **1.**

Numeral **32** represents a plurality of suction boxes arranged directly below the net conveyor and in vertical registration of spinning units **31.**

Numeral **33 – 35** represent trays arranged above the net conveyor **1** and adapted for supplying scouring liquor in showers towards the next conveyor, said trays consituting representatively the scouring stage "B".

Numeral **36** represents a plurality of water jet nozzles arranged above the next net conveyor **15,** so as to constitute the hydraulic perforation stage "C" for the execution of the perforation job, as was referred to hereinbefore, by use of water jet streams directed onto the fibrous web. Suction boxes **37** are also provided, below the net conveyor **15** and in vertical registration with the nozzle group **36. 38** represents a take-up roller pair for the cast-on and hydraulically perforated fibrous web and **39** represents a wing-up roll for the latter.

Next, referring to FIGS. **9** and **10,** the details of the spinning unit **31** will be described more in detail.

In FIGS. **9 – 10,** numeral **40** represents a spinning liquor supply pipe; **41** an outer casing; **42** a nozzle plate formed with a large number of spinning orifices, not shown, generally arranged in a horizontal plane, so as to represent an elongated rectangular or elliptical outline configuration; **43** an upper funnel element defining an upper coagulation liquid bath; **44** a lower funnel element defining a lower coagulation liquid bath; **45** an intermediate separator wall; **46** a supply inlet for primary coagulation bath liquid; **47** a supply inlet for secondary coagulation bath liquid; **48 – 51** respective rectifier plates; **52** a slit-like outlet opening formed at the lowermost end of the lower stage coagulation liquid bath.

In these figures, the spinning liquor is supplied through supply inlet **40** and extruded through a number of extrusion orifices formed through the nozzle plate **42** in the downwardly vertical direction.

As for the extrusion orifices, each of the latter may have, as an example, an orifice diameter of 0.8 mm. These orifices may have a mutual pitch of 1.5 mm and they may be arranged in 90 rows when seen in the travelling direction of the conveyor net **1,** and in 1,000 rows in the lateral direction thereto, thus being 90,000 orifices in total per unit.

The bath liquid introduced into the upper bath **43** is led to flow downwards therethrough and together with the extruded filaments from the nozzle orifices. As seen, the coagulation bath keeping its longer major axis unchanged in its length, will reduce, however, gradually in its lateral width, as the bath liquid flows down towards the bath outlet. Therefore, the bath liquid flow increases gradually its downflowing speed.

The inlet temperature of the coagulation bath liquid is set to a suitable level so as to provide proper coagulation degree of the extruded continuous filaments by contact with the bath liquid according to the prior technique.

The filaments are then brought into contact with the secondary coagulation bath liquid prevailing in the lower coagulation bath **44,** so as to be further coagulated and stretched to a proper degree, and arrive at the slit-like outlet opening **52,** thence therethrough discharged as being totally enveloped within a liquid curtain formed by the downwardly outgoing bath liquid.

This discharged liquid curtain from the slit outlet opening **52** will flow downwards with its lateral length kept unchanged, in the form of a liquid film or sheet, containing therein a curtain-like consisting of thus extruded, coagulated and stretched continuous filaments and representing a substantially constant thickness. In FIG. **5,** the thus and similarly formed three liquid curtains are shown in a highly simplified manner by parallel vertical lines at **53.**

These liquid curtains or sheets **53** containing therein a filaments curtain-like core are led to drop without destructing the rectified curtain flow through the free open air atmosphere under gravity action and impinge against the upper surface of the travelling net conveyor **1.** In a practical example of the cuprammonium rayon spinning process, the spinning units are arranged three in its number at a mutual distance of **1** meter in the direction of the travel of the net conveyor **1.**

As the net conveyor **1** advances, it is subjected to lateral oscillating movement, as was referred to in connection with FIG. **6.** As an example, the conveyor **1** is driven to travel at a speed of 10 m/min and laterally shaked at 250 cycles per minute with an amplitude of 20 mm.

