Nov. 2, 1965 J. A. GUERIN 3,214,819

METHOD OF FORMING HYDRAULICALLY LOOMED FIBROUS MATERIAL

Filed Jan. 10, 1961 2 Sheets-Sheet 2

Fig. 11.

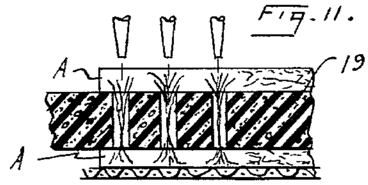


Fig. 12.

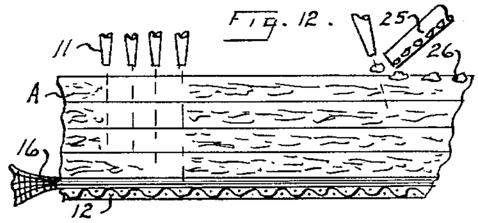


Fig. 14.

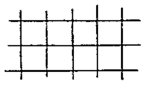


Fig. 15.

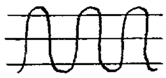


Fig. 16.

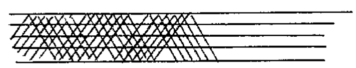


Fig. 17.

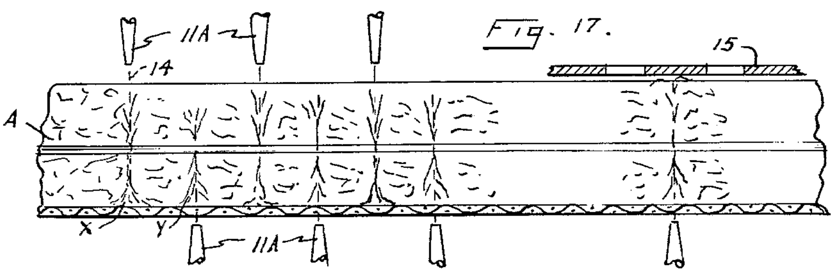


Fig. 18.

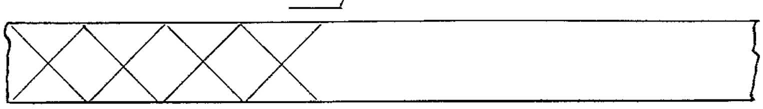


Fig. 19.

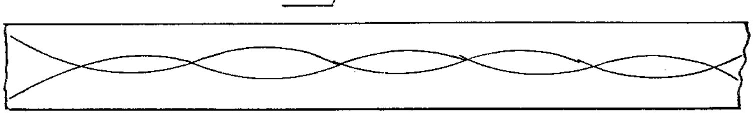
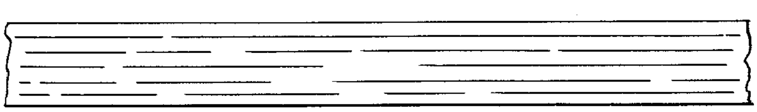


Fig. 20.



INVENTOR.
JOSEPH GUERIN
BY Howard T. Jeandron
AGENT

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METHOD OF FORMING HYDRAULICALLY LOOMED FIBROUS MATERIAL

Joseph A. Guerin, Forestdale, R.I., assignor to Howard T. Jeandron, Keyport, N.J.

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17 Claims. (Cl. 28—72.2)

This invention relates to fibrous materials and the method of interlocking non-woven fibrous material and more particularly, the process of treating a non-woven fibrous material such as a tenuous web of loosely associated textile fibers disposed in sheet form and lapped into a plurality of laminations with or without a supporting or reinforcing core or backing structure by applying jets of fluid (more particularly liquid) to the plurality of laminations to produce a reorientation of some fibers between laminations to provide a fiber-locking and entanglement of reinforced densified felt like material having a strength equal to a normal needle loomed fabric and with greater flexibility and diversification.

