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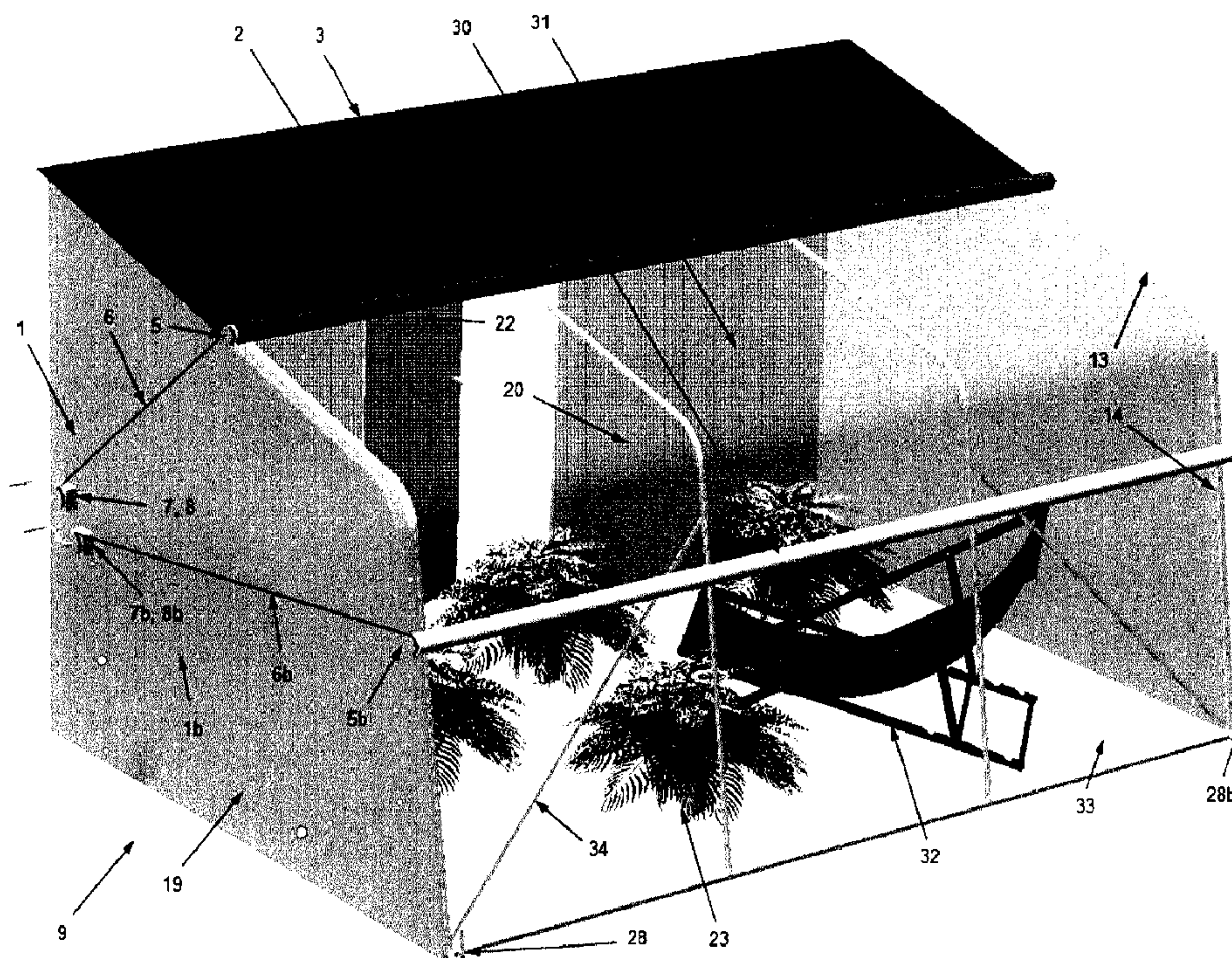
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(54) Titre : APPAREIL DE DEPLOIEMENT DE FEUILLE PLANE SUR UNE STRUCTURE

(54) Title: DEVICE FOR DEPLOYING A PLANAR SHEET OVER A STRUCTURE



(57) **Abrégé/Abstract:**

The invention is a planar sheet deployment system, primarily for use in cultivating short-day photoperiodic plants such as cannabis. The system is comprised of: a) a sheet of flexible, planar material suitable for being rolled upon itself for storage, the sheet material

(57) **Abrégé(suite)/Abstract(continued):**

having upper and lower edges and lateral side edges that are dimensioned to cover a predetermined area when deployed; b) a frame with an upper horizontal support for anchoring the upper edge of the sheet material in a generally horizontal alignment c) a linear winding rod spanning across and bonded to the width of the sheet material along its lower edge in parallel to the upper edge, for winding-up the sheet material into a roll surrounding the winding rod; d) a trackway comprising two separated parallel tracks extending from the upper support downwardly along respective paths that are displaced inwardly from the lateral edges of the sheet material, extending to a lower level, the trackway being positioned for supporting the sheet material as the winding rod unrolls the roll of sheet material while descending towards the unrolled location at that bottom of the trackway; e) a spool located along at least one end of the winding rod that extends outwardly from at least one side edge of the sheet material; f) a winding cord extending down from a point located at the height of an upper support portion of the frame and connected at its lower end to the lowered spool-portion on the winding rod, to be wound thereon in the opposite direction with respect to the winding direction of the sheet material, a first portion of the cord being provided to extend from the upper point to the spool when the sheet material is deployed at a fully unrolled location; and a second portion of the cord, of similar length, wound onto the spool; and g) a cord tensioner for drawing cord upwardly off the spool towards the upper point whereby, upon applying tension to the winding cord through the cord tensioner, the winding cord will unspool from the spool on the winding rod causing the winding rod to rotate and roll-up the sheet material while transferring the location of the winding rod and rolled-up sheet material towards the upper support of the frame.

Abstract

The invention is a planar sheet deployment system, primarily for use in cultivating short-day photoperiodic plants such as cannabis. The system is comprised of:

- a) a sheet of flexible, planar material suitable for being rolled upon itself for storage, the sheet material having upper and lower edges and lateral side edges that are dimensioned to cover a predetermined area when deployed;
- b) a frame with an upper horizontal support for anchoring the upper edge of the sheet material in a generally horizontal alignment
- c) a linear winding rod spanning across and bonded to the width of the sheet material along its lower edge in parallel to the upper edge, for winding-up the sheet material into a roll surrounding the winding rod;
- d) a trackway comprising two separated parallel tracks extending from the upper support downwardly along respective paths that are displaced inwardly from the lateral edges of the sheet material, extending to a lower level, the trackway being positioned for supporting the sheet material as the winding rod unrolls the roll of sheet material while descending towards the unrolled location at that bottom of the trackway;
- e) a spool located along at least one end of the winding rod that extends outwardly from at least one side edge of the sheet material;
- f) a winding cord extending down from a point located at the height of an upper support portion of the frame and connected at its lower end to the lowered spool-portion on the winding rod, to be wound thereon in the opposite direction with respect to the winding direction of the sheet material, a first portion of the cord being provided to extend from the upper point to the spool when the sheet material is deployed at a fully unrolled location; and a second portion of the cord, of similar length, wound onto the spool; and
- g) a cord tensioner for drawing cord upwardly off the spool towards the upper point

whereby, upon applying tension to the winding cord through the cord tensioner, the winding cord will unspool from the spool on the winding rod causing the winding rod to rotate and roll-up the sheet material while transferring the location of the winding rod and rolled-up sheet material towards the upper support of the frame.

Title: Device for deploying a planar sheet over a structure

Field of the Invention

The invention is directed towards enhancing the harvest from photoperiodic plants by selectively blocking their exposure to the sun.

Background of the Invention

The trend towards legalizing marijuana is creating new markets for high-quality cannabis. Commercial growing facilities are springing up to meet the need; many growers utilize the known plant-cultivation technique of “light-deprivation”.

The light-deprivation growing technique exploits the cannabis plant’s natural “short-day photoperiodicity” trait. It is practiced by strategically covering and uncovering the plant with an opaque planar sheet to create artificial periods of darkness, thereby creating a late-season (short-day) micro-environment. The plant’s natural response to this ruse is to prematurely sprout flower buds, thereby exposing them to optimal, mid-summer growing conditions. The resulting cannabis crop will provide the grower with much better yield and quality than if the same plants had spent their peak mid-summer growth period producing leafy vegetative mass of little commercial value.

Since cannabis evolved under a hot tropical sun, its genetic makeup responds optimally to intense natural sunlight shining directly onto its flower buds. No cannabis growing system based on artificial indoor lighting can possibly match the full-spectrum energy and intensity of the sun so outdoor growing is inherently better-suited to producing a higher-quality product, particularly if it is combined with the use of light-deprivation to lengthen the period during which the flower buds are exposed to direct intense sunlight.

The need for high-quality grapes to produce vintage wine provides a useful analogy: both grapes and cannabis must also be grown under ideal natural growing conditions in order to enable the plant’s complex genetic makeup to fully express itself in a high-value finished product. Over 100 cannabinoids have been identified in cannabis and while the cognitive effect of the THC cannabinoid has been the focus of public attention, the full

constrained to travel over a semicircular path to drag a opaque planar sheet or over the semicircular (quonset-style) greenhouse structure.

Another relevant prior-art planar sheet deployment device is US application number 20170071139 entitled: "Greenhouse with synchronizing cover assembly and method for inducing plant photoperiodism in plants" by Fence, Johah et al. Their light-occlusion mechanism (seen at www.emeraldkingdomgreenhouse.com) operates quite differently; it utilizes a pair of mobile electric motors that move in concert to rotate the ends of a rolls of opaque planar sheet membrane material such that each roll deploys over a curved side of the structure. A pair of telescopic rods, hinged to the ground are used hold and guide both the motors and their driven rolls of planar sheet material along the outside of the greenhouse structure; the rods telescopically adjusting to dynamically conform to the contours of a non-semicircular greenhouse.

The prior-art planar sheet deployment mechanisms are complex and poorly suited for providing all three of the environmental conditions needed for optimal results. It is therefore the goal of the present invention to provide a simpler and more multi-purpose planar sheet deployment system that eliminates their drawbacks.

A further goal is to provide both a planar sheet deployment mechanism and a complementary underlying support structure that concentrates all of the available sunlight onto the early-flowering plants contained within. A further goal is to provide a multi-purpose light-deprivation structure that adapts to both the small-scale growing needs of backyard gardeners as well as the large-scale needs of commercial growers. A further goal is to provide a compact, multipurpose structure that is easily reconfigured to serve either as a stand-alone light-deprivation greenhouse or as a general-purpose stand-alone shelter for use by homeowners in their backyards. A further goal is to provide a planar sheet deployment system and underlying structure that home-owners can easily add onto their dwelling as a sunroom extension.

The invention in its general form will first be described, and then its implementation in terms of specific embodiments will be detailed with reference to the drawings following

hereafter. These embodiments are intended to demonstrate the principle of the invention, and the manner of its implementation. The invention in its broadest and more specific forms will then be further described, and defined, in each of the individual claims which conclude this Specification.

Summary of the Invention

The invention can be summarized as follows:

1. A planar sheet deployment system comprising:
 - a) a sheet of flexible, planar material suitable for being rolled upon itself for storage, the sheet material having upper and lower edges and lateral side edges that are dimensioned to cover a predetermined area when deployed;
 - b) a frame with an upper horizontal support for anchoring the upper edge of the sheet material in a generally horizontal alignment;
 - c) a linear winding rod spanning across and bonded to the width of the sheet material along its lower edge in parallel to the upper edge, for winding-up the sheet material into a roll surrounding the winding rod;
 - d) a trackway comprising two separated parallel tracks extending from the upper support downwardly along respective paths that are displaced inwardly from the lateral edges of the sheet material, extending to a lower level, the trackway being positioned for supporting the sheet material as the winding rod unrolls the roll of sheet material while descending towards the unrolled location at that bottom of the trackway;
 - e) a spool located along at least one end of the winding rod that extends outwardly from at least one side edge of the sheet material;
 - f) a winding cord extending down from a point located at the height of an upper support portion of the frame and connected at its lower end to the lowered spool-portion on the winding rod, to be wound thereon in the opposite direction with respect to the winding direction of the sheet material, a first portion of the cord being provided to extend from the upper point to the spool when the sheet material is deployed at a fully unrolled location; and a second portion of the cord, of similar length, wound onto the spool; and
 - g) a cord tensioner for drawing cord upwardly off the spool towards the upper point whereby, upon applying tension to the winding cord through the cord tensioner, the winding cord will unspool from the spool on the winding rod causing the winding rod to rotate and roll-up the sheet material while transferring the location

of the winding rod and rolled-up sheet material towards the upper support of the frame.

