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(71) Applicant *(for all designated States except US)*: **GAL-GAG LTD.** [IL/IL]; P.O. Box 12, 12800 Katzrin (IL).

(72) Inventor; and
(75) Inventor/Applicant *(for US only)*: **SLUTSKI, Sagi** [IL/IL]; Meshek 24, 30820 Moshav Dor (IL).

(74) Agent: **FRIEDMAN, Mark, M.**; Beit Samuelov, Haomanim Street 7, 67897 Tel Aviv (IL).

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(54) Title: EXTRUSION MOLDING APPARATUS FOR CORRUGATED WEB AND ROOFING METHOD EMPLOYING THE SAME

(57) Abstract: An apparatus (14) for continuously producing corrugations in an extruded plastic web (2) includes a master roller (22) and at least one auxiliary roller (24). Each roller is mounted rotatably about its central axis. A first set of interchangeable, elongated, profiled inserts (28) are attachable around, and projecting from, the master roller (22), while a second set of interchangeable, elongated, profiled inserts (28') are attachable around, and projecting from, the first auxiliary roller (24). The two sets of inserts (22, 22') are configured such that, when the master roller (22) and the auxiliary roller (24) turn synchronously in opposite directions, the rollers and the first and second sets of inserts cooperate to define and advancing corrugated profile. Also described are various forms of the resulting web, and method for constructing a roof using such web.

Extrusion Molding Apparatus for Corrugated Web and Roofing Method Employing the Same

FIELD AND BACKGROUND OF THE INVENTION

The present invention relates to an extruded plastic web of indeterminate length, provided with corrugations extending across the longitudinal extent of the web, an apparatus for producing these corrugations in the plastic web after its extrusion, and a roof construction method utilizing such a web.

The use of corrugated material for roofs, fences and the like has long been known, the principal materials for these applications being asbestos-cement compounds, fiberglass, galvanized steel sheets, aluminum sheets, and plastics (PC and PVC sheets). These materials are imparted a corrugated configuration either by molding, or by hot or cold pressing.

While corrugated elements from the above-mentioned materials are formed with relative ease, they all suffer from a decisive disadvantage: they exist only in the form of separate sheets, having dimensions limited by the practical size of the molding or press-forming tools used to form them.

When the corrugated elements are used, e.g., for roofing, three main problems are encountered:

a) To prevent leaks, the separate sheets must overlap in two directions, i.e., along and across the roof, adding another 15-20% to the area of the sheets covering the roof.

b) There are problems with connecting points, especially where four corners of the roofing sheets have to be joined to each other and to the rafters. The additional problem of material cracking at these joints is created by the stresses produced by thermal expansion/contraction resulting from changes in the ambient temperature. This is a problem especially acute for brittle materials such as asbestos-cement and fiberglass, and also for large-sized sheets in which cumulative thermal movement may be substantial.

c) With a large number of separate sheets, greater attention must be given to the roof structure, especially to rafter spacing and parallelism, which increases costs.

U.S. Patent No. 5,651,734 discloses a ridge cap roof ventilator consisting of a blank of a corrugated plastic sheet material which is the structural equivalent of corrugated cardboard, having three bonded layers: two outer layers, each consisting of a smooth web, and an inner layer which is corrugated. However, these corrugations arc of a relatively small size and mainly serve as air passages, adding little, if anything, to the mechanical strength of this ridge cover. As can be seen in Fig. 1 of said patent, during application, the corrugated plastic ridge cap is bent about an axis perpendicular to the direction of the corrugations, which would be impossible with corrugations that are designed to impart mechanical strength. Furthermore, the plastic ridge vent is not intended to be directly applied to the rafters, needing as it does a special underlay or shingles.

U.S. Patent No. 4,116,603 discloses a machine for making corrugated material. The disclosure describes separate plate-like forming elements organized in a flat, continuous working table by being connected to a pair of chains driven by pulleys as an ordinary conveyor. At the upper part of the conveyor structure, the individual forming elements are contiguous and, at both ends of the conveyor, they are made to separate, to follow the curved path around the pulleys. Mechanical pressure from the top and vacuum suction from the bottom are used to assure good contact between the forming elements and the formed material. The apparatus described is a complicated, expensive and cumbersome piece of equipment.

SUMMARY OF THE INVENTION

According to one aspect, the present invention provides an extruded web of any desired length, having corrugations that extend across the width of the web (i.e. substantially perpendicular to the length) and are of a size large enough to impart to the web a substantial stiffness about an axis perpendicular to the corrugations.

According to a further feature of the present invention, the material of the web is sufficiently flexible to allow slight deformation of the corrugated form to accommodate strain introduced by forces along the length of the web.

There is also provided, according to the teachings of the present invention, an apparatus for continuously corrugating an extruded web, preferably as a post-extrusion rolling-molding process.

According to a further aspect of the invention, there is provided a method for constructing a roof structure including a covering consisting of at least one, single corrugated web extending along the entire length of the roof.

According to the invention, the above objects are achieved by providing a corrugated web of indeterminate length produced by extrusion, the corrugations of said web being post-extrusion-produced and extending at least across the width of said web, whereby lengths of said corrugated web can be rolled up into bundles for storage, transport and application, and wherein said corrugations are elastically deformable when acted upon by forces applied in a plane substantially parallel to the longitudinal extent of said corrugated web.

According to the invention, this further object is achieved by providing an apparatus for continuously producing corrugations in an extruded web, said apparatus comprising a master roller and at least one auxiliary roller mounted on a stand and adapted to operate in synchronism with said master roller, said rollers having substantially cylindrical bodies rotatable about their axes; a plurality of elongated, profiled inserts attachable around, and radially projecting from, said master roller and said at least one auxiliary roller, the effective profile of said inserts being determined by the desired profile of the corrugations to be produced, the angular distance between said inserts being determined by the desired pitch of said corrugations; and a distributor unit for controlled distribution of a pressurized fluid and/or an underpressure to the spaces between adjacent inserts.

The invention further provides a roof comprising a supporting structure and a covering, characterized in that said covering consists of at least one extruded

corrugated web extending along the entire length of said roof from one end to the other.

BRIEF DESCRIPTION OF THE DRAWINGS

The invention will now be described in connection with certain preferred embodiments with reference to the following illustrative figures so that it may be more fully understood.

With specific reference now to the figures in detail, it is stressed that the particulars shown are by way of example and for purposes of illustrative discussion of the preferred embodiments of the present invention only, and are presented in the cause of providing what is believed to be the most useful and readily understood description of the principles and conceptual aspects of the invention. In this regard, no attempt is made to show structural details of the invention in more detail than is necessary for a fundamental understanding of the invention, the description taken with the drawings making apparent to those skilled in the art how the several forms of the invention may be embodied in practice.

In the drawings:

Fig. 1 is a perspective view of a rolled-up length of corrugated web according to the present invention;

Fig. 2 shows, by way of example, four of a large number of possible profiles of the corrugated web;

Fig. 3 represents a first roofing application for the corrugated web;

Fig. 4 illustrates the connection of the roofing to a member of the roof structure on an enlarged scale;

Fig. 5 represents a second roofing application for the corrugated web;

Fig. 6 illustrates the connection of the roofing to a member of a different roof structure on an enlarged scale;

Fig. 7 is a schematic view of the plant used to produce the corrugated web according to the present invention;

Fig. 8 is an enlarged view of the corrugator of Fig. 7;

Fig. 9 is an exploded view of the master roller;

Fig. 10 is a cross-sectional view of the distributor rotor;

Fig. 11 is a perspective view of the distributor rotor of Fig. 10;

Fig. 12 is a perspective view of the distributor stator;

Fig. 13 is a cross-sectional view of the distributor stator of Fig. 12;

Fig. 14 is a perspective view of the master roller body, showing the access paths of pressurized air and underpressure;

Fig. 15 is an enlarged view of detail A in Fig. 14;

Fig. 16 illustrates the path taken by the pressurized air and the underpressure;

Fig. 17 shows the location of the air hole for the inserts of the upper auxiliary roller;

Fig. 18 illustrates the heating or cooling liquid circulation system in the rollers;

Fig. 19 is a schematic representation of a variation of the corrugator according to the present invention;

Figs. 20A, 20B and 20C show three additional examples of preferred forms of the corrugated web of the present invention;

Figs. 21A and 21B are schematic perspective views of a male circumferential mold insert and corresponding assembled mold roller, respectively, for use in forming the web of Figure 20A;

Figs. 22A and 22B are schematic perspective views of a female circumferential mold insert and corresponding assembled mold roller, respectively, for use in forming the web of Figure 20B;

Fig. 23 is a schematic perspective view of a distributor rotor similar to that of 11 but adapted to provide multiple connections via two separate stators;

Fig. 24 is a schematic perspective view of a master roller employing two distributor units, one of which employs the rotor of Figure 23; and

Fig. 25 is a sectioned perspective view of the master roller of Figure 24.

DESCRIPTION OF THE PREFERRED EMBODIMENTS

Referring now to the drawings, Fig. 1 illustrates a length of a corrugated web **2** according to the present invention, shown as reel **3**, rolled up on a core **4**, ready for application. Web **2** can be produced at any reasonable length and width, mainly limited by the present availability of wide extrusion nozzles and appropriate heavy-duty extruders. The thickness of the profiled web may typically vary between 0.7-2.0 mm, depending on the material used. The material of the web may be substantially any extrudable polymer material with appropriate mechanical properties. Preferred examples include, but are not limited to, thermoplastics and thermoplastic rubber (TPR), with optional additives to provide additional required properties, as is known in the art.

