

(19) World Intellectual Property Organization
International Bureau



(43) International Publication Date
19 October 2006 (19.10.2006)

PCT

(10) International Publication Number
WO 2006/108301 A1

(51) International Patent Classification:

D04H 1/22 (2006.01) **D04H 17/00** (2006.01)
D04H 1/08 (2006.01) **D06M 11/00** (2006.01)

(21) International Application Number:

PCT/CA2006/000598

(22) International Filing Date: 13 April 2006 (13.04.2006)

(25) Filing Language: English

(26) Publication Language: English

(30) Priority Data:

60/671,469 15 April 2005 (15.04.2005) US

(71) Applicant and

(72) Inventor: **LOXAM-KOHL, Deborah** [CA/CA]; 5861 Cedar Creek Road, PO Box 191, Winlaw British, Columbia V0G 2H0 (CA).

(74) Agent: **MUELLER, Heather**; 227 Tuscany Glen Park NW, Calgary, Alberta T3L 3E5 (CA).

(81) Designated States (unless otherwise indicated, for every kind of national protection available): AE, AG, AL, AM,

AT, AU, AZ, BA, BB, BG, BR, BW, BY, BZ, CA, CH, CN, CO, CR, CU, CZ, DE, DK, DM, DZ, EC, EE, EG, ES, FI, GB, GD, GE, GH, GM, HR, HU, ID, IL, IN, IS, JP, KE, KG, KM, KN, KP, KR, KZ, LC, LK, LR, LS, LT, LU, LV, LY, MA, MD, MG, MK, MN, MW, MX, MZ, NA, NG, NI, NO, NZ, OM, PG, PH, PL, PT, RO, RU, SC, SD, SE, SG, SK, SL, SM, SY, TJ, TM, TN, TR, TT, TZ, UA, UG, US, UZ, VC, VN, YU, ZA, ZM, ZW.

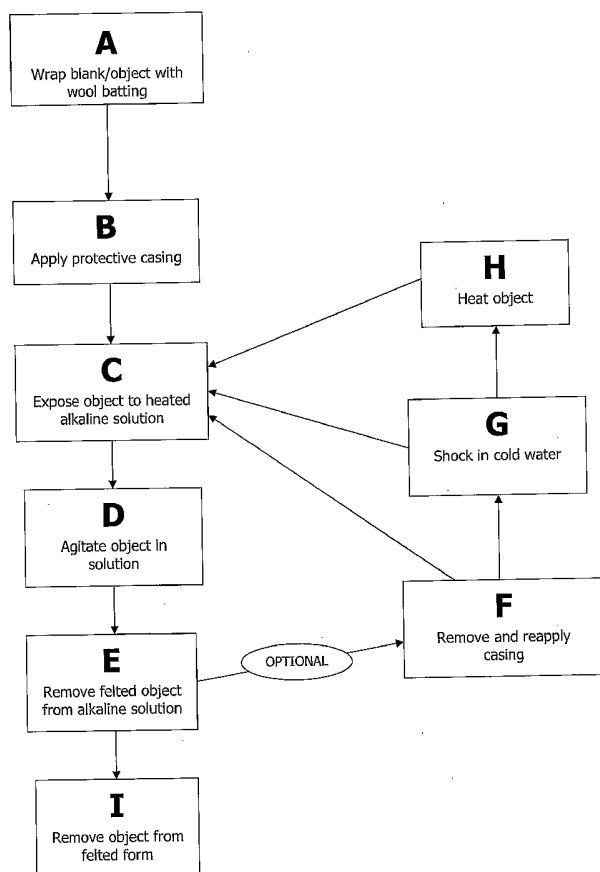
(84) Designated States (unless otherwise indicated, for every kind of regional protection available): ARIPO (BW, GH, GM, KE, LS, MW, MZ, NA, SD, SL, SZ, TZ, UG, ZM, ZW), Eurasian (AM, AZ, BY, KG, KZ, MD, RU, TJ, TM), European (AT, BE, BG, CH, CY, CZ, DE, DK, EE, ES, FI, FR, GB, GR, HU, IE, IS, IT, LT, LU, LV, MC, NL, PL, PT, RO, SE, SI, SK, TR), OAPI (BF, BJ, CF, CG, CI, CM, GA, GN, GQ, GW, ML, MR, NE, SN, TD, TG).

Published:

— with international search report

For two-letter codes and other abbreviations, refer to the "Guidance Notes on Codes and Abbreviations" appearing at the beginning of each regular issue of the PCT Gazette.

(54) Title: METHOD AND APPARATUS FOR FELTING THREE-DIMENSIONAL OBJECTS



(57) Abstract: A method and apparatus for felting three-dimensional objects is disclosed. The method involves wrapping a three-dimensional object with wool, and agitating the encased object within a drum in the presence of heated alkaline solution. The process may be repeated to achieve the desired felt consistency. An apparatus is provided for use with the method. Products produced in accordance with the invention have consistent texture, resiliency, and density throughout, with no visible seams or rough edges.

WO 2006/108301 A1

**METHOD AND APPARATUS FOR FELTING THREE-DIMENSIONAL
OBJECTS**

FIELD OF THE INVENTION

5 The present invention relates generally to felting. More particularly, the present invention relates to an apparatus and method for felting three-dimensional objects.

BACKGROUND OF THE INVENTION

10 Wool batting, the fleecy coat sheared from sheep, when combined with an alkaline solution, heat and agitation, has the unique ability to compress and interlock into a dense material called felt. The process of felting wool is 2,000 years old, originating in the highlands of northern Asia; it has since been embraced by cold weather cultures around the world. Felting has traditionally produced flat objects such as rugs, wall hangings, and fabric for clothing.

15 There are many qualities associated with felted wool. Aesthetically it is pleasing to touch, holds colour beautifully, and is warm and comfortable. Physically, it has a consistent nape; cuts without unravelling; is durable and protective; insulates against temperature, sound waves, and vibration; wicks moisture and retains its insulating abilities even when wet. Depending on the thickness of the felt, it can have a softness and lightness
20 like silk, or thickness and rigidity like leather. All are desirable characteristics that lend themselves to domestic, commercial and industrial applications.

 Felted objects can be used in a variety of ways, as in garment production, where the process of constructing garments and accessories of felted wool has been limited to die-cutting pattern pieces of flat felt, which are scored, folded, and glued or sewn together
25 to create form. Industry produces felt components such as cones for stereo speakers by injecting fibres with resin and pressing them into a mould to take on the shape of the desired form. Another process involves turning thick pieces of flat felt on a lathe to create tubes, which are cut and bent into circles, the ends sewn together to create 'o' rings.

 Prior to felting, the wool fibre has been scoured, or washed and cleansed, to
30 remove any foreign material from the fibre so that the fibre is accessible and receptive to receive additional processes (spinning, dyeing, weaving, felting). Wool may also be carbonized, a process involving immersion in dilute sulphuric acid, to remove burrs from

the fibres. Any natural waxes, oils and grease contained on the raw fibre, as well as any oils the mill uses for lubrication, are broken down and dissolved into a solution, and held in suspension (emulsified) by use of a soap, until they are rinsed away. This process is separate from the process of felting. The wool fibres are carded (combed) into alignment, and wrapped into batts. Wool batting is then applied in the process of felting. Felting is achieved by applying an alkaline solution, heat and agitation (the repetitive application of pressure) to the surface of wool fibres. Exposure to moisture and heat cause the wool fibre to swell and uncurl and the scales open up, making it receptive to agitation, a key factor in the process of felting.

10 In general it is agreed that there is no one factor that causes wool to felt, but rather a combination of a number of factors, as set forth in "Washing Wool Fibre and Textiles", by Tom Beaudet ©1998. Source: www.fibrearts.org. The first and most common factor in felting is the interlocking of the epidermal scales on the surface of the wool fibre. As the fibres are worked against one another the scales become locked. The second factor is
15 creep. Under external stresses the fibre tends to migrate, or travel, towards its root ends pulling adjacent fibres with them. The third factor is that in a low alkaline solution the wool fibre has excellent elongation and recovery properties. The theory is that under certain conditions and with a number of fibres in the same space, the fibre will stretch and recover forming a tighter and tighter mass with its neighbors. The fourth factor is the
20 natural twist of the fibre. When placed in water or in a saturated atmosphere the fibre tends to twist and revolve quite rapidly until rest. When that same fibre is placed in a dry atmosphere it wants to return to its original dry form and will twist and revolve back. The fifth factor is similar to the fourth but relates to the difference between how the cuticle and cortex of the fibre react under wet conditions. The theory is that the cortex tends to
25 contract more than the cuticle under wet conditions and therefore causes a curl of the fibre that it gives up when dried.

It is believed that all of the above factors contribute to some degree to the felting quality of the wool fibre. For example, the first factor is not solely responsible for felting, as under controlled conditions, a sample of wool fibre was descaled and still had good
30 felting qualities. It is generally agreed that the application of heat and agitation, in the presence of an alkaline solution (pH 7 to 9), will create optimal felting conditions. High

alkaline chemicals are caustic to wool and should generally be avoided. "Washing Wool Fibre and Textiles", by Tom Beaudet ©1998. Source: www.fibrearts.org.

An acceptable alkaline solution for use in felting may be prepared simply by adding mild soap or detergent to water. Such a solution acts as a surfactant, allowing the water to permeate into the fibres, and also provides lubrication, reducing fibre damage and permitting a tighter fibre mass.

Creating Three-Dimensional Felt Forms

The state of contemporary three-dimensional felting remains limited to two primary factors: felting flat pieces, and using them to construct form, and felting by hand. Currently, three-dimensional forms can only be created by indirect methods involving a number of manual steps between raw materials and finished product. The development of three-dimensional felt forms has generally been achieved through indirect processes of die-cutting pattern pieces of flat felt, which are scored, folded, and glued or sewn together to create form, or by casting wool over an object. Various methods for developing three-dimensional felt forms and for developing flat felt (which can be cut and sewn into a three-dimensional form) are described below.

Using a pattern: - Wool batting is flat felted either by hand or mechanical means, and using a pattern, is cut into pieces that are then sewn together to make a three-dimensional form.

