Sept. 3, 1968 J. H. LEMELSON 3,399,425

APPARATUS FOR SURFACE FORMING MATERIALS

Filed Aug. 23, 1966

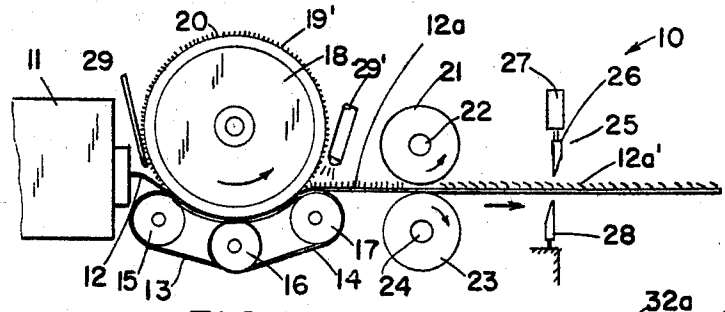

FIG. 1

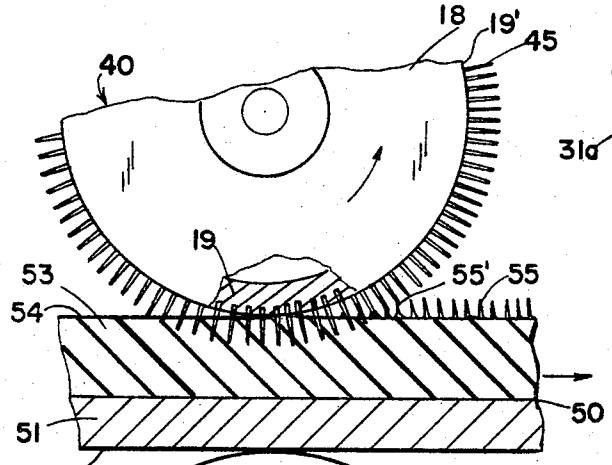

FIG. 2

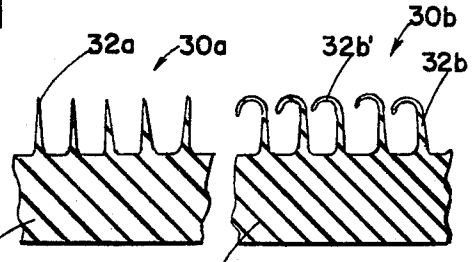

FIG. 3 FIG. 4

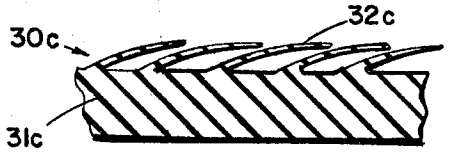

FIG. 5

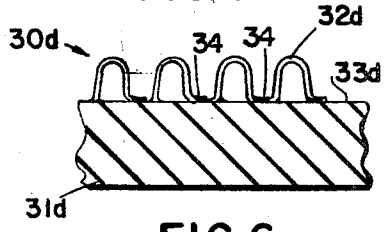

FIG. 6

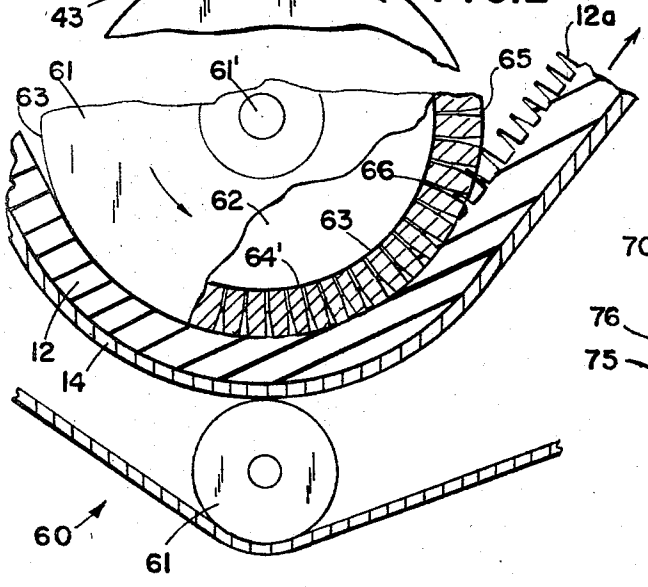

FIG. 7

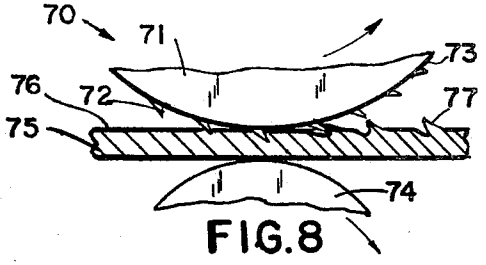

FIG. 8

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APPARATUS FOR SURFACE FORMING MATERIALS

