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(71) Applicant: **Telcon Packaging Ltd.**
Swanley, Kent BR8 8DE (GB)

(72) Inventor: **Bridge, Philip**
Buckingham MK18 2RH Buckinghamshire (GB)

(74) Representative: **Caswell, Susanna**
Marks & Clerk
90 Long Acre
London WC2E 9RA (GB)

(54) **Method of manufacturing a packaging tube having a polygonal cross section**

(57) The present invention relates to improvements in the manufacture of packaging, in particular of tubes for containing viscous fluids such as toothpaste, hair gel, cosmetic creams, food paste or the like. There is provided in a first aspect a method of manufacturing a tube having an elongate tube body (1) and a polygonal cross section comprising the steps of:

a) forming creases in sheet material (15);
b) using the creases in the sheet material (15) to locate and orient the sheet material during manufacture of the tube;
c) forming the tube body (1) in a polygonal form from said sheet material (15) such that the creases form edges (3) of the tube; and
d) applying a pre-formed shoulder (5) and a cap (4) to a first end of the tube body (1).

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Description

[0001] The present invention relates to improvements in the manufacture of packaging, in particular of tubes for containing viscous fluids such as toothpaste, hair gel, cosmetic creams, food paste or the like.

[0002] Traditionally, flexible tubes of either Aluminium, Aluminium Barrier Laminate form (ABL), Plastic Barrier Laminate form (PBL), ordinary plastic monolayer (Plastic), or Co-extruded form (Coex) tubes have been made predominantly in a round format, since their introduction over ten years ago. Such cylindrical tubes are typically used in the following industries and sectors - toothpaste, industrial and household products, cosmetics, depilatory creams, foodstuffs, pharmaceuticals and personal care products.

[0003] The present tube designs, despite their wide use and acceptance, do have several disadvantages. In particular, the traditional cylindrical tubes cannot be stacked one on top of another, in either plane, and therefore each tube requires packaging in a carton which cartons are in turn packaged in boxes to enable ease of transportation and ease of storage on shop shelves. The use of additional cartons, however, results in a substantial amount of wasted space in which no product is being transported. Also, the amount of material required per unit volume of product is relatively high. Finally, the cost involved in packaging the required amount of product in a given space is relatively high due to the inefficient packaging methods currently used.

[0004] The present invention therefore aims to ameliorate one or more of the above-mentioned problems.

[0005] According to a first aspect of the present invention, there is provided a method of manufacturing a tube having an elongate tube body and a polygonal cross section comprising the steps of:

a) forming creases in sheet material;
b) using the creases in the sheet material to locate and orient the sheet material during manufacture of the tube;
c) forming the tube body in a polygonal form from said sheet material such that the creases form edges of the tube; and
d) applying a pre-formed shoulder and a cap to a first end of the tube body.

[0006] According to a second aspect of the present invention, there is provided a tube which is made in accordance with the method of manufacturing given above.

[0007] The term "polygonal" has been used to mean "having flat edges or surface sections; can have sharp or rounded corners or edges". Preferably, the polygonal cross-section of the tube is regular and preferably tessellates. For example, the polygon in question may be a triangle, rectangle or hexagon. Preferably, when a plurality of the tubes according to the present invention is stacked together, a space-filling pattern is formed such that all available space is made use of without an unnecessary number of gaps. Also, the stack is preferably self-supporting such that additional support members are not required.

[0008] Accordingly, in a third aspect, the present invention provides a plurality of tubes, each made in accordance with the above mentioned method, the tubes formed into a space filling stack, in which the faces of the tubes are touching. Preferably, the stack is self-supporting.

[0009] The tube of the present invention may hold approximately 27% more volume than an equivalent round tube of the same diameter and overall height. However in practice this can increase to over 40% because of the respective geometry of the two tubes, which is further explained as follows. A round tube has a capped end at one end and a permanently closed end at the other. The closed end is usually in the form of a fishtail weld. However, because of its fishtail weld, the traditional tube begins to lose its perfectly cylindrical shape and starts to taper approximately 10-15% along its length. In contrast the tube of the present invention may only start to lose its perfectly rounded square form typically 80% along its length. In one embodiment of the present invention, the tube has a square end seal at its closed end so as to help retain the square shape of the tube. This enables the tube to be filled with product to a much greater height in the tube.

[0010] The tube made according to the present invention preferably has rounded corners, wherein the radius of each corner is between 0mm and 10mm, preferably between 1mm and 4mm.

[0011] The resulting advantages are wide-reaching. The tube size required to hold a specific volume may be shorter and therefore cheaper to produce than a traditional cylindrical tube. For example, a 35 mm diameter conventional round tube could be replaced by a 28 or 30 mm rounded square tube according to the present invention. This would result in an increase in the number of tubes per square metre of shelf space or lorry space, thereby reducing the expenditure, and increasing the revenue generated, per unit.

[0012] A traditional tube having the same footprint as a tube according to the present invention holds proportionally less product than the rounded square tube. Therefore, the tube according to the present invention having a given footprint may have a capacity of up to 40% more than a traditional tube of the same given footprint. The tube according to the present invention therefore results in improved revenue return per volume on shelf space, an increase in the volume of product sold and the ability for retailers to offer special promotions such as an extra amount of product for the same price *without* utilising any extra shelf space.

[0013] A further disadvantage of the prior art addressed by the present invention is the ability to clearly and visibly advertise on the side of the tube. The company who is making and/or selling the filled tube usually want to market the company's image, brand or logo on the side of the packaging to show that they are connected with that product. If a logo or advertisement is printed around the circular surface of a conventional round tube, the logo will not be clearly seen when the tube is placed, for example, on a shelf. However, with the tube according to the present invention, there are flat surfaces on which to print the company's brand, which brand is easily visible when the rounded square tube is stacked on, for example, a supermarket shelf.

[0014] Also, the rounded square shape of the tube according to the present invention may not require an additional carton to facilitate stacking and storage. The tube of the present invention is able to be stood on its end or on its side in a stable position on the shelf in a shop. A plurality of tubes of the present invention may be stackable on top of each other due to their polygonal shape.

[0015] The increase in capacity of the tube according to the present invention for a fixed height reduces the unit freight cost for the product by a similar amount. Freight costs can be considerable and include the cost of transporting empty tubes from the tube manufacturer to the producer, packer and/or filler, as well as filled tubes from the producer, packer and/or filler to the point of sale. This is a particularly important cost consideration when considering the 'Regional' structures (i.e. Europe/Americas/Far East/Asia) and ultimately the globalisation of blue chip producers, and therefore the significant overseas/overland freight costs.

[0016] The present invention enables the height of the tube to be reduced for a fixed capacity, resulting in the following advantages-

1. Noticeably reducing the raw material content of the tube, and reducing the amount of protective transport and storage packaging per unit volume of product.

2. Significantly increasing the volume of product per pallet transported and stored, because additional layers of product are possible due to the reduced height of the tubes. Similarly the amount of product in each shipping container or lorry is increased.

3. Optimised utilisation of the carton space. Traditionally, tube cartons for containing a single tube are oblong in shape because conventional round tubes have fishtail style ends. The tube cartons are made in an oblong shape to fit the tube in its diagonal dimension. The use of tube cartons results in an estimated 31 % increase in the amount of packaging material used that would not be required for packaging the tube according to the present invention.

[0017] The present invention also addresses the problem of how to seal an end of the tube. Conventionally, cylindrical tubes have fishtail style ends which result in a product that is not stable when stacked and which requires an inefficient design of transport packaging because the tubes usually need to be offset to each other in transport containers. This configuration can be as much as 66% less efficient in utilisation of space for a 75 ml tube in comparison to an equivalent sized tube according to the present invention.

[0018] According to the present invention, the tube preferably has an end seal in the shape of a petal or iris flat end, star, flat insert or end cap configuration, fold flat configuration or a pent configuration, as further described below.

[0019] Preferably, the tube has a closed end which is sealed by means of an end portion which portion has the same cross-sectional shape as the tube body. Alternatively, the tube has a closed end which is formed by folds in the body material, configured so that the body material at the closed end includes at least one reverse fold. A reverse fold is formed by bending an end of the side wall of the tube body towards the centre of the body. The tube according to the present invention may have a closed end which is formed by four reverse folds in the form of a star. Alternatively, the closed end may be formed by two reverse folds to form a triangular closed end.

[0020] With regard to the second aspect of the present invention, the material from which the tube is made preferably comprises pre-formed creases in order to assist with the creation of the square shape and the guiding of the material through the forming machine. This is achieved by passing the flat printed laminate material over a set of creasing rollers. Both rollers need to be set to an optimum pressure to ensure that the laminate material is provided with a crease for the square edge of the tube but that not too much pressure is applied to avoid damaging the barrier properties of the material.