Using a flat template: Wool batting is flat felted by hand or mechanical means on a water resistant, flat template, such as a piece of corrugated plastic. A layer of batting is applied to each side of the template, and over the edges. The wool is processed in the same manner that is used for felting flat pieces: applying hot water, soap and agitation to all surfaces. The template is removed after felting, resulting in a shape with a hollow interior, which requires draping or forming to create volume.

Using a three-dimensional template or object: Wool batting is wrapped around or over a three-dimensional form and felted using hand-held tools. The object may be open backed, permitting easy removal, or may need to be cut open to release the object inside.

Using hand-tools: To date, tools for felting have taken many forms. Northern European countries with a historical tradition of felting, design, manufacture, and export a variety of wooden hand-tools that represent the majority of tools available commercially.

The contemporary hand-felter, interested in making the process less arduous, will employ ordinary household articles in unconventional applications to achieve the same purpose.

Examples of these are:

5 *Hand and foot massagers* made of plastic or wood having a rotating wheel covered with knobs. Held in the hand and rolled over the surface of the wool, the tool is suitable for small flat areas (approximately 8 x 8 inches).

Exfoliating bath mitts made of abrasive nylon fibres. Worn on the hand and rubbed on the surface of the wool, the tool is suitable for three-dimensional objects that can be held in the hand or irregular shapes.

10 *Old-fashioned washboard* - The convoluted surface of the board is suitable for felting three-dimensional objects that can be held in one or both hands (max 8 x 8 x 8 inches) and rubbed on the surface of the board.

Nylon window screening - Flat sheets of wool batting are placed between two layers of screening; the edges are secured by a row of loose hand stitching. The screening stabilizes the fibres and is suitable for large, flat pieces. This is used in
15 combination with the Bamboo Window Blind.

Bamboo window blind - The bamboo sticks and the spaces between provide a convoluted surface that is suitable for felting large, flat pieces, which can then be sewn into three dimensional forms. The hardware is removed from the top and bottom of the
20 blind, and laid flat, forming a mat. The wool batting contained in the window screening is laid on the mat. Starting at one edge the mat is then rolled up, and secured at each end, capturing the layer of wool inside. Rolled back and forth on a flat surface, either by hand, or foot, the convolutions and action massage the surface of the wool.

Bubble wrap - Sheets of small bubble wrap can be introduced into the above
25 procedure when the wool has reached the soft-felt stage and the fibres have begun to matte and stabilize as one piece. The bamboo roll is opened, and the wool piece is removed from between the layers of nylon screening. A sheet of bubble wrap is laid on top of the bamboo mat, followed by the flat piece of wool, and a second layer of bubble wrap. The bamboo mat is rolled up again, capturing all the layers inside, and
30 secured. The package is then rolled back and forth again on a flat surface, either by hand, or foot. This procedure assists in removing the convoluted texture that is

imprinted into the surface of the wool by the bamboo mat, imparting a smoother, polished finish.

Using a mechanical device to agitate - Examples include:

5 *Washing machine* - The upright beater in top-loading models, or the rotation of the drum in front-loading models, provides a basic means of mechanical agitation and the wet environment suitable for felting simple three-dimensional forms. It is most commonly used for 'fulling' an article with high wool content. An article constructed of wool material sewn together, or knit together using wool yarn, is thrown into the washing machine and processed through the regular wash/spin cycle, ideally hot water wash followed by cold water rinse. The wool fibres mat and interlock to a lesser degree than when felting wool batting, as the structure of the fabric is maintained by the weave or knit. Some shrinking occurs, but the primary result is the softening of the surface appearance. This method is limited to small-scale objects, in the round, approximately six inches in diameter, that will fit between the agitator and wall of the drum.

15 Drawbacks in the use of a washing machine for felting include the excessive amount of water contained in the drum and the indirect agitation of the beater (in a top-loading model) or the rotation of the drum (in a front-loading model), which impede the felting process by preventing the fibres from matting. With repetitive processing in either of these machines, wool batting is capable of reaching the same soft-felt stage that is achieved in hand felting. For these reasons, the washing machine is appropriate for use by hobbyists, but unsuitable and ineffective for use by artisans or industry when a predictable method of manufacture providing consistent, quality products is required.

20 *Hand-held Palm Sander* - Used for flat felting, the resulting felt may be cut and sewn into a three-dimensional form. A sheet of plastic is placed on top of the wool and the sander is applied to the surface. The resulting vibrations and pressure massage the surface of the wool, inducing felt.

25 Needle Felting. The primary means employed by industry to produce flat felt. This is a dry process that involves repetitively inserting and extracting barbed needles into layers of wool batting. This causes the fibres to tangle and knot together. This process

produces a low quality of felt with a weak fibre matrix. It is used primarily for insulation and boot liners.

Steam Felting. A second method used by industry to produce sheets of hard-felted wool through a process of steaming and agitating layers of wool batting. The result is a stiff, consistent layer of felt with a strong fibre matrix. This quality of felt is used primarily for papermaking and printing. Felted into thicker slabs, it is cut into pieces as wide as the felt is thick, the full length of the felt sheet. This long piece is placed in a lathe and turned into a tube form. The tube is measured and cut into lengths, the ends bent around and stitched and/or glued into place to make a ring. These are used as gaskets in engines.

It is, therefore, desirable to automate the felting process. Various automated felting devices exist for producing flat felt. For example, US Patent 4,070,738 describes a flat felting machine having an upper and a lower row of driven rollers and compression beams. US 5,732,858 and US 6,021,931 describe a hat moulding machine that makes hat forms using male and female moulds. A wool blank is steamed and stretched over the forms to get the required hat shape and size. The method by which the hat forms are created is more in line with traditional millinery methods of steaming sheets of felt into simple, open-end cylindrical forms, rather than creating forms from wool batting.

The prior art does not describe any device that can be used to automate the process of felting three-dimensional objects, nor does the prior art describe an agitation device suitable for use in felting three-dimensional objects.

Agitation devices are generally known in various fields. For example, US 4,021,971 describes a multi-drum gem tumbler having a slowly rotating sealed drum. US 4,045,918 describes a horizontal, power-driven tumbling sealed drum for abrading and polishing. US 4,214,518 describes a meat tumbler which macerates the contents of a rotating sealed drum. US Design Patent D254,619 describes a revolving wire tumbler for removing flash from plastic moulded parts.

SUMMARY OF THE INVENTION

In accordance with an embodiment of the invention, there is provided a method for making a three-dimensional felt form comprising the steps of:

- a. wrapping a three-dimensional object with wool;

- b. securing the wool against the object;
- c. agitating the wrapped object within a drum in the presence of a heated alkaline solution; and
- d. repeating any of steps a through c until the wool becomes felted into a three-dimensional form around the object.

5

The method may further comprise the steps of cooling and drying the felt form, and cutting the felt form to remove the three-dimensional object therefrom.

In one embodiment, the wool is secured against the object with a water-permeable casing, which may be nylon. In an alternate embodiment, the wool may be secured with adhesive, such as liquid or spray adhesive

10

In a further embodiment, an amount of shot is added to the drum in step c to promote agitation of the object within the drum. In a preferred embodiment, the shot includes a plurality of polyhedra made from dense, resilient material such as rubber.

In another embodiment of the invention, the drum is cylindrical and includes a plurality of interior baffles for promoting agitation of the object within the drum. In an alternate embodiment, the drum may be prismatic in shape.

15

In a further embodiment, the heated alkaline solution is added to the drum prior to agitation in step c), and the drum includes a sealable lid to prevent leakage of the heated alkaline solution during agitation. In an alternate embodiment, the heated alkaline solution is applied as a spray or vapor.

20

In another embodiment, the drum is a cage or is otherwise perforated to permit alkaline solution to enter and exit the cage, and the heated alkaline solution is applied to the object during agitation from a location exterior to the drum.

The wool for use in various embodiments of the invention is preferably wool batting, but may be any suitable fibre that will felt. For example, although 100% wool batting is preferable, other battings of which wool is the majority fibre would also be suitable.

25

Moreover, the wool applied to the object may be flat felted wool that has been sewn into a three-dimensional form for fitting over the object.

30

In accordance with a second aspect of the invention, an apparatus is provided for use in felting a three dimensional object, the apparatus comprising:

- a drum for containing a wool-wrapped three dimensional object to be felted;

- a drum agitation system for manipulating the drum so as to agitate the wrapped object within the drum; and

5 - a heated alkaline solution application system for applying heated alkaline solution to the object prior to or during agitation.

In one embodiment, the drum is sealable to prevent leakage of alkaline solution during agitation. In an alternate embodiment, the drum is a cage or is otherwise perforated. The drum may be cylindrical or prismatic, or any other suitable shape, and may include
10 interior baffles to promote agitation of the object within the drum.

In accordance with a further embodiment of the invention, the drum agitation system comprises a roller system or conveyor system for supporting the drum and a drive system for driving rotation of at least one roller within the roller system or for driving a conveyor within the conveyor system so as to rotate or agitate the drum.

15 The drum agitation system may further comprise an axial support system for supporting the drum along an axis during rotation or agitation of the drum.

In a further embodiment, the drum agitation system includes a drum support, a system for fastening the drum against the support, and a motor for driving agitation of the drum.

20 In an embodiment of the invention, the heated alkaline solution application system comprises a removable and resealable hatch within the drum which may be removed to fill the drum with heated alkaline solution.

In another embodiment, the heated alkaline solution application system comprises a port within the drum through which heated alkaline solution may be added.

25 In a further embodiment, the heated alkaline solution application system comprises a supply line that enters the drum and a drain line that exits the drum for supplying and draining solution to and from the drum.

In a yet further embodiment, the drum is perforated and the heated alkaline solution application system comprises nozzles over the drum for supplying heated alkaline
30 solution or alkaline steam to the drum and contents.

Use of the method and apparatus of the invention results in a felted form produced with an efficiency and to a quality that surpass standards achieved using both hand-felting and industry flat felting methods.

5 In accordance with a third aspect of the invention, a three dimensional felt form is provided having consistent density, resiliency, and texture along the entire visible felted surface of the form.

In accordance with a fourth aspect of the invention, there is provided a three dimensional felt form produced in accordance with the method of any of the methods discussed herein.