Fig. 2 shows, by way of example, four of a very large number of possible profiles. Profile I conforms to the conventional, sinusoidal shape; profile II is of the omega-type, having arched main elements connected by relatively narrow, flat sections; profile III is substantially trapezoidal, and profile IV shows slight undercuts, which can be handled by the apparatus discussed further below. It should be noted in this context that the term "corrugated" is used herein to denote any form which has a non-planar repetitive shape or "relief" (or cross-sectional profile) in at least one direction. The term "corrugated" does not necessarily imply a smoothly undulating profile, as is already clear from the above examples.

It should also be appreciated that the corrugations of the web of the present invention may be formed in more than one direction. By way of example, Figures 20A-20C illustrate a number of additional preferred implementation of web **2** which are formed with a non-planar repetitive relief in two substantially perpendicular directions. In these preferred examples, the resulting pattern approximates to a pattern of overlapping tiles, thus providing an effect highly suitable for use in the roofing construction method of the present invention.

Fig. 3 illustrates a first roofing method employing corrugated web **2**. The roof construction comprises tubular roof beams **6** and rafters **8**. Further seen are purlins

10, advantageously made of an extruded aluminum profile and fixedly attached to rafters **8**.

The roof, constituted by two overlapping lengths of the corrugated web **2** of, in this case, profile II (Fig. 2), is attached to purlins **10** by means of, e.g., self-tapping screws **12**, as seen in the enlarged detail of Fig. 4. The advantage of the rolled-up corrugated web is clear: the reel **3** (Fig. 1), holding a length of web **2** advantageously precut to the length of the roof, can be lifted up onto the roof, resting on the first two purlins **10**. After one end of web **2** is attached to the end of the front purlin **10** using screws **12**, the web **2** is unreeled and screwed to purlin **10** at reasonable intervals along the entire length of the roof. The procedure is then repeated with the second, overlapping part of the roofing.

Fig. 5 represents a second roofing method in which purlins are not required, as the omega-type web **2** directly rides on rafters **8**, as seen in the enlarged detail A of Fig. 6. Here, another advantage of the corrugated web according to the invention becomes apparent: the distance a between rafters **8** need not be an exact multiple of the pitch **1**, of the corrugations, as by slightly compressing or stretching web **2**, the web will accommodate surprisingly large discrepancies.

The forms of Figures 20A-20C have an additional advantage of tending to accommodate strains (such as from thermal stress) in two directions.

The corrugated web according to the present invention is obviously also suitable for arched roofs and awnings. Due to its above-mentioned stretchability and compressibility, it is also suitable for use in awnings and similar structures that follow a conical geometry.

The web is also eminently suitable for use as fencing, either temporary, as on building sites, or permanent, attached to poles driven into the ground at reasonable distances.

The corrugated web can also be produced as a two-layer structure, either by co-extrusion of two different plastics, or by lamination, which, as will be shown further below, takes place after extrusion. The added layer may have different purposes, e.g., decorative or for commercial advertising. Another purpose would be

the enhancement of UV-resistance or thermal and acoustic insulation, when a foamed plastic is used for lamination. Furthermore, it is possible to provide the corrugated web with embossed markings, applied during the production process.

Fig. 7 is a schematic view of the plant used for the production of the corrugated web of the present invention.

The invention also provides corrugating apparatus **14** (hereinafter, "corrugator") which will now be described in detail. Extruder **16** and controlled-tension take-up winder **18** are per se known, and are shown for better understanding of the corrugator itself.

In the enlarged view of Fig. 8, there are seen three rollers mounted in stand **20**: master roller **22**, upper auxiliary roller **24** and lower auxiliary roller **26**. The rollers are driven in the conventional way and their center distances are adjustable by equally conventional means What appear to be "teeth" are in fact elongated inserts **28**, **28'**, which are attached to rollers **22**, **24**, respectively, extend over their entire length, and are replaced when the corrugation profile is changed (see Figs. 2 and 20A-20C), each profile requiring its own inserts. In certain cases, circumferential mold elements, spanning a larger part of the periphery of the rollers, are used in place of more numerous localized inserts to provide the required profile. An example of such circumferential inserts will be described with reference to Figures 21 and 22 below. Also seen is nozzle **30** of extruder **16**, from which a web of still hot, pliable plastic material issues right into the gap between upper auxiliary roller **24** and master roller **22**.

Turning briefly to Figures 21 and 22, these show male and female circumferential “inserts” or molds, respectively. In these cases, two or more complementary inserts completely encircle the roller to provide the required profile. In the case of Figures 21A and 21B, the inserts together form a male mold configuration suited for the underside of the web of Figure 20A (tile pattern on a rectangular grid). The male mold configuration must, of course, be opposed by a complementary female mold configuration (not shown) on the adjacent roller. The inserts of Figures 22A and 22B, on the other hand, together form a female mold

configuration, in this case suited to the upper side of the web of Figure 20B (staggered tile pattern). Here too, the female mold must be opposed by a corresponding male mold.

It is at this point that the corrugation work begins. As will be explained in greater detail further below, corrugation is preferably effected by the cooperation of three forces: the purely mechanical force with which an insert **28'** of auxiliary roller **24** pushes the web down into the space between two inserts **28** of master roller **22**; the force of jets of compressed air issuing from that insert **28'** which is just meshing with inserts **28** of master roller **22** (see small, outwardly directed arrow); and the force of underpressure or vacuum drawing the still pliable web into the space between two inserts **28** and holding it there along about a third of the circumference of master roller **22** (see small, inwardly directed arrows). With the rotation of master roller **22**, the underpressure is replaced by jets of positive pressure (see outwardly pointing arrow at the lowermost gap between inserts **28**, releasing the by-now fully formed and cooled corrugation which, together with the preceding corrugations, is deflected by lower auxiliary roller **26** and moves towards the controlled-tension take-up winder **18** (Fig. 7). In the case of circumferential inserts which substantially encompass the rollers, fluid pressure and underpressure must clearly be delivered via conduits formed through the material of the inserts themselves.

An explanation will be given further below as to how both the pressure and underpressure reach their points of action.

As can be seen, lower auxiliary roller **26** is not provided with inserts, serving mainly to cool and deflect the fully corrugated web as stated above, although for some types of corrugation profiles, inserts may advantageously be added.

All three rollers **22**, **24** and **26** are preferably provided with means for circulation of fluids, typically liquids, to either heat or cool the rollers. Master roller **22** requires cooling, as does lower auxiliary roller **26**, while upper auxiliary roller **24** typically requires heating. The circulation system will be discussed further below.

Also indicated in Fig. 8 is an attachment **34** for applying laminations, as mentioned above. A web **36** of the material used is drawn off a reel **38** mounted on

bracket **40** and introduced between rollers **22** and **24**, together with the hot web issuing from nozzle **30**. Thus, web **36** is fused with the freshly extruded web.

Fig. 9 is an exploded view of master roller **22**. There can be seen a plurality of inserts **28** surrounding body **42** of roller **22**. Inserts **28** are seated in recesses **44** and grooves **46**, into which fit keys **47** of the inserts. Body **42** is hollow and accommodates a tubular member **48**, the outside surface of which defines, with the inside surface of the hollow body **42**, an annular space **50**. As will be explained further below, annular space **50** serves for the circulation of a cooling liquid.

Also seen in Fig. 9 is a distributor unit **52** for the above-mentioned controlled distribution of pressurized air and underpressure. This unit is comprised of a distributor rotor **54** fixedly attached to roller body **42**, and a distributor stator **56** attached to stand **20** (Fig. 8) by means of lugs **58** which are used to define a desired angular orientation of distributor stator **56**.

A cross-sectional view of distributor rotor **54** is shown in Fig. 10. Rotor **54** is seen to comprise three different portions: a flange-like portion **60**, whereby rotor **54** is fixedly attached to roller body **42**, a central portion **62** on which stator **56** is seated, and an end portion **64** which serves as a journal member.

Rotor **54** is provided with a plurality of passageways **65**, of a number equal to the number of inserts **28** in roller **22**. Passageways **65** begin in circumferentially disposed holes **66** in the central portion **62** and end in peripherally located holes **68** in the face of flange portion **60** at such radial and angular positions relative to roller body **42** that they will communicate with grooves **46**, the depth of which exceeds the height of insert keys **47**. The course of passageways **65** is followed to better advantage in the perspective view of Fig. 11.

Fig. 12 is a perspective view of distributor stator **56** (without mounting lugs **58**), shown also in the cross-sectional view of Fig. 13. Stator **56** has two inlet ports provided with pipe connectors (not shown), port **70** for connection to a source of underpressure, e.g., a vacuum pump, and port **72** for connection to a source of pressurized air, e.g., a compressor. Port **70** communicates with a peripheral groove **74** at the inside of stator **56**. Groove **74** has an angular extent of about 75° and

provides underpressure to most of the left half of master roller **22** in Fig. 8 (see small, inward-pointing arrow). Port **72** communicates with another peripheral groove **76**, of a much smaller angular extent, and provides pressurized air to the point where the corrugated web is to be released from master roller **22**. Thus, at least some conduits are preferably connected sequentially to the source of pressurized fluid and to the source of underpressure alternately during each revolution.

It should be noted that, by rotating the angular position of distributor stator **56** about the axis of rotation, the regions of application of pressure and underpressure can be moved. This provides a valuable timing adjustment for accommodating variations in the type of material used for the web, as well as variations in web thickness and other parameters.

Figs. 14-16 explain the way in which pressurized air and underpressure from distributor unit **52** reach the corrugation area. As seen in Fig. 10, the exit holes **68** of passageways **65** are located opposite, and have access to, grooves **46** in roller body **42**. As the pressurized air and the underpressure are required between two inserts **28**, i.e., on the land **45** between two recesses **44**, a plurality of slots **78** is milled across all recesses **44**, the ends **80** of which slots are beyond the width of recesses **44**. Fig. 15 is an enlarged perspective view of detail B in Fig. 14. Fig. 16 clearly indicates the path taken by the pressurized air and the underpressure (obviously, in the opposite direction).