The prior art includes the numerous variations of a needle loom apparatus and all applications of needle punching used in treating fibrous material to provide the reorganization of the fibers in the direction of the impregnation by the barbed needles to reform the fabric in a reinforced organization. In all of the prior art in which the needle looming is performed, the apparatus requires a plurality of needles mounted in a desired pattern on a needle board. The repeated punching of the fabric with the needles produces a great deal of wear and breakage of the needles, which in turn requires the shut down of the device for replacement of the broken needle or needles, or the replacement of the complete needle board, as the case may be. This repeated punching of the fabric wears the mechanical needles and in turn the effect on the product changes, this effective change can be easily detected during one day of operating. Also the prior art shows that where a core or backing fabric or structure is used as an integral part of the non-woven fabric the needles cause a breaking and/or weakening of the core and a rupturing of some of the fibers. A further apparatus disclosed in the prior art illustrates a method of forming non-woven fabrics in which a layer of fibrous material is positioned between a rigid apertured means and a foraminous means and fluid is applied under pressure to the apertured means to cause some of the fibers of the material to move with the flow of the fluid into the foraminous means in a lateral direction to thus pack fibers into groups, according to the pattern of the apertured means and provide an interconnection of fibers with the foraminous means. The rigid apertured means is used as a confining and protecting layer, to hold the fibrous material on to or against a screen backing and prevent the destruction of the fibrous material by the force of the fluid applied. The fluid applied under pressure causes a lateral movement of the fibers that are under each aperture of the apertured means, this causes a packing of fibers in groups which move laterally to interconnect with the foraminous means. Care is taken to retain a definite pattern or grouping of fibers according to the pattern of the apertured means and no flooding is permitted to change this pattern. It is apparent that the method of forming foraminous fabrics according to Patent No. 2,862,251 is limited to those fabrics which necessarily have a foraminous backing and in all cases are formed or reformed by the reorientation of fibers of the fibrous material into a definite group pattern. The prior art also describes the non-cored felts, the cored felts, and the felts with a backing which are the types of material included in this invention. According to this invention, the prior

art also includes all types of fibers both natural and man made which have been utilized in the formation of fibrous materials.

It is an object of this invention to reorient the fibers in a non-woven material by applying a plurality of fluid jet streams to the material.

It is a further object of this invention to reorient the fibers in a non-woven material by applying a plurality of fluid jet streams to draw, pull or flow the fibers to form a reinforced fibrous felt like material.

It is a further object of this invention to reorient the fibers in a non-woven material by applying a plurality of fluid jet streams in variable directions and patterning to form a reinforced fibrous material.

It is a further object of this invention to form a non-woven fibrous material into a tenuous web of loosely associated textile fibers and in which the fibers are formed into a single in-line unlapped web produced by air doffing or screen collected and in which a plurality of high velocity needle nozzle jets of fluid (more particularly a liquid) are utilized to draw, pull or flow the fibers to produce a reorganization of fibers to form a reinforced fibrous material.

It is a further object of this invention to form a non-woven fibrous material into a tenuous web of loosely associated textile fibers, and in which the fibers are formed into a single lamination and in which the single lamination is lapped into layers or laminations and compressed and in which a plurality of fluid (more particularly a liquid) jets of variable force and shape are utilized to produce a reorganization of fibers between successive laminations to form a reinforced fibrous felt like material.

It is an object of this invention to provide a plurality of fluid (more particularly a liquid) jets for the treatment of a non-woven fibrous material that has been formed into a pad like layer with a core or backing of open mesh material and in which the liquid utilized includes an adhesive such as resin, and in which the liquid is applied to said pad like layer to induce a reorientation of said fibers to produce a reinforced fibrous felt like material.

A still further object of this invention is to provide a fluid needle looming process for the treatment of a non-woven fibrous material that has been formed into a layer of (vegetable, animal, mineral) natural fibers and/or synthetic fibers and/or admixtures thereof in which a plurality of needle jets of fluid (more particularly a liquid) are applied to said fabric and in which the liquid utilized includes an additive and in which the needle jets induce a reorientation of certain fibers to produce a reinforced layer.