Brief Description of the Drawings

FIG 1 illustrates the planar sheet deployment device mounted onto an asymmetric, south-facing greenhouse for use as a tool for light-deprivation of photoperiodic plants and with its opaque light-deprivation sheet fully retracted.

FIG 2A is a large-scale view of the planar sheet deployment device shown in FIG 1.

FIG 2B is a large-scale view of the planar sheet deployment device shown in FIG 2A.

FIG 2C is a large-scale view of the planar sheet deployment device shown in FIG 2A.

FIG 3 illustrates the structure and device of FIG 1 once its opaque planar sheet has been fully deployed.

FIG 4 is a large-scale view of the planar sheet deployment device shown in FIG 3.

FIG 5 is a large-scale view of the planar sheet deployment device shown in FIG 4.

FIG 6 illustrates a frontal view of a greenhouse structure having one translucent planar sheet deployment device mounted to it as well as the opaque planar sheet shown in FIG 1, both planar sheets being shown in their fully retracted configuration.

FIG 6b illustrates the greenhouse structure of FIG 6 showing how an optional fairlead stringer affixed to the structure to facilitate planar sheet deployment device.

FIG 7 illustrates the structure of FIG 6 with its translucent planar sheet partially deployed and its opaque planar sheet fully retracted.

FIG 8 illustrates the structure of FIG 6 with its translucent planar sheet more fully deployed than in FIG 7 and its opaque planar sheet less fully deployed.

FIG 9 illustrates the structure of FIG 6 with its translucent planar sheet fully deployed

and its opaque planar sheet more fully deployed than in FIG 8.

FIG 10 illustrates the structure of FIG 6 with both its translucent planar sheet and its opaque planar sheet fully deployed.

FIG 11 illustrates a symmetric greenhouse structure having both its south-facing opaque and translucent planar sheets partially deployed while its north-facing opaque planar sheet is fully retracted and its north-facing translucent sheet is partially deployed.

FIG 12 is a large-scale view of the structure of FIG 11 showing details of the tensioned cables used to actuate the structure's four planar sheet deployment devices.

FIG 13 illustrates the structure of FIG 11 with all four planar sheet deployment devices fully deployed.

FIG 13B illustrates the simplest embodiment of the invention when attached to an existing building; in this case a shelter to cover the patio in front of a restaurant.

FIG 14A is an image of an opaque, multi-layer planar sheet material suitable for use in the light-deprivation device shown in FIG 1.

FIG 14B is an image of a sidewall insulation material suitable for use in the greenhouse structure shown in FIG 1.

FIG 15A illustrates a trellis used for promoting optimal growth of plants contained within the structure shown in FIG 1.

FIG 15B illustrates a horizontally extended growing trellis used for inducing optimal growth of plants contained within the structure shown in FIG 1.

FIG 16 illustrates another embodiment of the horizontally extended trellis shown in FIG 15B.

FIG 17 illustrates an embodiment that includes a hinged reflective panel, the panel shown in its fully-opened configuration: lying on the ground in front of the structure.

FIG 18 shows the embodiment of FIG 17 and including the trellis of FIG 16.

FIG 19 shows the embodiment of FIG 18 with its hinged reflective panel partially raised and supported at an angle that enables it to act as a heliostat which redirects sunlight onto the trellis of FIG 16.

FIG 20 shows the embodiment of FIG 18 with its hinged reflective panel fully raised and locked against the structure's sloped portion to act as a security barrier.

Description of the Preferred Embodiments

With reference to FIG 1 and FIG 2, the planar sheet deployment device 1 is affixed to a suitably configured greenhouse structure 9, thereby forming a system for enhancing the growth of short-day photoperiodic plants 23.

Greenhouse structure 9 includes left and right trackways 11 and 12; each trackway forms the inclined upper contour of left and right end-walls 18 and 19 respectively. Each trackway slopes continuously downwards from the structure's apex towards the ground. To maximize headroom inside the structure, the continuous downward slope of end-walls 18 and 19 may be either curved or segmented into two or more straight sloping segments; for example, in FIG 1 segment 13 slopes downward at a 15 degree angle and segment 14 is sloped at 135 degrees. A plurality of matching intermediate trackways 15 may be provided to give additional support to planar sheet 3 (when deployed) or to rigid translucent panels 17 (described below). A plurality of joined members 21 form a frame that gives structural rigidity to end walls 18 and 19 as well as to back wall 20 thereby forming a U-shaped greenhouse structure with its open sides orientated towards the equator for optimal solar irradiation of its interior. Door 22 provides access through any of the structure's three vertical walls 18,19,20.

To enable sunlight to enter the structure while simultaneously protecting the plants from wind and cold, its sloping top surface is covered with translucent sheeting 17. The

translucent covering may be flexible greenhouse film that is secured about its perimeter to surrounding frame members, thereby fully enclosing and protecting the growing plants 23. Alternatively, the translucent, portion of structure 9 may be covered by a plurality of rigid translucent panels 17 made of glass or plastic, each panel being gripped around its perimeter by suitable edge clamps to the surrounding frame members. Stringer 16 may be provided to facilitate the attachment and use of either rigid or flexible translucent sheeting 17 as well as to provide additional structural integrity when flexible sheeting film is used instead of rigid panels. The structure's three vertical walls (18, 19, 20) are preferably formed from rigid material such as plywood however wall panels formed using flexible film or insulated film are also suitable (see FIG 15A and 15B). At least one endwall 19 includes a rigid support portion capable of securely mounting the tensioning motor 8 used to actuate planar sheet deployment device 1.

The sheet deployment mechanism:

To enable light-deprivation of plants 23, planar sheet deployment device 1 is affixed to structure 9 along its apex at 10 and along a sidewall 19. Planar sheet 3 is made of flexible opaque material and is affixed along its upper edge to the apex of structure 9 by means of a gripping clamp 10. In FIG 1 and FIG 2, planar sheet 3 is shown fully wound onto winding rod 4 to form roll 2. Its width enables sheet 3 to span between left trackway 11 and right trackway 12 and may slightly overhang them; the purpose of the sheet's (optional) overhang is described further below. When it is fully deployed (by allowing roll 2 to traverse down incline 13 and 14), the length of sheet 3 extends to the ground, thereby preventing any sunlight from entering into the structure.

With reference to large-scale FIG 2A, 2B and 2C, unless it is restrained, the weight of cylindrical roll 2 resting on the incline of trackways 11, 12 will cause planar sheet 3 to be unrolled away from clamp 10 by gravity and thereby quickly deploy it over the structure and plunge plants 23 into darkness (as shown in FIG 3). To insure correct deployed alignment onto the structure, sheet 3 is accurately rectangular and trackways 11 and 12

are accurately parallel, thereby forcing roll 2 to unroll orthogonally onto it, held in place at its upper edge by gripping clamp 10 such that tension across the membrane constrains the roll's travel to the desired path.

To control the roll's gravity-driven descent and also enable the unrolled planar sheet 3 to be accurately rewound back up the inclined trackway into its fully-rolled storage configuration, drive-spool 5 is affixed to one end of winding rod 4, immediately adjacent to a side edge of the sheet (see FIG 2B). A tensioned drive cord 6 is wound onto winding-rod drive-spool 5 in the opposite direction from that used to wind the sheet onto the rod. For example: in the right-side drive configuration shown in FIG 2A, planar sheet 3 is wound counterclockwise onto rod 4 so that roll 2 can be correctly affixed to the structure using clamping strip 10. Tensioned cord 6 is therefore wound clockwise onto drive-spool 5, to correctly apply counter-rotative torque to the winding rod that can either restrain roll 2 from descending the structure or propel it back up by winding the tensioned back onto winding rod 4. To maintain compact drive spools, winding cord 6 should be as thin as possible: high-strength fishing line or light-duty aircraft control cable provide good results.

Winding cord 6 is belayed at its lower end by winding it onto tensioning spool 7, which is rotateably affixed to end wall 19 via drive motor 8, thereby enabling the motor to act as a controllable winch that feeds tensioned cord 6 onto and off of drive-spool 5. Drive motor 8 may be automatically actuated using an internal electric motor to rotate spool 7. Alternatively, tensioning-spool 7 may be manually rotated using crank 24 as shown; an internal ratcheting mechanism actuated by button 25 being used to belay the cord as needed. If tensioning motor 8 is actuated electrically then its housing is preferably mounted inside of structure 9, high up on wall 19 to optimise the cord's force vector geometry as it actuates roll 2. If motor 8 is mounted internally onto the inside of endwall 19 (not illustrated) then its tensioning spool 7 is rotated via a drive shaft that protrudes through the wall far enough to align spool 7 with the drive-spool 5.

As is evident in FIG 2A, decreasing the tension in cord 6 will enable roll 2 to descend

along trackway 12 while laying down a deployed portion of sheet 3 along its path. Conversely, increasing tension in cord 6 will induce counterclockwise rotation in winding rod 4 and roll 2, thereby causing the roll to winch itself back up inclined trackway 12. Tension across sheet 3 will maintain orthogonal alignment of roll 2 as it mounts the structure.

FIG 3 illustrates the result of spooling out sufficient cord from tensioning spool 7. Roll 2 has been permitted to roll down incline 13, over the precipice 16 of structure 9 and then down incline 14, leaving planar sheet 3 in its path so that plants 23 are plunged into a simulated nighttime environment (when door 22 is closed). Note that during the planar sheet's controlled deployment, the force vector of tensioned cord 6 swings through an arc that follows the changing direction between spool 7 and spool 5.

Sheet deployment in windy conditions:

FIG 4 is a larger scale view of FIG 3 that gives clearer understanding of how planar sheet 3 lies upon structure 9 and how tensioned cord 6 drives the deployment mechanism. The sheet's overhang past the outer edge of trackway 12 improves its light-tight seal against the trackway and endwall. The overhang also provides a loose flap of excess material which can be used to secure the sheet more firmly to the structure in the event of high winds. FIG 5 is a larger scale view of FIG 4 that gives a clearer understanding of how the problem posed by high winds can be dealt with. In this example, the structure's frame members 21 are made of steel and a plurality of magnets 26 are used to secure the edge of sheet 3 onto it; the user simply removes the magnet, folds the excess material down and around the frame and then replaces the magnet. Even in high winds, this measure will typically prevent wind from getting under the sheet and causing its light-tight seal to fail. The use of magnets 26 is one example of how sheet 3 can be more securely affixed over structure 9. Other sheet fixation means such as snaps, Velcro or edge-gripping spring-clamps may also be provided.

A second sheet-handling feature that mitigates the effect of high winds is J-hook 28. When roll 2 has been fully lowered into its light-deprivation position, the J-hook helps

secure it against the incline 14 of structure 9. Installing J-hooks at the bottom of both trackways also provide a structure capable of using padlocks to prevent unauthorized raising of the sheet (not illustrated). If combined with a multilayer sheeting material that includes a cut-resistant wire mesh layer, this security feature provides further discouragement to thieves wishing to cut through the sheet, particularly if the mesh is metal and charged using a low-powered electric fence energizer. Yet another security feature is to provide a contact switch at the bottom of J-hook 28 that sets off an alarm if an unauthorized person lifts roll 2 in an attempt to gain entry (see Automated security features further below).

Another means for stabilizing sheet 3 in high winds is to add extra weight to its lower edge. Winding rod 4 is typically formed of lightweight hollow tubing so its weight can be substantially increased by inserting cylindrical weight 27 into the tube during assembly (inserting it through the tube's open end, opposite drive-spool 5). Once inserted into winding rod 4, weight 27 applies extra tensioning force onto the lower edge of sheet 3, thereby insuring that it maintains a light-tight seal against structure 9.