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Continuation-in-part of application Ser. No. 249,921, Jan. 7, 1963. This application Aug. 23, 1966, Ser. No. 574,416

6 Claims. (Cl. 18—10)

This invention relates to improvements in sheet materials and methods for producing same and is a continuation-in-part of my copending application Ser. No. 249,921 filed on Jan. 7, 1963, entitled, Plastic Sheet and Method, and having as a parent application Ser. No. 410,489 filed on Feb. 16, 1954.

Various articles of manufacture such as textile articles and the like are produced of sheet material having a pile or fur-like surface which is operative to impart resiliency, softness of touch, insulation characteristics and the like to said material and to render same with improved physical characteristics. Such sheet materials are generally produced by relatively complex procedures involving the formation and attachment of a multitude of fibers or filaments by adhesive or other means to a web of textile material and often the lamination of said web to further web. Such procedures are costly and time-consuming and frequently result in the production of a pile fabric or the like which is limited in its application and has numerous shortcomings.

This invention is primarily concerned with the production of structures in sheet materials having a multiplicity of filament-like elements protruding from major surface of the sheet and integrally formed of the material of the substrate from which they protrude. It is, accordingly, a primary object of this invention to provide a new and improved structure in a sheet material having a multiplicity of elements protruding from a surface of said sheet.

Another object is to provide a sheet material having a pile or spring surface structure which is produced by mechanical means directly on the surface of the sheet material from the material itself.

Another object is to provide a new and improved structure in a sheet material having a pile-like surface of hook shaped elements formed of the material of the surface strata of said sheet material and capable of retentively engaging itself or sheet materials with filamental loop formations therein.

Another object is to provide a new and improved structure in a material having a multitude of filamental loop-like formations provided in a surface thereof capable of fastening said sheet to a hooking material.

Another object is to provide new and improved apparatus for producing sheet materials having a multiplicity of filament-like formations or otherwise shaped protrusions formed in the surface of the sheet materials.

Another object is to provide a new and improved method for producing tufted or filamented sheet materials by deforming or molding molten plastic forming at least part of said materials.

With the above and other such objects in view as may hereinafter more fully appear, the invention consists of the novel constructions, combinations and arrangements of parts as well as methods of fabrication which will be hereinafter more fully described and illustrated in the accompanying drawings, but it is to be understood that changes, variations and modifications may be resorted to which fall within the scope of the invention as claimed.

In the drawings which form part of the description:

FIG. 1 is a schematic representation of an apparatus for continuously producing a sheet of material having a filamental or pile-like surface by continuously deforming said surface while in a molten condition;

FIG. 2 shows in side view, a modified form of the apparatus disclosed in FIG. 1;

FIG. 3 is an end view of a fragment of material producible by means of apparatus of the type illustrated in FIGS. 1 and 2;

FIG. 4 is an end view of a fragment of a modified form of the material shown in FIG. 3;

FIG. 5 is an end view of a fragment of another modified form of material producible by means of apparatus of the type shown in FIGS. 1 and 2;

FIG. 6 is an end view of a fragment of sheet material having a plurality of loop-like formations or filaments formed integral with or bonded to the surface of said sheet;

FIG. 7 is a schematic representation of a modified apparatus applicable to the apparatus illustrated in FIG. 1 for producing a tufted or spiny surface in a sheet of formable plastic material, and

FIG. 8 is an end view of a modified form of apparatus of the type illustrated in FIGS. 1 and 2.