As the dropping continuous filaments impinge against the upper surface of the longitudinally travelling and laterally oscillating net conveyor **1,** they are cast on the latter while describing an off-phasedly combined sinusoidal curves, as was referred to hereinbefore in connection with FIG. 2 at (I). Upon execution of said impinge of the continuous filaments enveloped by the liquid curtain, the liquid will be sucked into by the respective suction boxes **32.** For this operation, the filament velocity, the conveyor travelling velocity and the conveyor oscillation frequency are properly adjusted, so as to set the values of $V_F/V_{N\,.\,max}$ and V_F/v_N within the reasonable range as set forth hereinbefore.

By adopting proper values of $V_F/V_{N\,.\,max}$ and V_F/v_N and by selecting the number of the spinning units at **3,** 4 and **6,** respectively, differently cast-on filaments schemas as shown at (I), (II) and (III) in FIG. **2** will be realized for providing non-woven fibrous webs.

At the peaks and valleys of the sinusoidal curve, the filament is more densely accumulatedly cast on the pervious carrier web **1** and they deposit rather linearly along its transient portions between peaks and valleys on the carrier web. It results in the formation of such web comprising filaments portions generally forming a latticework skelton as shown in FIG. **7***a* and those representing finely and rather densely folded filaments portions, said both kinds portions being mixedly entangled with each other to provide said non-woven web.

The thus formed web is carried away as cast-on onto the advancing conveyor and subjected to a scouring step. In the case of the cuprammonium spinning, a diluted sulfuric acid aqueous solution of 5%-acid concentration is delivered from the first tray **33** for this purpose. Fresh and clean water is delivered from the succeeding trays **34; 35** for the same purpose. In this way, the constituent filaments of the web have been regenerated and washed.

Upon thus water-cleaned, the web is transferred from first conveyor **1** to second conveyor **15** which carries it further. During this advancing movement of the second conveyor, the web is subjected to a hydraulic perforating job, as was referred to hereinbefore.

During this step, water jet streams are injected from flat spray nozzles **36** positioned directly above the second conveyor, as shown in FIG. **8***a*, against the travelling web. At the same time, the suction boxes **37** are operated to suck water from below the second conveyor. In this figure, numeral **54** represents the web at this stage.

At this stage, the constituent filaments of the web is in its state that they are shiftable in their mutual position upon subjected to pressure liquid action. Therefore, the filaments are rearranged in their position by receiving the influence of the liquid energy. The rearranging operation has been illustrated in FIG. **8***b*. Part of the web **54** shown in FIG. **8***a* has been shifted and has dropped into mesh openings of the carrier web, the latter portions of the web being thereby high densely enlarged together. In this case, even when parts of the latticework skelton may be shifted in the similar manner, however, the whole structure of the skelton can not be destroyed. Thus, the liquid energy may serve to shift parts of the filament bundle skelton and to concentrate them locally.

Destruction of the skelton will not occur if the water jet energy is controlled so as not to break the constituent filaments.

Those filaments parts of the web which are finely zig-zag formed can be transferred in their position with relatively small amount of energy. The water jet energy is set to by consideration of such facts. Favorable results were obtained in the case of cuprammonium non-woven web, the jet water delivery rate of 10 lit./min. and at the pressure of 20 kg/cm^2 per spinning set, the nozzles being positioned at 150 mm above the web.

The thus hydraulically perforated non-woven web represents a regular arrangement of elongated perforations and downwardly directing projections, the latticework-maintaining filaments portions densely and intimately entangled with finely zig-zag shaped filaments portions. Therefore, it will be seen the basic latticework is maintained in its substance, but losing its original plan configuration and being bundled together.

The thus fabricated web, having regularly perforated and projected web is conveyed on the second carrier web through a hot roller type drier zone and finally wound up into a roll.

The non-woven fabric thus prepared naturally consists of a large number of continuous filaments highly entangled together, yet preserving the original rigid structure in its substance, thereby representing high values of longitudinal as well as lateral tensile strength comparative to woven fabrics, and indeed, by preparing with no use of glueing agent.