10 In an embodiment, the blank over which the felt is formed may be removed and replaced with an alternate object, thus incorporating the alternate object into the final felted product.

The felt forms of the invention may be combined, joined, or connected to create various useful and marketable products.

15 In comparison to existing industrial felting processes, the method and apparatus of the invention may be used to produce a denser, smoother and more resilient felt than the needle-felt method. Felted wool currently produced using industrial methods (steam process and needle-felting) is not suitable to applications in fashion due to coarseness of texture, instability of felt, and aesthetically unsuitable (as in needle felting), or stiffness of
20 felt (as with steam process). In relation to the existing wet-felt methods that produce flat sheets of felt, the benefit of the present method includes quality comparable or more favourable than any felt produced by hand or by industrial process, but in-the-round. Therefore, the production of three-dimensional forms is more direct and efficient with the methods of the present invention, eliminating the need for die-cutting, scoring, folding and
25 gluing or sewing felt pieces into the desired form. The method of the present invention produces felt forms directly from wool by utilizing the natural ability of wool fibres to interlock and matte into a single, cohesive substance that is capable of retaining its shape without the need for stiffeners.

30 In comparison to existing hand felting processes, the apparatus of the present invention removes the dependency of the process on the human-element as providing the primary source of energy in the creation of agitation and automates this task. A three-dimensional object is created in the round that has a consistent appearance in surface

texture, wall thickness and density. Research and testing has shown that these characteristics have rarely been attempted or achieved using traditional hand-felting methods.

5 The quality of felt produced by the present process has a remarkably smooth surface texture that makes it aesthetically suitable for products on-view to consumers. It also has a consistent fibre matrix that provides structural integrity, providing excellent surface wear and a resistance to further shrinkage, and it can be moulded to take on the form of any concave or convex form.

10 The potential advantages for the consumer include an aesthetically pleasing material that expresses the warmth; comfort and ease of wear associated with wool. The felted wool produced by the present method and apparatus has exemplary structural integrity, providing stability and resistance to surface wear, while retaining these aesthetic qualities desired by the consumer. Other advantages include the renewability of wool as a natural resource that is non-toxic, and eco friendly.

15 Applying the technology to the production of existing products made using existing methods will generate significant improvements in quality and design. For example, wool liners in ski boots may be made seamless, improving comfort. In addition, the technology lends itself to mass-manufacturing methods, complementing existing methods and machinery utilized by manufacturers, making for easy integration into
20 existing systems.

Using the method and apparatus of the invention, forms can be constructed solely from 100% wool, requiring no adhesives or binders, thereby opening the field to applications that have stringent purity regulations, requiring natural, non-toxic, hypoallergenic, or environmentally friendly materials. An example might be soundproof
25 wall panels for residential, commercial and industrial uses, as well as garments or accessories worn on the body.

Other products that may be produced using the present invention include:

The manufacture of fashion accessories such as hats, boots, shoes, handbags;

30 Insulating panels in automobiles: located in front dash, side doors, overhead, under seats, and trunk liners; die cut from flat felt pieces; protect against sound, vibration and temperature;

Air, oil and water filters, wicks and gaskets in automobiles: components are currently constructed from thick felt, turned on a lathe; the resulting tube shape is cut to length, bend into a circle, with the ends sewn together to create an 'o' ring;

5 The construction of orthopaedic insoles, where the method of manufacture requires cutting and sewing flat-felt together to make three-dimensional forms;

 The manufacture of moulded luggage, computer cases, and archival storage cases;

10 Non-obtrusive, and aesthetically engineered shock-absorbent pads (ie: elbow, knee) for protection in sports, physiotherapy, and the design of prosthetics;

 Lightweight, custom moulded packaging to fit electronics, computer, and digital devices;

15 Shock dampening applications in computer equipment; and

 Recycle wool (knit, woven or felted), macerated into fibres, reconstituted into a liquid medium, and cast into forms or slabs of wool (for insulation, packaging, components).

20 Other aspects and features of the present invention will become apparent to those ordinarily skilled in the art upon review of the following description of specific embodiments of the invention in conjunction with the accompanying figures.

BRIEF DESCRIPTION OF THE DRAWINGS

25 Embodiments of the present invention will now be described, by way of example only, with reference to the attached Figures, wherein:

 Fig. 1 is a schematic diagram of a method in accordance with an embodiment of the invention;

 Fig. 2 is a perspective front view of an apparatus in accordance with an embodiment of the invention, shown with drum and motor cover;

30 Fig. 3 is a perspective front view of the apparatus shown in Figure 1, shown without the drum and motor cover;

Fig. 4 is a perspective back view of the apparatus shown in Figure 3;

Fig. 5 is an exploded view of a drum in accordance with an embodiment of the invention, showing lid, drum, baffles, and base;

5 Fig. 6 is a perspective view of polyhedric rubber shot in accordance with an embodiment of the invention;

Fig. 7 is a schematic diagram of an apparatus in accordance with an embodiment of the invention; and

10 Fig. 8A-C are photographs of felt forms made in accordance with certain embodiments of the invention and related products that may be created using same.

DETAILED DESCRIPTION

Generally, the present invention provides an apparatus, system, and method for use in creating three-dimensional felt forms.

5 The method of the invention generally involves the steps of wrapping an object with wool, securing the wool against the object, placing the wrapped object in a drum and exposing the object to heated alkaline solution and agitation. The time of agitation and exposure to heated alkaline solution may be varied to attain the desired quality of felt. Once felting is complete, the three-dimensional felt form may be cut open to release or
10 replace the object encased by the felt. Alternatively, the object may remain encased within the felt in the final product.

Example 1: Felting Method

With reference to Figure 1, a method for felting a three-dimensional object is provided in which an apparatus in accordance with the invention is also employed.

15 ***Wool wrapping***

In accordance with the method shown in Figure 1, the object or blank to be felted is first wrapped with wool batting in step A. Multiple layers of wool batting are built up around the object, with each subsequent layer of wool batting placed upon the previous layer with the wool fibres preferably misaligned between each layer. The object should be
20 wrapped with sufficient batting to result in the desired felt thickness (approximately 1-1/2 to 2 inches of batting will compress down to 1/4 to 3/8 inch thick of hard felt). The object that is to be felted may be a solid object such as a ball, or may be an inflated blank having an appropriate shape and size for felting.

Protective casing

25 A protective casing is then applied B to the wrapped object to hold the wool in place, preventing unravelling. In addition, the casing secures the fibres against the walls of the form, so as the fibres begin to shrink, they shrink against the walls of the form and take on the shape of the form. The casing also maintains the surface consistency of the felted form through the various stages of felting, and imparts a smooth surface texture to the
30 felted form. The protective casing may be any water-permeable material which is suitable for holding the wool in place for a period of time. The casing is preferably somewhat elastic so as to easily be applied and removed as necessary. A nylon material (60-80

denier) is particularly suitable for use as the protective casing. It is also contemplated that a permeable, water-soluble casing may be pulled over the wool or an adhesive applied or sprayed onto the wool, which would remain stable through the duration of time necessary to ensure felting to a stage at which the wool body is secure, but may gradually dissolve so as not to be present in the final product. As well, a protective casing could be applied to the form and left on throughout the felting cycles, becoming integrated into the felt, if so desired.

Heated alkaline solution

The wrapped object is then exposed C to heated alkaline solution. Exposure to moisture and heat cause the wool fibre to swell and uncurl and the scales to open up, making it receptive to agitation. The application of heat and agitation, with an alkaline solution between a pH 7 to 9 range, create optimal conditions for felting wool. In a preferred embodiment, the alkaline solution is hot water mixed with saponified liquid soap. However, any equivalent alkaline solution may be used that promotes effective felting.

Agitation

The object is agitated D within the heated alkaline solution. Although agitation may be achieved by various methods, the inventor has found the placing the wrapped object within a drum of heated alkaline solution along with rubber shot and rotating or shaking the drum provides suitable agitation to felt the wool. In agitating drums from other art fields, hard plastic or metal shot is typically used to promote agitation. For the present use, a softer, more resilient material is preferable so as not to damage the casing and wool fibres. Rubber is suitable as it has sufficient density to provide weight for striking the object, and is resilient to prevent damage to the wool fibres while providing additional kinetic energy to the process.

As shown in Figure 6, the rubber shot 20 is preferably cut into a complex geometrical form/polyhedron that creates several edges on each piece, with minimal surface area on any one side of the piece. The polyhedric shape allows for the optimum amount of bounce to occur between the shot and the walls of the drum, and the shot and the sides of the form being felted. The size and shape of the shot enables it to reach into undercuts and concave surfaces that larger, more symmetrical shapes may not reach. In a

preferred embodiment, the polygonal shot has approximate dimensions of $1\frac{1}{2} \times 1\frac{1}{4} \times \frac{3}{4}$ inches.

In selecting the amount of shot to include within the drum, the weight of rubber shot in relation to the object being felted should be determined by the size of the object and how much space it occupies in the drum. Smaller objects benefit from more shot in the drum, providing even coverage to the object, accelerating the felting time, and allowing the felt to reach the hard-felt stage more quickly.

Larger objects with little clearance to the sides of the drum benefit from loading half the shot on the bottom of the drum and the other half on top of the object before closing the lid. The object may require longer processing time, as it needs to be rotated to make contact with the shot on all sides.

Smaller objects benefit from felting more than one object at a time. In addition to the shot, the weight and impact with the other objects in the drum facilitate the felting process. However, it is more effective to use more shot and fewer objects to allow the objects to circulate freely, impacting the sides of the drum, the baffles, the shot and the other objects.

The drum contents may be agitated D by placing the drum on a felting apparatus (an embodiment of which is shown in Figure 2) for a length of time necessary to felt the wool to the desired degree.

In certain embodiments of the process, the run time may be split into a number of cycles to permit the protective casing to be removed and reapplied periodically, preventing the wool fibres from felting and encasing the protective casing. When nylon is used as the protective casing, the machine is preferably run for five minutes, after which the object is removed E from the drum to remove and reapply F the protective casing to the wool-wrapped object. After this first cycle, the fibres have begun to interlock but the wool is still loose around the object, and very soft. The drum is filled again with hot alkaline solution and rubber shot, and the drum is placed on the felting machine for another five minutes. After this second cycle, the wool has reached the soft-felt stage, with a density equivalent to that produced when felting by hand.