This invention is primarily concerned with the fabrication of new and improved sheet materials having at least one major surface formed with a multitude of individual formations protruding outwardly from said surface and preferably made of the material of the sheet or the surface strata thereof from which they protrude. In preferred forms of the invention, the sheet or portion thereof from which the individual formations protrude, is a flexible polymer such as vinyl, polyethylene, ethylene vinyl acetate or the like and the surface protrusions are filament-like in shape and closely spaced to provide a tufted or pile-like surface which is flexible and soft to the touch permitting use of the sheet against the human skin or springy in nature permitting the sheet to be used for many packaging, sound and vibration damping purposes, etc. The apparatus provided hereafter or modified versions thereof, may be used to produce sheet materials with protrusions of filament-like formations which vary from a few thousandths of an inch in diameter to 1/16" or greater in diameter and in length from about 1/32" to 1/4" or more depending on the application. The filament-like formations may be used as formed, trimmed by automatic means, curled or deflected or otherwise changed in shape downstream of the apparatus illustrated.

FIG. 1 illustrates an apparatus **10** for producing a sheet of material containing surface protruding formations such as spines or filaments on a continuous basis. The apparatus **10** includes extrusion means **11** for continuously forming a sheet **12** of thermoplastic material and feeding same directly against a processing roll or drum **18** which provides the desired surface formations **12'** in at least one surface of the freshly formed sheet just after it emerges from the extruder **11** and is in a molten and easily formable condition. The sheet **12** is fed directly to the upper surface of the belt **14** of an endless belt conveyor **13** which is power operated to drive the belt **14** at substantially the speed of the extruding sheet and which belt is guided by a plurality of rollers **15, 16, 17** to retain sheet **12** against a portion of the peripheral surface **19'** of a power rotated drum or roller **18** adapted to predeterminately form a plurality of spines or filaments **12*a*** in the surface of sheet **12** and across said surface before the sheet is removed therefrom.

Situated beyond the forming apparatus **13**, **18** are a plurality of rollers **21** and **23** which are operative to deflect the formations **12***a* in the surface **12'** of sheet **12** to provide formations thereof as will be hereinafter described. Notations **22** and **24** refer to the power operated shafts of rollers **21** and **23** and **20** to the power rotated shaft of drum **18**. Located downstream of the forming means **21**, **23** is a cutting apparatus **25** including a blade **26** driven by a servo device **27** such as a solenoid to cooperate with a second blade **28** in cutting predetermined lengths of sheet **12** without stopping the continuous process described.

Notation **29** refers to a heater such as a radiant heating element disposed immediately above sheet **12** for rendering the surface strata thereof to be deformed, molten just prior to engagement with the forming surface **19'** of drum **18**. Depending on the nature of the material being extruded to form sheet **12**, the distance between the extruder **11** and the forming apparatus, the operating characteristics of said apparatus and the speed at which said material is extruded, the heating means **29** may or may not be required to render said sheet in a condition for forming same with a plurality of protruding spiny or filamental elements as will be hereafter described.

A number of techniques may be used for forming the molten surface of the sheet **12** and include the provision of short narrow needles or pin-like protrusions **20** extending outwardly from the main cylindrical surface **19'** of the drum **18**. The protruding elements **20** are forced into the molten material and each serve to pull a quantity of molten plastic out of the molten strata thereof into which the elements have been projected as the sheet **12** is removed from the surface **19'** of the drum **18**. By properly controlling the temperature of the plastic material comprising sheet **12**, material in the shape of tapered spiny formations or filaments **12***a* protruding from the surface **12'** may be formed as an integral extension of the base sheet **12** which filaments **12***a* may be caused to solidify and retain either their shape as formed or a modification thereof. Accordingly, means such as one or more nozzles **29'** may be employed to direct a heat transfer fluid such as air or liquid against either or both surfaces of sheet **12** after it is guided away from drum **18** to solidify or fuse same before the formations **12***a* have had an opportunity to sink back into the sheet **12**. Again need for the coolant nozzles **29'** may be eliminated depending on the condition of the sheet **12** upon leaving drum **18**, its attitude with respect to the horizontal and the shape desired of the elements protruding from the surface **12'**.

In one mode of operation, the belt **14** of conveyor **13** may be cooled by means of air or water sprays while drum **18** may be heated to render the surface strata of sheet **12** molten. The sheet **12** may thus also be fed from a roll and comprise thermoplastic material per se, or a lamination of thermoplastic material and another material such as another polymer, textile material, woven fabric, non-woven fabric, metal, paperboard, foamed plastic or other suitable base which may be roll fed and laminated to or extrusion coated with the material comprising the formable sheet **12**.