It is a still further object of this invention to provide a fluid needle looming process for the treatment of non-woven fibrous material that has been formed into a pad like layer and in which a plurality of needle jets deliver a liquid containing either natural or synthetic soap(s), natural or synthetic fulling agents, lubricants, other desired chemicals, solvents, etc., or any admixtures of these to said fabric.

It is a still further object of this invention to provide a fluid needle looming process for the treatment of a non-woven fibrous material that has been formed into a pad like layer and in which a plurality of needle jets deliver a liquid containing either natural or synthetic soap(s), natural or synthetic fulling agents, lubricants, other desired chemicals, solvents, etc. of any admixtures of these to said fabric to induce a pulling and coiling of the fibers to produce a felt like reinforced layer.

It is a still further object of this invention to provide a fluid jet looming process for the treatment of a nonhesives (powder, liquid, fibers or paste) to glue or weld the fibers together.

This is a continuous uninterrupted process, that is, in the past felting needle loom processing was operated intermittently, the stock advanced, stopped, punched and again advanced, etc. The process was continually interrupted because of mechanical punching, needle breakage, needle wear, new needle boards, breaking of core material, etc. The hydroloom process depends upon a jet of liquid penetrating the fibrous material, obviously the liquid jets cannot break and they can be operated continuously, also the stock or web is moved continuously, also the force of the liquid jets may be controlled (variable) and the core or backing will not be damaged, also the degree of force can be used to control the degree of densifying of the fabric, its loftiness may be retained or reduced as desired. The velocity or force may be regulated so that any core or heart material will not be damaged but will co-act with the filaments forced therethrough. It is apparent that various cores or backing may be used with a liquid punching loom, the core may be tough or hard as desired, it may be an open mesh or it may be a foam material with open cells or pores such as plastic or rubber. The surface may also include the addition of various nubs, slugs and solid objects that may be introduced for novelty effect as desired, this variation cannot be produced with a mechanical needle loom.

In the present invention the liquid jets may include any wet or molten liquid stream. Likewise, the size and shape of the needle jet may vary. Likewise the force may vary from a low velocity to a high velocity jet. It is also to be noted that the fibers bing treated may be slightly separated to allow the flexibility of movement necessary. The fibers may be random oriented as found with most mass laid fibers such as in felting or the fibers may be specifically oriented in one pattern or in varying patterns (not found in felting) as desired. This process makes a product with the fiber-locking and entanglement provided in felt, but without the stiff boardy feel of felt. This process also improves and speeds up the conventional process for making felt.