A third cycle will allow the wool to reach the hard-felt stage. This felt can be considerably thicker than hard felt produced by hand felting. A fourth cycle results in a very hard felt with a polished surface that cannot be achieved by hand felting.

After each cycle, the wool object may be immersed in cold water for the purpose of shocking G the fibre. The sudden temperature change assists in tightening the interlock between the fibres, creating a denser felt. If the felted object is to continue on to an additional cycle, it is preferably first heated H, for example by immersion in hot water to
5 bring the fibres back up to the appropriate temperature and ensure the fibres are responsive immediately when immersed in the fresh, heated alkaline solution at the start of the new cycle. Although this shocking step is optional, it contributes to the formation of a denser felt.

Once the desired degree of felting has been achieved, the object is removed from
10 the apparatus.

Removal of Object From Felted Form

To remove I the object encased in the wool, the felt may be cut as follows:

If a deflatable interior form/blank is used:

A small aperture is cut that is large enough to accommodate the removal of
15 the interior form when deflated.

The size of the opening remains relatively the same, regardless of the increase in the scale of the form.

The interior form is drained or deflated, and extracted through the opening.

This method is used when a felted form with a return is desired, for
20 example, a spherical shape.

If a solid form/blank is used:

- a. An incision around the widest part of the form can be cut to release the form within, or
- b. If the form is symmetrical, an incision that bisects the form will produce
25 two open forms. For example, a sphere may be cut to produce two open cup-shaped forms.
- c. The two-halves are separated, revealing the interior form.
- d. The interior form is extracted.

Alternate Methods

30 Objects Suitable for Use as Blanks

Use of a weighted blank or form may assist the felting process by contributing to the agitation of the wool. The weight of the object, wrapped inside the wool, creates a

greater impact against the walls of the drum, and with the shot, thereby increasing the amount of pressure and agitation upon the object, and expediting the felting process.

Blanks for use in making three-dimensional felted objects may be made from any material, over which wool may be wrapped in accordance with the method disclosed
5 herein. The blank may remain within the felted product; layers of the felted product may be cut and removed, revealing layers of felt beneath; openings may be cut in the felted product to reveal a portion of the blank; or the felted product may be cut to remove or replace the blank completely.

Blanks for use with the invention should be able to withstand vigorous processing
10 and may be filled with appropriate material, such as water, to provide weight and absorb the impact of agitation. In instances where forms are hollow and made of breakable materials, it is preferable to fill the interior void of such forms with an appropriate material to protect against breakage.

It is contemplated that interior forms/blanks may take various shapes, and need not
15 be round or symmetrical. Deflatable or collapsible blanks are an option, for example, plastic blanks constructed of several pieces sealed at the seams, with an airtight aperture to allow inflation/deflation of the form. Such blanks could be filled with air or water, and would be easily drained or deflated to remove the blank from the felted form.

Other Suitable Fibres

It is noted that both natural and artificial fibres can be incorporated into the felting
20 process, utilizing the same process and apparatus, although it is preferred that wool remains the majority fibre. Utilizing the natural abilities of the wool fibre to felt, a matrix is formed that integrates the wool and mixed fibres, creating a new material that retains the qualities of pure wool felt, while exhibiting new characteristics. Natural fibres are more
25 likely to be 'accepted' by the wool fibre, with the natural fibre being integrated into the felting process when the wool fibres begin to interlock. Artificial fibres may require selection of the appropriate format for the fibre being introduced. Examples of common material modes are loose strands, spun fibre, worsted, knit, woven, flocked, and the characteristics that are available within each of these categories. Some fibres, both natural
30 and artificial, have contradictory reactions when applied as a knitted or woven material in conjunction with wool batting. For example, a knitted layer may see the wool permeate the layer and fasten it into the felt matrix, when a previous attempt with the same fibre, in

loose strands, was unsuccessful, or vice versa. The process permits the integration of recycled fabric remnants, in a macerated or chopped format, in between layers of wool batting.

Different types of wool fibres or wool in combination with other materials may be applied in layers to a single blank. Each layer would use the previous layer as the base or blank for the following layer. For example, a layer of wool may be felted in accordance with the method to a consistency between soft and hard felt, at which point a new layer would be applied over the first layer. The layers may be comprised of the same wool, or a combination of different types, modes, or colours of wool, or other materials. Should the base-layer of felt reach the hard-felt stage before another layer is applied, the felt may require roughening or loosening with a physical implement such as a brush. The finished felted form may be cut to remove the innermost blank, to reveal portions of the interior of the felted product, to reveal the various layers of felt formed on the object, or to reveal portions of the interior blank, with the intention of the blank remaining part of the finished product.

Moreover, wool sliver (wool that has been scoured, carded, and formed into a continuous untwisted strand), wool/worsted top (a continuous untwisted strand of only long, scoured wool fibres from which short fibres have been removed), or wool roving (a carded batt or sliver of wool that has been drawn out and slightly twisted into a long, continuous strip) may be used alone, in combination, or in layers with other materials, to wrap the blanks for processing in accordance with the method.

Other Uses of the Method

The present method and apparatus may also be used for the process of 'fulling', which generally refers to the process of increasing the weight and bulk of woollen cloth by shrinking or beating (Source: The American Heritage® Dictionary of the English Language, Fourth Edition Copyright © 2000 by Houghton Mifflin Company). Fabric with a high percentage of wool, and a stabilized fibre matrix, such as knit, woven, or non-woven fabric may be applied to a form and subjected to the method of the present invention, thereby causing the fabric to shrink and take on the shape of the form. The resulting surface texture resembles felted wool, but by nature of it having a pre-established fibre matrix, it is fulled.

In another related use of the method, wool with cut edges or seams may be placed over a blank in place of batting and processed in accordance with the method of the invention in order to seal or felt the cut or sewn edges. Furthermore, once the cut or sewn wool is placed over the blank, additional layers of batting may be applied over the cut or
5 sewn wool prior to or during processing in accordance with the method in order to add further layers of felt over the cut or sewn wool.

It is recognized that the order of certain steps in the process may be changed and that certain steps of the above method may not be necessary in certain circumstances. For instance, if the protective casing need not be removed, suitable means could be employed
10 to continually heat the drum and contents, thereby avoiding the need to split the run time into cycles to remove the casing and to change the alkaline solution after each cycle. Moreover, the alkaline solution may be provided by spray or steam injection into the drum, in which case the drum may include ports for the injection of heated alkaline solution, the drainage of excess moisture and condensation, and the venting of steam
15 pressure.

Example 2: Apparatus

An embodiment of a machine for use with the above method is shown in Figures 2 through 5.

Motor

20 The motor 1 drives the v-belt 5 that in turn drives the pulley 6 attached to the active roller 7a, thereby rotating the drum 15 as it lies horizontally upon rollers 7a, 7b. The motor 1 should be selected so as to provide ample power for the scale of the machine, allowing the machine to function and not labour under the weight of the drum and its contents. A weak motor may overheat and may not be effective in carrying the combined
25 weight of the drum + rubber shot + water + object. This will cause the drum to shuffle between the rollers rather than spinning.

The motor may include various speed settings for flexibility, allowing different configurations or different sizes of drum to be used. Experimentation has shown that a motor speed of 875 rpm is suitable for small objects felted in a 12-inch diameter
30 cylindrical drum, which results in a drum speed of approximately 33 rpm.

A step-up ring 4 may be used with the motor 1, motor sled 2, and adjustment in v-belt length to allow flexibility in adjusting the drum agitation based on the motor speed.

The adjustability is particularly useful with a stronger motor to accommodate the added weight of a larger object, or when a smaller or larger diameter drum 15 is used for felting longer, larger or shorter objects. In a preferred embodiment, a 2-5/8" inch diameter setting is used.

5 ***Motor Sled***

The motor sled 2 allows the motor to be moved along sled tracks 3, shortening or lengthening the distance between the motor 1 and active roller 7a. This allows a shorter or longer length v-belt 5 to be installed for the purpose of increasing or decreasing the RPM of the active roller 7a, or accommodating a smaller or larger diameter drum 15. By
10 adjusting the relationship between the length of the v-belt 5, the size of the pulley 6, and the size of the drum 15 the user can maintain the ideal RPM setting of the main embodiment, and felt larger, longer or more objects. Understanding and adjusting the proportions of these three elements ensures that felting will occur, and with the same degree of consistency and efficiency that the default settings accomplish.

15 The sled tracks 3 are provided in the machine base 12, along which the motor sled 2 slides when adjustments are made or a v-belt 5 is installed.

V-Belt 5 and Pulley 6

A v-belt extends from the step-up ring 4, attached to the motor shaft, to the pulley 6, in order to rotate the active roller 7a, thereby rotating the drum 15 and passive roller 7b.
20 The pulley 6 slows the high RPM of the motor 1, such that the RPM of the drum 15 is conducive to circulating the shot and object around the interior of the drum, consistently, such that the wool-batting wrapped form receives the amount and force of agitation necessary to promote felting.

When the motor is set too fast, the centrifugal force holds the shot 20 and form
25 against the wall of the drum 15, impeding agitation to the form, and inhibiting the felting process. The inventor has found that a v-belt 5 of 50" accommodates the diameter of a standard 5-gallon 12-inch diameter drum, and in combination with a 9" pulley 6 creates a preferred drum rotation when the motor is set between 875 and 1130 RPM.

Rollers 7a, 7b

30 The active roller 7a with attached pulley 6 is driven by the v-belt 5 that is driven by the motor 1. The passive roller 7b is propelled by the turning of the drum 15, which is propelled by the turning of the active roller 7a and pulley 6.

Rollers 7a/7b preferably include a roughened or malleable surface to prevent the drum 15 from slipping while the machine is running, and the rollers rotating. For example, closed-cell foam may be used to provide a supple surface into which the edges of the drum lid 16 and drum base 19 sink, providing traction.