Referring back to Fig. 8, it is clearly seen that the pressurized air jet active in upper auxiliary roller **24** must issue from the center of inserts **28**. This makes the routing of the pressurized air much simple, as all that is needed is a hole **81**, drilled from key **47** through insert **28** (see Fig. 17).

To keep the various rollers at a prescribed temperature range (master roller **22** - cool; upper auxiliary roller - hot; lower auxiliary roller - cool), a circulation system that will maintain these temperature characteristics must be provided for each roller. The present invention solves this problem by providing a second distributor unit **84** (see Fig. 18) in which stator **85** has an inflow opening **86** for the hot, respectively cold, liquid, and a return flow opening **88**, axially displaced from the inflow opening,

for the cooled-down, respectively warmed-up, liquid. In this case, the distributor stator (not shown) preferably has two flow channels each encompassing an entire 360° range for maintaining continuous flow connection with openings **86** and **88**. There is also provided a system of baffles **82**, preferably in the form of a two-start Archimedean screw (double-helix) mounted in annular space **50**, thus creating two separate helical chambers, one for the inflow, indicated by solid lines in Fig. 18, and one for the return flow, indicated by broken lines. The return flow is led to a heat exchange recirculation system (not shown), where it is reheated, respectively re-cooled, before being pumped back to inflow opening **86**.

While in the embodiment represented in Fig. 18, distributor unit **52** and distributor unit **84** are mounted on opposite ends of rollers **22** or **24**, a design is definitely feasible in which these units are mounted one behind the other, on the same end of these rollers. An example of a distributor rotor for such an application is illustrated schematically in Figure 23, while Figures 24 and 25 show a preferred implementation of a master roller employing such a distributor unit. Such a double unit may be a replacement for the separate cooling/heating fluid distributor, or as a addition thereto. In the latter case, the provision of more numerous flow conduits offers increased flexibility for application of fluid pressure, treatment chemicals or underpressure to different regions of the roller. Furthermore, the use of two separate distributor stators enables independent adjustment of the angular timing of the different fluid flow connections.

Although the above description has, in places, referred primarily to the structure and features of the master roller, it will be appreciated that the features of the upper auxiliary roller **24** are typically fully analogous to those of the master roller **22**, and will be self-evident to one ordinarily skilled in the art. Roller **26** typically needs only the distributor unit for the cooling unit.

A variant of the corrugator according to the present invention is seen in Fig. **19**. This variation uses pre-manufactured rolls **90** of plastic webs, which are run through corrugator **14** via two deflection rollers **92, 94**. On the way to corrugator **14**,

this web is pre-heated by passing below a series of heating elements **96** that ensure the pliability required for the corrugation process.

It will be evident to those skilled in the art that the invention is not limited to the details of the foregoing illustrated embodiments and that the present invention may be embodied in other specific forms without departing from the spirit or essential attributes thereof The present embodiments are therefore to be considered in all respects as illustrative and not restrictive, the scope of the invention being indicated by the appended claims rather than by the foregoing description, and all changes which come within the meaning and range of equivalency of the claims are therefore intended to be embraced therein.

WHAT IS CLAIMED IS:

1. An apparatus for continuously producing corrugations in an extruded plastic web, the apparatus comprising:

(a) a master roller and at least a first auxiliary roller, each of said rollers having a central axis and being mounted rotatably about its central axis, said rollers being adapted to operate synchronously;

(b) a first set of interchangeable, elongated, profiled inserts attachable around, and projecting from, said master roller;

(c) a second set of interchangeable, elongated, profiled inserts attachable around, and projecting from, said first auxiliary roller, said first and second sets of inserts being configured such that, when said master roller and said first auxiliary roller turn synchronously in opposite directions, said rollers and said first and second sets of inserts cooperate to define an advancing corrugated profile.

2. The apparatus of claim 1, further comprising a distributor unit associated with said master roller and configured to provide controlled distribution of a pressurized fluid or an underpressure to at least one region of an outer surface of said master roller.

3. The apparatus of claim 2, wherein said controlled distribution occurs along fluid flow paths formed in said master roller.

4. The apparatus of claim 2, wherein said controlled distribution occurs along fluid flow paths formed at least in part by portions of said inserts.

5. The apparatus of claim 2, wherein said distributor unit includes:

(a) a distributor rotor fixedly and concentrically attached to an end of said master roller, said distributor rotor including a plurality of conduits; and

(b) a distributor stator surrounding at least part of said distributor rotor, said distributor stator having at least one flow channel deployed so as to selectively come into fluid communication with a subset of said plurality of conduits, said distributor stator having at least one port for connection to a source of pressurized fluid or underpressure.

6. The apparatus of claim 5, wherein said subset of conduits in fluid communication with said at least one flow channel is defined by an angular range about said central axis of said master roller, and wherein said distributor stator is rotatably adjustable so as to allow adjustment of an angular position of said angular range.

7. The apparatus of claim 5, wherein said at least one flow channel is implemented as a first flow channel for supplying pressurized fluid and a second flow channel for supplying underpressure, said first and second flow channels being deployed such that each of said plurality of conduits comes into sequential fluid communication with each of said first and second flow channels during each revolution of said master cylinder.

8. The apparatus of claim 2, wherein said distributor unit includes:

(a) a distributor rotor fixedly and concentrically attached to an end of said master roller, said distributor rotor including a plurality of conduits;

(b) a first distributor stator surrounding a first part of said distributor rotor, said first distributor stator having at least one flow channel deployed so as to selectively come into fluid communication with a subset of said plurality of conduits, said first distributor stator having at least one port for connection to a source of pressurized fluid or underpressure; and

(c) a second distributor stator surrounding a second part of said distributor rotor, said second distributor stator having at least one flow channel deployed so as to selectively come into fluid communication with a subset of said plurality of conduits, said second distributor stator

having at least one port for connection to a source of pressurized fluid or underpressure.

9. The apparatus of claim 1, wherein said master roller is hollow and contains at least one heat exchange fluid flow conduit.

10. The apparatus of claim 9, wherein at least part of said at least one heat exchange fluid flow conduit assumes a substantially helical form extending along substantially an entire length of said master roller.

11. The apparatus of claim 9, further comprising a distributor unit associated with said master roller and configured to connect a supply of heat exchange fluid so as to generate a fluid flow through said at least one heat exchange fluid flow conduit.

12. The apparatus of claim 11, wherein said distributor unit includes a distributor rotor fixedly and concentrically attached to an end of said master roller, said distributor rotor including a plurality of conduits, and a distributor stator surrounding at least part of said distributor rotor, said distributor stator having at least a supply channel connected to a fluid inlet port and a drain channel connected to a fluid outlet port, said distributor stator being configured to maintain fluid connection between each of said supply channel and said drain channel and a corresponding selected group of said plurality of conduits during rotation of said master roller.

13. The apparatus of claim 11, further comprising a heat exchange recirculation system associated with said inlet and outlet ports of said distributor stator.

14. The apparatus of claim 1, wherein said first auxiliary roller is mounted above said master roller, the apparatus further comprising a second auxiliary roller mounted below said master roller.

15. A web comprising an elongated web of extruded material having a direction of elongation parallel to a direction of extrusion and a width perpendicular to said direction of elongation, wherein said web features a non-planar repetitive relief which is repetitive along both said direction of elongation and said width.

16. The web of claim 15, wherein said non-planar repetitive relief approximates to a pattern of overlapping tiles.

17. A method for constructing a roof comprising the steps of:

(a) providing an open support structure defining an inclined roof portion having a length substantially perpendicular to said incline and a width along said incline;

(b) providing at least one roll of extruded thermoplastic web;

(c) deploying said web so as to substantially cover said inclined roof portion with a plurality of cut-lengths of said web, each of said cut-lengths spanning substantially the entirety of said roof portion length, each of said strips overlapping at least another one of said strips in the direction of said roof portion width.

18. The method of claim 17, wherein said web is a corrugated web deployed with corrugations extending substantially parallel to said width.

19. The method of claim 17, wherein said web is formed with a non-planar repetitive relief in two substantially perpendicular directions.