To more specifically understand the application of this invention in practice we must understand the particular material and materials as well as all the necessary elements or adjuncts to carrying out of the process. To clarify all of the above references to the variations of the invention above specified, we may refer to the figures in which FIG. 1 illustrates a typical fibrous material. In one form "A," the fibrous material is the usual random laid non-woven fibers. In a still further form "B" the non-woven fibers are oriented such as a parallel laying of fibers. We may also include the form "C" in which the random laid non-woven fibers are crimped into a three dimensional form. Of course it is to be understood that the fibrous material "A" or "B" may be of any practical thickness according to the intended application. Referring to the treatment of fibrous materials with a liquid jet according to one embodiment of this invention, we should refer back to the definition of felting and specifically the effect produced in the treatment of virgin wool in which the inner core of the fiber is normally in a stretched condition supported by the outer cortex. When the liquid jets affect the physical properties (plasticity), also where a soap, natural or synthetic, or a chemical is added to the liquid jet the outer supporting layer becomes plastic releasing the elastic core and causing length-wise contraction of the fibers. As already described in the previous definition of felting these uneven forces do not contract in a straight line but instead the fiber tends to curl and coil into a tangled mass thus the plurality of fibers entangle and reorient into a thoroughly mixed entanglement. This effect is similarly produced with many of the synthetic fibers thus the entanglement is not entirely a matter of carrying the fibers in the direction of the jet stream. The jet produces the original effect but the coiling and twisting of the fiber is independent of the jet stream. Likewise this coiling and twisting of the fibers as well as utilizing a core or backing adds tensile strength and abrasion resistance to the finished materal without resorting to a binder or additive to fuse fibers or the introduction of an adhesive to glue the fibers together and thus reduces the operation to a single hydrolooming operation for producing a material equivalent to a felting needle loomed material that has been additionally treated with an additive or adhesive. This treatment of wool fibers by hydrolooming to effect a coiling and twisting and provide a felt like material without an additive or adhesive does not rule out the possibility of hydrolooming with an additive or adhesive, that is, the same nonwoven fibrous materials or non-felting fibrous material may also be treated with the liquid jets introducing an additive for some fibers or an adhesive for other fibers thus producing a double or two way reinforcement. The hydrolooming as already explained produces an entanglement of fibers which gives greater tensile strength and abrasion resistance, however when an adhesive such as resin in liquid form is added the binder is permeated through the material to anchor the fibers in their new oriented form and increase even further the tensile strength and abrasion resistance. In addition the liquid will remove undesirable foreign matter and in some instances with aqueous soap and alkali solutions added, will remove the undesirable oil found with the fiber such as in wool. Thus it is apparent that the cleaning and hydrolooming may be produced in a single operation. In addition the single operation of hydrolooming may be controlled with a loosely formed fibrous layer to increase its density compacting it or reducing its loftiness as desired in the same operation.