[0021] It is very important to ensure that during the creasing and scoring of the laminate the barrier material is not fractured as part of the laminate structure. This can be achieved by creasing and/or scoring of the laminate on the unprinted internal side or on the printed external side, which is the preferred method. As stated above, the amount of pressure applied during the creasing process is critical. Too much pressure and the barrier structure is fractured; insufficient pressure and the creases are not adequately formed to produce the square shape for the tube.

[0022] The creasing may be achieved using two methods-

a. forming the creases on the outside of the laminate on the printed surface;
b. forming the creases on the inside of the laminate on the unprinted surface.

[0023] The forming of the creases may be done on the printing press, as an offline process (i.e. on a separate process line to the main tube forming line, for example a creasing unit may be provided on the rewind stand after printing logos or the like on the laminate on the printing press), or on the tube forming machine. However, it is preferable to incorporate the creasing process in the tube forming process to increase the speed of production. Also, creasing on the printing press offline may be less satisfactory because the natural tension in the rewinding process of an elastomeric laminate material will tend to flatten any creases made, and thereby make it difficult to form a square or rectangular shaped tube on the tube making machinery.

[0024] In any instance the critical factors are the pressure applied to the creasing and scoring elements, and the type of devices used. Too much pressure results in scoring of the laminate and consequent breakdown of the barrier structure. Too little pressure and the edges of the square or rectangle are not properly pre-formed, making the construction of the tube at high speed in the tube machine difficult. Also, as the creases in the material are used to guide the material through the manufacturing process, malformed creases could have a detrimental effect on the positioning of the tubes.

[0025] The optimum pressure to be applied varies with the laminate thickness, depending on the type and thickness of laminate material used. For example, for laminates containing 12 to 40 micron of aluminium barrier (ABL) or for laminates containing 15 to 30 micron of EVOH barrier (PBL), a pressure of between 2 and 20 psi would be appropriate.

[0026] The method according to the invention comprises the step of forming the tube body from sheet material, preferably a laminate sheet material. This has the advantage that the walls of the tubes are strong, yet flexible, and the tube is suitable for the storing of products for human consumption.

[0027] With the traditional method for manufacturing a round tube, the main body is allowed to be rotated independently to the front section in its housing to obtain alignment. However, this is not possible with a polygonal tube. The method according to the present invention involves pre-forming creases in the tube material and the use of the pre-formed creases in the material to act as the guiding and locating system for the tubes. In particular, the pre-formed crease may be used to guide the tube bodies onto polygonal profiled mandrels during the production process.

[0028] A specific embodiment of the invention will now be described by way of example only with reference to the accompanying drawings in which:

Figure 1 shows a perspective view of a tube according to the present invention;

Figure 2 shows a plurality of tubes according to the present invention stood vertically on a shelf;

Figure 3 shows a partial view of another embodiment of the present invention;

Figure 4 shows a plurality of tubes according to the present invention stacked within a shipping container;

Figures 5A to 5E show various embodiments of the closed end of the tube according to the present invention;

Figure 6 shows schematically the method of forming creases in the tube body material to assist in the formation of sharp radius edges to the tube;

Figure 7a shows a side view of a welding shaft assembly according to the present invention;

Figure 7b shows a cross sectional view along the line A-A in Figure 7a;

Figure 8 shows a body cutting machine;

Figure 9 shows a side view of a packing machine;

Figure 10 shows schematically a side view of the lead in of the material into the polygonal tube form; and

Figure 11 shows a view in the direction of A-A of Figure 10.

[0029] Initially, there will be described in detail the product of the method of the invention. Referring to the drawings, the tube comprises an elongate body 1, for containing a viscous fluid, having a first end 11 and a second end 12. A nozzle 2, through which a viscous fluid contained in the body 1 can exit the tube, is located within a shoulder 5 of the tube, which shoulder 5 is attached to the first end 11 of the body 1. The nozzle 2 is preferably cylindrical, although it may also be oval, polygonal or the like in shape.

[0030] The body 1 of the tube has four corners 3 which result in the tube having a square cross-section. The shoulder 5 also has a square cross section to match the cross section of the tube body 1. Each corner 3 of the tube body 1 has a rounded form and the radius of each corner is within the range 0 to 10 mm. This range allows the tube to maintain its squared shape whilst still being relatively simple to manufacture. More preferably, the radius of the corners is within the range 1 to 4 mm.

[0031] Referring to Figure 2, the body 1 is provided at its first end 11 with a cap 4 which closes off the nozzle 2. The cap 4 preferably has the same external cross-sectional shape as the body 1 but is also provided with an inner portion which co-operates with the outer dimensions of the nozzle 2 in order to prevent viscous fluid held within the body 1 from escaping through the nozzle 2, as can be seen from Figure 2. The cap 4 may be attached to the nozzle 2 by means of a screw thread, push fit or click-fit.

[0032] The advantage of the cap 4 and the body 1 having the same external cross-sectional shape is that a plurality of tubes may be stood next to each other to form a stable grouping. This is particularly advantageous to a retailer who wishes to store as many tubes as possible next to each other on the shelf in his shop.

[0033] Preferably, both the cap 4 and/or the tube are provided with alignment means such that the corners of the cap are in alignment with the corners of the tube. This results in a tube which has a smooth outline even after the first use of the tube.

[0034] Referring to Figure 4, the increase in capacity of the tube over the traditional cylindrical tube can clearly be seen. This is further emphasised by the following calculations:

$$\text{Volume of conventional cylindrical tube} = \pi\, r^2\, L$$

where r = radius of cylinder, L = length of cylinder between the shoulder and the start of the fishtail weld.

[0035] In contrast,

$$\begin{aligned}\text{volume of rectangular prism shaped tube} &= (2r)^2\, L \\ &= 4r^2\, L\end{aligned}$$

where 2r = width = height of tube and L = length of prism.

[0036] Therefore, the volume of the tube is about 27% higher than the volume of the traditional round cylindrical tube.

[0037] Figure 5 shows a variety of different shapes which may be used to close off the second end 12 of the body 1. Figure 5a shows a flat-fold top in which each side of the body 1 is extended to form flaps 1F, 2F, 3F and 4F. The flaps are simply folded over and either glued or welded together in order to seal the second end 12. Figure 5b shows a pent style closure for the second end 12 in which two opposing sides of the body 1 are folded towards each other to form two reverse folds 9 and the remaining two opposing sides are then pushed towards each other and a single weld along the joint is made to form the closed second end 12, such that the second end 12 has a triangular shape when viewed from the side.

[0038] Figure 5c shows a flat end cap or portion 8 which is sealed onto the second end 12 of the body 1 in order to form a seal at the second end 12. Figure 5d shows a star shaped end in which each of the four sides of the square prism shaped body 1 is pushed into the centre of the body 1 in order to form a star shape with the reverse folds 9 formed by each folded side of the body 1. The second end 12 is then welded or glued along the four resulting reverse folds 9 such that the second end 12 has a star shape when viewed from the end. Figure 5e shows a petal or iris flat shape end in which the sides of the body 1 at the second end 12 are shredded and twisted and folded together to close off the second end 12 of the tube.

[0039] As shown in Figure 3, the second end 12 may additionally be provided with a hanging insert 6 to enable the tube to be hung on a rack in a shop rather than stood on a shelf.

[0040] Existing technology in laminate tube forming allows cylindrical tubes to be produced from flat, pre-printed laminate and pre-made, injection-moulded shoulders and caps. There are two principle types of laminate used to form traditional tubes, namely Aluminium Barrier Laminate (ABL), which consists of aluminium sandwiched between layers of Polyethylene (PE), and Plastic Barrier Laminate (PBL), which is similar to ABL but with the aluminium layer replaced by a polymer barrier, for example Ethylene Vinyl Alcohol Co-polymer (EVOH).

[0041] The three main components of the tube are brought together on a machine in three in-line stages. The first of these stages is the body forming process, followed by the application of shoulders and caps and the final stage is the packing of the completed tubes into cartons and/or boxes. This conventional method has been improved, adapted, and developed by the present inventor to form tubes having a polygonal cross section.

Creasing

[0042] According to the present invention, reels of a standard laminate material are loaded onto an unwind end of a first forming machine. It is an advantage of the present invention that the method of manufacture may be carried out using standard, readily available, materials and that materials having special properties are not required.

[0043] The laminate passes between a pair of lateral trimming blades, which are set the required distance apart to ensure that the width of the laminate material is correct. The trimming blades remove a small amount of material from each edge of the laminate in order to obtain a perfectly straight edge prior to welding, which material is collected and disposed of as process waste.