20. The method of claim 19, wherein said non-planar repetitive relief approximates to a pattern of overlapping tiles.

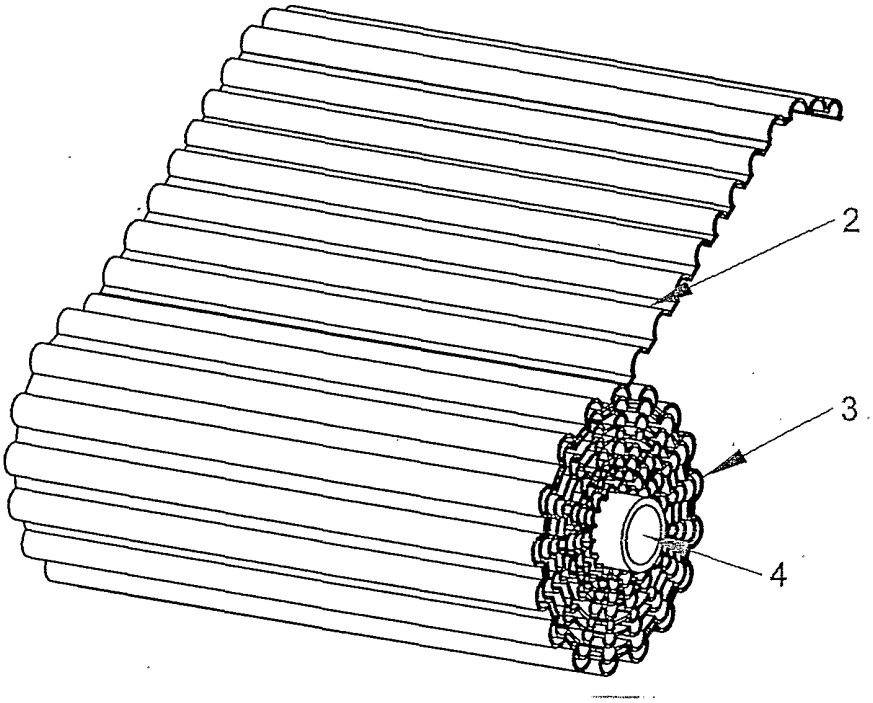


Fig .1

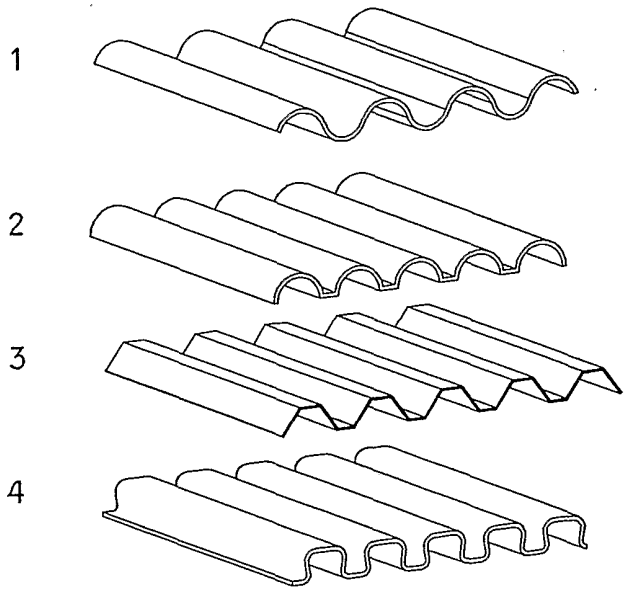


Fig .2

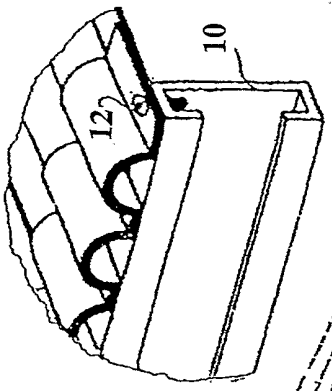


Fig. 4