Referring to FIGS. 2A, 2B and 2C there is illustrated a needle jet board **10**. The needle jet board **10** in FIG. 2A is provided with a plurality of jets **11** fixed in a particular position according to a predetermined pattern, that is to say, the liquid jets may be positioned in a straight line longitudinally across and directly over the pad or web "A," "B" or "C" to be treated. Or the jets in FIG. 2B may be positioned at an angle to the pad or web as it is passed under the jets in FIG. 2C or the jets may be positioned in a staggered relation or any other pattern as desired. But in all instances the jets are positioned as illustrated in FIG. 3 slightly above the pad or web (or below the pad or web as in FIGS. 7 and 8) and of course the jets may be raised or lowered according to the velocity of the liquid jet and according to the impregnation of the pad or web as desired. Although the jets **11** are shown as a needle jet, it is to be understood that the jets **11** may be larger where it is necessary as in the handling of heavier materials and where a greater degree of compacting of the material is desired. In FIG. 3 jets **11A** are of a normal round shape or form of liquid stream is ejected. However other type jets such as **11B** may be utilized in which the jet takes a particular expanded form. The particular form of jet **11B** (conical, spade, fantail, duckbill, barrel, flat, etc.) may be varied as desired according to the material being treated. FIG. 3 also illustrates the general arrangement for handling a fibrous material, that is, the material "A," "B" or "C" (FIG. 1) is carried on a screen conveyor **12**. The conveyor may be of open mesh to support the fibers. The conveyor **12** thus supports the mass laid fibrous material whether it be of very long, long, medium or short fibers and/or admixtures of long and short fibers such as found in fibrous materials or whether it be the short fibers found in the manufacture of paper products. It is to be understood that the treatment of the fibrous material by the application of a liquid jet may also be carried out in a vertical position (FIG. 4), with or without a supporting screen conveyor **12**. The liquid jets may be a continuous jet while the conveyor screen 12 carries the fibrous material past the jet, or the liquid may be turned on and off to provide an intermittent or pulsing jet also an increasing and decreasing or variable velocity of liquid. The particular force may be varied by the velocity of the jet or may also be controlled or set so that the liquid jet may penetrate a fairly soft thin fibrous material without damaging the material and at the same time provide the necessary reorientation of the fibers, or the velocity of the jet may be greatly increased to penetrate a thicker and heavier material. This penetration of the fibrous material by the liquid jet is better shown in FIG. 17 in which the jet 11A provides a liquid stream 14 that penetrates the fibrous material A and produces a reorienting effect on the loosely laid mass fibers. If the velocity of the liquid jet is sufficient it will carry these fibers with which it co-acts downward to the degree of penetration provided by the velocity of the jet. It is desirable to provide sufficient velocity to produce a complete penetration through the material thus the longer fibers will be pushed either through the material as at "X" or practically through the material as at "Y" and the fibers will be spread due to the turbulence of the liquid as it impinges with the screen conveyor and/or plate positioned below. Thus the fibers are pulled through the material and interlocked with the fibers at the lower surface to provide a strong tie from the upper to the lower surface. Of course it is to be understood that this process may be applied from either side of the fabric as shown in FIGS. 4 and 17 in which the jets 11A are set on both sides of the fabric. When the jets are utilized from both sides, it may be necessary to provide a core mesh 16 in the material (for strength) or a foraminous plate 15 (FIG. 17) above the material to provide the means of producing the turbulence of the liquid on the top surface. A further variation of the use of the liquid jets 11 may be found in FIGS. 7 and 8 in which the liquid jets provide a flow 14 downward through the fibrous material and a plurality of additional jets 11 are provided at the bottom surface but are positioned in an angular relation to the fibrous material. Thus when the fibers of the material are drawn or reoriented downward through the material instead of depending upon the turbulence of the liquid as it impinges upon the screen conveyor and/or positioned below, we may use the additional liquid jets to redirect and reorient the ends of these fibers in a different direction to provide an entanglement with the fibers on the lower surface of the material, or as in FIG. 8 to reorient the ends of these fibers upward in a different direction into the fibers of the material. Likewise in FIG. 5 the liquid jets 11 may be positioned above the fibrous material but in an angular position and they may be positioned so that the liquid jet stream may actually cross each other or in addition a jet stream may be directed from directly above so that all streams will cross each other, thus the fibers in the material will be crossed with each such application as shown at "Z" in FIG. 13. The particular manner of utilizing the liquid jets may vary as already described the jets may be applied from directly above the fibrous material in a pattern such as a single line of jets or as a plurality of lines of jets as illustrated in FIG. 3 or they may be positioned to provide a cross pattern of jets as shown at "M" in FIG. 2 which results in a pattern shown in FIG. 18. A still further embodiment of the invention is to provide a pair of jets 11 that are movable with relation to each other so that they may be moved toward and away from each other in a repeating cycle as the web or pad is moved on the conveyor under the jets 11. This will produce a pattern as shown in FIG. 19. A still further embodiment of this invention is to utilize spaced jets on the jet board 10 in a continuous fluid stream as the fibrous material passes under the jets thus producing a pattern as illustrated in FIG. 20. It is apparent that many variations may be produced as if the jets are pulsating rather than continuous all of the aforementioned designs are changed. This whole process will greatly improve, speed up, and make more economical the conventional process for making felt.

Referring to FIG. 6 there is illustrated a further embodiment of this invention in which a core 16 is positioned between two layers of fibrous material A. The core 16 may be as already described any type of open mesh material. The selection of the core material depends upon the type of finished product desired. In this embodiment the liquid jets 11 as in the previous embodiment provide a liquid jet penetrating the fibrous material "A" and carrying or pulling the fibers downward through the core 16 and into or through the lower layer "A" thus providing the reorientation of the fibers and a locking and entanglement of fibers between the two layers either side of the core 16. Referring to the core material 16, this may be a foraminous or open mesh material as illustrated in FIG. 14 such as a woven material. It may be a plurality of overlaid strands using a monofilament as in FIG. 15 or it may be a plurality of overlaid strands cross lapped as illustrated in FIG. 16. In any instance the core or filament will impart the necessary tensile strength and increase the abrasive strength of the material. A further embodiment of the process as described with relation to FIG. 10 includes the use of a suction means below the lower layer of fabric "A." It is apparent that with heavier or thicker fibrous material the jet may not provide a complete penetration to the lower surface of the lower layer A. To assist in providing the proper penetration and to assist in carrying the jet through the material rather than producing a turbulence of the liquid within the material a plurality of suction elements 18 are situated adjacent the lower surface of layer A; the degree of suction may be varied. Of course it is understood that the fibrous material "A" is supported on a screen conveyor 12. Thus the suction will be to pull the fibers as far as the screen conveyor without damage to the lower surface of the material being carried by the screen conveyor. This process of hydrolooming is further illustrated in FIG. 11 in which the core material may be a sheet of foam rubber 19. However only the open core type of foam material may be utilized as in penetration of the needle jet through the fibrous layer A it must also penetrate through the open core of the foam material, it should not impinge on the upper surface of the foam material. As in the previous embodiments the fibers will be carried or pulled downward by the liquid jet through the open cores of the foam material and will be reoriented to entangle with the fibers of the lower layer A thus producing a material with a fibrous finish on both sides and a foam core.