[0044] Following the trim operation, the material passes through a laminate accumulator, which allows for an automatic flying-splice to be made to the next reel of laminate with no interruption to the body forming process. The laminate is then fed by tension rollers to the creasing unit.

[0045] To assist with the creation of the square shape, it is necessary to pre-form creases in the flat laminate material. As shown in Figure 6, the creases are achieved by passing the flat printed laminate material 15 through a set of creasing rollers 13, 14. There is a male creasing roller which typically lies above the laminate material with a matched but adjustable rubberised roller 13 with inserts or shims that allow for adjustment of the rollers for creasing different sized sheets of laminate. Both rollers 13,14 need to be set to apply optimised pressure to ensure that the creases are sufficient to form the corners of the tube whilst at the same time the pressure does not damage the barrier properties of the laminate material.

[0046] The creasing rollers or formers 14 comprise a hard and a resilient surface. The following combinations of roller types may be used-

- Hard into soft. This is the use of a hard male roller (metallic or other) to indent the laminate material to form a V or U sectioned crease up to 150 microns in depth and at an angle of 30 degrees to the centre line of the crease for a 275 micron thick laminate material. The soft or resilient female roller, which is located on the other side of the laminate to the male roller, supports the forming of the V or U section to prevent scratching, scuffing or cutting of the laminate.
- Soft into hard whereby the above is reversed.

The preferred method is to use a hard male roller to apply the creases to give the optimum crease formation. Typically, the laminate is drawn through one pair of creasing rollers.

[0047] Formers and applicators of creases are rollers having protrusions to form the crease and can be made of PTFE or natural or synthetic nitrile rubber compounds or the like, preferably of 60° shore hardness. The female roller may be made of acetyl, steel, aluminium or brass or the like. Such a combination of rollers provides the best crease without breaking or damaging the barrier layer.

[0048] Creases may be arranged in such a way as to have the welded seam equidistant from both adjacent creases or offset on or towards the square edge of the tube.

[0049] The creasing or scoring rollers can be of several constructions-

i. One piece machined or moulded.
ii. Separate creasers which are shimmed and adjusted for different tube sizes to accommodate variable distances across the "flats", i.e. the distance across the flat surface of the laminate that will form the tube.

[0050] The laminate is drawn through a series of guide rollers which assures the correct positioning of the material through the first machine. The laminate material as it enters the body-forming unit is advantageously positioned and oriented by way of the creases pre-formed in the material.

Body Forming

[0051] In order to create the tube body 1, the material is guided, by way of the creases in the material, through a pre-forming unit 31 into a body-forming die 32 where the material is formed into a continuous tube having a square cross-section. This process is shown schematically in Figure 10. The pre-forming unit 31, which is a device to commence the forming process from flat laminate into a square-shaped tube, may be seen in Figure 11. The laminate is fed from the reel, through a shaped aperture 33 in the pre-forming unit 31 in order to encourage the material to form upward into a curved channel, prior to being fed into the body-forming die 32. The aperture 33 may be in the shape of a "U" or of a "⊔ "..

[0052] A critical part of the forming process is the lead into the U or square shaped pre-forming unit 31 from a round bar. It is essential that the aspect ratio of the angle of incline α to the distance of the lead-in x is exact to avoid wrinkling or malformation of the laminate whilst it is being formed from a flat sheet to a square shaped tube. This incline may be in the range of 5-10 degrees and preferably between 5 and 6 degrees to the horizontal plane.

[0053] The aspect ratios are critical because of the need to lead in a flat material off a reel to subsequently be formed into a square shape. Too steep an incline over too short a distance x results in too much friction, and the square shape not being formed properly. As a result the laminate would drag, perhaps tear and certainly jam the feed device. It would also damage the print surface because in the forming process the laminate passes down through a very narrow guide annulus in the forming process.

[0054] The forming bar in the body-forming die 32 may have perfectly flat, convex or concave sides to facilitate the forming process.

[0055] Once the material has passed through the forming die, optionally being guided by way of the creases, the shaped material is wrapped around a square welding shaft 10, as shown in Figures 7a and 7b. The tube body is produced such that the two edges overlap by about 1.5mm to provide an adequately strong join while minimising the width of material required to make each tube, thereby keeping costs to a minimum.

[0056] The position of the welding shaft 10 in relation to the body former 31 is crucial to the forming of good quality square tubes. The clearances set must be very precise otherwise fouling of the laminate will result in material jamming, machine blockage and spoilage.

[0057] Once the initial positioning is achieved, which is dependent on the size of tube being made and the thickness and type of laminate, the relative positions of the welding shaft 10 and the body former 31 are marked and fixedly located using the setting device and grub screws. The clearances can then be altered if a new batch of differently shaped tubes is to be formed.

[0058] In the case of tubes made from ABL, the overlap is welded by means of a radio frequency (RF) alternating current through a welding coil that heats the aluminium layer of the laminate by induction and melts the PE layers. Pressure is applied to the heated weld joint immediately by a series of rollers in order to seal the weld. The rollers are cooled using chilled water to reduce the temperature of the laminate.

[0059] For tubes made from PBL, the sealing is effected in a different way to that described above, due to the absence of aluminium which renders the RF useless. A tube made from PBL material is sealed using heat pads and pressure rollers. The heat pads heat the plastic internally through the welding shaft and externally through a steel belt with a non-stick coating that follows the tube. Pressure is then applied by the rollers to seal the tube and a further pad then cools the weld.

[0060] Rubber belts underneath and either side of the rounded square profiled welding shaft 10 drive the continuous tube towards a cutting unit 40. According to one embodiment of the invention, the cutting unit comprises a pair of rotating blades 16 that are designed to cut the tube 1 into suitable lengths to produce finished tubes. The blades 16 are mounted on the outside of individual shafts, one of which is above the tube body 1 and the other is below. Rotating in opposite directions, the blades 16 meet after one complete revolution and shear the tube 1, as can be seen in Figure 8.

[0061] Cutting the tube 1 into tube lengths within the cutting unit 40 may be carried out by laterally rotating cutters or cutter-wheel, although such cutters have a tendency to distort the square formed tube by compressing it across its diagonal. This method would thus not be convenient for high speed filling of the tube 1, for example. Two ways to address this disadvantage is to use an alternative cutting method or to re-shape the tube once cutting has taken place.

[0062] Such alternative forms of cutting include:

- Laser
- Hot Wire
- Guillotine
- High speed rotating cutter, which is a lateral cutter that would slice across the body of the tube from the side.

[0063] Reforming of the deformed tube may be achieved by the use of belt reformers in the transition from cutting to the capping process. These belts may be four sided guide belts, made of fibre, rubber or reinforced rubber, and can be flat or convex shaped as necessary to compress the tube back into its square form. These belts would normally be convex to deform the surfaces of the tube in a concave manner, thereby allowing for the memory of the material to spring it back to the flat position like a reflex movement.

[0064] The cut tube body 1 is therefore passed through a reforming unit with the aim of squashing the tube back into its original rounded square shape. Once cut and reshaped, the tube body 1 passes via a transfer belt to a manipulating device which comprises either suction cups, or vacuum turners to orientate the tube for the remaining processes. In the corrected orientation, the polygonal tube falls into a vacuum turner shaped to suit the polygonal profile.

[0065] At this point, any tube whose side seam has been produced without an adequate weld at the machine's start up or tubes that are not the correct length are automatically ejected from the process, immediately after the re-forming operation. All remaining tube bodies pass along a transfer conveyor to the next stage of the process.

[0066] It is also possible to improve the squareness of the creases on the tubes by mounting the tubes on a square mandrel in readiness for the shoulder welding operation and passing a square-cross-sectional sleeve over the tube, thereby trapping the tube between the mandrel and the sleeve. Further movement of the sleeve with respect to the tube then imparts a square shape to the tube.

Application of Shoulder and Caps

[0067] This main assembly unit consists of a fixed number of identical rounded square profiled mandrels spaced evenly around the circumference of a central hub. Each mandrel is attached to the central hub by means of a locking grub screw which holds the mandrel in the correct orientation with regard to the central hub. The axes of these mandrels are parallel to the axis of rotation of the central hub. Each mandrel is designed to exactly fit the cross-sectional square shape of the tube and has a nipple at the end remote from the central hub to accept an injection-moulded polygonal shoulder.

[0068] During this process, perfect alignment of all the components is necessary to ensure no damage occurs to tooling parts and to maintain a good quality tube. With conventional round tubes, if the mandrel spins during manufacture then location is still automatically achieved. With a square tube, the grub screw ensures that the mandrel is in the correct orientation for accepting a tube body over the mandrel. The whole assembly indexes through a set angle after a regular interval.