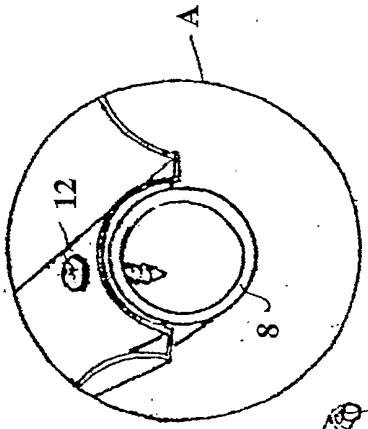


Fig. 6

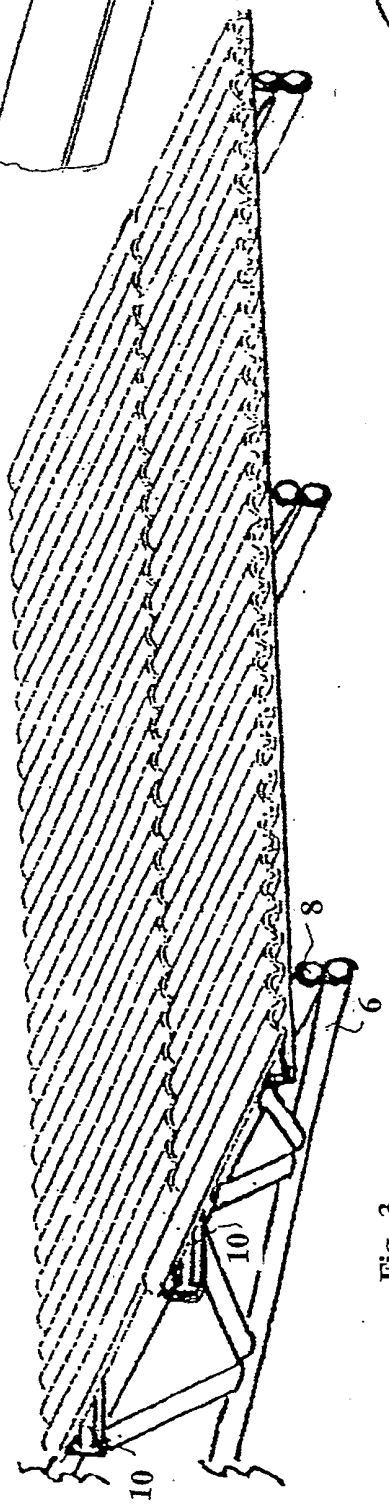


Fig. 3

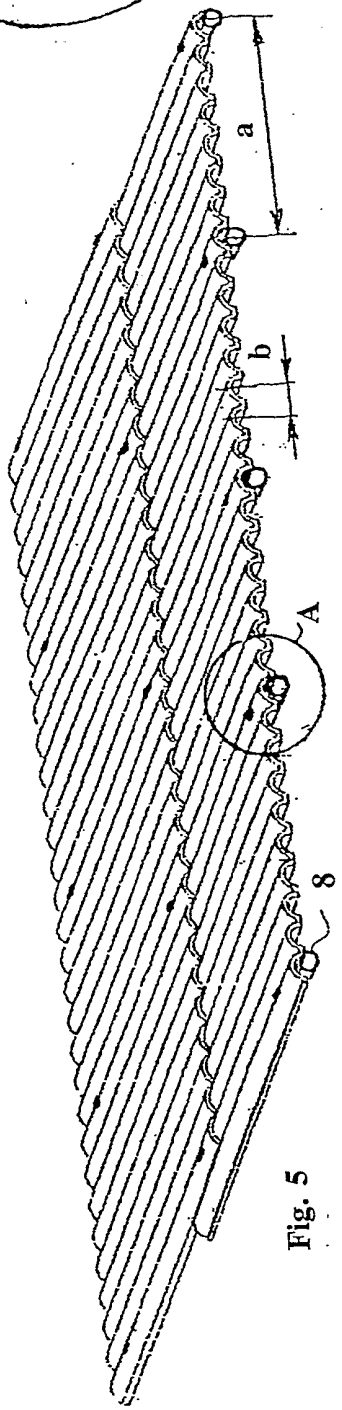


Fig. 5

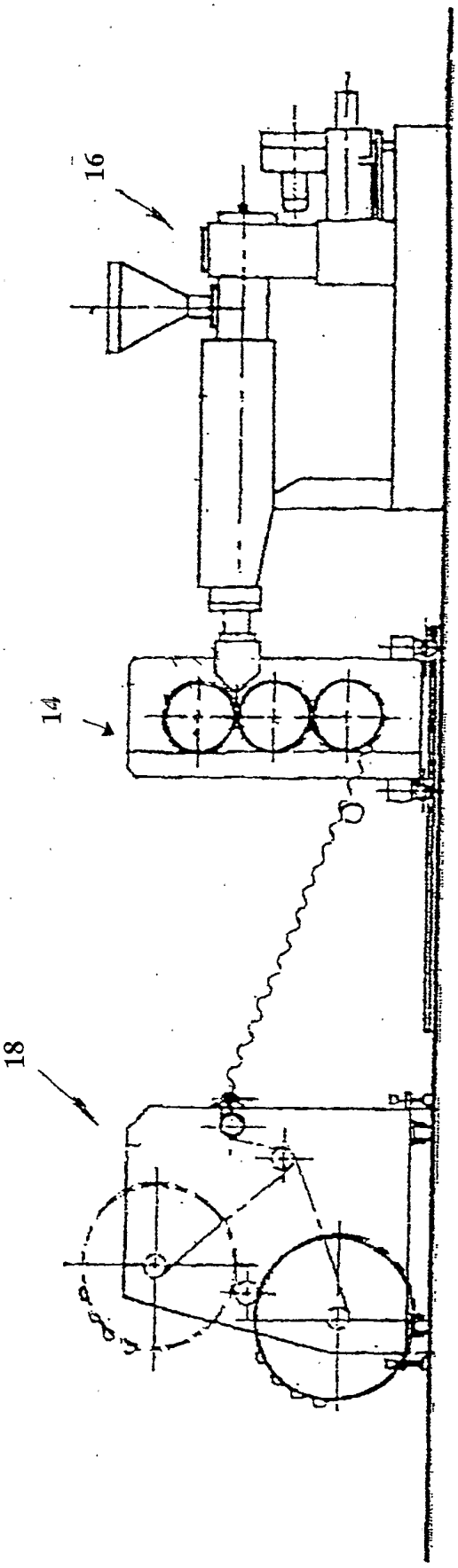


Fig. 7

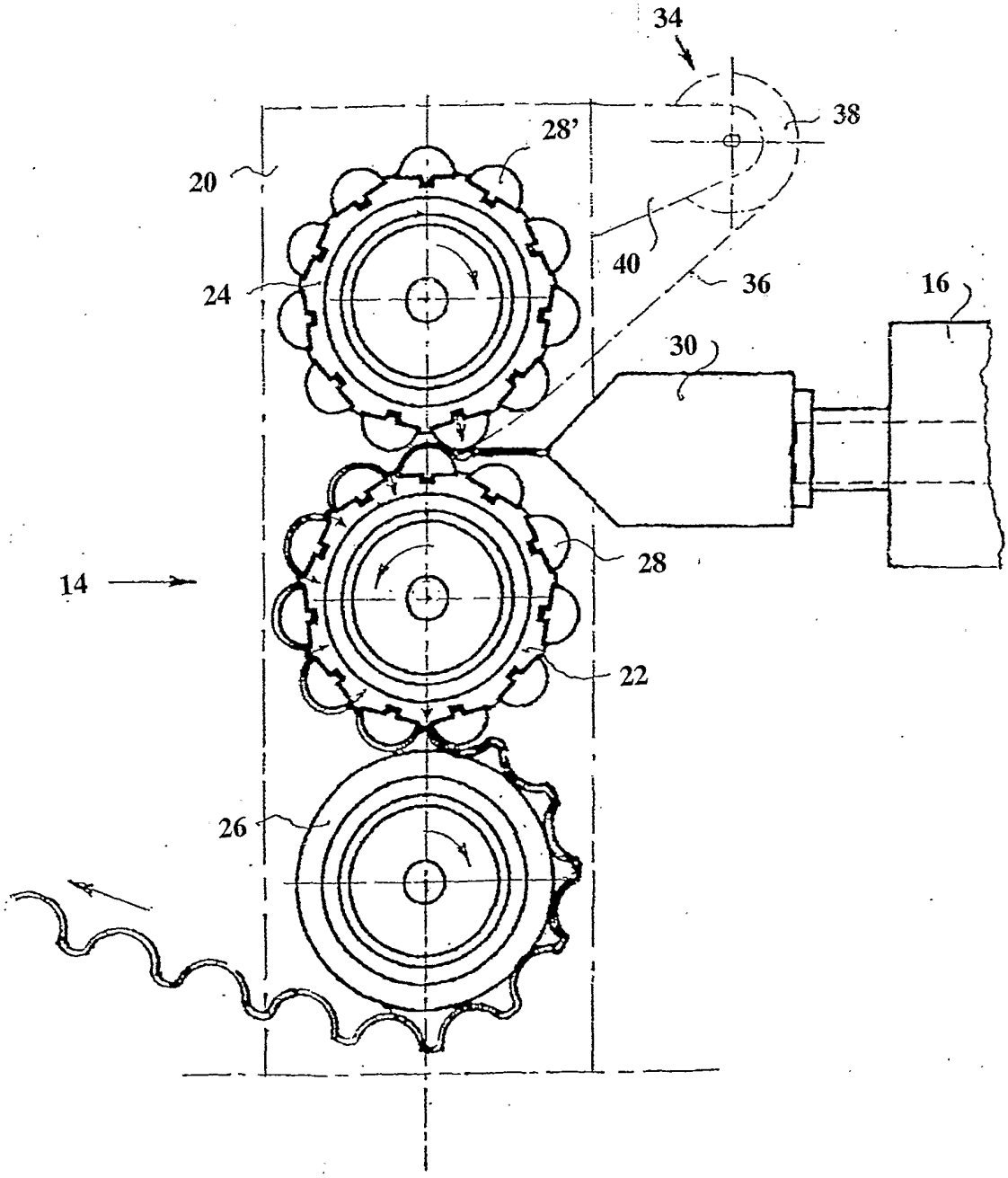


Fig. 8

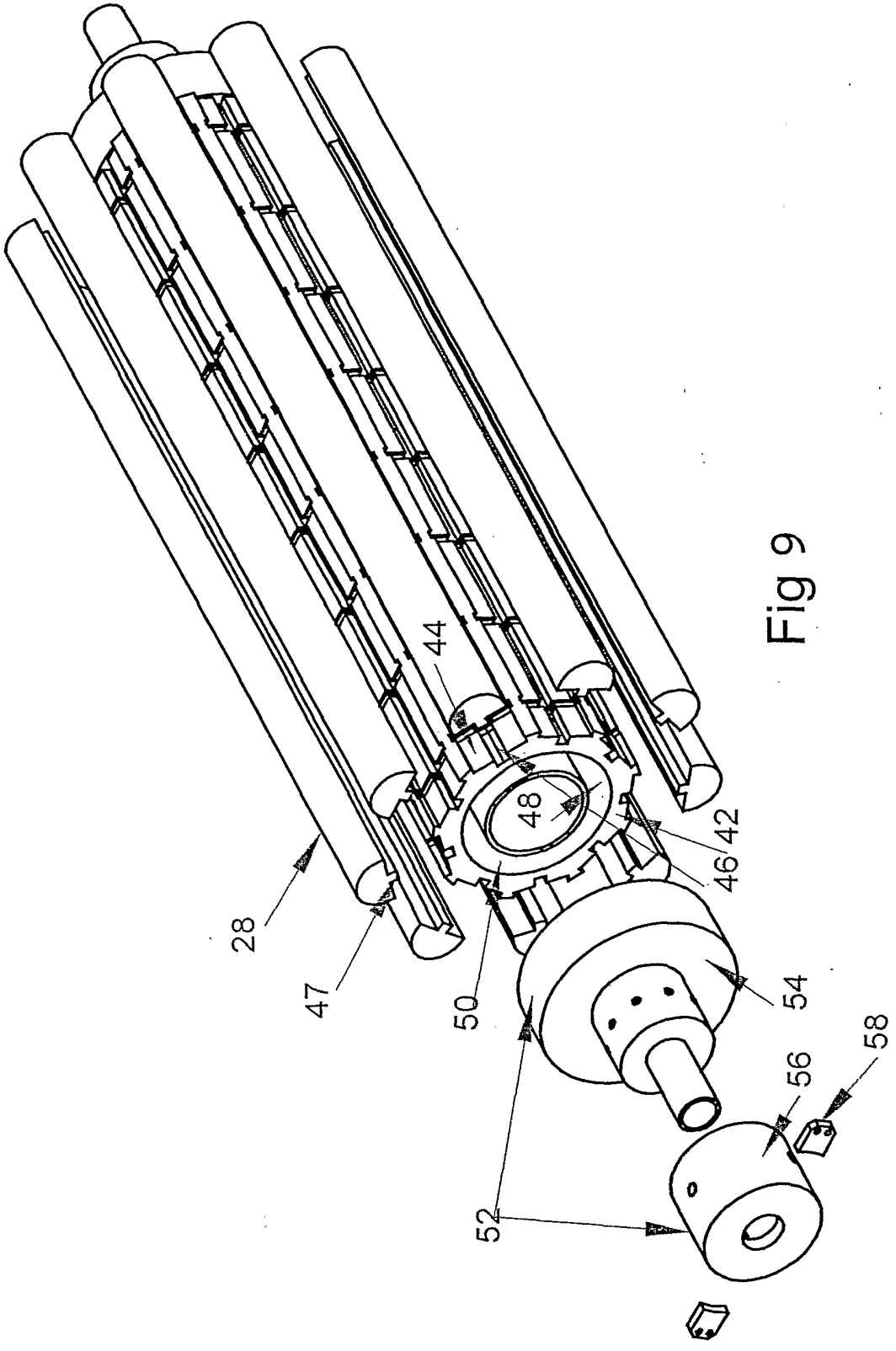


Fig 9