While the sheet forming apparatus **10** of FIG. 1 includes a forming roll and endless conveyor which cooperate in forming sheet **12**, said apparatus may also comprise two endless conveyor bels or two power driven rollers between which the sheet **12** is driven and one of which contains protruding pin-like formations or otherwise-shaped irregular formations which are operative to each pull a small quantity of molten material from the surface strata as described. Furthermore, reciprocating platen means with pin-like protrusions may also be employed to form the sheet as described.

The apparatus of FIG. 1 may also contain a plurality of the drum and belt forming means **13**, **18** of FIG. 1 longitudinally disposed to receive the sheet being formed one after the other so as to provide a greater density of surface formations **12***a* in the sheet **12**. In other words, one surface forming drum and belt means for retaining the sheet against it peripheral surface may first operate on a first surface of the sheet to form a first array of spaced apart protruding filaments therein while the second forming drum situated downstream of the first drum operates on portions of the surface of the sheet between the filaments formed by the first drum to form said unformed portions into other filaments of the same or different in shape than the first formed filaments.

There is shown in FIG. 2 a modified form of the apparatus of FIG. 1 for producing a sheet material having a tufted or filamented surface layer defined by a plurality of filaments made of the material of at least a portion of the sheet. The apparatus **40** includes a first rotating roll or drum **18** having a second rotating roll or drum **43** cooperating therewith in receiving and driving a sheet **50** therebetween. The material **50** may comprise a single sheet of material such as a thermoplastic polymer capable of being formed while at least a portion thereof is in a semi-molten condition. The sheet **50** illustrated in FIG. 2 comprises a multi-strata material including a base sheet or web **51** the lower surface **52** of which is engaged by the lower rotating drum **43**. Disposed against and laminated or coated on the upper surface of base sheet **51** is a layer or sheet **53** of thermoplastic material having an upper surface **54** which faces the surface **19'** of the drum **18** and preferably, although not necessarily, is compressively engaged thereby.

Disposed in a plurality of radial holes **44** extending into the wall **19** of drum **18** are a plurality of rods or pointed pins **45** which project a short distance outwardly from surface and are operative to penetrate the thermoplastic material preferably while said material is in a molten or semi-molten condition. The needles **45** preferably are closely spaced across substantially the entire peripheral surface **19'** of drum **18** or at least that portion of said drum which is desired to effect the formation of filaments of the surface layer of the material fed thereagainst.

As the sheet material **50** leaves the surface of drum **18**, the needles serve to each draw a small amount of molten or semi-molten material from the surface **54** of the feeding member or sheet **53** as illustrated by the partially drawn filament-like formations **55** and **55'**. At a certain point beyond the drum **18**, the drawn material separates from the pin **45** which is drawing same leaving a filament-like formation **55'** protruding outwardly from the surface **54**. Depending on the thermoplastic polymer comprising sheet **50** or layer **53**, control of the temperature gradient of said material from its location just prior to being fed to the bite of drums **18** and **43** to the location where the formations **55'** separate from the pins **45** and beyond said location, will result in the formation of filaments of substantially predetermined shapes resulting in a web of material having a filamented surface suitable for various useful applications which will depend on the characteristics of the material so formed. If, for example, the material comprising member **50** or surface layer **53** is a flexible polymer such as plasticized polyvinyl chloride, low or medium density polyethylene, polypropylene, ethylene vinyl acetate or other suitable polymer or copolymer, the web material **50** may be utilized for various applications ranging from its use as a textile material in the production of clothing or other flexible articles, mats, floor or ground coverings such as rugs, artificial grass or the like, heat sealable components of inflatable articles, vibration dampening or packaging material, etc. If the material **50** or layer **53** thereof is semi-rigid or rigid in nature, the spine-like protrusions **54** may be used as brushing, scouring, friction-producing, abrasive or brushing elements of a belt, plate or otherwise shaped article made therefrom.

If the sheet **50** is produced of a lamination or multilayer formation of different materials, the base **51** may comprise a woven or non-woven fabric, flexible or rigid material such as plastic, paper, paperboard, metal or other sheet material which is coated with or laminated to the layer **53**.