[0069] With a square shoulder and cap in particular, there are serious alignment issues in locating the cap onto a shoulder without fouling any of the bevelled edges on the taper from the screw threaded neck to the square edge of the shoulder.

[0070] The first operation in this part of the process is the application of the shoulder to the mandrel tip. The shoulder 5 is the portion of the tube between the tube body 1 and the nozzle 2, as shown in Figure 1. Pre-moulded polygonal caps and shoulders are oriented in a bowl feeder and subsequently gravity-fed into a chute where they are stacked, or banked, in a shoulder transfer magazine ready for application on to the tube bodies. A shoulder is transferred to the tip of a mandrel by a manipulator. The main unit then indexes to the next station.

[0071] The tube bodies arriving from the body forming process along the transfer conveyor are orientated by a manipulator and placed in a depression on the outer circumferential surface of a cylindrical rotating unit. The depression itself is rectangular in cross-section and has a series of small holes along its length through which air is drawn from the atmosphere creating a suction device that holds the tube body in place as the unit rotates. The bodies are transferred from this device by a push rod onto the mandrel over the pre-positioned shoulder and the whole unit indexes once again.

[0072] At the next station, the tube body is positioned relative to the shoulder using another push rod. The unit indexes to the next station and the body is clamped to the mandrel to ensure that its position is maintained. At this station, the body and shoulder are prepared for the welding operation by localised controlled heating using hot air. After indexing, the tube and shoulder are welded together using another high frequency welding coil. At the same time the rounded square body is formed around the perimeter of the shoulder portion under pressure in a ceramic forming ring, which has a rounded square aperture profile. PBL material relies on hot air heating and pressure from a non-stick coated forming ring to weld the tube body to its shoulder.

[0073] Should the tube require a membrane seal over the nozzle, for example for hygiene reasons or tamper-proofing, a membrane is applied at the next station. Membrane material is loaded onto an unwind station in reel form and is fed through a membrane tool which consists of a heating element and a die cutter. The membrane tool approaches the shoulder and welds the membrane material to the nozzle purely by heat and light pressure. Simultaneously the cutting die of the membrane tool punches the required shape from the material.

[0074] Caps are applied at the next station in a similar manner to the shoulders in that they are sorted and orientated by a feeder bowl and fed down a chute to the applicator. When the tube is in position, the applicator finger ejects the cap from the cassette and loads it into the capping tool. For caps which have a screw thread, the cap is introduced to the thread on the nozzle and is screwed into place. The capping tool retracts and the main unit indexes once again. The next operation is cap tightening. This is achieved by applying a rapidly rotating rubber disc or moulded sleeve under a fixed pressure to the cap of the tube.

[0075] Alternatively, if the cap has a push fit, the cap is simply applied firmly to the nozzle. If the cap has a square external profile, it is important that the cap is located squarely on the nozzle so that the outer profile of the finished tube is smooth. In order to achieve this, alignment means are provided, either on the cap thread, on the inner surface of the cap if no thread is present, externally on the nozzle or shoulder or on both the cap and the shoulder.

[0076] The unit indexes to its final position, completing a full cycle of 360°, where the clamps are removed from the body and the tube is ejected from the mandrel by a burst of compressed air through its tip into a receptacle on a transfer conveyor.

Tube Packing

[0077] The tubes proceed along the transfer conveyor and any tubes that were produced with an inadequate shoulder weld or no cap are automatically removed from the process.

[0078] Referring to Figure 9, the remaining tubes 25 are delivered to an accumulator 22 before being transferred onto a smooth or profiled packing belt 24 which allows them to settle onto a flat face. The differential timing of the packing belt 24 with regard to the timing of the tube delivery is designed to maintain a regular spacing between the tubes. When a sensor 23 detects that sufficient tubes have accumulated against an end stop 21, the accumulator 22 and packing belt 24 stop and a push bar loads the appropriate number of tubes 25 into a waiting box 20. This cycle then repeats until the box 20 is fully loaded. Once full, the box 20 is automatically removed from the machine and replaced with an empty one. Boxes are then sealed and palletised ready for despatch.

[0079] Due to the advantageous shape of the tube according to the present invention, a carton for each individual tube is not required, but may be used if desired. In this case, the tubes would be packed into cartons prior to being packed into boxes.

[0080] Although throughout the description, the tube has been described as having a rounded square cross-sectional shape, it is also envisaged that the tube could have a rounded rectangular or other polygonal cross-sectional shape. An angular polygonal cross section would also be possible.

[0081] Furthermore, the method of manufacturing the tube body using laminate sheet material has been described. However, the tube bodies could also be made using a single layer sheet or other suitable material form.

[0082] The present invention has been described above purely by way of example, and modifications can be made within the spirit of the invention, which extends to equivalents of the features described. The invention also consists in any individual features described or implicit herein or shown or implicit in the drawings or any combination of any such features or any generalisation of any such features or combination.

Claims

1. A method of manufacturing a tube having an elongate tube body and a polygonal cross section comprising the steps of:

   a) forming creases in sheet material;
   b) using the creases in the sheet material to locate and orient the sheet material during manufacture of the tube;
   c) forming the tube body in a polygonal form from said sheet material such that the creases form edges of the tube; and
   d) applying a pre-formed shoulder and a cap to a first end of the tube body.

2. A method of manufacturing a tube as claimed in claim 1, wherein the creases are formed on a printed surface on the outside of the sheet material.

3. A method of manufacturing a tube as claimed in claim 1, wherein the creases are formed on an unprinted surface on the inside of the sheet material.

4. A method of manufacturing a tube as claimed in any of the preceding claims, wherein the creases are formed by drawing the sheet material between a first crease-applying roller and a second crease-forming roller.

5. A method of manufacturing a tube as claimed in claim 4, wherein the first crease-applying roller has a harder outer surface than the second crease-forming roller.

6. A method of manufacturing a tube as claimed in claim 4 or claim 5, wherein the hardness of the first crease-applying roller is 60° shore hardness.

7. A method of manufacturing a tube as claimed in any of the preceding claims, wherein the sheet material is on a reel prior to step a).

8. A method of manufacturing a tube as claimed in any of the preceding claims, wherein step c) comprises drawing the sheet material through a shaped aperture in a body former to initiate the shaping of the sheet material into a polygonal form.

9. A method of manufacturing a tube as claimed in claim 8, wherein the angle of incline of the sheet material to the horizontal prior to passing through the body former is in the range of 5° to 10°, preferably 5° or 6°.

10. A method of manufacturing a tube as claimed in claim 8 or claim 9, wherein step c) further comprises drawing the sheet material from the body former through a forming die to form the sheet material into a polygonal form.

11. A method of manufacturing a tube as claimed in any of the preceding claims, wherein the creases are used to guide the sheet material to a welding station

12. A method of manufacturing a tube as claimed in any of the preceding claims, wherein edges of the sheet material are welded together to form a tube after step c).

13. A method of manufacturing a tube as claimed in any of the preceding claims, wherein the sheet material is cut into tube lengths by way of laser cutting, hot wire cutting, a guillotine, a rotating blade or high speed rotating cutter-wheel.

14. A method of manufacturing a tube as claimed in claim 12, wherein the cutting takes place before step d).

15. A method of manufacturing a tube as claimed in any of the preceding claims, wherein a belt reformer is used to reform the tube body in a polygonal form if deformation occurs after step c).

16. A method of manufacturing a tube as claimed in any of the preceding claims, further comprising the step of filling the tube with toothpaste, hair gel, a cosmetic cream or a food paste.

17. A method of manufacturing a tube as claimed in any of claims 1 to 15, further comprising closing a second end of the tube by means of an end portion which portion has the same cross-sectional shape as the tube body.

18. A method of manufacturing a tube as claimed in any of claims 1 to 16, further comprising closing a second end of the tube by means of forming folds in the sheet material, configured so that the sheet material at the closed end includes at least one reverse fold.

19. A method of manufacturing a tube as claimed in any of claims 1 to 16, further comprising closing a second end of the tube by means of forming folds in the sheet material, configured so that the sheet material at the closed end includes four reverse folds in the form of a star.

20. A method of manufacturing a tube as claimed in any of the preceding claims, wherein the cap and shoulder have the same cross-sectional shape as the tube body.

21. A method of manufacturing a tube as claimed in any of the preceding claims, wherein the sheet material is Aluminium, Aluminium Barrier Laminate form (ABL), Plastic Barrier Laminate form (PBL), or ordinary plastic monolayer (Plastic).

22. A tube made by the method of any of claims 1 to 21.

23. A plurality of tubes, each tube being made by the method as claimed in any of claims 1 to 21, formed into a space filling stack, in which the faces of the tubes are touching.