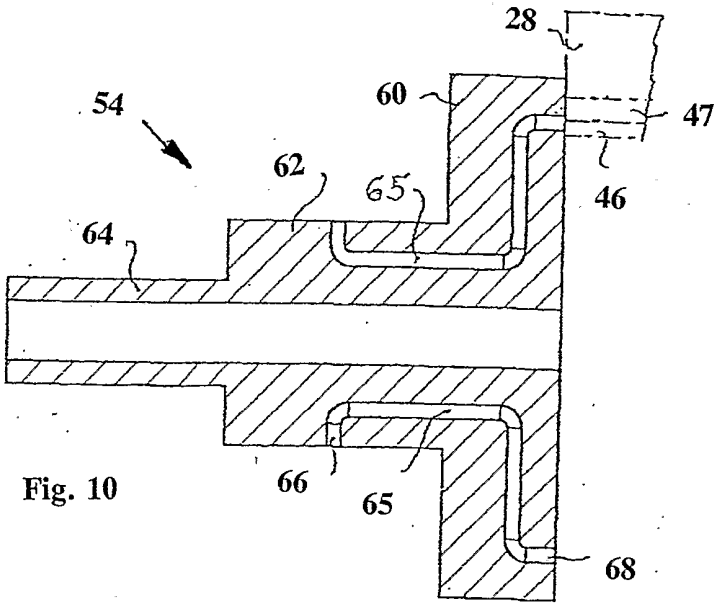


Fig. 10

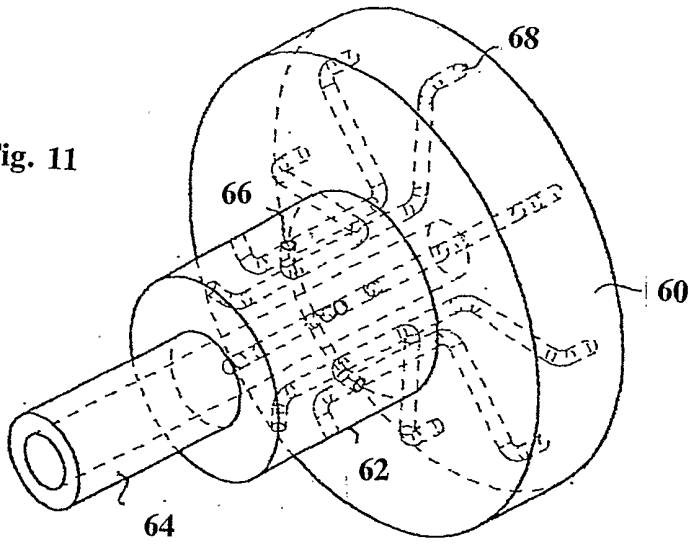


Fig. 11

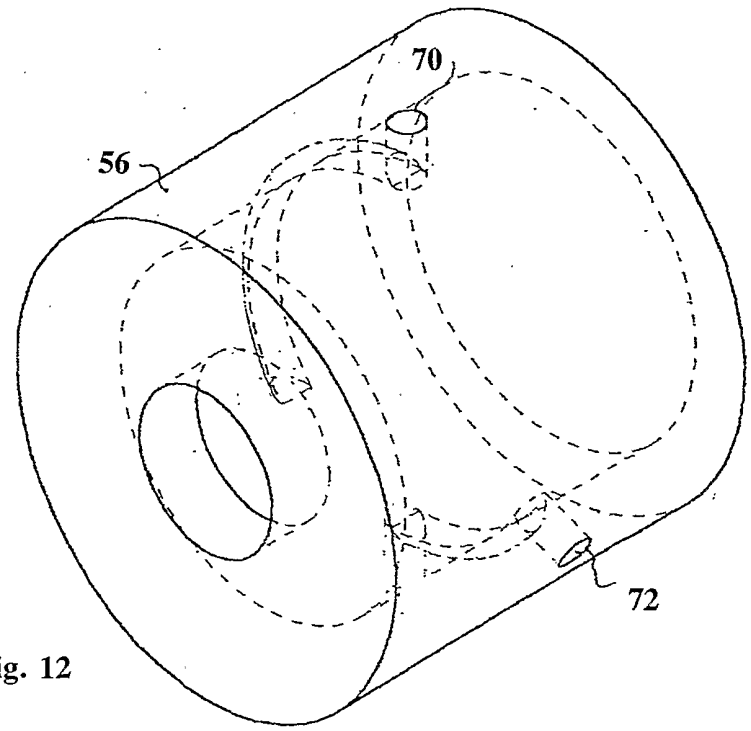


Fig. 12

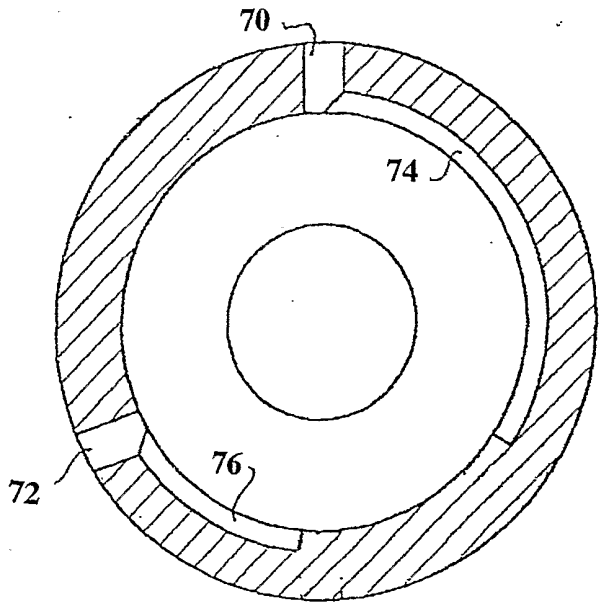


Fig. 13

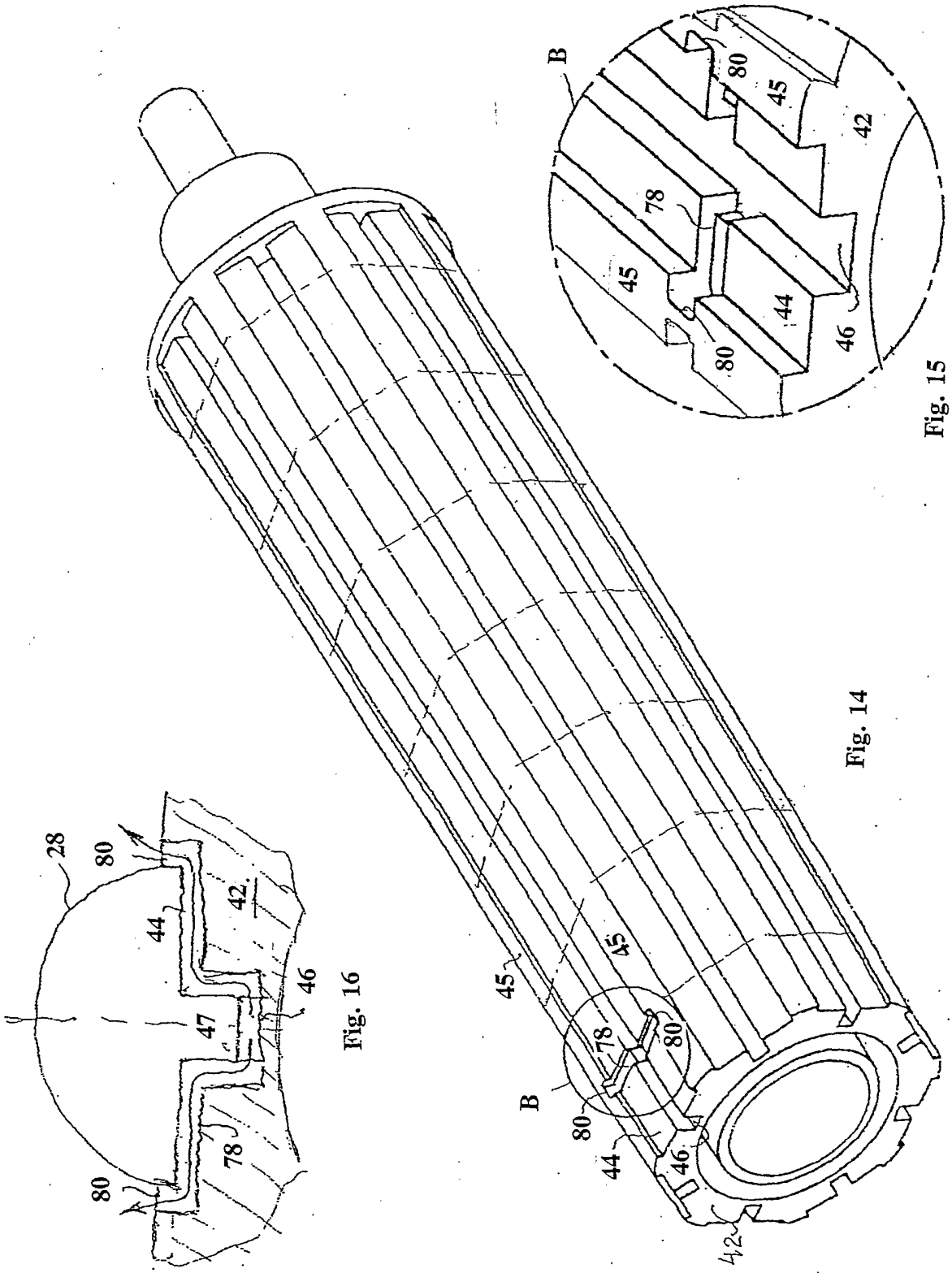


Fig. 15

Fig. 14

Fig. 16