Since the non-woven fabric web according to this invention represents a regular arrangement of a large number of small elongated perforations and small downwardly directing projections and the very maintainance of highly entangled filaments entanglement without use of any special adhering agent, the overall hand touch thereof is similar to sanitary gauze clotch and finds its vast and various usages as sanitary, wiping and disposable cloth materials.

The non-woven fabrics according to this invention can be prepared as well by use of acrylonitrile filaments in place of those of cuprammonium or viscose rayon.

EXAMPLE 1

Perforated non-woven fabric web was manufactured by use of cuprammonium regenerated cellulose filaments in accordance with the processing step schematically shown in FIG. **5.** Three wet spinning units were used, each being of the type shown schematically in FIGS. **9** and **10** in its perspective outline and in its schematic elevational section, respectively. These units were arranged in series in the travelling direction of the pervious carrier conveyor at a mutual distance of **1** meter. water which

Used cuprammonium cellulose spinning liquor prepared according to the common practice and having a composition of cellulose concentration 10.0 wt.%; ammonium concentration 7.0 wt. % and copper concentration 3.6 wt. % was extruded from a large number of

90 × 1,000 extrusion orifices of the nozzle plate as at **42**, FIG. **10**, so as to perform the funnel spinning step. The bath liquid was deaerated soft fresh which was fed to the bath funnels in two successive vertical stages in an overflowing in-flowing method. The orifices were of 0.8 mm bore and arranged in a rectangular matrix, the mutual pitch being 1.5 mm.

The bath liquid consisting of deaerated fresh water was fed at the rates of 100 lit./min. (34°C) and 110 lit./-min. (46°C) for the two stage coagulating baths, respectively.

In this way, the extruded fine spinning liquor streams were coagulated and were discharged with the entraining bath liquid flow through the outlet slit openings 5.0 mm wide, and in the form of the composite curtain containing parallel-arranged sheet-like filaments core.

The composite curtain of a substantially constant thickness was caused to flow 500 mm downwards freely through an open atmosphere and to impinge against at $V_F = 40$ m/min at stainless steel wire gauze net (of 400 mesh) advancing at a constant speed of 10 m/min. The conveyor was laterally oscillated forcibly at 125 cycles per minute with an amplitude of 20 mm. For each of the three spinning units, $V_F/V_{N\ .\ max}$ was set to 2.2 and V_F/v_N to 4, respectively.

Upon the impinge of the composite curtain, the bath liquid on the carrier conveyor was sucked through the mesh openings thereof by respective suction boxes having slit-like suction openings arranged oppositely to and similar opening dimensions of the corresponding spinning units.

The thus cast-on non-woven web was carried away by the travelling carrier net and washed with aquious acid solution and fresh water as being conveyed, for the purpose of the regeneration as known per se and then transferred onto a further stainless steel net conveyor of 30 mesh. This transferred fibrous web was then subjected to a hydrous perforation job by applying from upper water jet streams from a plurality spray nozzles of the flat type which are positioned at a distance of 150 mm above this second conveyor net. The water supply jet for these spray nozzles was set to 10 lit./min per spinning unit and at a pressure of 20 kg/cm².

A similar suction box was provided below the net conveyor for sucking into the exhaust water upon carrying out the hydraulic perforation job and through the mesh openings of the conveyor and at a suction pressure of 74 mmHg which could be applied to the first suction boxes cooperating with the spinning units.

As the second conveyor travel along, the thus perforated web was passed through a tunnel dryer for drying thereof to provide the final product.

The thus manufactured perforated non-woven fabric web had high longitudinal and lateral strength similar to surgical cloths as well as superior hand touch comparative to woven fabrics.

In the following Table 1, tensile strengths and drape characteristic of the non-woven fabric web thus obtained are shown.

Table 1

Dry Strength*		Wet Strength		Drape** Characteristic
Long.	Lat.	Long.	Lat.	
24.4	17.3	16.6	11.8	3.6

*unit ..... (g/cm)/(g/cm²)
**cm. results as measured by the cantilever method.