24. A plurality of tubes as claimed in claim 23, wherein the stack is self-supporting.

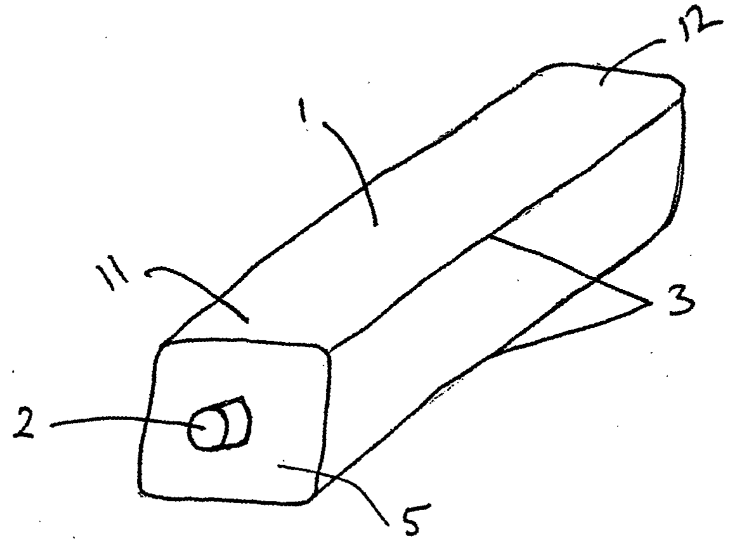


FIGURE 1

FIGURE 2

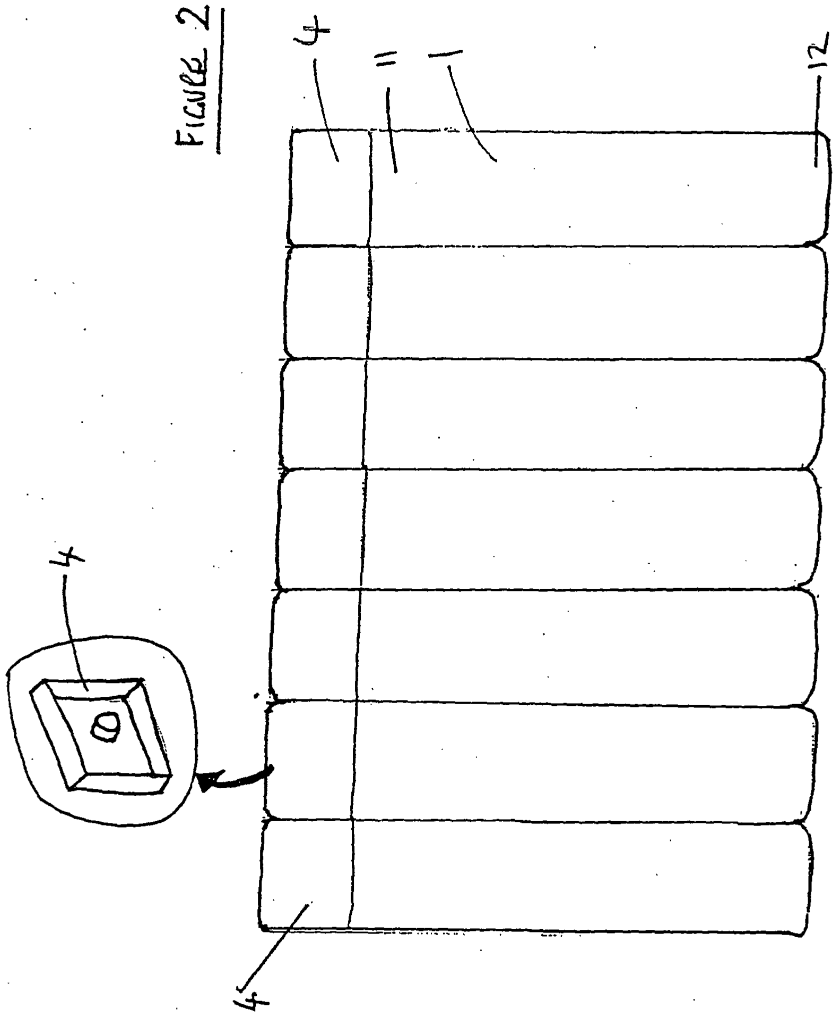


FIGURE 3

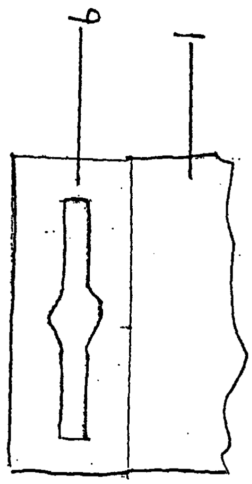
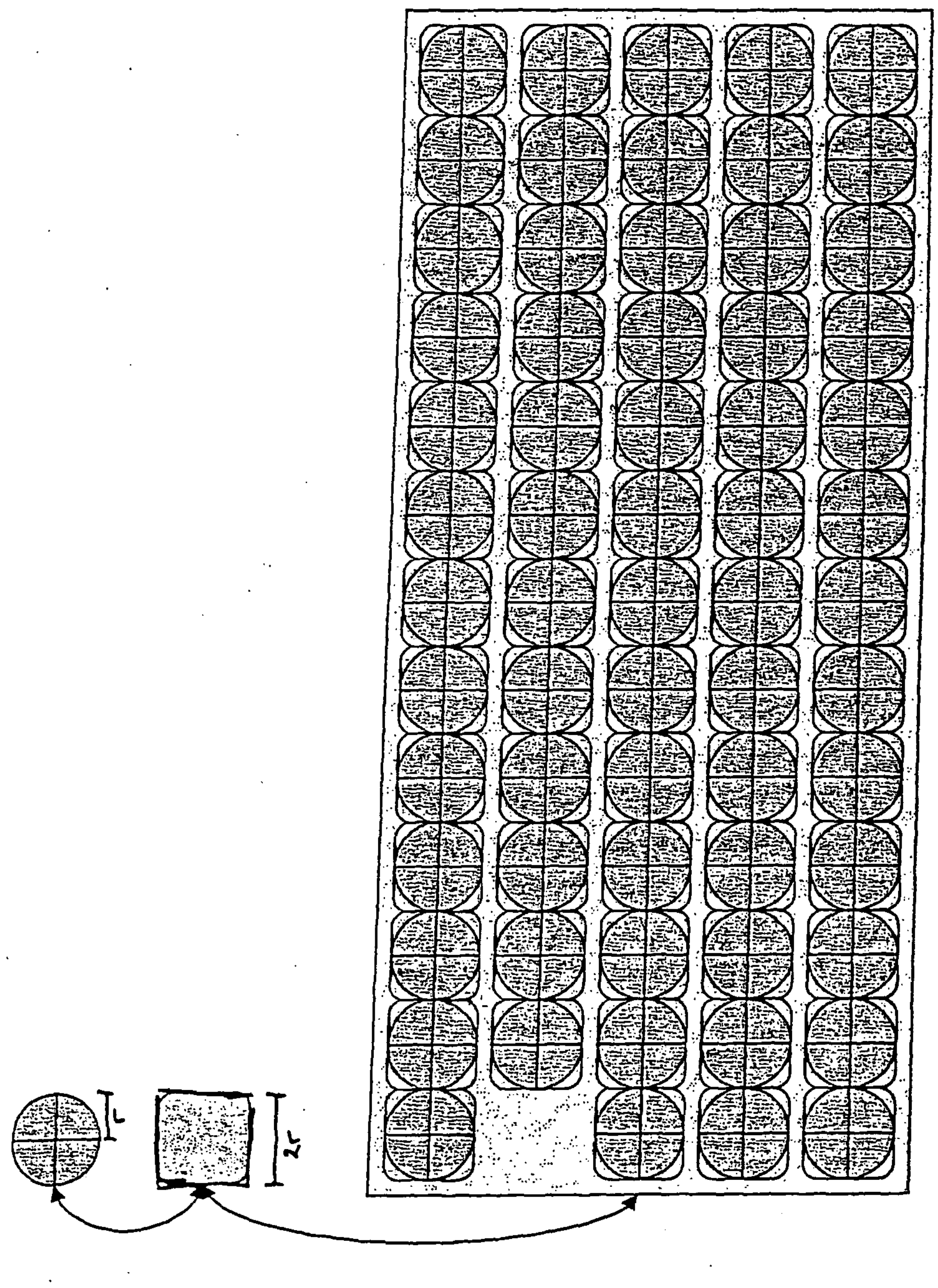