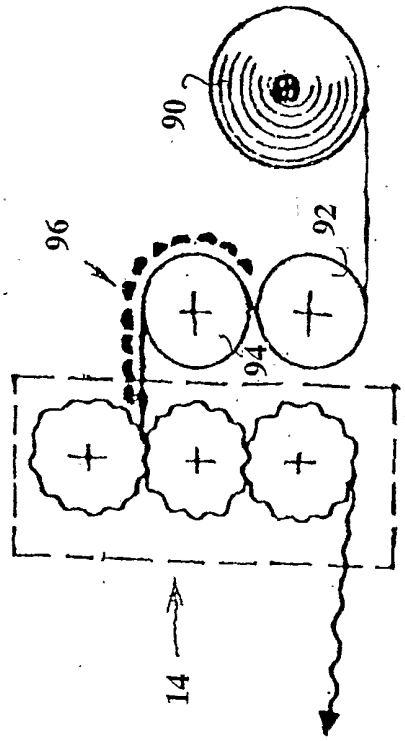


Fig. 19

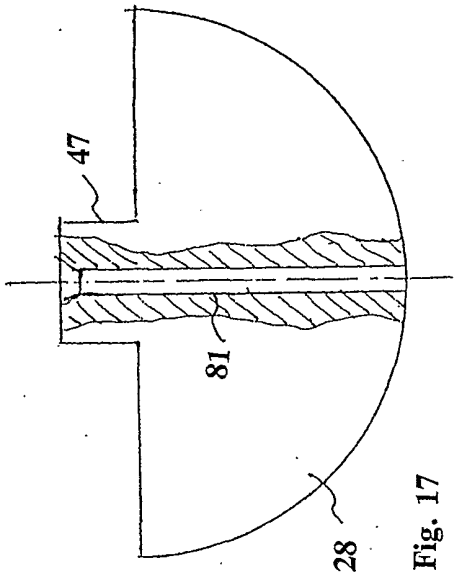


Fig. 17

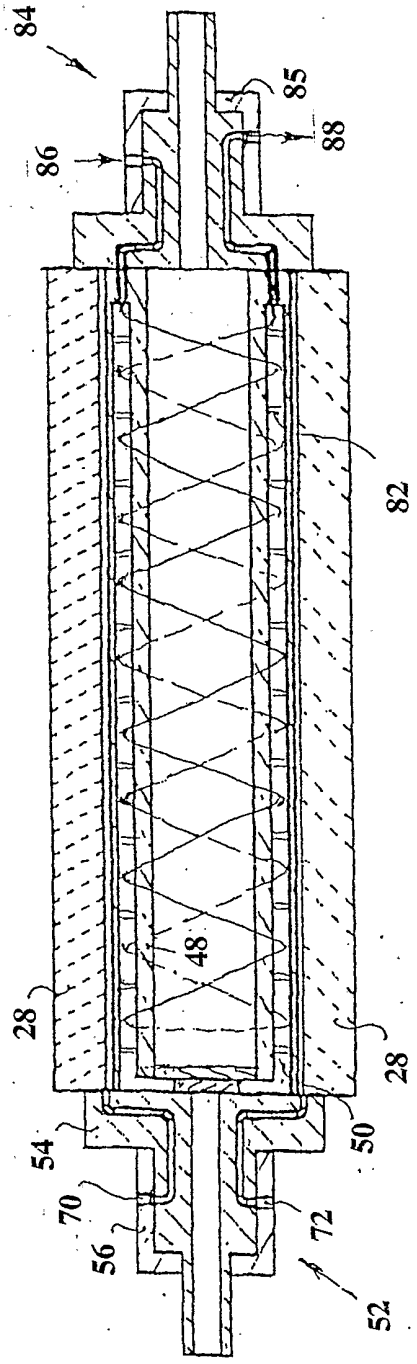


Fig. 18

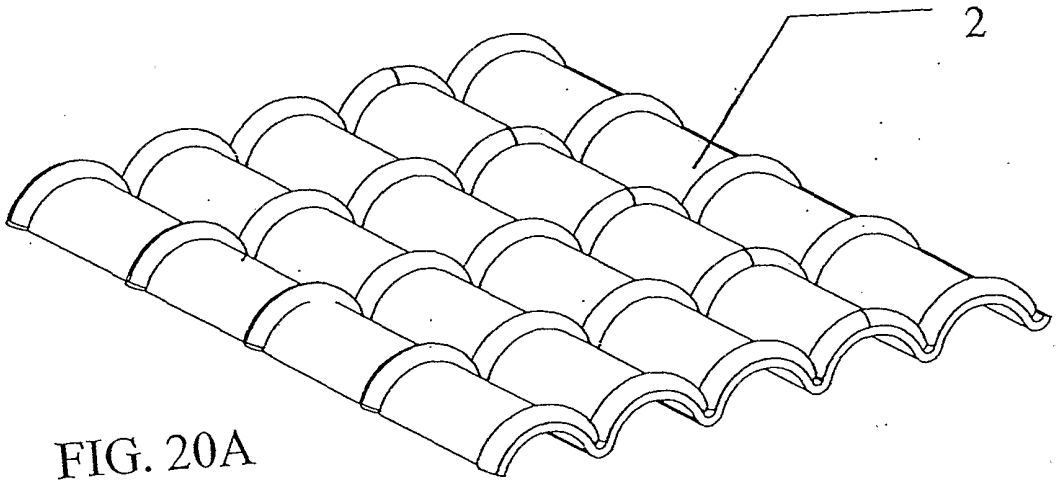


FIG. 20A

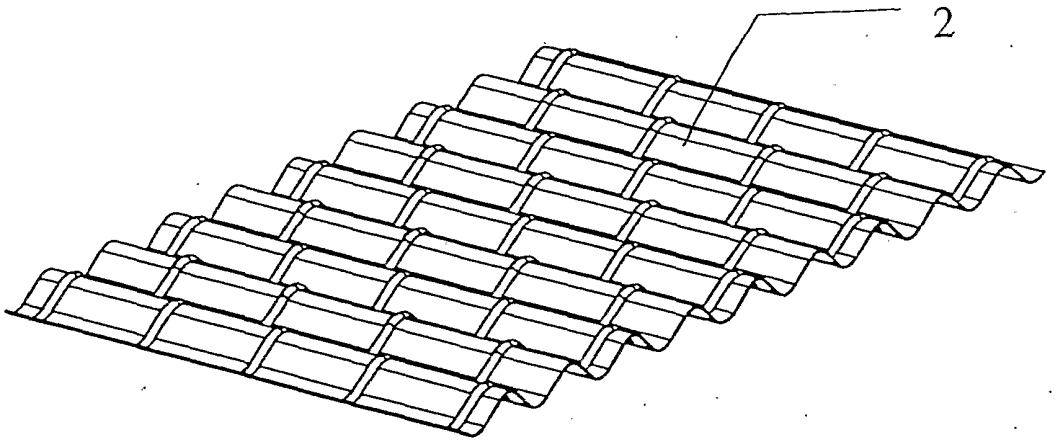
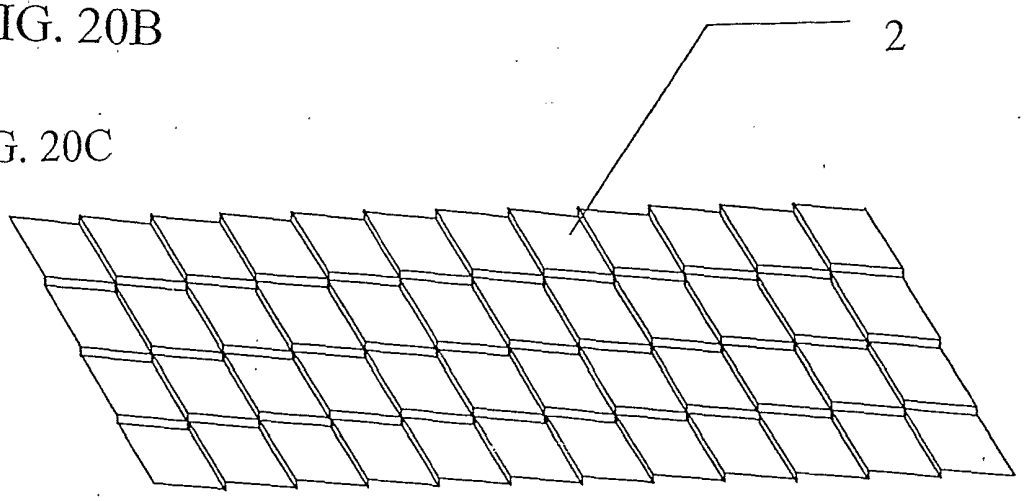