Compensating for asymmetric drive components:

Another benefit of inserting weight 27 inside of winding rod 4 is that the user can strategically place it at a location in the tube that applies asymmetric tensioning force onto sheet 3. This enables the installer to fine-tune how tension is distributed onto the roll as it winches itself back up the structure in response to increased tension in cord 6. This sheet-tensioning adjustment can be used to prevent asymmetric imperfections in the sheet material from causing wrinkles to form on roll 2 as it climbs the structure towards its fully open position. The magnitude of weight applied by 27 inside winding rod 4 will govern the amount of tension that is applied along the lower edge sheet 3. The diameter of both winding-rod 4 and winding-spool 5 will also affect sheet tension because cord 6 applies tangential force onto them; the greater their diameter, the more weight 27 will be leveraged to create tension in sheet 3. To prevent cord 6 from applying any significant lifting force onto roll 2 (instead of a turning force), the diameter

of its cord spool 5 should be made equal to or greater to the diameter of the spooled sheet 3 when fully wound onto winding rod 4.

Yet another method for increasing the tension applied onto sheet 3 is to position cord 6 more parallel to incline 14. The orientation of tensioned cord 6 can be adjusted by positioning its drive motor 8 higher up on structure 9. More importantly, cord 6 can be routed over a “cord fairlead” mounted onto endwall 19 at a location that orients the cord more parallel to the path of roll 2 as it is retracted up the incline of structure 9. See FIG 11 and FIG 12 to understand how a cord fairlead (29) can be used to redirect tensioned cord 6, thereby improving its force vector geometry.

FIG 6b illustrates another means for facilitating smooth actuation of the tensioned planar sheet. Curved stringer 16 may be provided and joined to trackways 11 and 12, as well as to intermediate supports 15. If present, curved stringer 16 is positioned at the juncture of inclines 13 and 14, thereby acting as a fairlead where the tensioned sheet exerts greatest pressure onto structure 9. Curved stringer 16 thereby strengthens the structure while facilitating smooth and taut deployment of the tensioned planar sheet over the structure 9. Curved stringer 16 is preferably formed from a rectangular sheet of strong translucent material such as polycarbonate plastic. A plurality of diagonal-bracing and/or X-bracing members 34 may also be provided to augment the lateral rigidity of open-topped structure 9.

To further prevent gusting winds being able to get under the deployed planar sheet 3, its overhanging portions on each side may be fringed to create laminar disturbance that reduces a wind gust’s ability to create an opening in the light-tight seal between the tensioned sheet and the roll trackways 11 and 12. In the example overhang of sheet 3 shown in FIG 2B, the 2-inch overhang might be fringed with a 1-inch slit every half-inch; the fluttering edge will further reduce the weighted sheet’s tendency to lift off in strong winds and break its light-tight seal against trackways 11 and 12. To further ensure that the seal remains light-tight, the width of each trackway may be extended somewhat towards the interior of structure 9.

Deploying both a light-deprivation sheet and a translucent sheet:

FIG 6, FIG 7, FIG 8, FIG 9 and FIG 10 illustrate how two deployable planar sheets can act in concert to provide varying degrees of optimal shading and protection to plants 23. Each figure illustrates a frontal view of an embodiment of the invention in which a second instance of the planar sheet deployment device (1b) is mounted onto structure 9. Instead of the opaque sheet 3 wound onto roll 2 and deployed for light deprivation, the second copy of the device includes roll 30, which deploys a translucent planar sheet 31 over the structure 9. Roll 30 is actuated and deployed using a separate: winding rod 4b, drive spool 5b, tensioned cord 6b, tensioning spool 7b and tensioning motor 8b. Adding a second (translucent) planar sheet (31) compliments the opaque sheet 3 and enables structure 9 to provide all three of the environmental conditions needed for optimal plant growth.

Translucent roll 30 is positioned beneath opaque roll 2 such that it can be independently deployed down structure 9 while leaving the light-occluding sheet 3 in its upper stored configuration. This dual-sheet embodiment thereby provides light-deprivation when needed as well as varying degrees of translucent plant protection when needed (during stormy periods or during cold weather). When the weather improves, sheet 30 can be fully retracted, thereby enabling the early-flowering plants to enjoy the benefits of direct sunlight open-sky ventilation.

Adding a second (translucent) planar sheet 31 complements the opaque sheet 3 and enables structure 9 to fulfill all three of the environmental conditions needed for optimal growth (listed above under Background of the Invention).

FIG 7 illustrates the structure of FIG 6 with its translucent planar sheet 31 partially deployed and its opaque planar sheet still fully retracted.

FIG 8 illustrates the structure of FIG 6 with its translucent planar sheet more fully deployed than in FIG 7 and its opaque planar sheet partially deployed.

FIG 9 illustrates the structure of FIG 6 with its translucent planar sheet fully deployed

and its opaque planar sheet more fully deployed than in FIG 8.

FIG 10 illustrates the structure of FIG 6 with both its translucent planar sheet and its opaque planar sheet fully deployed.

Automation features:

The invention can be easily adapted for computer control because the rotation of cord-tensioning spools 7 and 7b can be independently controlled using electric motors 8 and 8b. Scheduled automatic deployment of sheet 3 and sheet 31 to induce early-flowering in plants 23 is easily accomplished using a smartphone app and readily available home automation devices, thereby enabling the grower to remotely control and monitor the automatic light-deprivation process. Additional automation features might include:

- Temperature and humidity sensors placed near the plants can be used to automatically open and close the translucent sheet 31 as needed to maintain optimal growing conditions. A supplementary heater and/or ventilation fan might also be turned on or off as needed to maintain optimal growing conditions within the structure.
- A light meter placed inside the structure might be used to control sheet deployment for shade-loving plants or to help modulate temperature. For sun-loving plants such as cannabis, the light meter might also be used to turn on supplementary electric lights on very cloudy days.
- A digital anemometer might be used to warn the remote operator that wind gusting has reached the point where damage to the sheets might occur if they are not either fully retracted by remote control or else secured manually along their edges as described above.
- Security of the structure and its contents can be automated by linking the user's smartphone to a surveillance camera that enables them to monitor the site. A motion sensor can also be used to trigger an alarm if an unauthorized person approaches the structure; the alarm might include flashing lights, voice

annunciation that the intruder is being captured on video and/or intense siren noise. If an intruder disturbs a contact switch on the structure, it might also trigger the armed security system. Shock electrification of the metal structure (or a metalized mesh embedded in sheet 3) might also be incorporated into the automatic security system, thereby further discouraging thieves from tampering with the structure or its contents.

Other sheet deployment applications:

The presence of lounging chair 32 in FIGs 6 to 10 signifies that structure 9 can provide significant user-benefits over and above its use as a light-deprivation greenhouse. The same factors that favor optimal plant growth (solar exposure, wind-protection, air-ventilation and temperature-modulation) are also relevant to humans wishing to enjoy a comfortable and private space in their backyard. The compact structure shown in FIGs 1 to 10 will fit conveniently into most backyards, where it can also serve as both a greenhouse and a patio shelter (BBQ shelter, hot-tub shelter, picnic-table shelter, general-purpose storage shed etc). The illustrated (8-foot x 12-foot) light-deprivation greenhouse provides sufficient space to optimally and legally cultivate a few cannabis plants for personal use and it makes optimal use of standard-sized building materials. Regardless of its utility as a tool for growing high-quality cannabis, the illustrated structure is an excellent place for home-owners to simply sit and relax in a natural environment they can easily control.

If the compact greenhouse module shown in FIG 1 or FIG 8 is scaled up in size or connected end to end in chains (not illustrated), it lends itself admirably to large-scale commercial light-deprivation grow operations. The planar sheet deployment mechanism also has non-agricultural commercial applications in public spaces. For example: a restaurant-patio can become more attractive to customers when they are protected from the elements by the dual “patio-awnings” shown in FIGs 1 to 10. Another commercial application is to use the modules as private living spaces within larger structures: for example a much larger greenhouse might be subdivided into

private bedroom modules to serve as an attractive youth hostel or a warehouse might be temporarily converted into an emergency shelter.

Routing the tensioned cords over a fairlead

FIG 11 illustrates a laterally-symmetric, north-facing / south-facing greenhouse structure 9 that is more complex and less energy efficient than the asymmetric, equator-facing structure shown in FIG 8. It is also less amenable to attaching to a wall of a residence to form a sunroom extension. It is however more typical of existing commercial greenhouse structures and may provide some advantages when used as a stand-alone structure in some agricultural applications. It also illustrates how an existing (translucent) greenhouse structure can be easily upgraded for light-deprivation use by retro-fitting it with the present invention.

The bidirectionally-oriented structure 9 of FIG 11 requires four instances of the planar sheet deployment device (1, 1b, 1c and 1d). FIG 12 is a large-scale view of FIG 11 illustrating the four independent planar sheets (3, 3b, 31, 31b), four independent tensioned cords (6, 6b, 6c, 6d) and four controllable tensioning means (8, 8b, 8c, 8d) that are needed to control deployment of the four rolls (2, 2b, 30, 30b). The complexity of directing four tensioned cords in straight-line paths towards the various rolls as the traverse each side of the structure highlights the advantage of routing them over fairlead post 29. Fairlead post 29 is rigidly affixed to endwall 18 at a location that presents a fairlead guide surface to tensioned cords 6, 6b, 6c and 6d, thereby enabling each one to be redirected towards its respective roll (2, 2b, 30 and 30b). As a tensioned cord slides over fairlead 29 it applies the roll-torque needed to deploy or retract sheets 3, 3b, 31 and 31b.

Note that additional fairleads may be affixed at strategic endwall locations to prevent the cord from fouling and optimized their powertrain performance. For example: if a (not illustrated) second fairlead 29b were positioned near the structure's main slope inflection point 16, it would redirect both cord 6 and cord 6b along a more effective actuation geometry towards rolls 2 and 30 respectively. See FIG 13B for an example.

The cord fairlead 29 may be a simple post 29 form of low friction material such as Delrin. Alternatively, the fairlead may incorporate one or more pulleys to reduce cord friction even further while redirecting the cord for improved sheet-tensioning geometry.

FIG 5 clarifies how the roll actuation geometry can be improved by routing each cord over a strategically located fairlead. The cord needs to stay as close as possible to slope 14 in order to produce maximum tautness in the sheet as it rolls and unrolls over the structure. FIG 13 illustrates the structure of FIG 11 with all four planar sheet deployment devices fully deployed for light deprivation.

Embodiment that affixes to an existing building:

FIG 13B illustrates the restaurant-patio example cited further above under Other Applications. Since it attaches to an existing structure and has no need for light-deprivation, it presents the opportunity to practice the invention in its simplest form. Only two trackways 11 and 12 are needed to form a structure that is suitable for attaching the planar sheet deployment device 1.

Bolt flanges welded onto both ends of each trackway 11 and 12 enable them to be bolted directly to the restaurant's existing outer wall 20 (at the trackways' upper ends) and to the sidewalk or existing patio deck 33 (at their lower ends). Translucent sheet-roll 30 is affixed along the apex of the structure, as described for FIG 1, and deployed over it using a motor 8 that is secured to the restaurant's existing wall 20. Cord fairleads 29 and 29b are affixed to one trackway (12) thereby enabling the user actuate drive-spool 7 such that tensioned cord 6 drives roll 30 to deploy over the structure as needed. The result is an open-ended patio-shelter structure with a translucent covering that can protect restaurant customers from wind and rain when lowered. To further prevent inclement weather from disturbing restaurant customers, translucent curtains may be drawn across the open ends of the structure as needed.

Embodiment that serves as a sunroom extension in a house:

Similarly to the restaurant-patio embodiment, a single family dwelling can be converted into more attractive living space if the present invention is attached to a south-facing

wall and used as a sunroom extension. If the structure of FIG 1 or FIG 8 is attached to a house, the light-tight door 22 will typically be a sliding “pocket-door style rather than the hinged door shown. To improve its year-round livability, the structure may be winterized by laying down a layer of translucent “bubble wrap” insulation underneath the translucent planar sheet 31 to retain it in place (not illustrated). To configure the winterized embodiment, edge-clamping the sheet to the structure is advisable (as described above under FIG 5). Alternatively, winterization can occur by replacing the thin and flexible translucent sheet 31 with removable rigid plastic panels 17 (as shown in FIG 1). If winterizing with bubble-wrap, walls 18, 19 and 20 may also be insulated, preferably using “Ecofoil”, an engineered bubble wrap with aluminized and/or reflective white outer surfaces that will serve to prevent excess heat buildup during the summer (see FIG 14B).

To facilitate the structure’s recreational use during summer, an insect-screen (not illustrated) may be attached as a base layer under the opaque and translucent layers 3 and 31. To facilitate switching in a screen layer or a bubble insulation layer, the planar sheet gripping strip 10 shown in FIG 2B may include quick-release fixations (not illustrated) that facilitate sheet switching. This feature also makes it easier to replace the opaque sheets 3 or the translucent sheet 31 when they become damaged.