Magnified photographs a part of the non-woven perforated web are shown by the reproduction in FIGS. **11** and **12.** FIG. **11** represents the front or upper surface taken with a magnifying factor **10,** while FIG. **12** shows the rear or lower surface of the same non-woven fabric taken with a magnifying factor **3.**

EXAMPLE 2

In this example, four spinning units were used which were arranged in series in the travelling direction of the first carrier web at a mutual distance of 1 m. The spinning and the conveyor drive conditions were same as before. The number of lateral oscillations and conveyor advancing speed were so selected that the continuous filaments groups from these were cast on successively one after another at mutual off-phase relationship of ¼ oscillation period.

The thus prepared basic web was transferred to a second carrier web or conveyor, of 28 mesh, stainless steel plain-woven net, and then subjected to a hydraulic perforation job. Spray nozzles were of flat type. The jet water was delivered at a rate of 5 lit./min, the delivery pressure being 13 kg/cm². The characteristics of the thus prepared, perforated non-woven fabric were similar to those obtained in the foregoing example 1.

EXAMPLE 3

Six spinning units of the type same as before were used. The free dropping distance of the multifilaments for the first and fourth spinning units was set each to 700 mm. That for the second, third, fifth and sixth spinning units was set to 400 mm, respectively. The spinning speed for the first case was 56 m/min and that for the second case was 31 m/min.

The travelling speed of the carrier web was set to 15 m/min at 180 lateral oscillations per minute with an amplitude of 20 mm.

$V_F/V_{N\ .\ max} = 2.0$ for the first and fourth units.

$V_F/v_N = 3.7$

On the other hand, for the second, third, fifth and sixth units:

$V_F/V_{N\ .\ max}$ 32 1.2

$V_F/v_N = 2.2$

The thus cast-on web was transferred onto a second carrier web, plain-woven stainless wire gauze net of 30 mesh, and subjected to a hydraulic perforation job as before. The spray nozzles were of flat type.

The water supply rate was 10 lit./min at 20 kg/cm².

The dried web represented the following characteristic data.

Table 2

Dry Strength		Wet Strength		Drape Characteristic
Long.	Lat.	Long.	Lat.	
30.2	21.7	19.5	14.8	4.3

EXAMPLE 4

Viscose spinning liquor prepared as conventionally with: cellulose concentration 8.4 wt. %; alkali concentration 6.5 wt. %; mean polymerization degree 290; gamma value 55 and viscosity **53** seconds was used for spinning the continuous filaments. The spinning arrangement was same as shown in FIG. **5.** Spinning units were three in its number. The orifice plate was provided with 30 × 200 orifices, 0.1 mm bore, 1.5 mm pitch.

The thus formed composite curtain was led to impinge upon a conveyor not positioned at 500 mm below said outlet and travelling at 5 m/min which consists of a 40-mesh stainless steel wire net. V_N amounted to 26 m/min. The conveyor was oscillated at 50 cycles per minute with an amplitude of 30 mm. $V_F/V_{N\ .\ max} = 24$; $V_F/v_N = 5.2$

The thus cast-on filaments web was transferred onto a second carrier web, made of a 30-mesh stainless steel gauze wire net and then subjected to a hydraulic perforation job as before. Water delivery rate was 10 lit./min at 20 kg/cm^2.

The results were substantially same as before.

EXAMPLE 5

The coagulation bath liquid contained: 130 g/lit. of sulfuric acid; 300 g/lit. of sodium sulfate; and 20 g/lit. of zinc sulfate. At the first stage, the bath liquid was supplied at a rate of 100 lit./min (40°C) and at the second stage, it was fed at equal rate (60°C).

The thus extruded, coagulated and somewhat stretched continuous filaments were delivered through each slit-like outlet of 2.0 mm width and in a filament curtain enveloped within a downflowing bath liquid curtain.

Acrylonitrile 94 wt. parts; acrylamide 5.5 wt. parts; acrylsulfonate 0.5 wt. part; ammonium supersulfate 4 wt. parts and thiogrycol 0.2 wt. part were dissolved in 1,000 wt. parts of water, adjusted pH3 with addition of a small amount of sulfuric acid and left at rest at 60°C for 5 hours. The thus formed polymer was dissolved in 70%-nitric acid, 0°C, so as to prepare a spinning liquor containing 12 wt. % of the polymer.