- 5 The roller front support 9 holds the front end of the rollers 7a/7b in place, elevating the rollers above the base of the machine 12. The roller back support 10 holds the back end of the rollers 7a/7b in place, elevating the rollers above the base of the machine 12.

Drum 15

- 10 The drum 15 includes a drum lid 16, the drum 15, and the drum base 19. The drum should be watertight when sealed, and preferably includes baffles 18 to maintain mobility of the shot and object, facilitating further agitation. The drum lid 16 is watertight and secure-fitting, to ensure it remains attached to the drum 15 while the machine is in motion, and to prevent the contents of the drum from leaking. The drum may include one or more steam vents 17. The steam vent 17 allows the pressure that builds in the drum, from the heat, moisture and movement of the contents, to be released, in order to prevent the seal on the drum lid 16 from being compromised, and leaking. Additional steam ports or vents may be added in order to facilitate spray or steam injection, if desired.

The inventor has found that a 12-inch diameter drum is suitable for felting objects up to 8 x 8 x 8 inches, and weighing up to 5 lbs.

- 20 In the embodiment shown in the Figures, a drum base 19 is attached to the bottom of the drum to bring the circumference of the bottom of the drum 15 equal with the circumference of the drum lid. This is useful to ensure that when placed horizontally on the rollers 7a/7b, the drum is level, allowing for even distribution of shot 20 and consistent agitation along the horizontal axis of the drum.

- 25 Drum baffles 18, which, in the embodiment shown are placed around the interior of the drum 15 and perpendicular to the wall, are included to ensure the contents are continuously circulated within the drum 15. The baffles flip the shot 20 off the sides of the drum and into the object, thereby generating agitation through repetitive contact, and furthering the felting process.

- 30 ***Additional Components***

The back plate 11 prevents the drum 15 from migrating off the back of the rollers 7a/7b when the machine is running.

The machine base 12 is a platform to which the stationary parts of the machine are attached. The base stabilizes the machine when the machine is operating.

The feet 13 are dispersed around the perimeter on the underside of the machine base 12. The feet are short and wide, to provide support and stability when the machine is operating. The feet transfer vibration through to the surface upon which the machine sits, and prevent the machine from migrating across the tabletop when the machine is running.

The motor cover 14 protects the motor from contact with water, and protects the user from coming in contact with the electrical wires.

In an embodiment, the machine includes the following specifications: 1/6 HP 1.7 amp 2-speed motor (1130/875RPM) 60Hz PH 1 with capacitor; three-step pulley: 1-3/4", 2-5/8", 3-3/8"; (2) 1-5/8" diameter x 21-3/4" L rollers; 1/2" x 9" diameter pulley; 50" v-belt; 24" x 36" water-proof rubber-covered deck; 12" diameter five-gallon plastic drum with baffles; 2-1/2 pounds of rubber shot cut into complex angles to facilitate bounce and to reach into interior angles on complex shapes.

To increase the capacity of the machine for the purpose of felting larger objects, the capacity of the machine can be adjusted by moving the motor sled along the sled tracks to accommodate a longer v-belt, thereby increasing the distance between the motor shaft and the active roller, providing room for a drum with a larger diameter. In increasing the length of the belt from the current default, the size of the pulley should be reduced in size to optimize the drum rotation speed. A smaller pulley will increase the RPM of the active roller, yet decrease the RPM of the larger diameter drum, thereby creating an approximation of the RPM that effectively facilitate felting. Depending on the size of the drum and object, an increase in the capacity of the motor may be necessary to accommodate the larger drum, added weight of additional shot, water, a larger object or more objects.

To increase the capacity of the machine for the purpose of felting longer objects, the existing front and back rails may be removed, and the rollers suspended from low-profile bushings. In this manner, a longer length drum could be employed on the same machine base, provided a front and back stop were installed to prevent the drum from migrating and to keep it in place. This longer length drum would enable felting of longer forms.

Example 3: Apparatus

With reference to Figure 7, a further embodiment of the apparatus is shown in which the drum 25 is a six-sided prismatic drum without interior baffles, the drum constructed of a rigid and perforated material such as perforated stainless steel, metal mesh or screening. A door or hatch 26 is present to provide access to the drum interior for placement and removal of the wrapped object along with rubber shot 20. A spray system 30 is present for receiving heated alkaline solution or steam from a reservoir 35 and spraying the solution over the drum 25 and its contents. The heated alkaline solution or steam will penetrate the drum and the wrapped object inside the drum to facilitate felting during agitation. As the heated solution or condensation arising from steam application will drip from the drum during agitation, a bottom tray 36 is present to collect the excess, which may be discarded or heated and recycled back to the reservoir 35.

The drum 25 may be driven directly by the motor or may sit atop an active roller which is driven directly by the motor. Alternatively, and as shown in Figure 7, a sprocket and chain drive system 40 may be used to rotate the drum to agitate the drum contents.

The drum 25 and spray system 30 may be encased within a chamber 37 to confine the moisture, humidity and heat therewithin. The chamber may be placed within the tray such that it will collect the condensation that forms on the walls. The chamber has a door or hatch 38 to allow access to the interior, the drum 25 and its contents, and the tray 36. Such chamber will minimize the energy input required to maintain the temperature of the contents and protects external parts, such as the motor, from moisture damage.

This apparatus enables the felting process to be continuous, avoiding cooling which would otherwise necessitate replacement of the alkaline solution and interruption of the felting process. This is particularly desirable in applications in which the protective casing need not be removed or reapplied.

Example 4: Finished Product

Figures 8A, 8B, and 8C illustrate examples of felt forms that may be produced using the methods and apparatus of the invention. In Figure 8A, a stainless steel bowl 50 is shown resting within a fitted felt form 51. Such a form 51 may be made in accordance with the invention by using a spherical blank of identical diameter to the stainless steel bowl 50. The spherical form produced would be cut to appropriate size and the blank would then be replaced with the bowl 51.

Figure 8B similarly illustrates a felted glass vessel 60 with a portion of the felt form removed to create a window 61 through which objects in the glass vessel may be viewed. Figure 8C illustrates a felt form in which two colours of felt have been layered over a blank according to the method of the invention.

- 5 Other products that may be produced in accordance with the invention will be readily apparent to those of skill in the art.

Accessories

- 10 Optional devices and methods may be used with the invention. For example, a wool batting wrapping machine may be used to assist in the wrapping of wool around the form; other mechanical devices are also available to assist the process. For example, a machine with rotary, vibrating action and interchangeable rubber cups that permit the agitation of cut edges of various diameters may be helpful to assist with the felting of cut edges, rather than having to perform the action by hand.

Modifications to the apparatus

- 15 To further encourage felting and expedite the process, the walls of the drum could be texturized to increase agitation to the wool fibres.

The felting machine described above may also be used in other non-fabric related applications, for example as a polishing device or as a rotary tumbler for removing flash from plastic moulded parts.

- 20 The above-described embodiments of the present invention are intended to be examples only. Alterations, modifications and variations may be effected to the particular embodiments by those of skill in the art without departing from the scope of the invention, which is defined solely by the claims appended hereto.

CLAIMS:

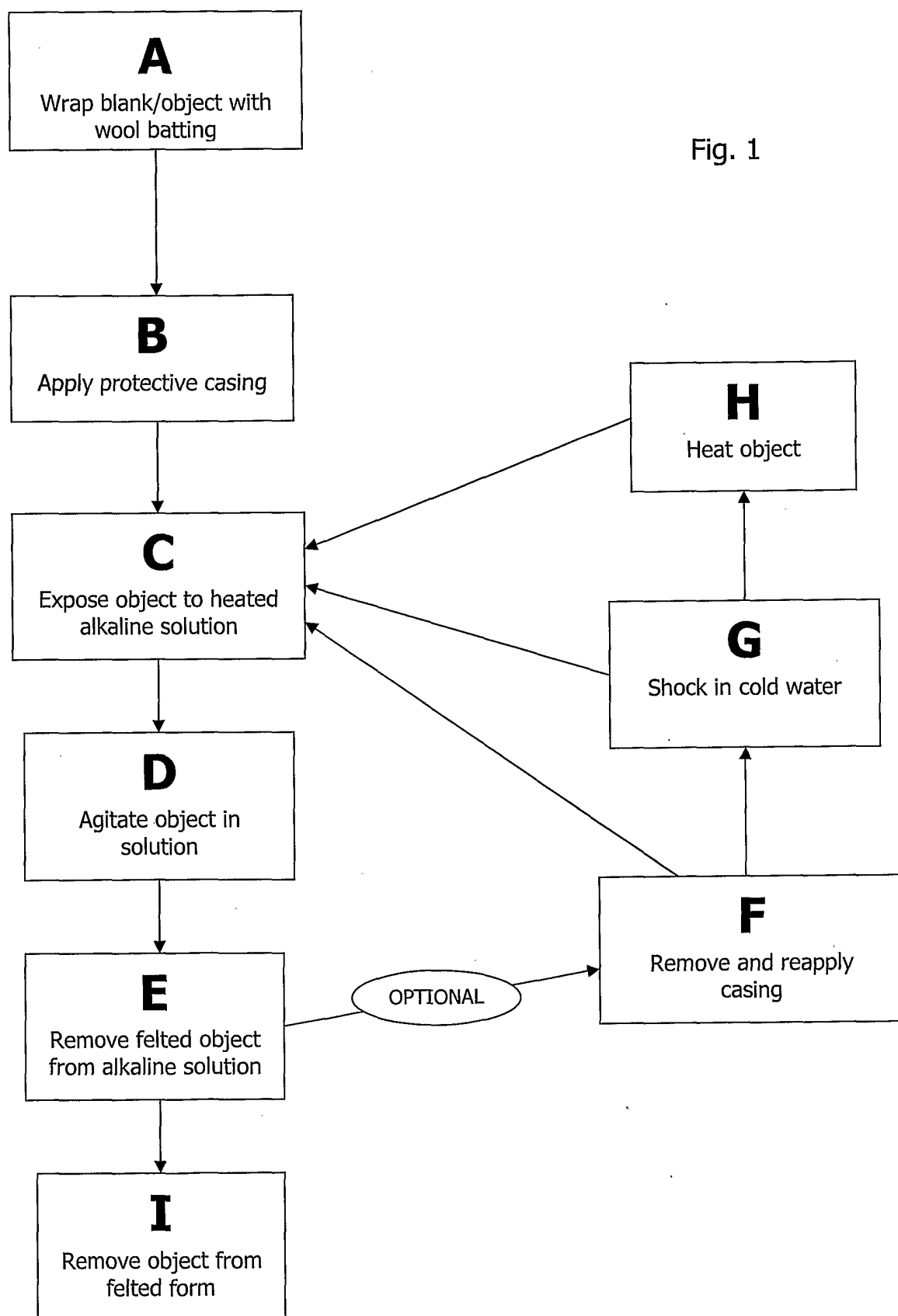
1. A method for making a three-dimensional felt form comprising the steps of:
 - a. wrapping a three-dimensional object with wool;
 - 5 b. securing the wool against the object;
 - c. agitating the wrapped object within a drum in the presence of a heated alkaline solution; and
 - d. repeating any of steps a through c until the wool becomes felted into a three-dimensional form around the object.
- 10 2. The method as in claim 1 further comprising the step of cooling and drying the felt form.
3. The method as in claim 1 or 2, further comprising the step of cutting the felt form
- 15 to remove the three-dimensional object therefrom.
4. The method as in claim 1 wherein the wool is secured against the object by applying an elastic, water- permeable casing over the wool.
- 20 5. The method as in claim 4 wherein the casing is nylon casing.
6. The method as in claim 1 wherein the wool is secured against the object with adhesive.
- 25 7. The method as in claim 1 wherein an amount of shot is added to the drum in step c to promote agitation of the object within the drum.
8. The method as in claim 7 wherein the shot comprises a plurality of polyhedra made from dense, resilient material.
- 30 9. The method as in claim 8 wherein the dense, resilient material is rubber.