Optimizing light distribution within the structure:

Referring back to FIG 8: an important aspect of optimal cultivation is providing complete light distribution onto all parts of each plant 23. Therefore, in a preferred embodiment, the structure’s three interior walls 18, 19 and 20 as well as its floor 33 are covered with a reflective material such as aluminum foil or white paint. Door 22 is also coated to match the high reflectivity of its surroundings. The resulting reflections inside of structure 9 will cause solar rays that miss impinging on a plant 23 to be reflected and concentrated back onto them for improved light absorption and growth.

Managing excess heat

With reference to FIG 3, FIG 10 and FIG 13, it is obvious that when opaque sheet 3 is

fully deployed, solar energy absorbed by its dark-colour will result in intense heat buildup inside the greenhouse structure 9 and that it will endanger the enclosed plants. Cannabis thrives under intense solar radiation however it can only do so in an open-sky environment that can instantly vents the accompanying away heat.

To minimize heat-stress, opaque planar sheet 3 may include a multi-layer structure formulated for light-deprivation in greenhouses. Its outer surface is reflective, thereby greatly reducing the amount of solar heating it generates in the closed structure. FIG 14A is an image of a suitable planar sheet material with built-in reflectivity: this sample of "Bold™" greenhouse tarp is white on its outer surface to protect against overheating the plants; it's black inner layer ensures total light-opacity and a strengthening mesh is included to increase its durability. Less costly "Panda Film" greenhouse sheeting is also suitable for preventing harmful heat buildup.

The structure's back wall 20 and end walls 18 and 19 are also prone to introducing excessive heat that can harm the plants and should also be constructed with an outer layer that reflects light rather than absorb it. FIG 14B is an image of a suitable "Double Bubble™" brand insulation material can be integrated into the wall construction to provide a choice of reflective surfaces facing towards both the structure's interior (to improve photosynthesis and its exterior (to prevent overheating). The insulation layer separating the reflective surfaces adds value for winterization the structure (when it's attached to a house as a living space) as well as for heat retention around the plants (during chilly nights late in the growing season).

A trellis that further optimizes light distribution

In order for the sunlight reflecting about inside structure 9 to have maximum effect, each plant 23 should be conditioned for optimal light penetration through leafy vegetation and onto its flower buds. Various pruning techniques have been developed that force the cannabis plant to produce a higher quality harvest. "Topping" is one well-known pruning technique that forces the plant to send out new branches that sprout new flowers.

"Supercropping" and "Scrogging" are also effective "Plant Training Techniques" that

enhance the crop's yield of high-value flowers. If those pruning techniques are practiced while continuously binding the growing plant to a 3D trellis, the result will be a dense 3D grid of spaced-apart flower buds that takes maximum advantage of whatever sunlight is irradiating the greenhouse structure's interior.

FIG 15A illustrates a suitable growth-training trellis 41 which may be provided to work in concert with the planar sheet deployment device and thereby further optimize the crop's yield, quality and value. Cylindrical trellis 41 enables plant 23 growing in pot 40 to be pruned for optimal productivity; as the plant rises up as a seedling, the grower prunes it judiciously and binds new branches to nearby trellis supports to maximize light penetration to all parts of the plant. When the matrix of cannabis buds reaches the outer circumference of trellis 41, the grower can then train the plant towards the ground as well as upwards to complete filling of the entire space. When used inside the greenhouse structure 9 of FIG 1 or FIG 8, the resulting vegetative mass makes maximum use of all available sunlight.

FIG 15B illustrates a modified trellis 42 that includes a horizontal "bridge" portion spanning between two plants in two pots. The elevated portion of vegetation trained to grow into and along the "bridge" towards its neighboring plant will be optimally exposed to sunlight reflected off the floor 33 of structure 9. FIG 16 is a modified version of the curved trellis of FIG 15B which has been optimized for compact storage and shipping. Once its six gridded-wire sides are fastened together to form a cage structure, the user completes the trellis by lacing an internal support network of string (not illustrated) that is pulled taut through the cage's exterior grid.

A multipurpose heliostat embodiment:

FIG 17, FIG 18, FIG 19 and FIG 20 illustrate a means for optimizing the amount of sunlight absorbed by the plants growing in structure 9. To redirect additional sunlight into the structure and onto the plants, a reflective "porch-panel" 43 may be hingedly affixed at ground level to structure 9, where it serves as a rudimentary heliostat. The rectangular, hinged panel 43 extends east-west across the open side of structure 9 and

includes a separate propping means 44 that enables the user to tilt and hold the panel at an upward angle which redirects additional sunlight into the structure. To actuate the heliostat, the user simply props the hinged reflective panel 43 at whatever angle is needed to redirect solar radiation from in front of the structure towards the crop and thereby increase its eventual yield. The propping means may be a propping-stick 44 of suitable length as shown however adjustable-length chains spanning between endwalls 18 and 19 and the adjacent ends of hinged reflective panel 43 might also be used.

When hinged reflective panel 43 is not serving as a rudimentary heliostat, the reflective porch-panel may be swung down and left lying flat on the ground in front of the structure (it's "front-porch" lounging function). Alternatively, the panel may be swung all the way up and padlocked onto the structure's lower inclined slope portion (14), thereby forming a robust "drawbridge" style of barrier that protects the structure's contents from thieves.

FIG 17 illustrates an embodiment that includes a multipurpose hinged reflective panel, that panel being in its horizontal configuration in front of the recreational shelter.

FIG 18 shows the embodiment of FIG 17 with the trellis of FIG 16.

FIG 19 shows the embodiment of FIG 18 with its hinged reflective panel partially raised and supported at an angle that enables it to act as a heliostat which redirects sunlight onto the trellis of FIG 16.

FIG 20 shows the embodiment of FIG 18 with its hinged reflective panel fully raised and padlocked against the structure's sloped portion to act as a security barrier. Once the barrier 43 is secured, rolls 2 and 30 may be fully deployed to close-off the structure as shown in FIG 10.

Conclusion

The foregoing has constituted a description of specific embodiments showing how the invention may be applied and put into use. These embodiments are only exemplary.

The invention in its broadest, and more specific aspects, is further described and defined in the claims which now follow.

These claims, and the language used therein, are to be understood in terms of the variants of the invention which have been described. They are not to be restricted to such variants, but are to be read as covering the full scope of the invention as is implicit within the invention and the disclosure that has been provided herein.

It is appreciated that certain features of the invention, which are, for clarity, described in the context of separate embodiments, may also be provided in combination in a single embodiment. Conversely, various features of the invention that are, for brevity, described in the context of a single embodiment, may also be provided separately or in any suitable subcombination.

Claims

1. A planar sheet deployment system comprising:
 - a) a sheet of flexible, planar material suitable for being rolled upon itself for storage, the sheet material having upper and lower edges and lateral side edges that are dimensioned to cover a predetermined area when deployed;
 - b) a frame with an upper horizontal support for anchoring the upper edge of the sheet material in a generally horizontal alignment;
 - c) a linear winding rod spanning across and bonded to the width of the sheet material along its lower edge in parallel to the upper edge, for winding-up the sheet material into a roll surrounding the winding rod;
 - d) a spool located along at least one end of the winding rod that extends outwardly from at least one side edge of the sheet material;
 - e) a winding cord extending down from a point located near the height of the upper horizontal support portion of the frame and connected at its lower end to the spool-portion on the winding rod to be wound thereon in the opposite direction with respect to the winding direction of the sheet material, a first portion of the cord being provided to extend from the upper point to the spool when the sheet material is deployed at a fully unrolled location; and a second portion of the cord, of similar length, wound onto the spool; and
 - f) a cord tensioner for drawing cord upwardly off the spool towards the upper point whereby upon applying tension to the winding cord through the cord tensioner, the winding cord will unspool from the spool on the winding rod causing the winding rod to rotate and roll-up the sheet material while transferring the location of the winding rod and rolled-up sheet material towards the upper horizontal support of the frame.
2. A system as in claim 1 including a trackway comprising two separated parallel tracks extending from the upper horizontal support downwardly along respective paths that are displaced inwardly from the lateral edges of the sheet material, extending to a lower level, the trackway being positioned for supporting the sheet material as the winding rod unrolls the roll of sheet material while descending towards the unrolled location at that bottom of the trackway.