Figure 4



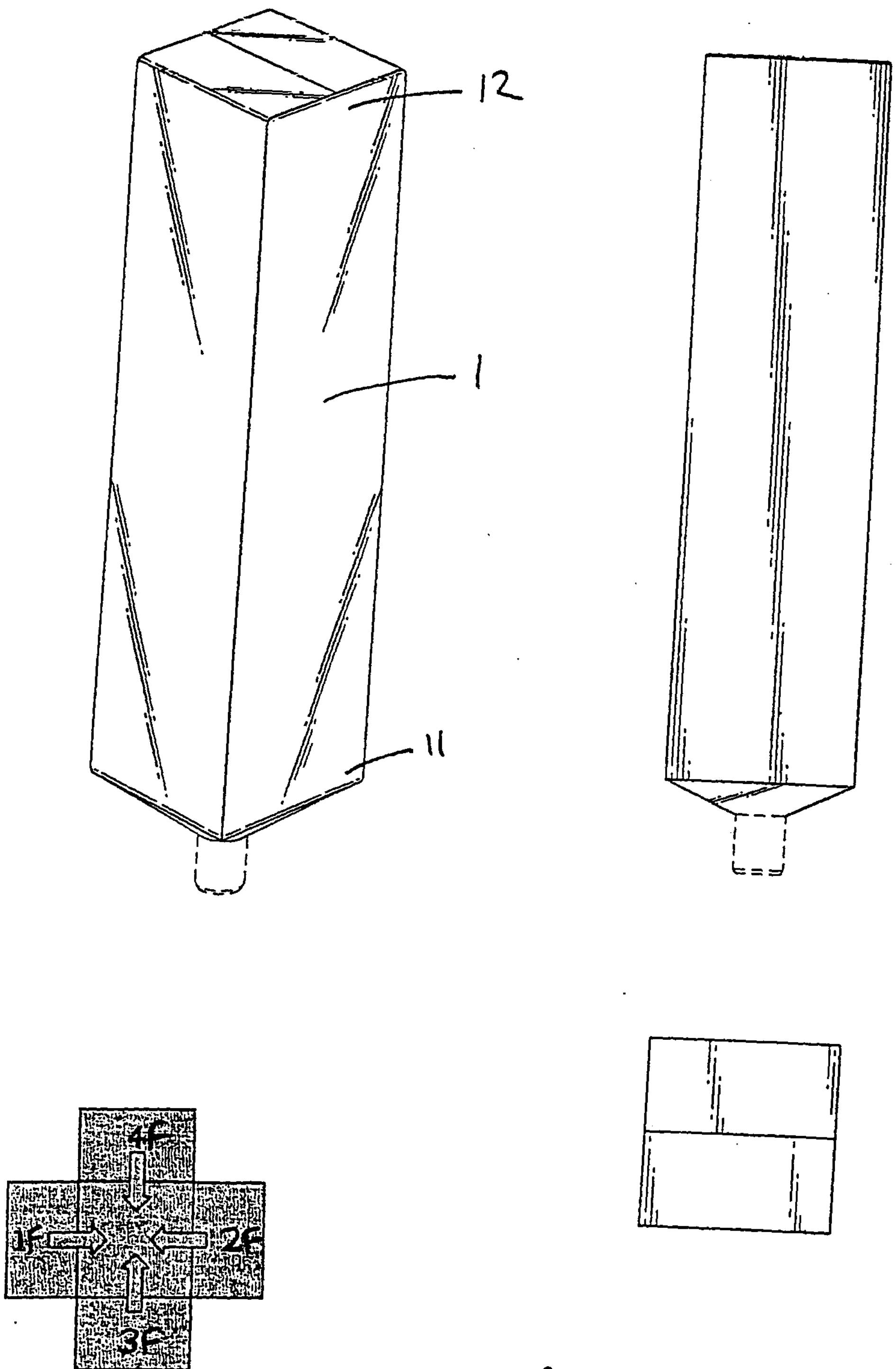
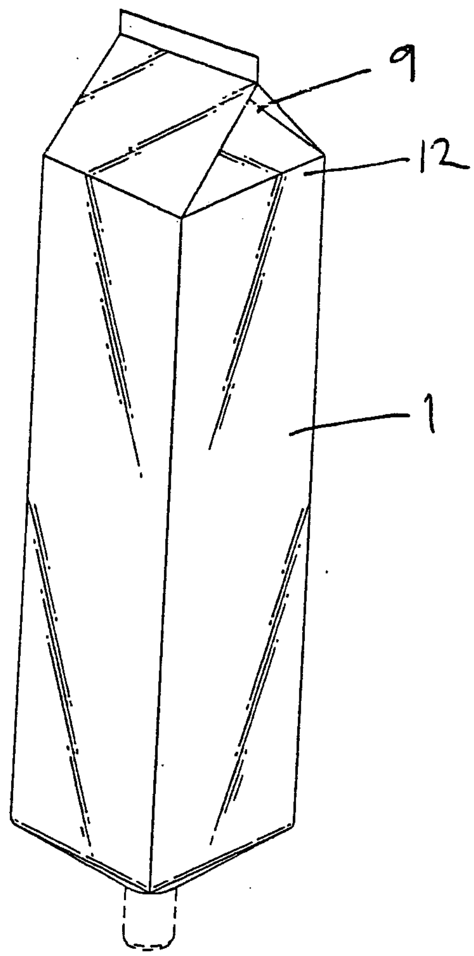
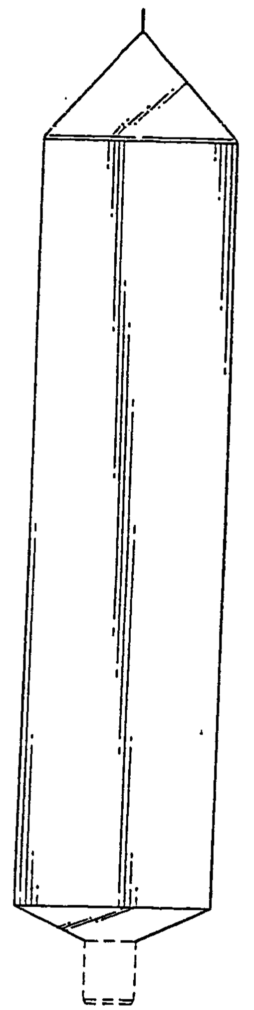


Figure 5a





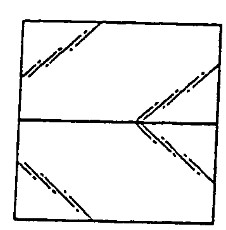
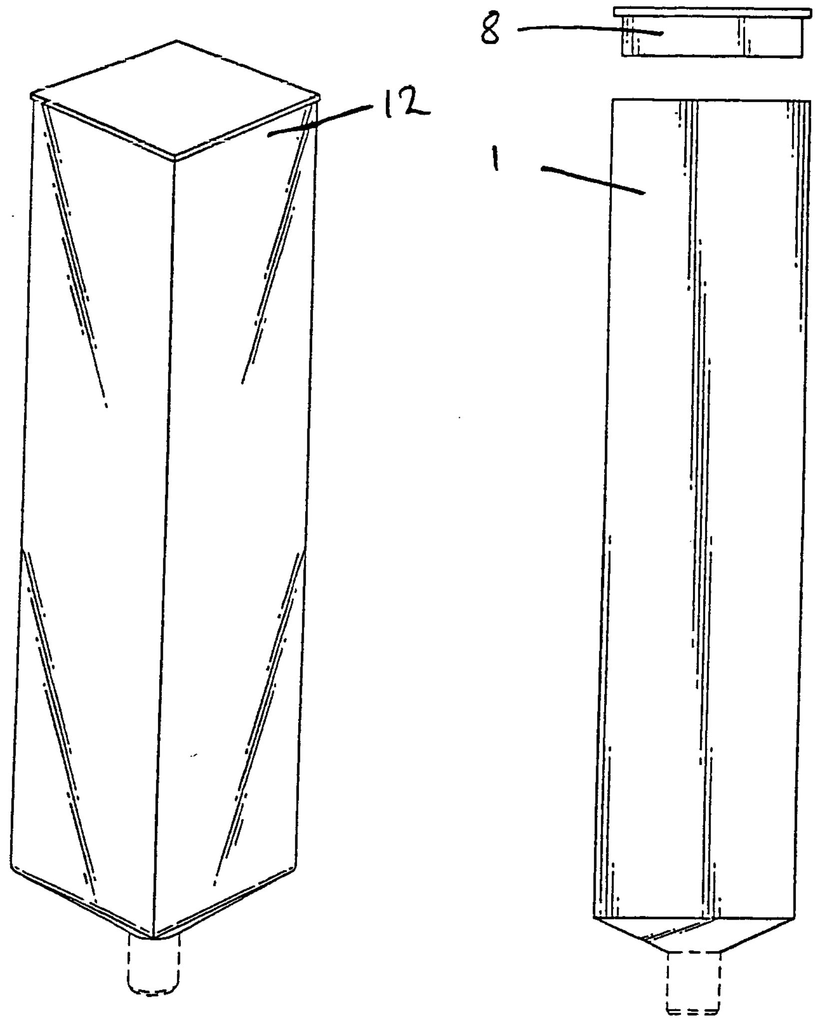