10. The method as in claim 1 wherein the drum is cylindrical and includes a plurality of interior baffles for promoting agitation of the object within the drum.
11. The method as in claim 1 wherein the drum is prismatic.
- 5 12. The method as in claim 1 wherein the heated alkaline solution is added to the drum prior to agitation in step c), and wherein the drum includes a sealable lid to prevent leakage of the heated alkaline solution during agitation.
- 10 13. The method as in claim 1 wherein the heated alkaline solution is applied as a spray or vapor.
14. The method as in claim 13 wherein the drum is a cage or is otherwise perforated to permit alkaline solution to enter and exit the cage, and wherein the heated alkaline solution
15 is applied to the object during agitation from a location exterior to the drum.
15. The method as in claim 1 wherein the wool is wool batting, wool top, or wool roving of which wool is the majority fibre.
- 20 16. The method as in claim 1 wherein the wool is flat felted wool that has been sewn into a three-dimensional form for fitting over the blank.
17. An apparatus for use in felting a three dimensional object, the apparatus comprising:
- 25 - a drum for containing a wool-wrapped three dimensional object to be felted;
- a drum agitation system for manipulating the drum so as to agitate the wrapped object within the drum; and
- a heated alkaline solution application system for applying heated alkaline
30 solution to the object in the drum prior to and/or during agitation.

18. The apparatus as in claim 17 wherein the drum is sealable to prevent leakage of alkaline solution during agitation.
19. The apparatus as in claim 17 wherein the drum is a cage or is otherwise perforated.
- 5 20. The apparatus as in claim 17 wherein the drum is cylindrical.
21. The apparatus as in claim 17 wherein the drum is prismatic.
- 10 22. The apparatus as in claim 17 wherein the drum includes interior baffles to promote agitation of the object within the drum.
23. The apparatus as in claim 17 wherein the drum agitation system comprises a roller system for supporting the drum and a drive system for driving rotation of at least one
15 roller within the roller system so as to rotate the drum.
24. The apparatus as in claim 17 wherein the drum agitation system comprises a conveyor system for supporting the drum and a drive system that drives the conveyor system so as to agitate the drum.
- 20 25. The apparatus as in claim 23 or 24 wherein the drum agitation system further comprises an axial support system for supporting the drum along its axis during rotation of the drum.
- 25 26. The apparatus as in claim 17 wherein the drum agitation system includes a drum support, a system for fastening the drum against the support, and a motor for driving agitation of the drum.
- 30 27. The apparatus as in claim 17 wherein the heated alkaline solution application system comprises a removable and resealable hatch within the drum which may be removed to fill or drain the drum with heated alkaline solution.

28. The apparatus as in claim 17 wherein the heated alkaline solution application system comprises a port within the drum through which heated alkaline solution may be added or removed.
- 5 29. The apparatus as in claim 17 wherein the heated alkaline solution application system comprises a fill line that enters the drum and a drain line that exits the drum for supplying and draining solution to and from the drum.
30. The apparatus as in claim 17 wherein the drum is perforated and wherein the
10 heated alkaline solution application system comprises nozzles over the drum for supplying heated alkaline solution or alkaline steam to the drum and contents.
31. A three dimensional felt form having consistent density, resiliency, and texture along the entire visible felted surface of the form.
- 15 32. A three dimensional felt form produced in accordance with the method of any of claims 1 through 16.
33. The form as in claim 32 wherein the object over which the felt is formed has been
20 removed and an alternate object has been inserted into the felt form.
34. A product comprising one or more felt forms as in claim 31 or 32.