FIG. 20B

FIG. 20C



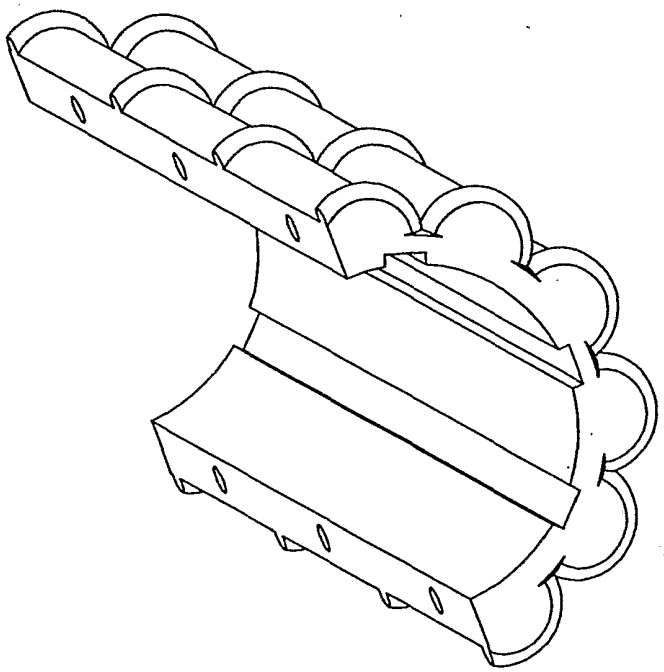


FIG. 21A

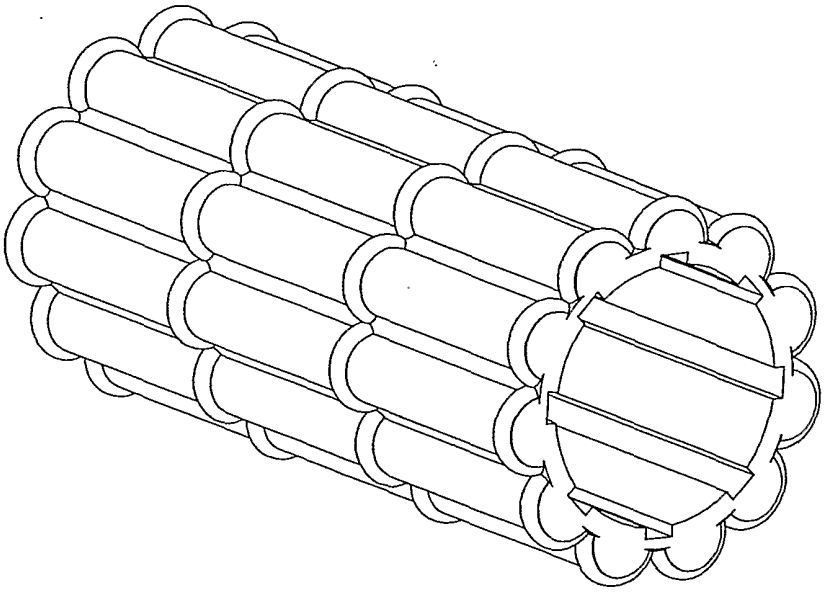


FIG. 21B

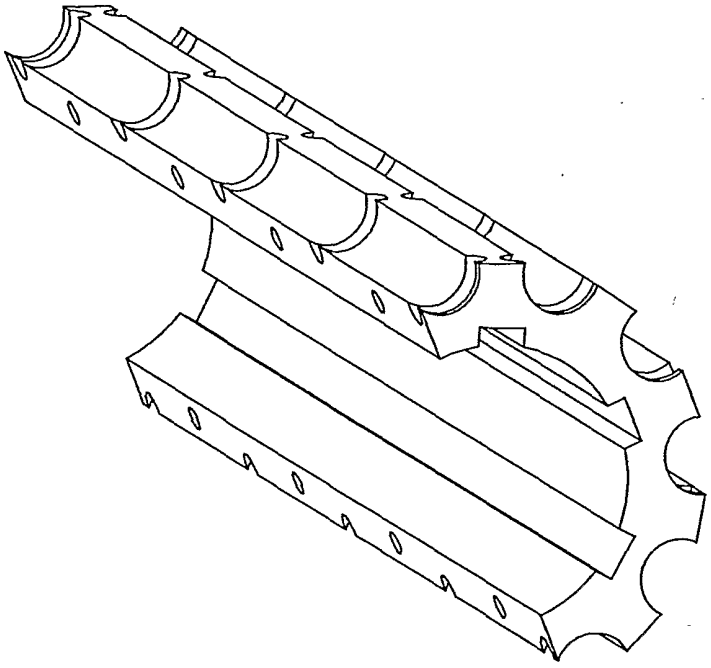


FIG. 22A

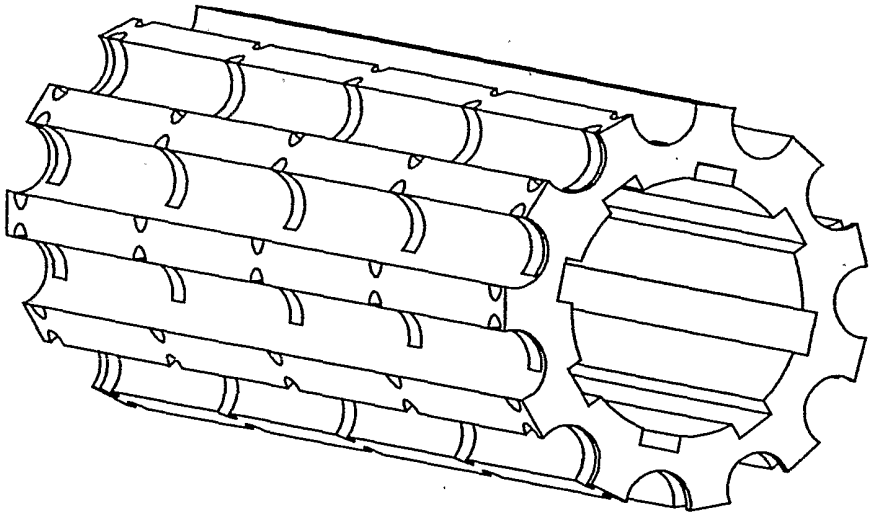


FIG. 22B

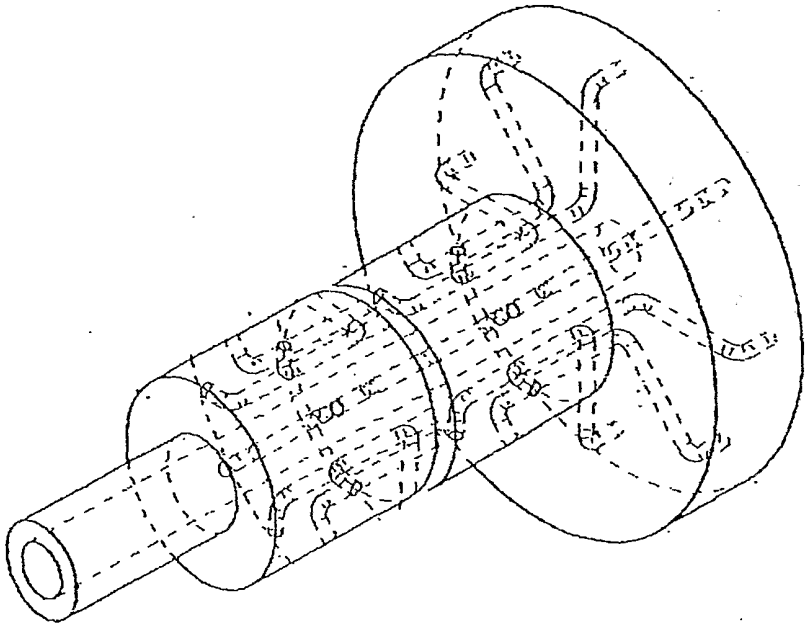


FIG. 23

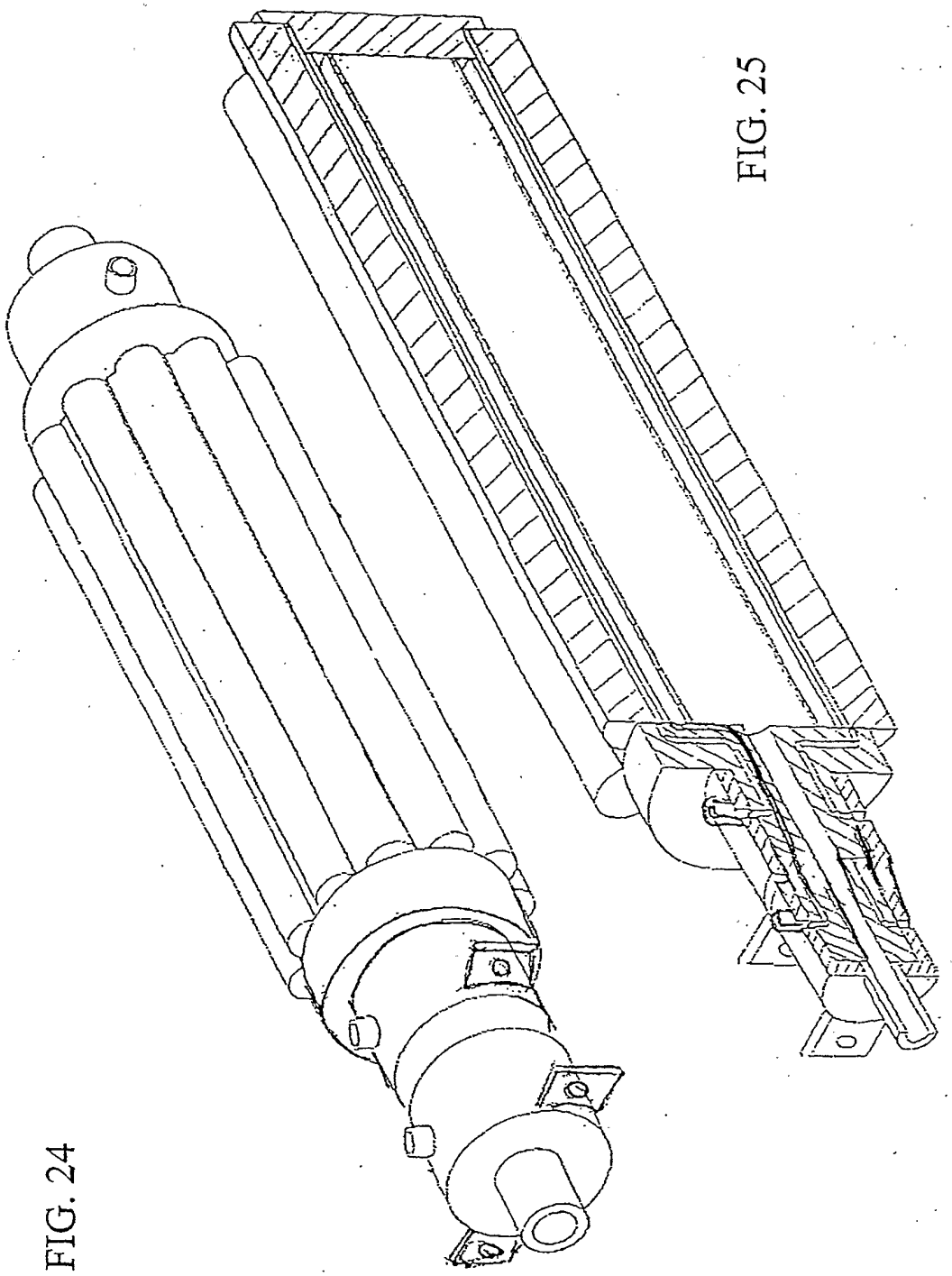


FIG. 24

FIG. 25

INTERNATIONAL SEARCH REPORT

International application No.
PCT/IL01/00578

A. CLASSIFICATION OF SUBJECT MATTER

IPC(7) :B29C 43/46, 53/24; E04D 3/32
US CL :Please See Extra Sheet.
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)

U.S. : 425/194, 369; 52/409, 492, 540, 555, 746.11, 748.1, 748.11; 428/182, 183

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

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

C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
X ----- Y	US 1,892,812 A (ROUS) 03 January 1933, Figures 11-12, page 2, lines 98-101.	1,9 ----- 2-8,10-14
X ----- Y	US 3,470,053 A (RULE) 30 September 1969, Figure 3.	1 ----- 2-14
X	US 4,290,248 A (KEMERER et al.) 22 September 1981, Figure 3, col. 13, lines 35-39.	15-20
X	US 5,526,626 A (LOUCKS) 18 June 1996, Figure 31, col. 2, lines 15-17 and 53-54.	15,17,19
Y	US 4,310,375 A (SEKI) 12 January 1982, Figures 6-12.	1-14

[X] 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 document 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 05 NOVEMBER 2001	Date of mailing of the international search report 30 NOV 2001
Name and mailing address of the ISA/US Commissioner of Patents and Trademarks Box PCT Washington, D.C. 20231 Facsimile No. (703) 305-3230	Authorized officer JAMES MACKEY Telephone No. (703) 308-0651

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INTERNATIONAL SEARCH REPORT

International application No.
PCT/IL01/00578

C (Continuation). DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
Y	WO 99/16985 A (PEDERSEN) 08 April 1999, Figures 1 and 5.	16,20
Y	US 4,320,648 A (EKMARK) 23 March 1982, Figure 2.	16,20
Y	GB 2,239,031 A (SALVOSALMI) 19 June 1991, Figures 6-7.	16,20
A	US 6,050,042 A (DURACHKO) 18 April 2000, col. 4, lines 35-37.	15-20

INTERNATIONAL SEARCH REPORT

International application No.
PCT/IL01/00578

A. CLASSIFICATION OF SUBJECT MATTER:
US CL :

425/194, 369; 52/409, 492, 540, 555, 746.11, 748.1, 748.11; 428/182, 183