Referring to FIG. 12 it is apparent that the core 16 of FIG. 6 may be utilized as a backing 16 in FIG. 12 and of course the same fibrous material "A" whether a single layer or a plurality of layers may be mounted on the backing 16 and the backing 16 in turn mounted on the conveyor 12. In this instance the action of carrying or pushing the fibers from the layer or layers A downward will result in the longer fibers being carried through the backing 16 and due to the turbulence of the liquid against the conveyor 12 will tend to spread the fibers to interlock with the backing 16. Of course this embodiment may be varied as to the number of layers fibrous material applied or as to the type of backing 16 utilized. Any of the materials suitable for a core may also be suitable for a backing. A further modification also illustrated in FIG. 12 permits the introduction of nubs, or solids into the fibrous material. In this embodiment any particular form of introducing the nubs or solids such as a chute or tube may be employed to convey the object to the surface of the material where the jet of liquid will impinge on the object driving it into the layer or layers A. Thus the material may be similar to that illustrated in FIG. 12

with a backing **16** but in addition provided with an aggregate **25** or inclusion of nubs or solids **26** as desired.

Referring to FIG. 9 there is illustrated a similar combination to that illustrated in FIG. 6 that is a fibrous layer A either side of a core **16** but in this instance in addition to the screen conveyor **12** there may be provided a solid or perforated plate **20**. This plate **20** positioned below the screen conveyor but not in contact with, provides a positive surface for the impinging liquid to insure a great deal of turbulence and a redirection of the flow of the liquid passing through the material. The spacing of the plate may be varied to increase or decrease the flow. The flow of the liquid may be in the direction of movement of the conveyor **12** and thus there is a carrying of the longer fibers in the same direction. Or the flow of liquid may be in the opposite direction and thus the fibers will be carried in the opposite direction producing a reorientation and an entanglement to lock the fibers into the lower surface of the lower layer A.

Although we have shown the process moving in a horizontal direction, it may move vertically with the jets situated in the same relationship, and although we have referred to natural fibers such as wool, cashmere, mohair, silk, angora, etc. this invention shall include all other fibers of a natural formation such as hemp, cotton, flax, etc. or any of the man made fibers such as nylon, rayon, Dacron, etc. and although we have suggested and illustrated typical short and long fibers mostly of a fine composition we may include shreddings or formations of fibers that are a great deal heavier and not necessarily considered as a fiber but having the form of a fiber. Also although we have referred to the use of a core either of a foraminous material or an overlaid or lapped monofilament, we may include any type of core or backing whether woven or fused as long as it provides openings to permit the interlacing of the fibers through the core or backing and although we have referred to water and other liquids, this application is specifically concerned with liquids only, it is intended that the liquid cover liquids of different density, viscosity, surface tension, etc., and although we have shown generally a needle type of jet, the jet may change in its size and velocity according to the particular material being treated and although we have shown a round shaped jet the shape of the jet may be varied to provide a different pattern, the spacing and positioning of the jets may be varied to provide a differing pattern as long as the general scheme of treatment is evolved without departing from the spirit of this invention and this invention shall be limited only by the appended claims.