With use of this spinning liquor, continuous filaments were extruded, coagulated, stretched and cast-on onto a travelling pervious conveyor with use of the arrangement shown in FIG. 5. The spinning units were same as used in the foregoing Example 1. However, the number of the spinning units was four in place of three. Each unit had an orifice plate having an array of 20 × 150 orifices, 1.0 mm bore diameter, arranged at pitches of 2 mm.

The coagulation bath liquid was a 37%-nitric acid aqueous solution. The inlet rate between first and second bath stage was 1 : 1. Bath temperature was set to 3°C for the both.

The width of the lower outlet opening amounted to 2.0 mm, and the net conveyor was positioned therebelow at a 300 mm-distance and driven to travel at 7 m/min. The conveyor was a 40-mesh stainless steel wire gauze net.

$$V_N = 27 \text{ m/min.}$$

Lateral oscillation was at 75 cycles per minute with an amplitude of 20 mm. For all the four units:

$$V_F/V_{N\ .\ max} = 2.1;\ V_F/v_N = 3.9$$

The thus cast-on filaments web was subjected to a hydraulic perforation job with use of flat type spray nozzles at water delivery rate of 6.4 /min per spinning unit at a delivery pressure of 15 kg/cm^2. The suction boxes were operated at 740 mmHg. The filaments entanglement and mutual fixture were performed without use of any bonding agent.

The results were superior as before.

The general structure of the perforated non-woven web prepared according to this invention is shown schematically in FIGS. **13** and **14** in its plan view and in its cross-section, respectively.

In these figures, numeral **101** represents regularly arranged elongated perforations, while **102** represents downwardly extending projections which are again regularly arranged. In the general aspect, when seen horizontally in FIG. **13,** perforations **101** and projections **102** are arranged alternatively with each other.

The projection **1022** represents a densely condensed and mutually entangled filament mass. As seen from FIG. **13,** these projections **102** are laterally (horizontally in FIG. **13**) and longitudinally (vertically in FIG. **13**) connected one after another by relatively thin band-like connecting portions **103.** When horizontally seen, a pair of the projections **102** define one end of said elongated perforation or opening **101.** When vertically seen, the next pair of the projections **102** define the opposite end of the next succeeding perforation or opening **101.** These four projections **102** are connected crosswise by two physically cross-linking band portions **107.** Vertically seen in FIG. **13,** each two projections **102** are connected with each other by substantially parallely seen filament strip **106.** Two projections **102** are connected with each other laterally by a substantially parallely seen filament strip **108.** This strip **108** takes generally a convex curve when seen in FIG. **14. 105** represents a yarn loops extending from each projection **102,** providing favorable chance of entanglement with similar yarn loops of a further similar web when several similar webs are overlapped one after another, for providing any desired thick web group.

The foregoing explanation relating FIGS. **13** and **14** concerns the appearance or visual apparent observation only. The true structure of the whole organization is based upon the unique latticework-and-entanglement combination explained by reference to FIG. **2** and the like as set forth hereinbefore.

The embodiment of the invention in which are exclusive property or privilege is claimed are as follows:

1. A perforated non-woven textile web made from continuously extruded filaments produced by a wet spinning process, wherein the web consists essentially of alternately arranged continuous filaments of relatively linear portions (A) which are physically cross-linked to each other without the use of bonding agents at various portions along the length of said filaments to form a latticework structure, said filaments also have finely folded portions (B), wherein the finely folded portions are evenly distributed over the entire area of the web, the web having regularly arranged projections and perforations such that the filament portions (A) and (B) are entangled with each other at each of the projections to fix and reinforce the latticework structure, the web having an arrangement such that the web represents an infinite number of projections distributed geometrically over the whole surface of the web and the filaments being united with each other at these projections.

2. The web according to claim **1** wherein the projections and perforations are alternately arranged in the lengthwise and laterwise directions of the web.

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