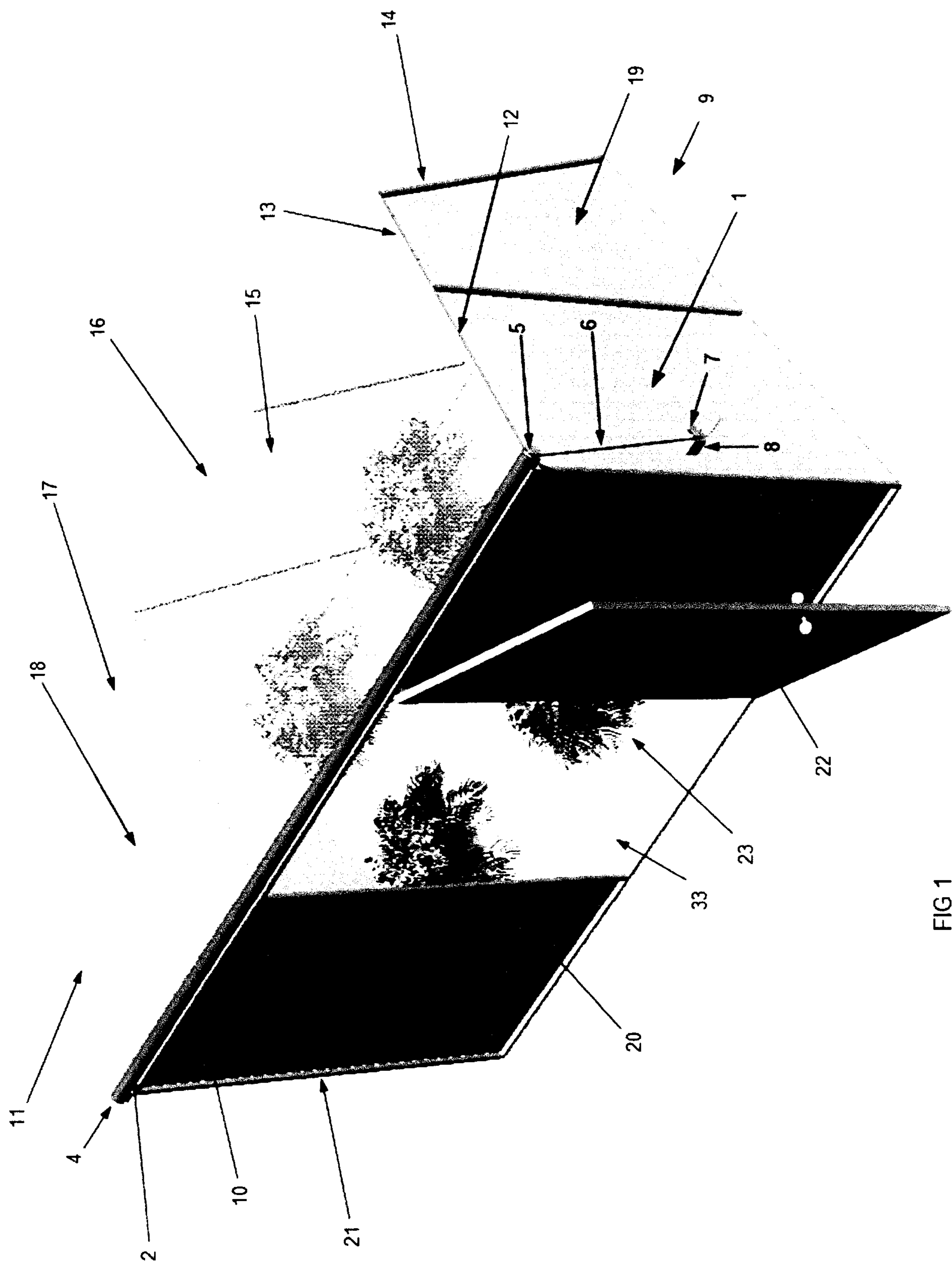
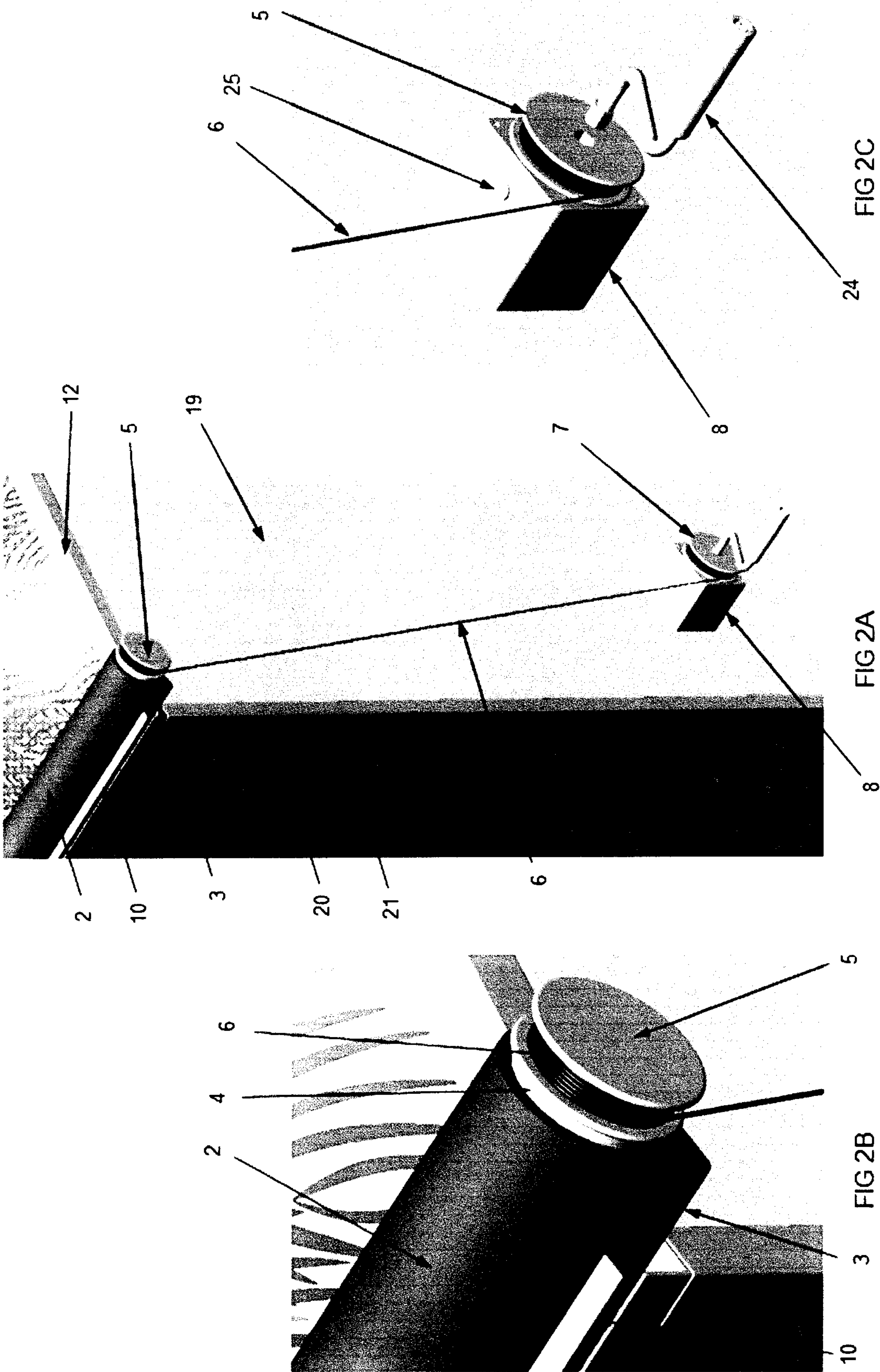
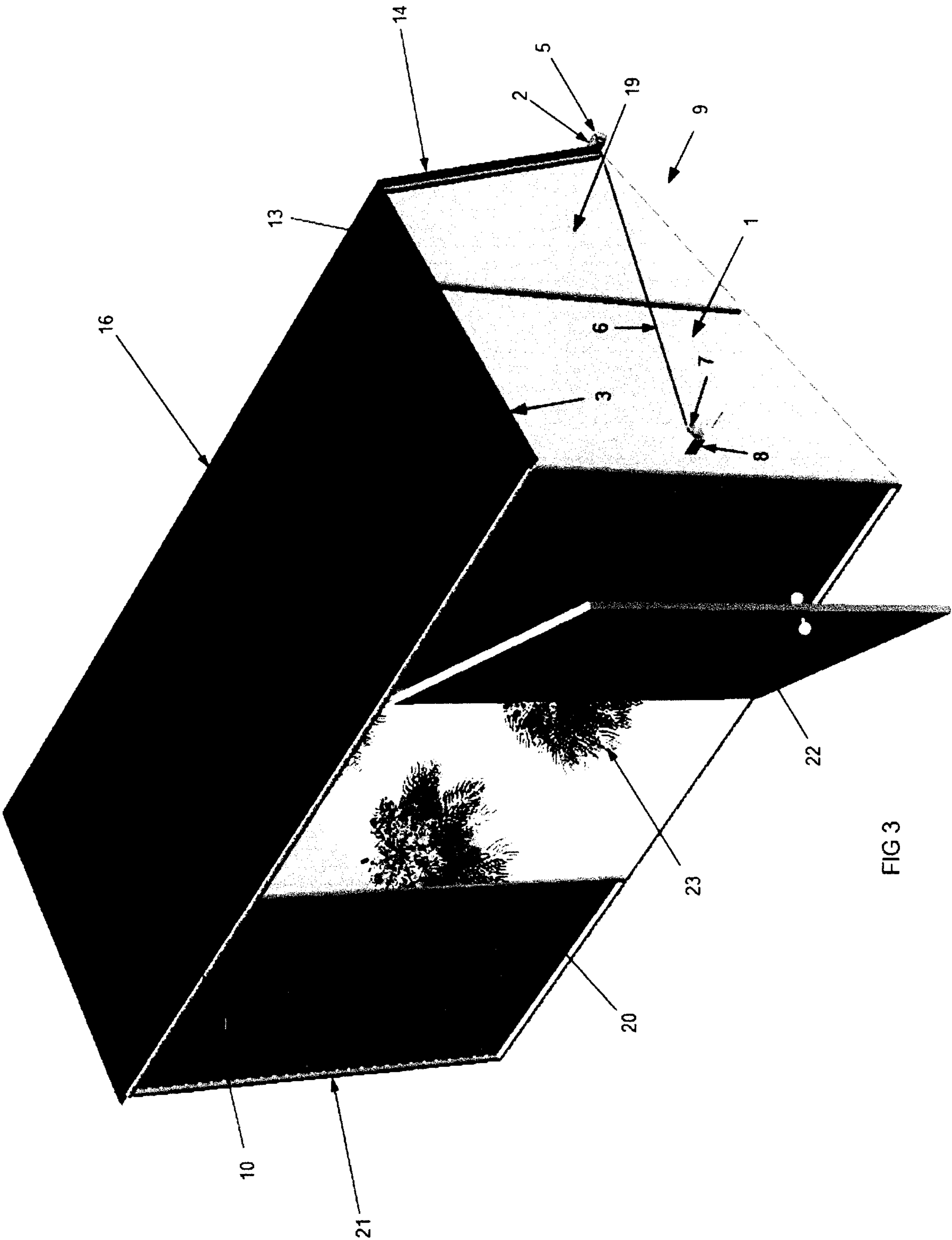


FIG 1





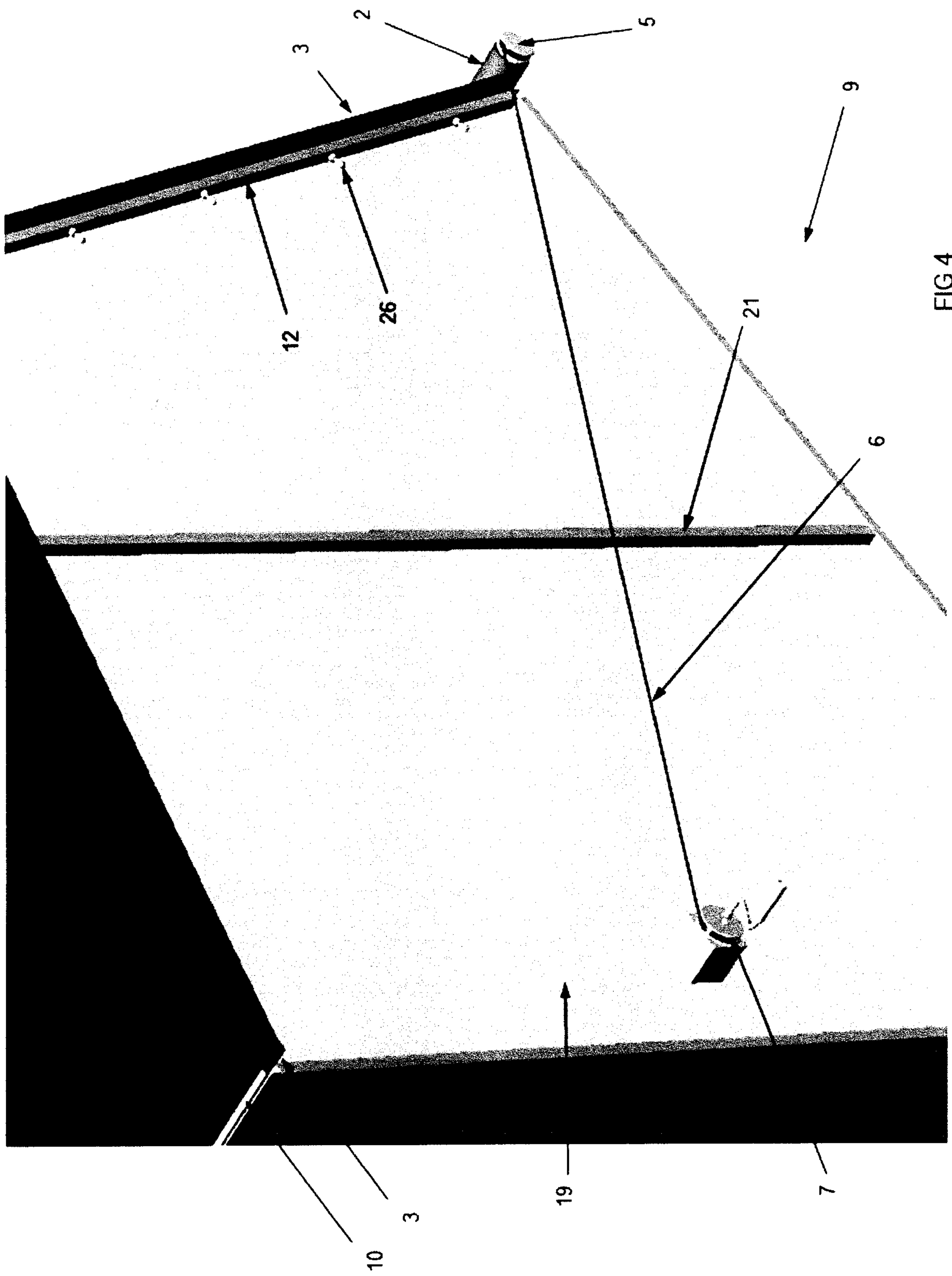
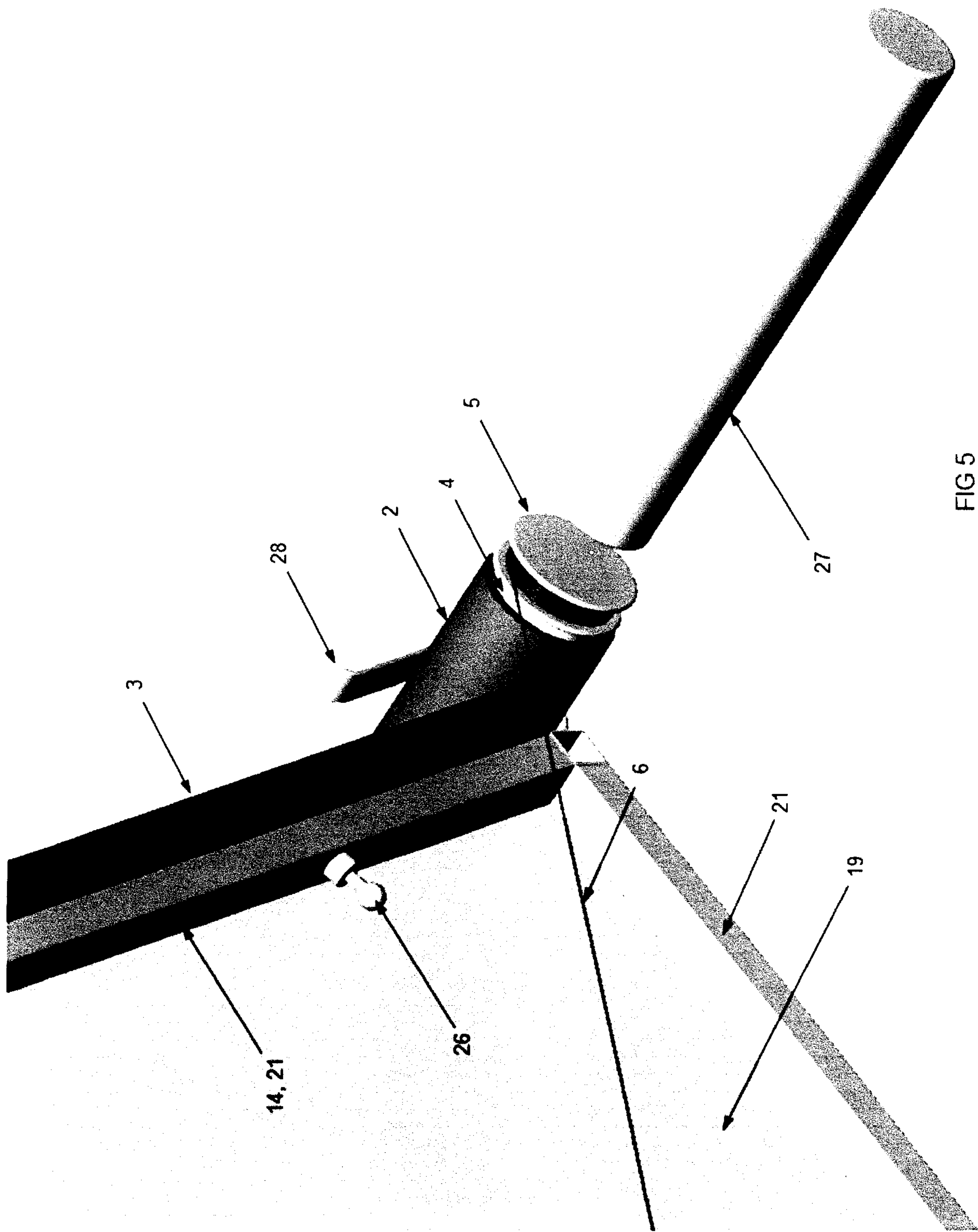