The apparatus of FIG. 2 preferably includes means for rendering the layer **53** or the upper strata thereof in a molten condition permitting the drawing of the filament-like formations **55** outwardly from the surface **54** as described. Accordingly, a suitable radiant heating means may be disposed on the upstream side of the drum **18** for rendering said plastic material molten. The drum **18** may also be heated by any suitable means so as to conduct and/or radiate heat to render a sufficient portion of the material **50** in a molten condition to permit the described formation of the upper surface thereof. In one form of the invention, the rolls or drums **18** and **43** may comprise components of a calendering apparatus operative to receive formable thermoplastic material and to form same into a sheet having one flat surface and the other surface containing a plurality of integral filaments or spiny formations as described.

In another form of the invention, the rolls **41** and **43** may be operative to receive a sheet of freshly extruded thermoplastic material formed per se or extrusion coated on or laminated to a second sheet such as **51** of FIG. 2 just prior to feeding same to the bite of the rolls **18** and **43**. Accordingly, such extrusion may be carried out in a manner to provide layer **53** in a molten condition by the time the material reaches the forming apparatus so that it will not be necessary to heat the roll **18** or the material **53** just prior to entering the forming apparatus. Depending on the nature of the material being formed, it may be desirable to guide the sheet formation **53** so as to remain against an extended portion of the surface of drum **18** wherein said material will be rendered molten for the intended purpose.

FIG. 3 illustrates a fragment of a first form of sheet material **30***a* produced by apparatus of the type shown in FIGS. 1 and 2. The base sheet **31***a* is provided of any suitable flexible or rigid polymer and has formed integral therewith a plurality of closely spaced, substantially straight upwardly extending and slightly tapered filament-like formations **32***a* which extend over a substantial portion of the width of sheet **31***a*. The material **30***a* may be used for various different purposes depending on the flexibility of said material. The formations **32***a* may be rigid or semi-rigid and may serve such purposes as brushing elements, vibration damping means, packaging material and the like. More flexible formulations of thermoplastic materials utilized to form the member **30***a* may render said member suitable for use as carpeting, product trim or the like. The base **31***a* may also be made of a lamination or otherwise formed composite web as described.

In FIG. 4 is shown a modified form of the material illustrated in FIG. 3 which comprises a sheet-like formation **30***b* having a base portion **31***b* and a plurality of filament-like elements **32***b* the upper ends of which are curled exposing a greater portion of the side surfaces thereof and providing a different surface than provided by the formation of FIG. 3. The upper curled ends of elements **32***b* may be randomly or uniformly directed and may be a natural shape resulting from when the formations **32***b* pull away from the pins or needles used for forming same as illustrated in FIG. 2. If the material comprising formations **32***b* of FIG. 4 is rigid or semi-rigid plastic, said material may be utilized as a so-called hooking material wherein the looped or curled ends **32***b'* of the formations **32***b* will hook and hold a plurality of similar formations in another sheet thereof or modified forms of loops or broken hooks so as to serve as a fastener.

In FIG. 5 is shown a fragment of a modified form or filamented material **30***c* producible by means of apparatus of the type illustrated in FIG. 1. The filament-like formations **32***c* which extend outwardly from the base sheet **30***c* extend oblique to said surface in somewhat of a flattened or partially-flattened condition giving the effect of grass or hair formations. The formations **32***c* of FIG. 5 are produced by either guiding the sheet formed by the apparatus of FIG. 1 between a plurality of rollers either prior to solidification of the material thereof after it is driven from the apparatus **13**, **18**, molten or by reheating the surface **12***a* of the filamented material and deflecting the filament elements **32** by means of a blast of a suitable fluid such as air or by passing same between rollers which are operative to deflect and permanently deform the elements **32** as illustrated.