Figure 5b



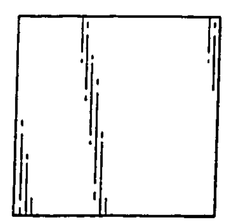
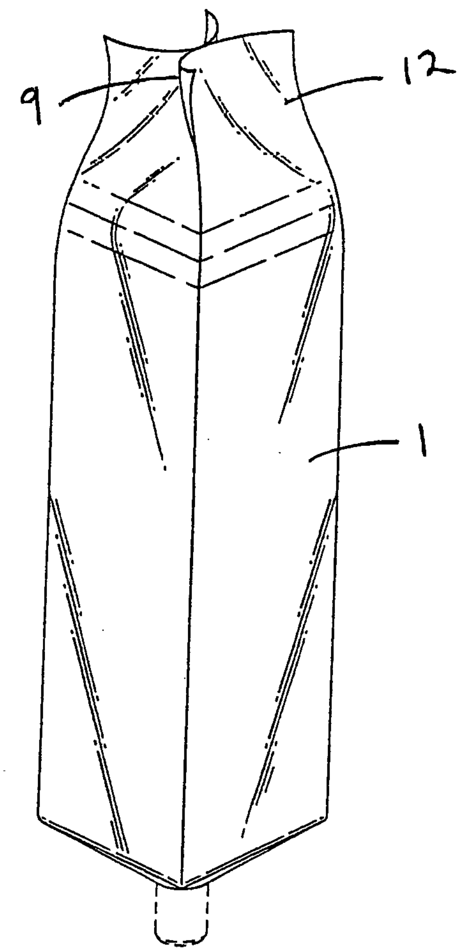
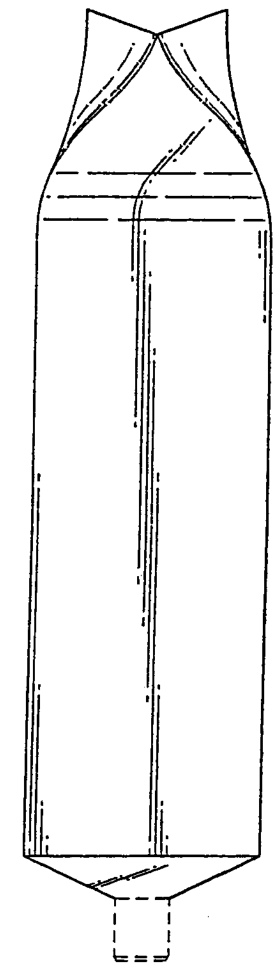


Figure 5c





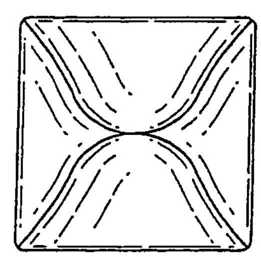
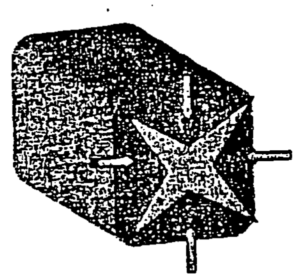