FIG 4



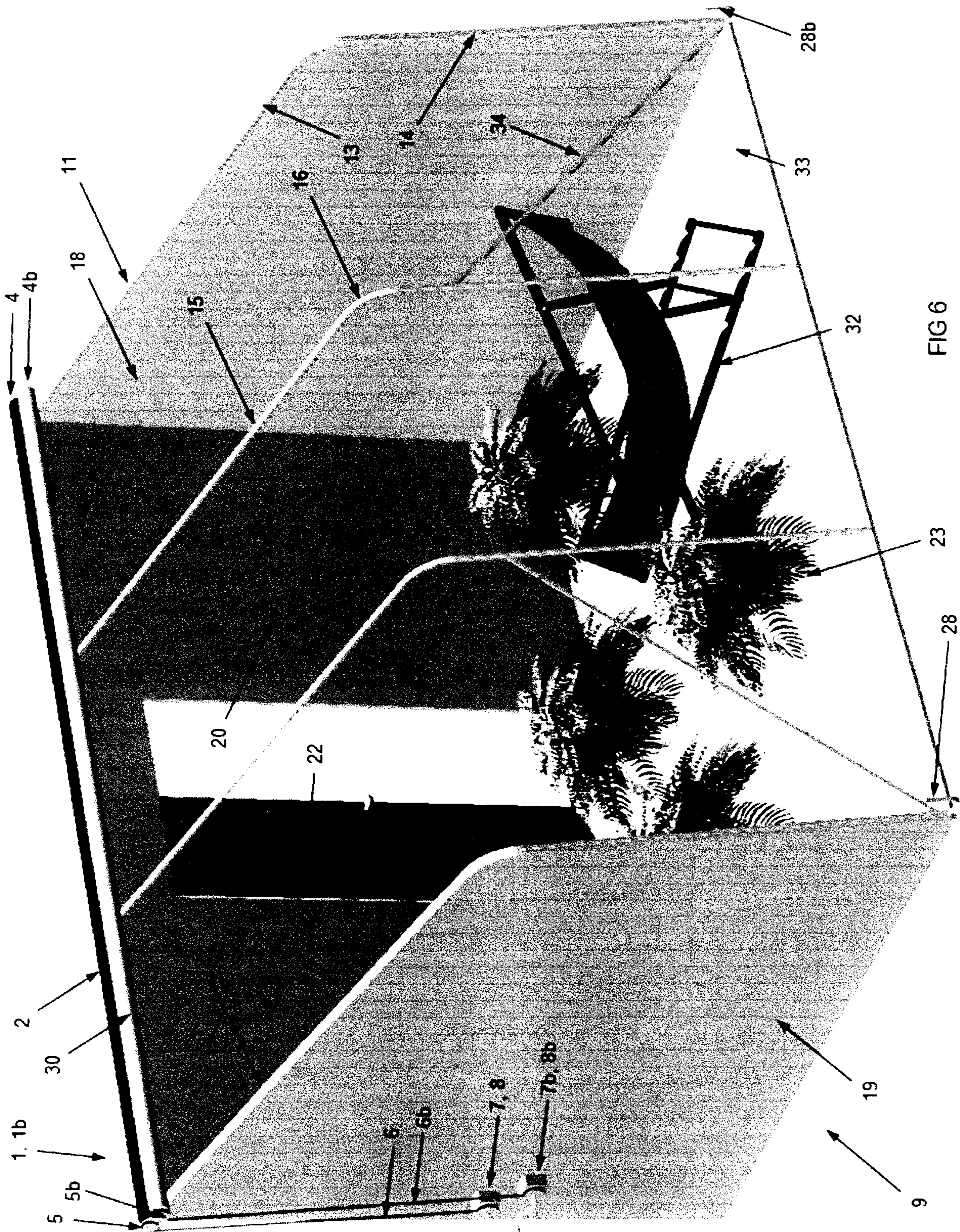


FIG 6

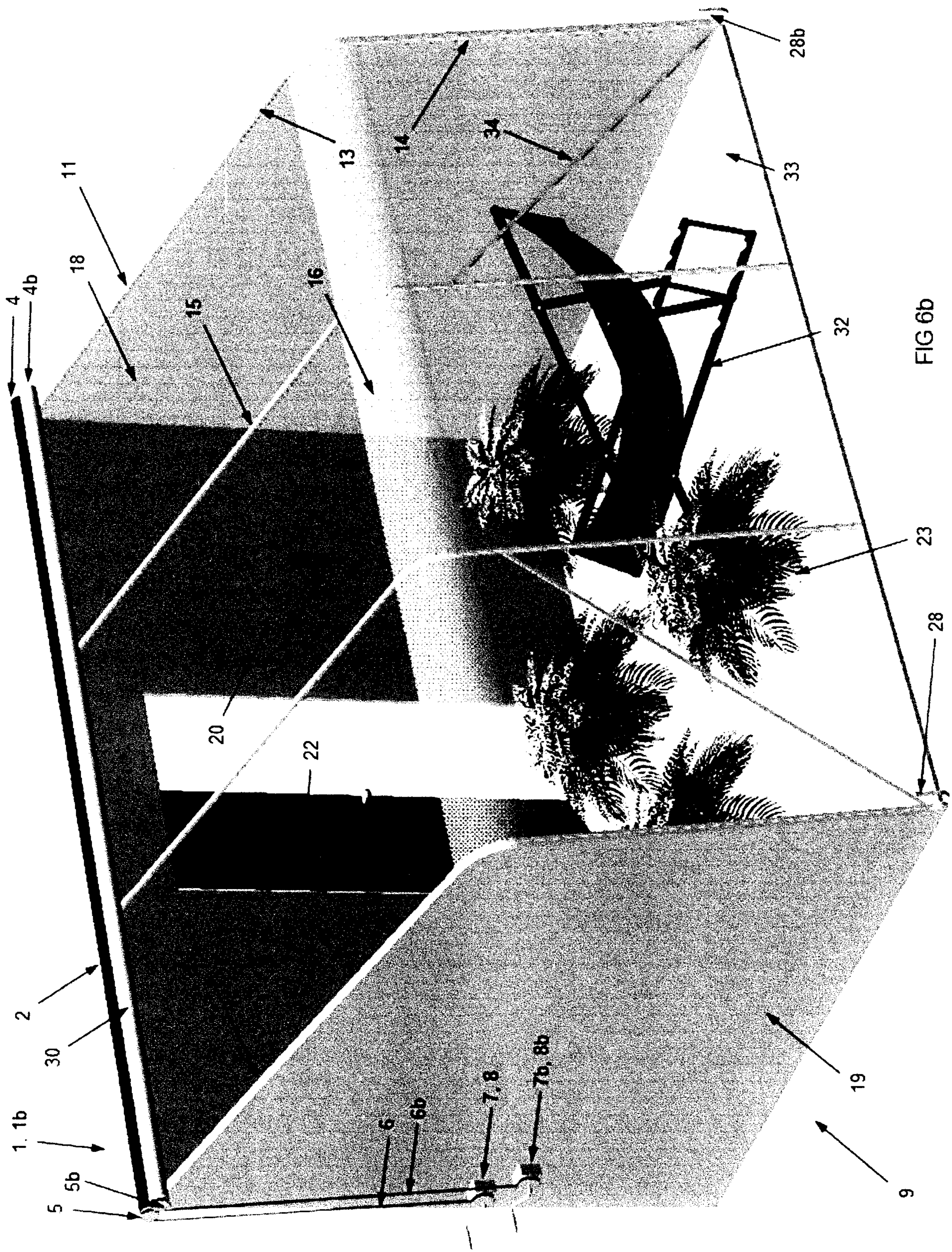


FIG 6b

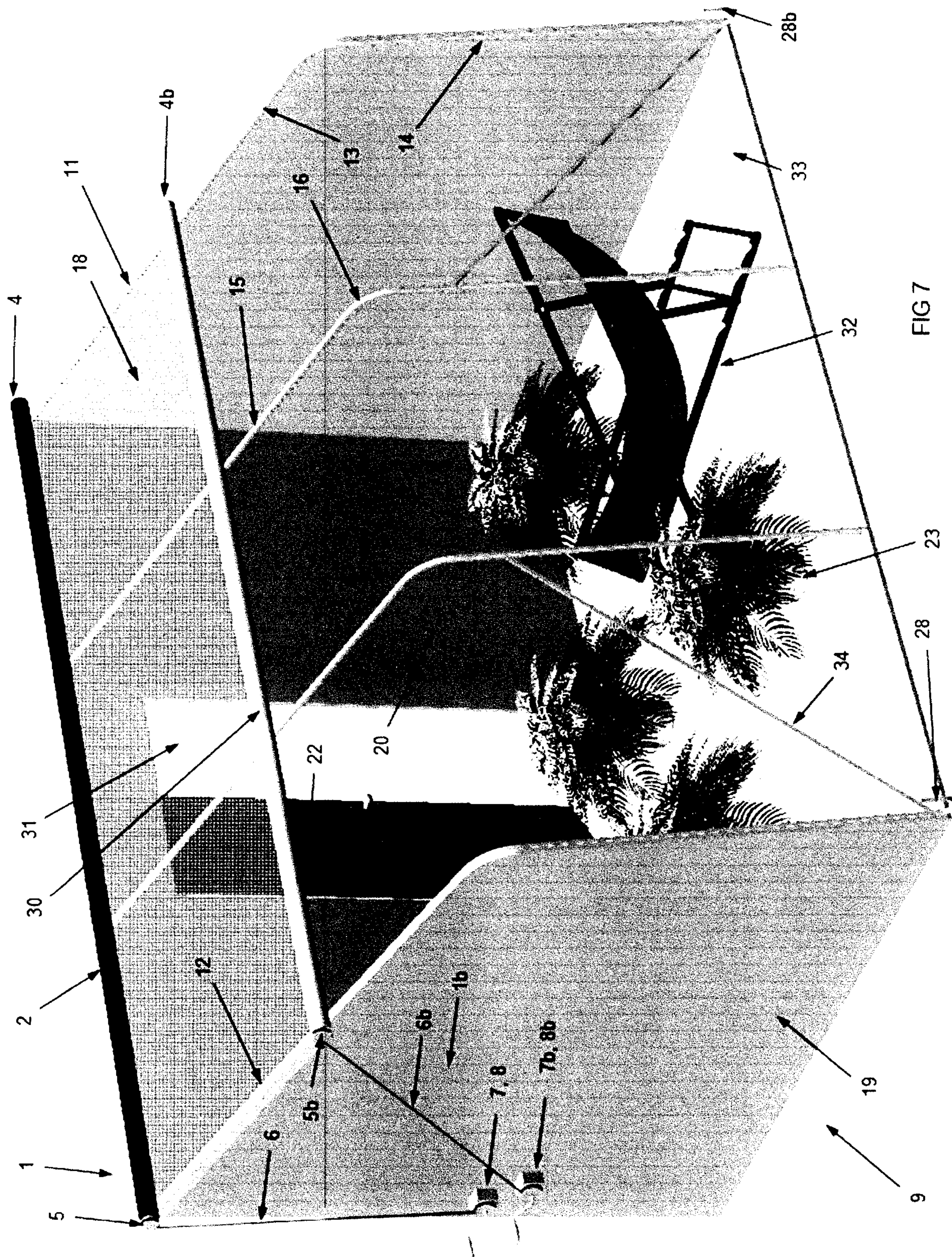