In FIG. 6, a web or sheet **30***d* of material is formed as described and comprises a base sheet portion **31***d* from which upwardly protrudes a plurality of filament-like elements **33***d* which have been formed in the upper surface **32***d* of the sheet **31***d* as described. The formations **33***d*, after being formed, are either forced or permitted to droop by gravity before they completely solidify so that the end portions of each become welded to or fuse with the upper strata or surface layer of the material comprising sheet **30***d*. Notation **34** refers to the welded or integrally bonded end portions of the filament-like formations **33***d*. The surface of sheet member **31***d* is thus comprised of a plurality of loop formations defined by the filament-like formations **33***d* which have been drawn from or molded integral with the sheet. Such a structure may be used for abrading or scouring purposes. In still another application, the structure illustrated in FIG. 6 may be used as a component of a fastener system having another component shaped as in FIG. 4 and having a plurality of hook-like formations similar to **32***b* with hook-like or curled ends **32***b'* adapted to engage and hook the loop-formations **33***d* of FIG. 6 across the mating surfaces.

In another embodiment, it is noted that one or more sinusoidally formed filaments or wires of plastic or metal with a plurality of U-shaped loop-like formations therein, may be embedded in a molten sheet formation, upper strata or coating on a base sheet and retained thereagainst upon solidification of said molten material to provide substantially the structure illustrated in FIG. 6 which may be used for scouring purposes or as a component of a hooking material fastener as described.

FIG. 7 illustrates a portion of sheet forming apparatus similar to that illustrated in FIG. 1 but modified as to the means for forming the spine or filament-like formations in the sheet material. The apparatus **60** includes, in addition to means as described for supplying a sheet **12** of molten thermoplastic material or a lamination including same, to the space between a power operated roller or drum **61** and the belt **14** of an endless belt conveyor **13** which is operative to receive said sheet and compressively retain same against the cylindrical peripheral surface **64** of the wall **63** of drum **61**. Radially provided through the wall **63** of drum **61** are a multitude of small holes **65** into each of which is forced a sufficient quantity of the molten sheet compressed against the drum or the molten upper strata sheet material being formed. Fine capillary holes **66** may be provided between the inner ends of the radial holes **65** which holes **66** extend to the inside surface **64'** of the wall **63**. Thus, if the interior **62** of drum **61** is connected to a source of negative pressure or vacuum, such as a vacuum pump, molten material from sheet **12** will be drawn by vacuum into the radial holes **65** to facilitate the formation of said spine or filament formations protruding from the surface of the sheet being formed. Accordingly, a vacuum pump system may be connected through a passageway in the axle or shaft on which drum **61** rotates to the interior volume **62** of the drum for providing negative pressure therein which will assist in draw-

ing molten material into the radial cavities **65** extending from the outer surface **64** of the drum.

Depending on the characteristics of the material being formed, it may suffice to guide the conveyor belt **14'** away from the surface **64** of drum **61** while the material in the cavities **65** is in a molten or semi-molten condition which may serve to further elongate the filaments before the material thereof is completely removed from said cavities as the sheet **12** is drawn further away from the drum **61**. In other forms of the invention, the wall **64** of the drum may be cooled to facilitate and hasten solidification of the material forced into the cavities **65** and/or a coolant gas or liquid may be directed against belt **14'** to further hasten solidification of the molten portions being formed.

The capillary holes **66** are preferably of such a dimension as to prevent the molten or semi-molten material entering the larger diameter holes **65** from passing through said capillary ducts **66**.

In another form of the invention, the radial holes **65** may extend completely through the solid wall portion **63** of the drum and a liner of porous metal may cover the inside surface of the drum wall **63** and prevent the escape of molten material to the interior volume **62**. In a preferred embodiment, the holes **65** are coated with a low-friction material such as Teflon or are highly polished and extend only partly through the wall **63** so that the filament or spine-like formations are formed entirely as the result of pressure exerted by belt **14'** against the molten sheet material forcing portions of said material into the cavities **65** which portions become solidified therein as the drum rotates and are removed from each cavity as the sheet material **12** is drawn away from the surface **64** of the drum **61** as described.

FIG. 8 illustrates a modified form of the invention wherein the sheet forming drum is modified to form a plurality of different sheet materials with surface formations which are modified forms of the previously described structures. The apparatus **70** includes, in addition to features hereinabove described, a pair of cooperating rollers or drums **73** and **74** adapted to receive a sheet **75** of material to be formed between said rollers. Protruding outwardly from the surface **73** of the roller **71** and preferably extending across said surface about the complete periphery of the roller are a multitude of formations or elements **72** defining sharp teeth of wedge-like shape. Said teeth **72** are each adapted to be driven into the surface **76** of sheet **75** as the sheet is compressively driven through the rollers and, as the sheet **75** emerges from the rollers, to lift outwardly from said sheet and form a plurality of tapered formations **77** which protrude outwardly from said sheet as illustrated. The formations **77** may remain in the shape they are formed or may be further worked by automatically operating means situated downstream of the rollers **71** and **74** which may operate to deflect, curl, trim, grind or otherwise form same.