What is claimed is:

1. The method of producing a fabric without a patterned configuration which includes a layer of fibrous material in which the individual fibers are capable of movement created by an external force which is a liquid in the form of a jet stream which comprises laying a layer of fibers on an open type screen conveyor to form a layer of fibrous material, and advancing said conveyor and layer of fibrous material under a plurality of liquid streams which penetrate into said fibrous material, and draw and pull the fibers in the direction of the penetration of the liquid streams so that the individual fibers are reoriented into an entanglement with successive fibers to provide greater tensile strength to said material.

2. In a method according to claim **1** in which the liquid streams are grouped into a predetermined pattern.

3. In a method according to claim **1** in which the liquid density may be increased for greater penetration.

4. In a method according to claim **1** in which the liquid is heated to a predetermined temperature.

5. In a method according to claim **1** in which a fulling agent is added to said liquid.

6. In a method according to claim **1** in which the liquid streams are from above and below the fibrous layer.

7. In a method according to claim **6** in which the liquid streams from above are vertical and the fluid streams from below are generally horizontal.

8. In a method according to claim **1** in which an adhesive bonding agent is added to said liquid.

9. In a method according to claim **1** in which the liquid jet stream is projected in a predetermined form.

10. In a method according to claim **1** in which the liquid streams are continuous streams and in which the liquid streams are moved in an oscillating fashion to provide a predetermined pattern.

11. The method of producing a textile fabric with a core which comprises laying a layer of fibers on an open type screen conveyor to form a layer of fibrous material, laying a foraminous core over said layer of fibrous material and laying a layer of fibrous material over said foraminous core and compressing said layers by advancing them under a plurality of liquid jet streams which penetrate into layers and said foraminous core so that the individual fibers are entangled with the foraminous core and said layers.

12. In a method according to claim **11** in which the foraminous core is an open cell type of foam material.

13. In a method according to claim **11** in which a plurality of nubs or slugs are introduced into the fibrous material by said liquid jets.

14. The method of producing a textile fabric with a backing which comprises laying a foraminous backing on an open type screen conveyor, laying a layer of fibers on said foraminous backing and advancing said backing and layer of fibers under a plurality of liquid streams which penetrate through said fibrous layer and backing to draw and pull the fibers so that the individual fibers are reoriented into an entanglement with successive fibers and backing.

15. The method of producing a fabric without a patterned configuration which includes a layer of fibrous material in which the individual fibers are capable of movement created by a plurality of external liquid jets and in which the individual fibers are also capable of movement created by a force of suction which comprises laying a layer of fibers on an open type screen conveyor to form a layer of fibrous material and advancing said conveyor and layer of fibrous material under a plurality of liquid streams and simultaneously applying suction below said fibrous layer so that the individual fibers are reoriented into entanglement with successive fibers to provide greater tensile strength to said material.

16. The method of producing a textile fabric without a patterned configuration which includes keratin fibers in which the individual fibers are capable of movement created by an external force such as a liquid jet, which comprises laying a layer of said fibers on an open type screen conveyor to form a layer of fibrous material and advancing said conveyor and layer of fibrous material under a plurality of heated liquid streams which penetrate into said fibrous material in which the heated liquid affects the plasticity of the fibers and the liquid streams draw and pull the fibers in the direction of the penetration of the liquid streams so that the individual fibers are reoriented into an entanglement with successive fibers and there is foreshortening of the mass of fibers in length and breadth while producing a gain in thickness and density of said layer.

17. A method of producing a non-woven web comprising advancing a layer of fibrous material and impinging a plurality of high velocity liquid jet streams upon said advancing layer to draw and pull and flow components of said layer, influenced by said streams, in the direction of penetration of the streams to cause intermingling and entanglement of said components and form a self-coherent web.