FIG 7

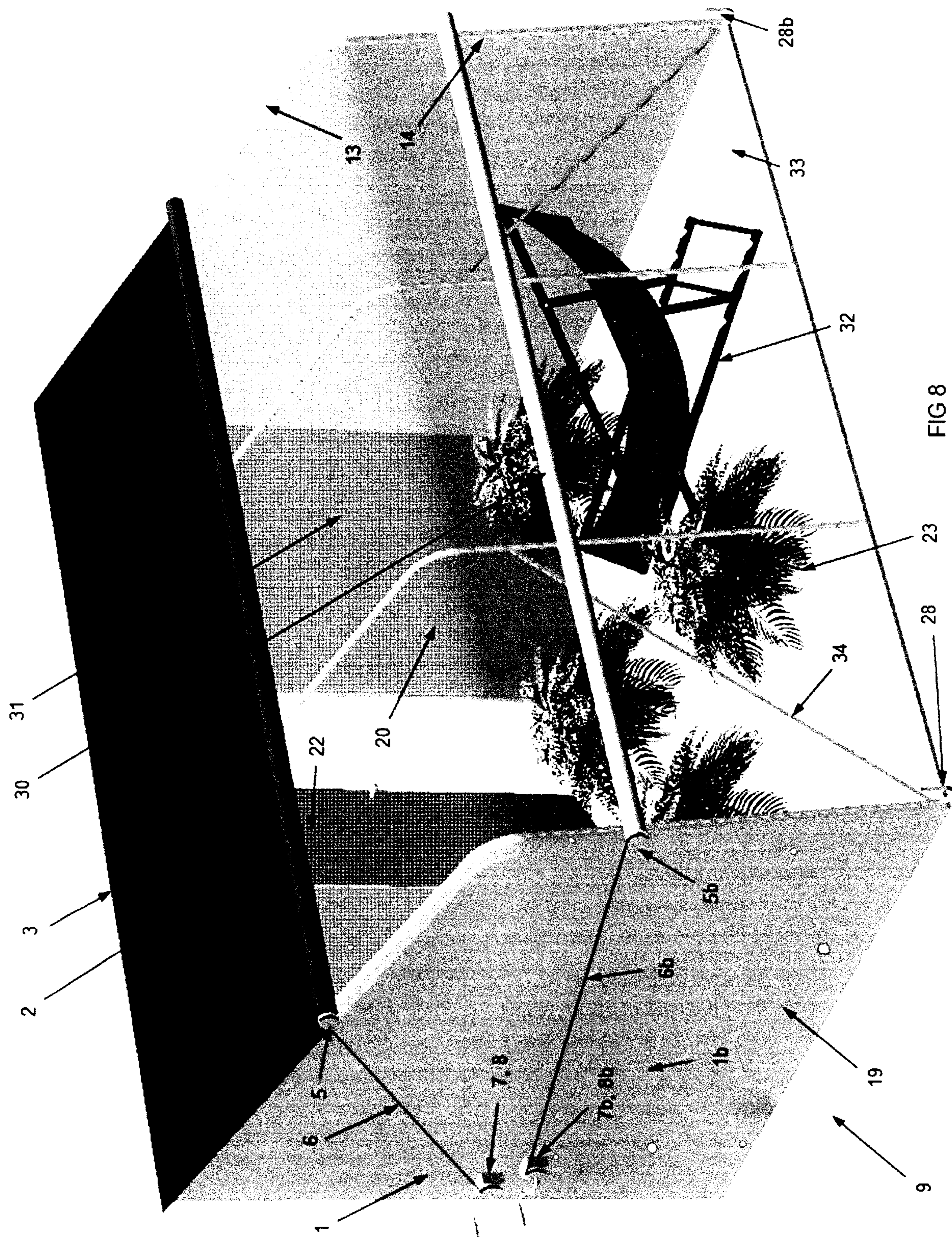
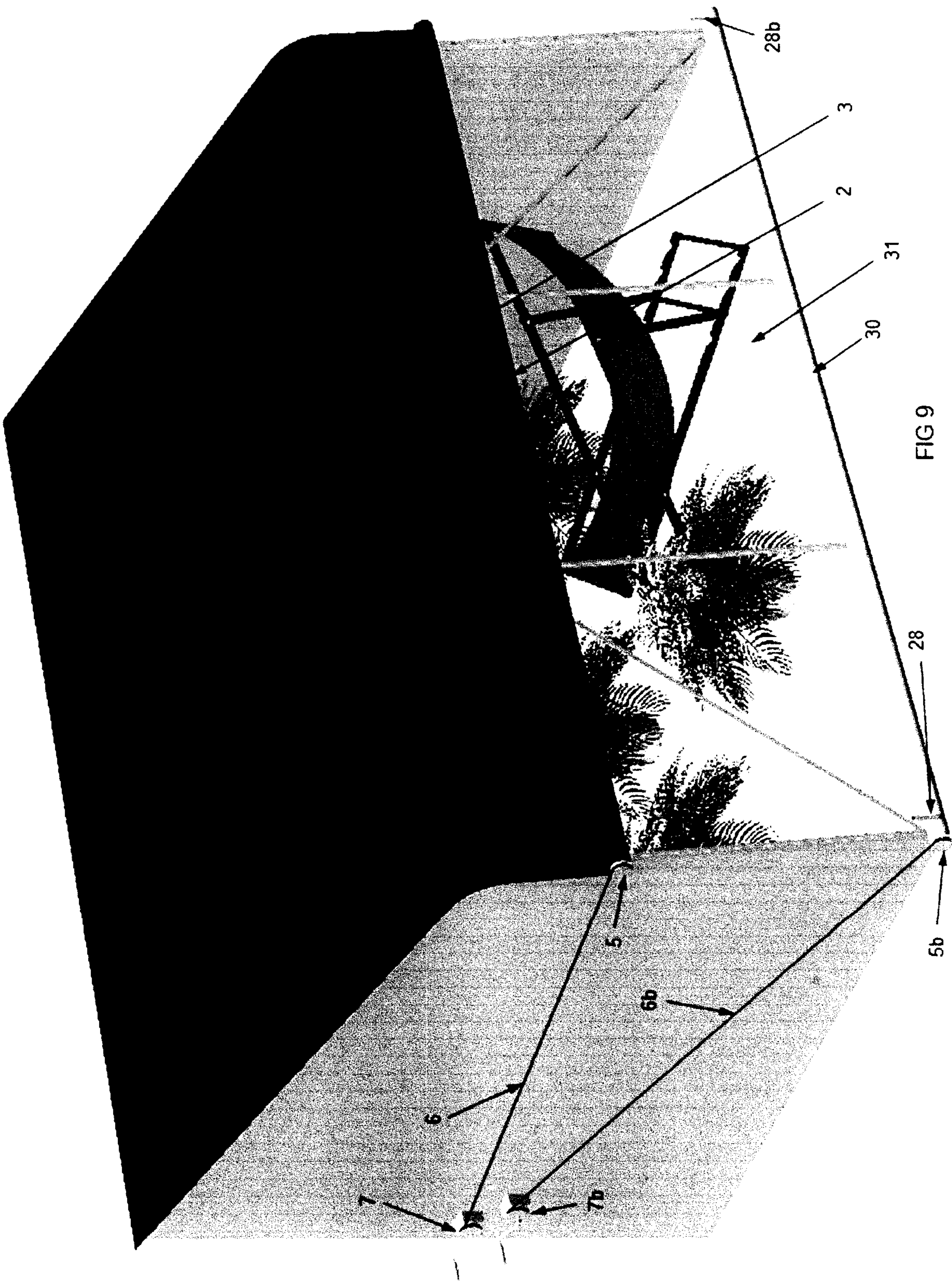
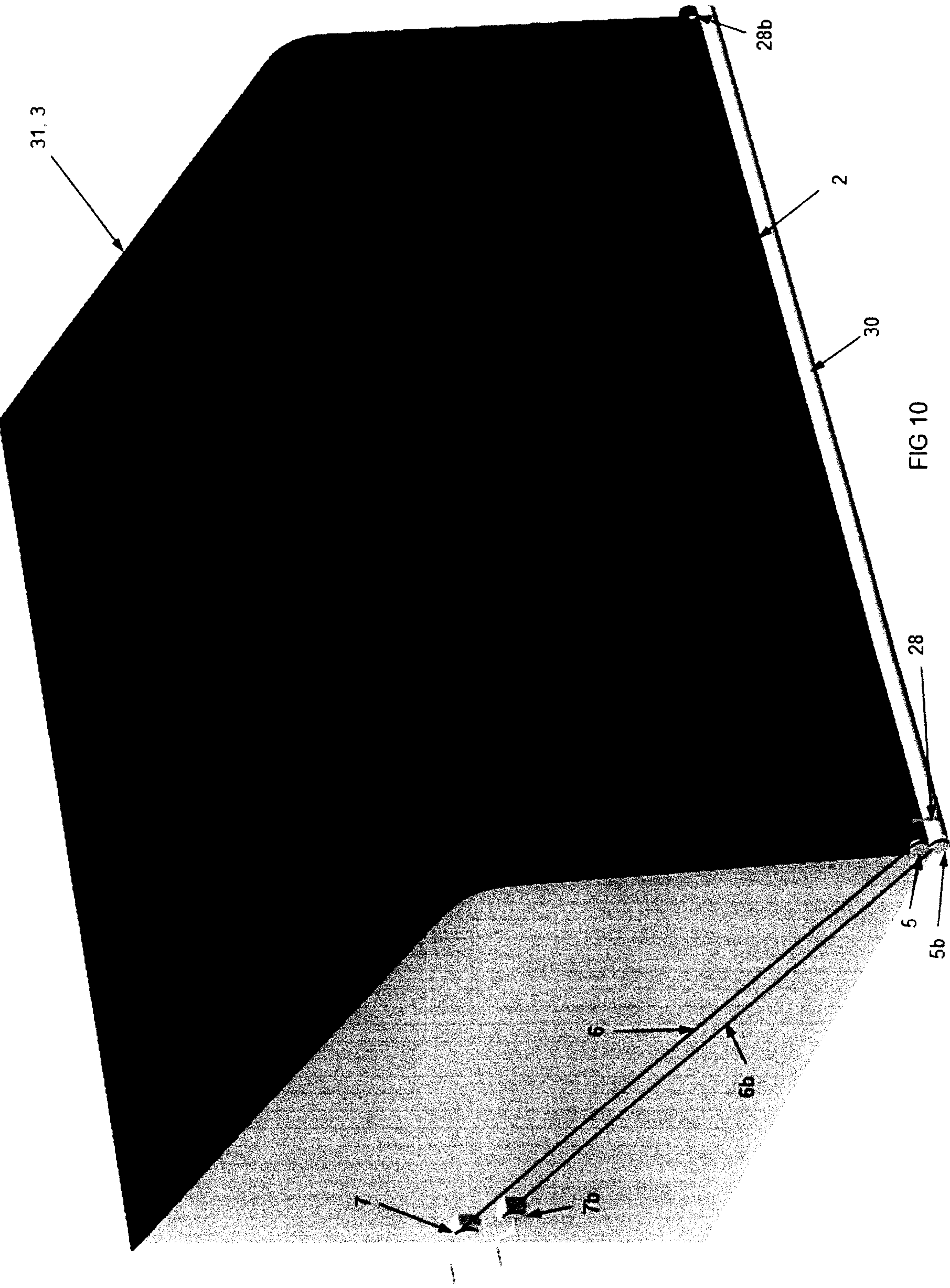