Figure 5d



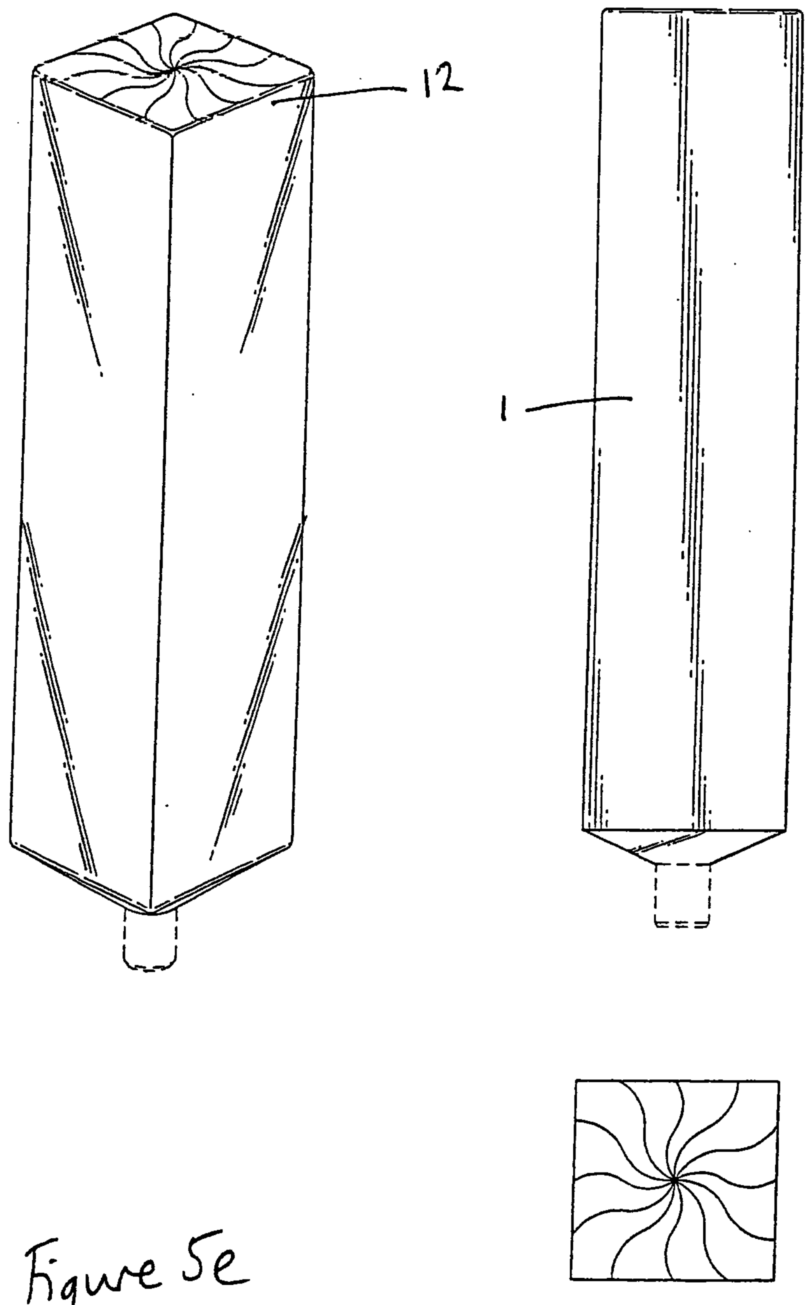


Figure 5e

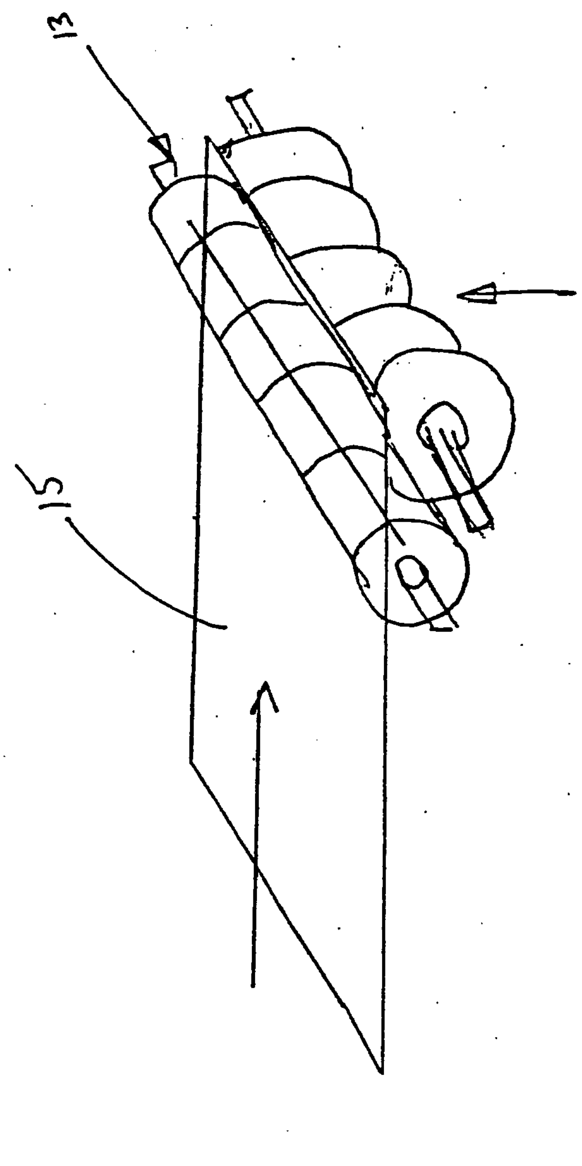


Figure 6

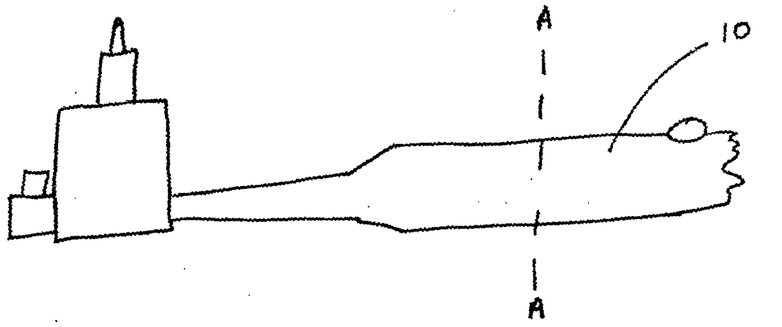


figure 7 a

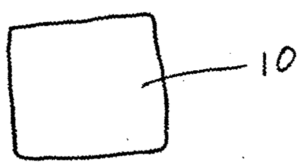


figure 7b

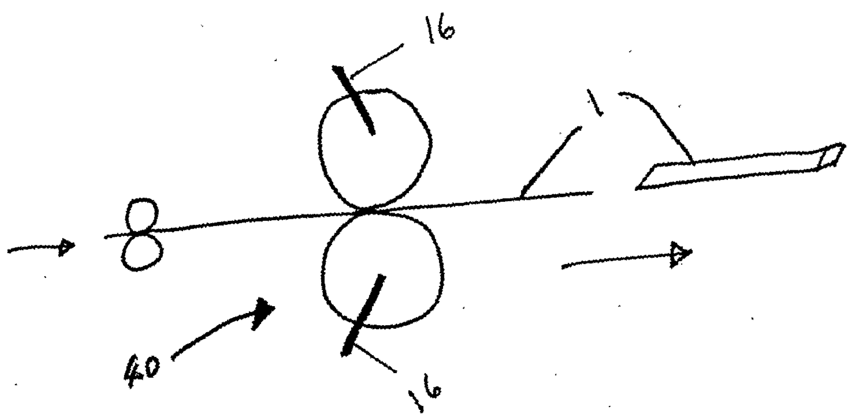


figure 8

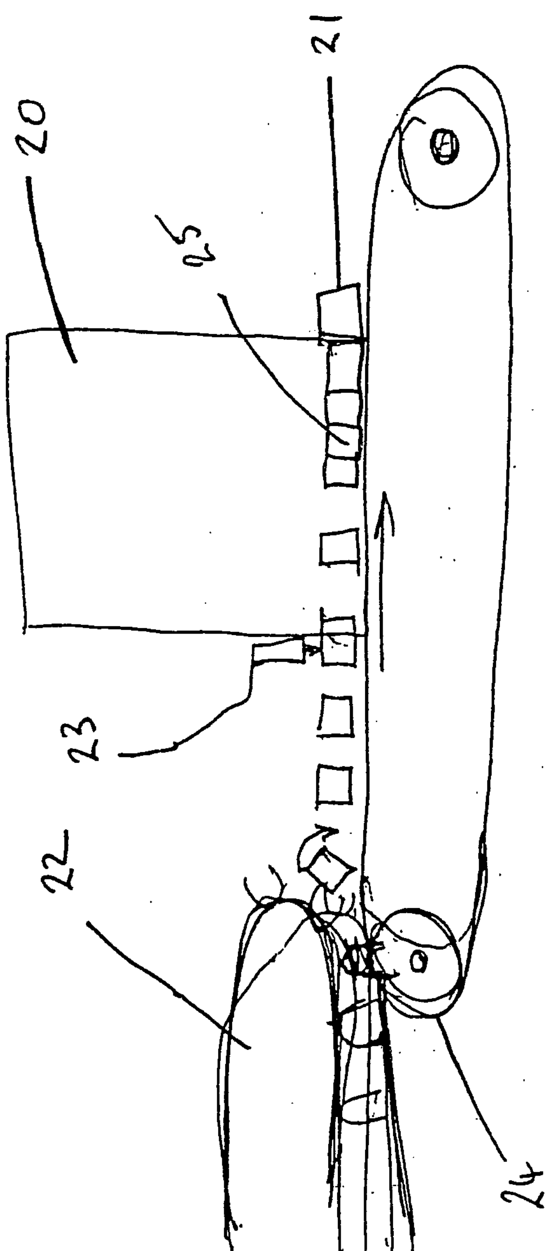


figure 9

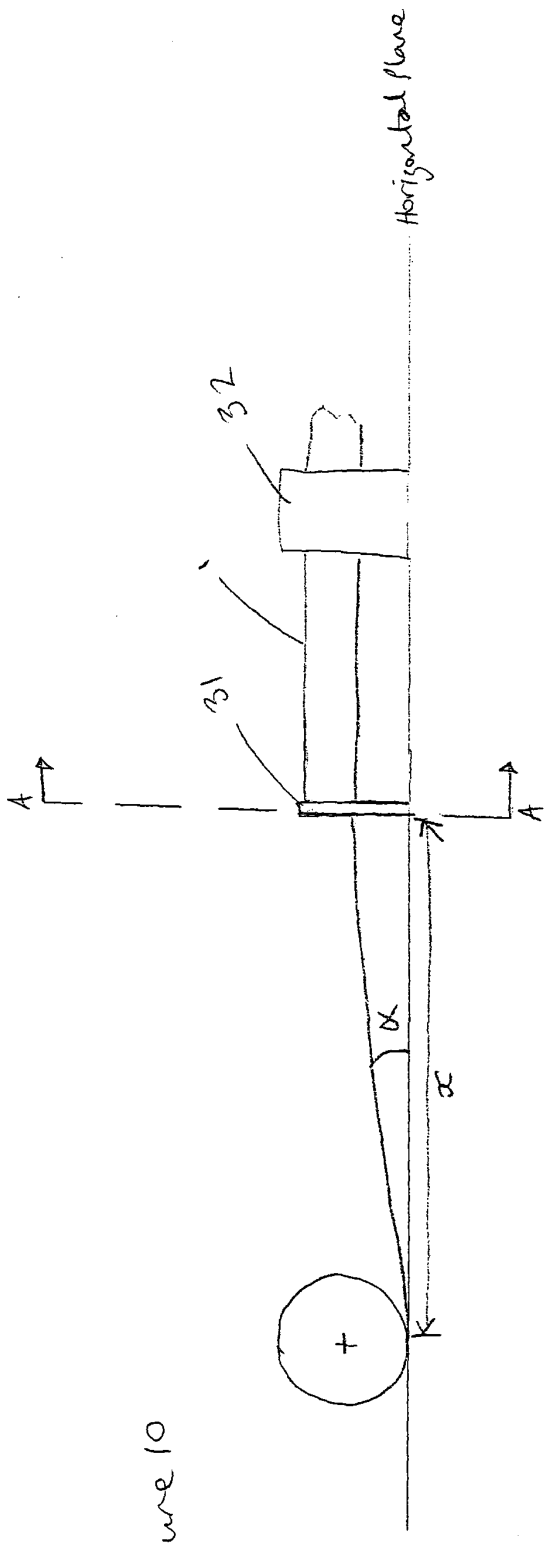


figure 10

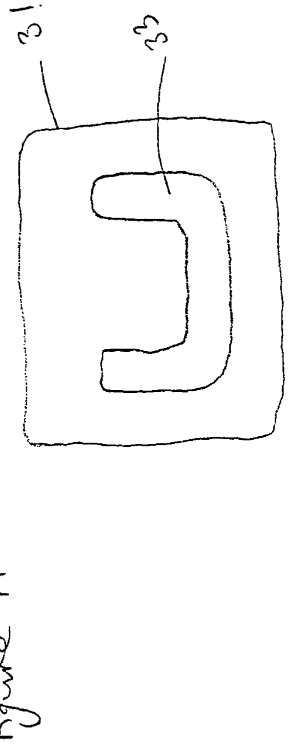


figure 11