The sheet **75** may comprise a thermoplastic or thermosetting polymer, ceramic, metal or other suitable material or composite or laminate. Said sheet may be fed to the power driven rollers **71**, **74** as extruded or rolled in a softened or molten condition or in a fully solidified state. Depending on the material of sheet **75**, the tooth-like formations **77** therein may be used to impart resiliency to the surface **76** particularly if the material comprising said sheet is a resilient or medium density polymer such as polyethylene, polypropylene or the like, or in the event that the material is metal or ceramic, may be used for abrading purposes or to enhance the adhesion or mechanical bonding of the surface **76** to other materials.

The teeth **72** protruding from surface **73** of drum **71** may be formed in the wall of the drum by the means described for forming sheet **75** prior to assembly of the drum, may be cast integral with said wall or may comprise teeth of a hard material such as titanium carbide, aluminum oxide or the like welded to or cast integral with the drum wall.

In a preferred form of the invention, sheet **75** may comprise a sheet of metal such as aluminum with the formations **77** having sharp edges and used for abrading purposes. If the sheet **75** is a thermoplastic material or metal provided in a molten condition at the bite of the rollers, the formations **77** may be drawn upwardly and curled in shape by the action of the teeth **72** which each serve to pull material off the surface of the sheet. The sheet **75** may also be driven by a pair of rollers or other means disposed downstream and/or upstream of the rollers **71**, **74** at such a speed, lower than the rotational velocity of the surfaces of drums **71** and **74** to permit the teeth **72** to draw the formations **77** a greater degree outwardly from the sheet than if the sheet were travelling at the same speed as the drum **71**.

I claim:

1. Apparatus for producing a tufted sheet material or the like comprising:

(a) means for supplying a sheet of formable material,

(b) sheet deforming means for continuously operating on said sheet material to provide a plurality of spine or filament-like formations of the material of said sheet with said formations protruding outwardly from a surface of said sheet,

(c) means for continuously feeding said sheet to said forming means,

(d) means for providing at least a portion of said sheet in a molten condition whereby said sheet deforming means may shape said molten portion with said filament-like formations, and

(e) means for operating on said filament-like formations after they have been formed by said sheet deforming means to permanently deform said formations to a shape other than that to which they are first formed by said sheet deforming means.

2. An apparatus in accordance with claim **1** wherein said sheet deforming means includes a movable base having a plurality of cavities, means for causing molten material from said sheet to flow into said cavities to shape the surface of said sheet to contain said filament-like formations, protruding therefrom.

3. Apparatus in accordance with claim **2** wherein said movable base comprises a drum and said cavities are elongated, radial holes in the peripheral surface of said drum for forming filament-like protrusions of the material of said sheet.

4. Apparatus in accordance with claim **1** whereby said sheet deforming means includes a member having a plurality of relatively narrow, elongated elements arranged with their free ends adapted to be plunged into the molten surface of said sheet, means for guiding and driving said sheet past said member containing said narrow elements and means for causing the ends of said narrow elements to first penetrate the molten surface of said sheet and thereafter each draw a quantity of molten material out of the sheet forming said filament-like formations in the surface of said sheet.

5. Apparatus in accordance with claim **1** whereby said means for operating on said filament-like formations after they have been formed by said sheet deforming means comprises roller means operative to receive the sheet and permanently deform said filament-like formations.

6. Apparatus for producing a material having filament-like surface formations comprising in combination:

(a) means for continuously forming and feeding a first deformable material,

(b) deforming means for continuously operating on said first material to provide a plurality of filament-like formations of the material with said filament-like formations protruding outwardly from a surface thereof,

(c) means for providing at least a portion of said material in a molten condition whereby said deforming means may easily shape said molten portion, and

(d) means for operating on said filament-like forma-

tions after they have been first formed by said deforming means to change their shape to a shape other than the shape first defined by said deforming means.

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WILLIAM J. STEPHENSON, *Primary Examiner.*