1/8



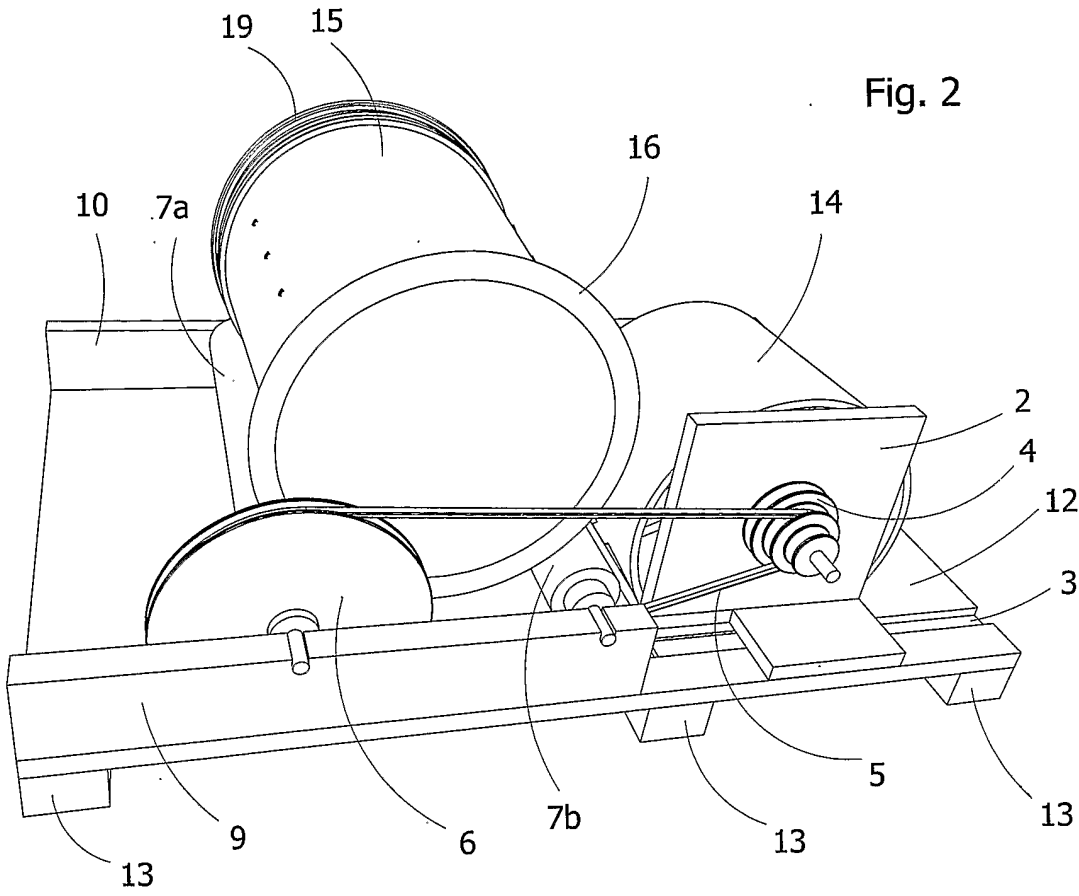
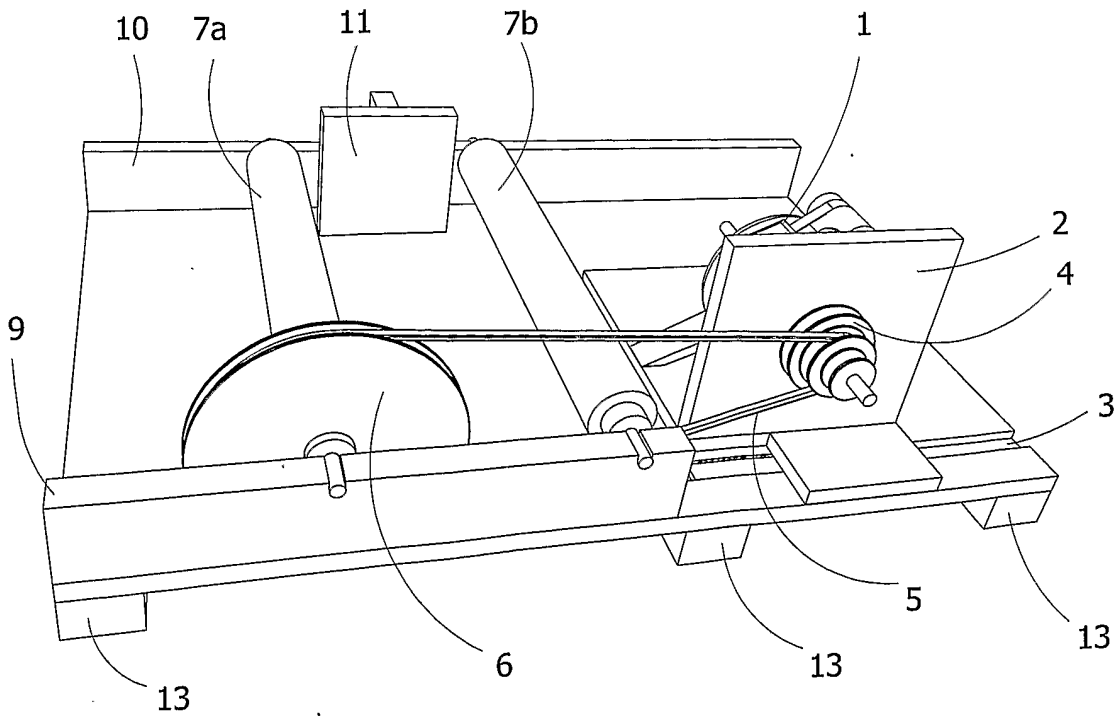
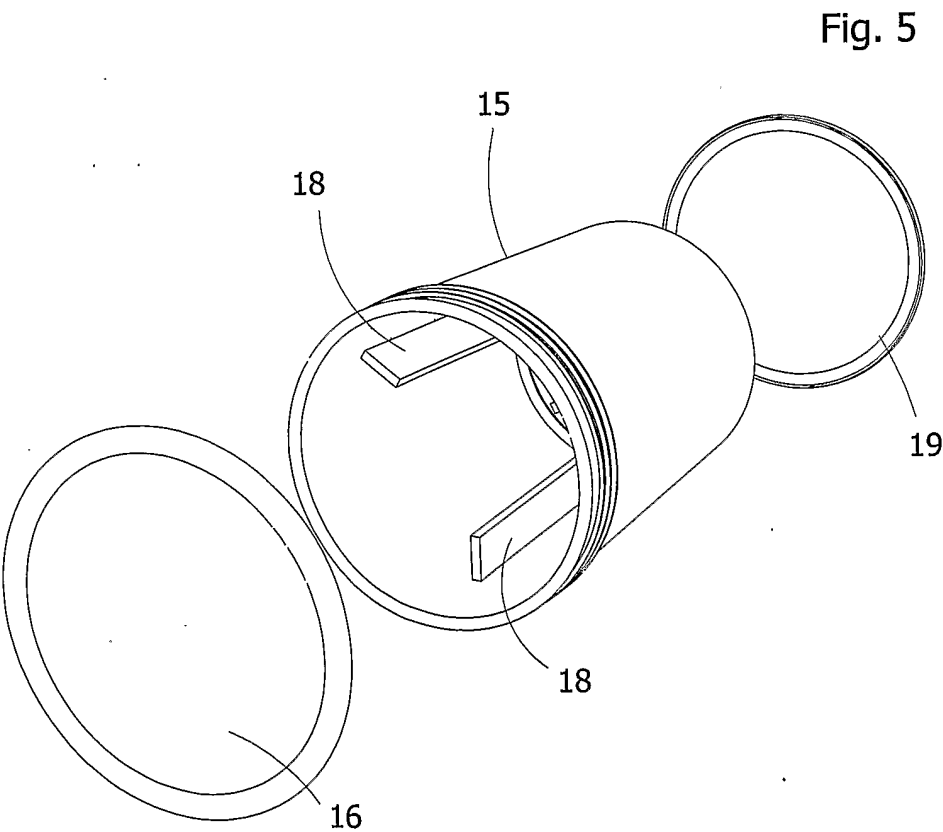
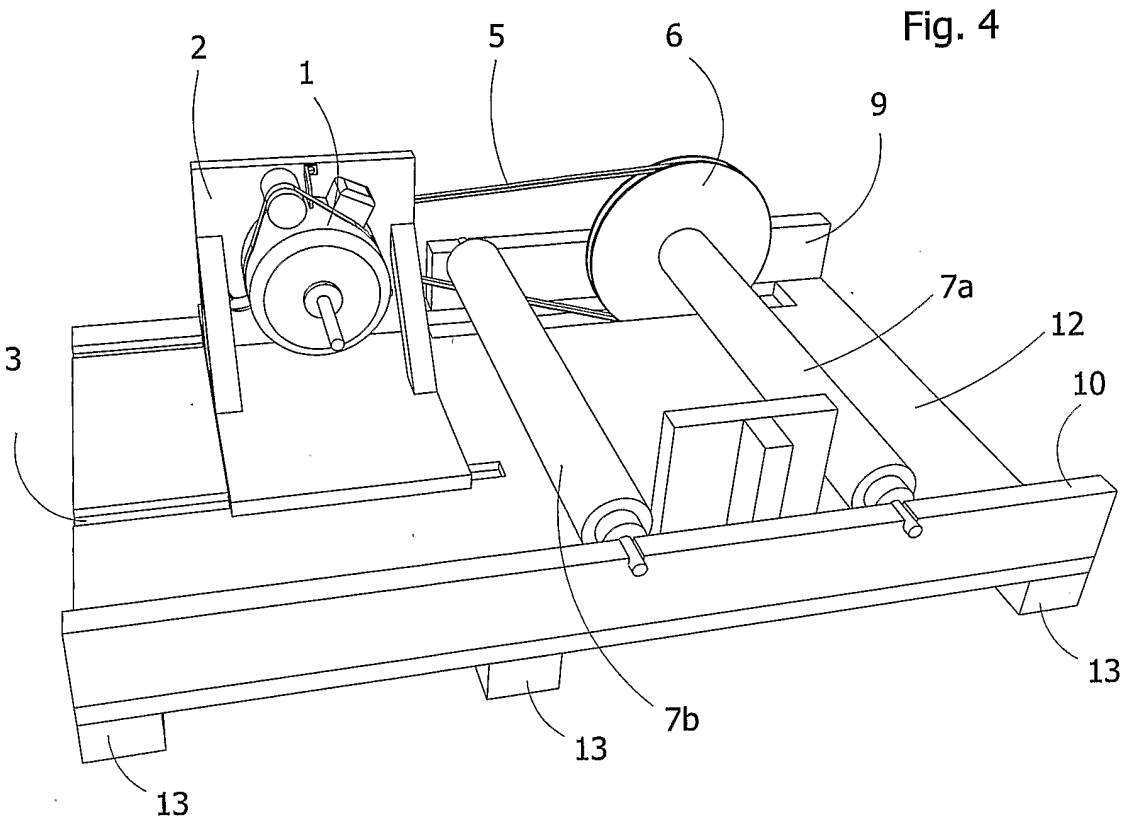


Fig. 3





4/8

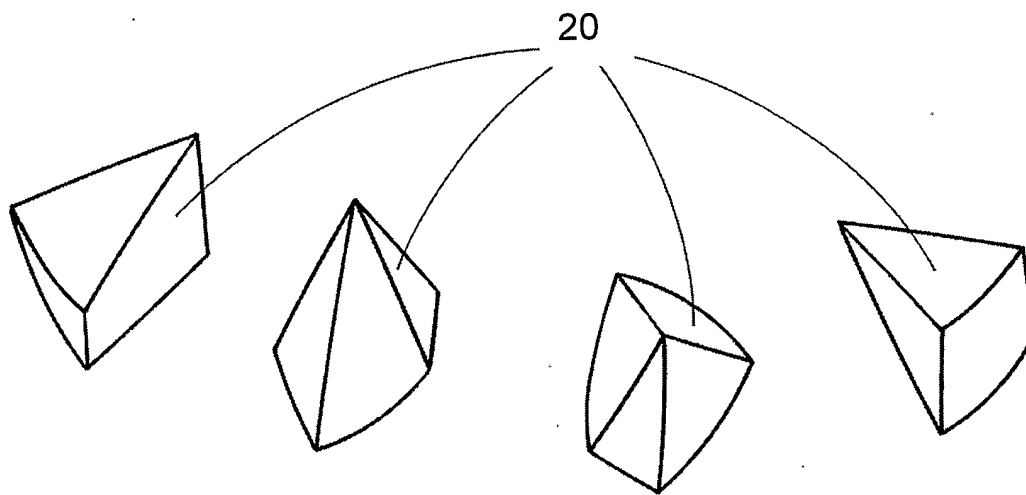
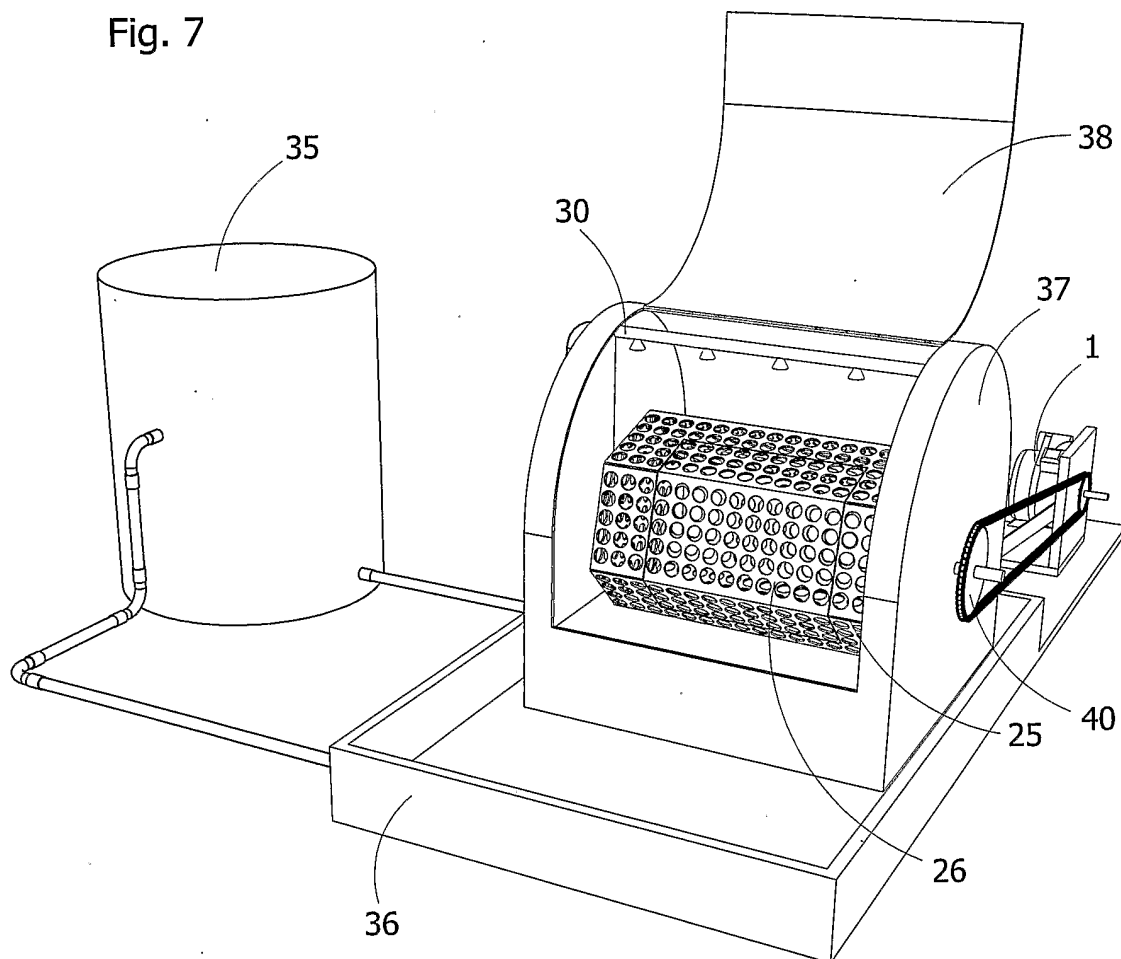