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DONALD W. PARKER, *Primary Examiner.*

RUSSELL C. MADER, *Examiner.*

STEEL FOIL AND MANUFACTURE

Filed Feb. 8, 1963 2 Sheets-Sheet 1

FIG. 3

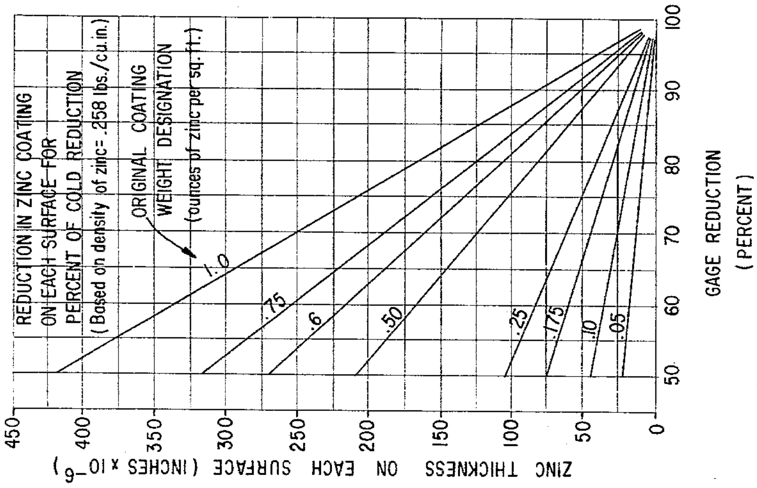


FIG. 2

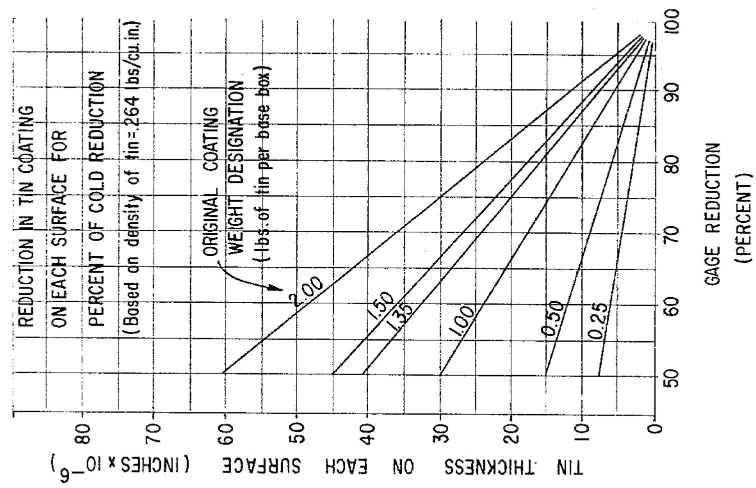
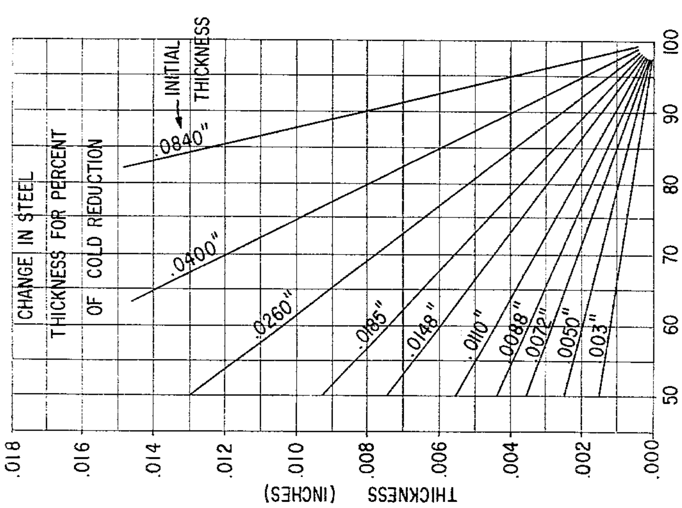


FIG. 1



GAGE REDUCTION (PERCENT)

INVENTORS
EDWIN J. SMITH
EDWARD P. SPENCER

SHANLEY AND O'NEIL
ATTORNEYS