Fig. 6

5/8

Fig. 7



6/8

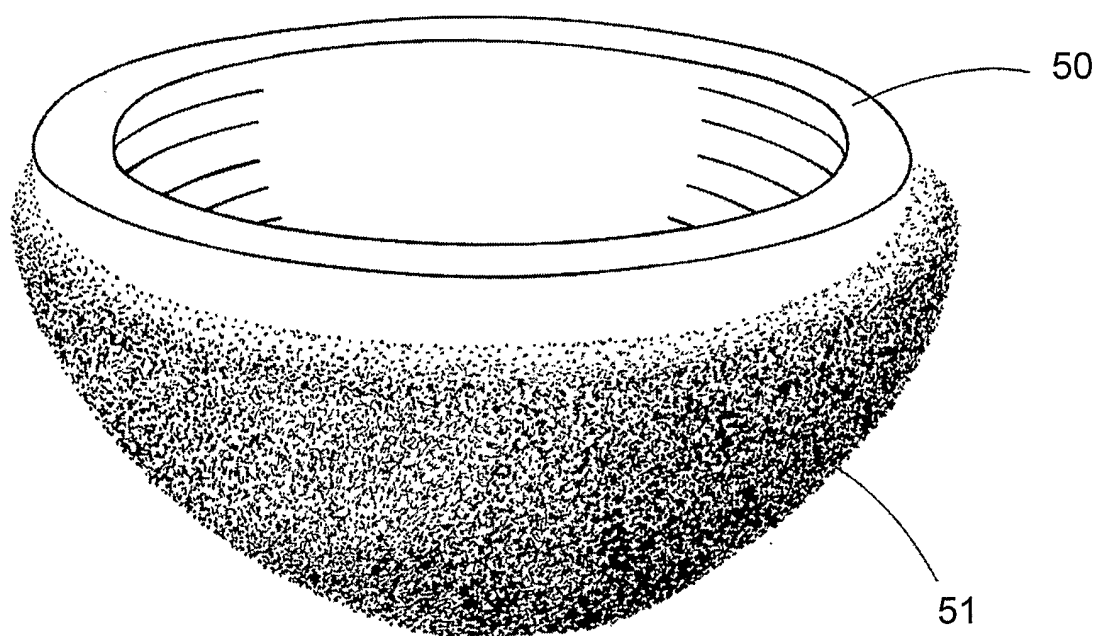


Fig. 8A

7/8

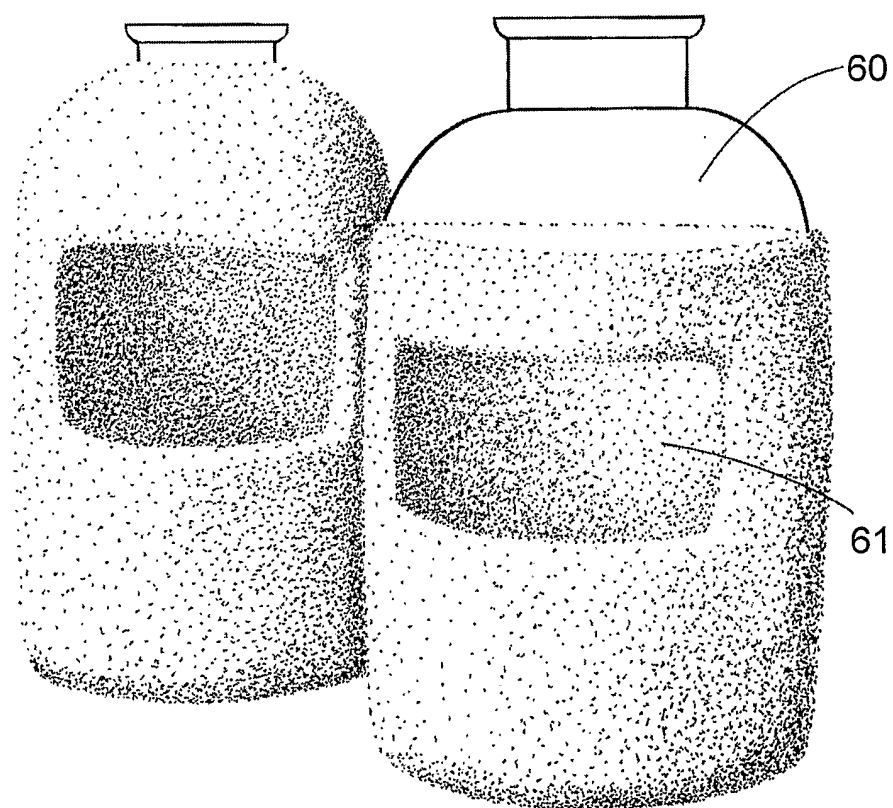


Fig. 8B

8/8

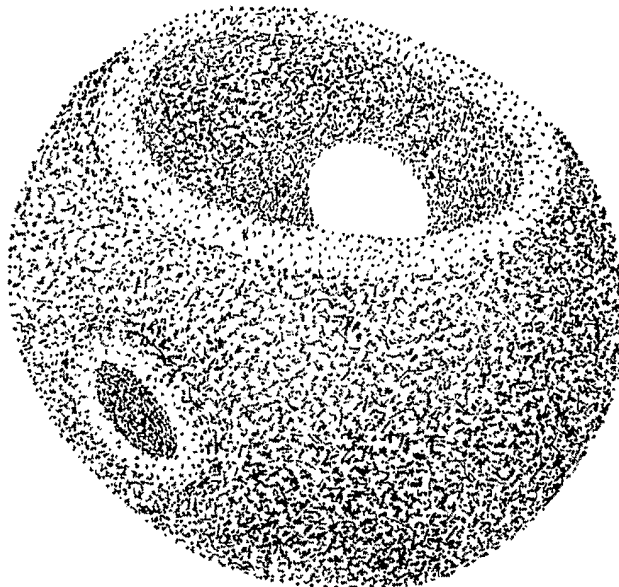


Fig. 8c

INTERNATIONAL SEARCH REPORT

International application No.
PCT/CA2006/000598

A. CLASSIFICATION OF SUBJECT MATTER

IPC: **D04H 1/22** (2006.01) , **D04H 1/08** (2006.01) , **D04H 17/00** (2006.01) , **D06M 11/00** (2006.01)

According to International Patent Classification (IPC) or to both national classification and IPC

B. FIELDS SEARCHED

Minimum documentation searched (classification system followed by classification symbols)

IPC: D04H (2006.01), D06M (2006.01)

Documentation searched other than minimum documentation to the extent that such documents are included in the fields searched

Electronic database(s) consulted during the international search (name of database(s) and, where practicable, search terms used)

Delphion, WEST, USPTO, CPD, with key word, such as, felting

C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
X A	JP 2004339657 A2 (MIYAKE, S. et al.) 2 December 2004 (02-12-2004) *whole document*	1, 2, 6, 10, 12, 14 - 15, 17 - 20, 22 - 23, 25 - 26, 31 - 34 3, 11, 13, 21
X A	JP 2005002479 A2 (KAMIYAMA, K.) 6 January 2005 (06-01-2005) *whole document*	1, 13, 15 - 18, 27 - 28, 31 - 34 19, 29 - 30

☐ Further documents are listed in the continuation of Box C.

☒ See patent family annex.

* Special categories of cited documents :	"T" later document published after the international filing date or priority date and not in conflict with the application but cited to understand the principle or theory underlying the invention
"A" document defining the general state of the art which is not considered to be of particular relevance	"X" document of particular relevance; the claimed invention cannot be considered novel or cannot be considered to involve an inventive step when the document is taken alone
"E" earlier application or patent but published on or after the international filing date	"Y" document of particular relevance; the claimed invention cannot be considered to involve an inventive step when the document is combined with one or more other such documents, such combination being obvious to a person skilled in the art
"L" document which may throw doubts on priority claim(s) or which is cited to establish the publication date of another citation or other special reason (as specified)	"&" document member of the same patent family
"O" document referring to an oral disclosure, use, exhibition or other means	
"P" document published prior to the international filing date but later than the priority date claimed	

Date of the actual completion of the international search

27 June 2006 (27-06-2006)

Date of mailing of the international search report

01 August 2006 (01-08-2006)

Name and mailing address of the ISA/CA
Canadian Intellectual Property Office
Place du Portage I, C114 - 1st Floor, Box PCT
50 Victoria Street
Gatineau, Quebec K1A 0C9
Facsimile No.: 001(819)953-2476

Authorized officer

Julia Zhu (819) 997-5173

INTERNATIONAL SEARCH REPORT
Information on patent family members

International application No.
PCT/CA2006/000598

Patent Document Cited in Search Report	Publication Date	Patent Family Member(s)	Publication Date
JP 2004339657 A2	02-12-2004	NONE	
JP 2005002479 A2	06-01-2005	NONE	