FIG 8





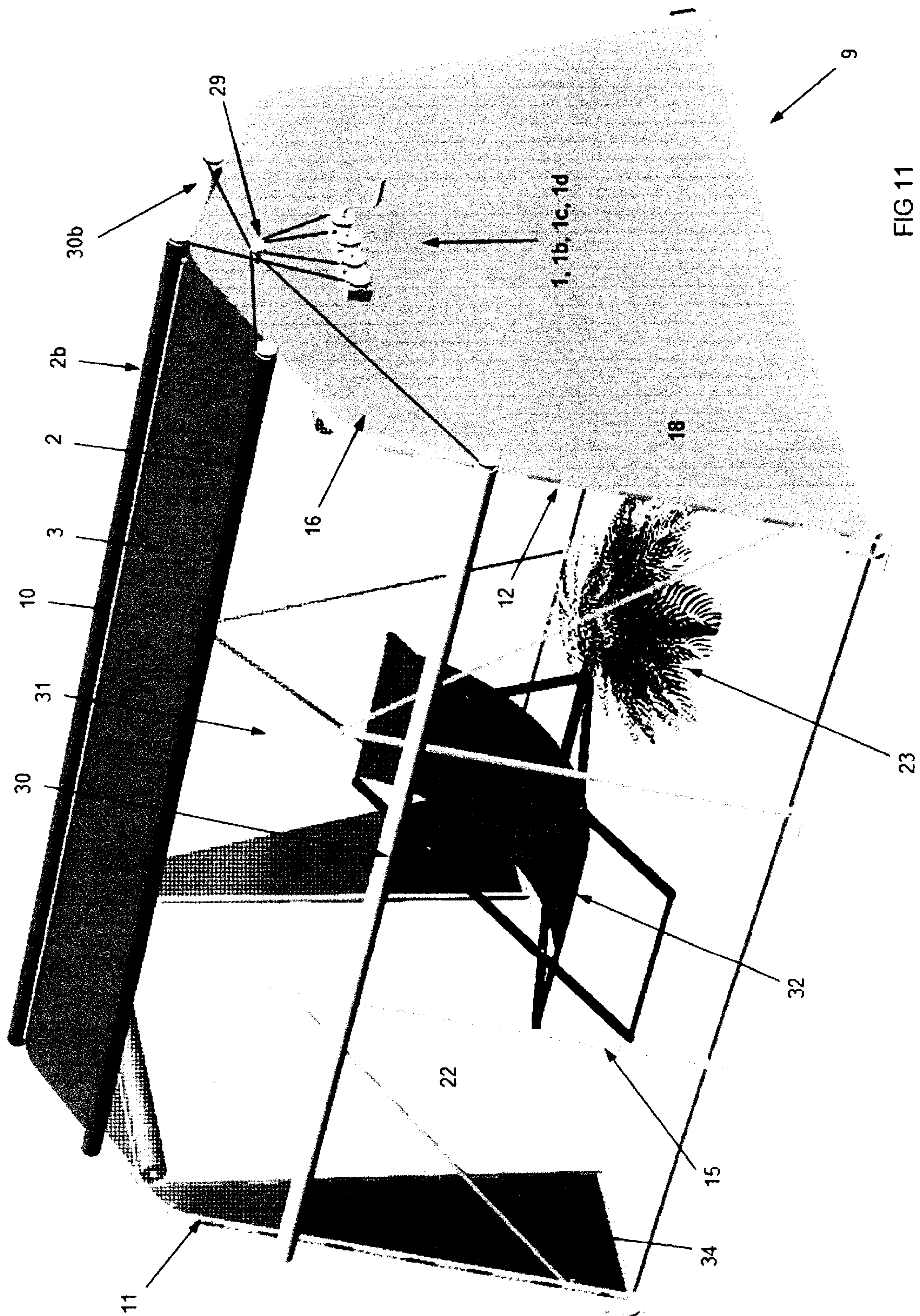
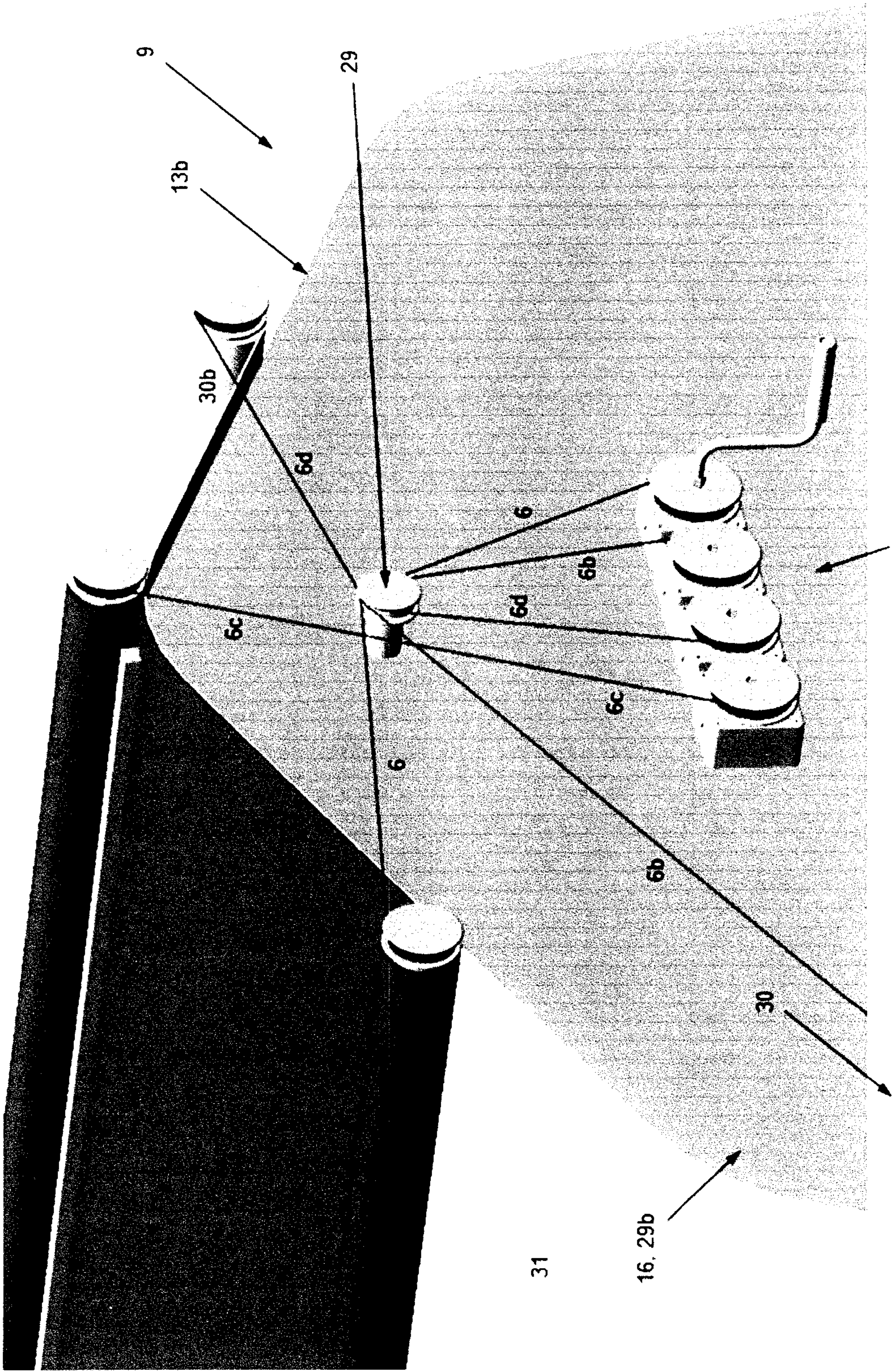


FIG 11



1, 1b, 1c, 1d

FIG 12

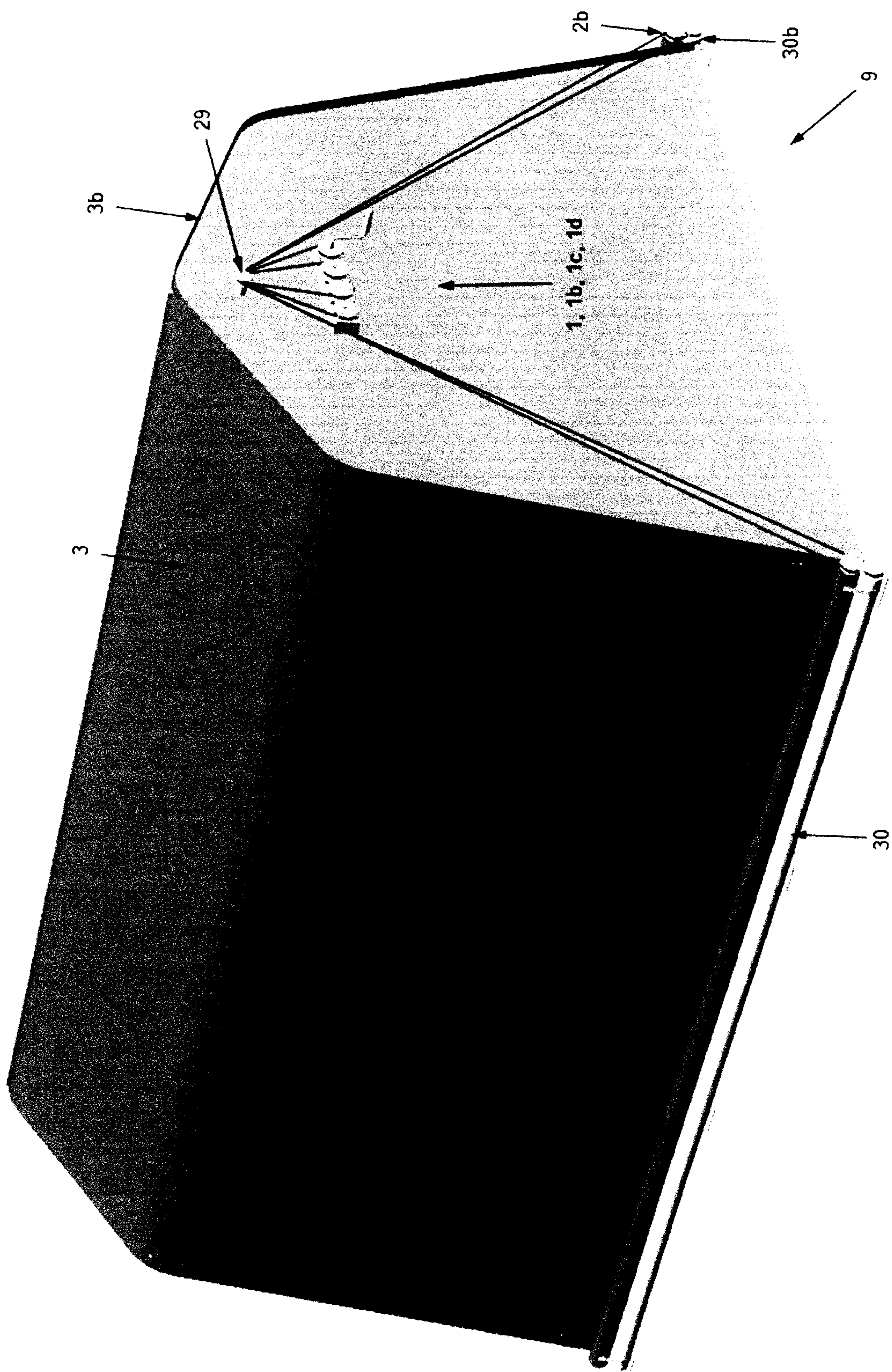


FIG 13

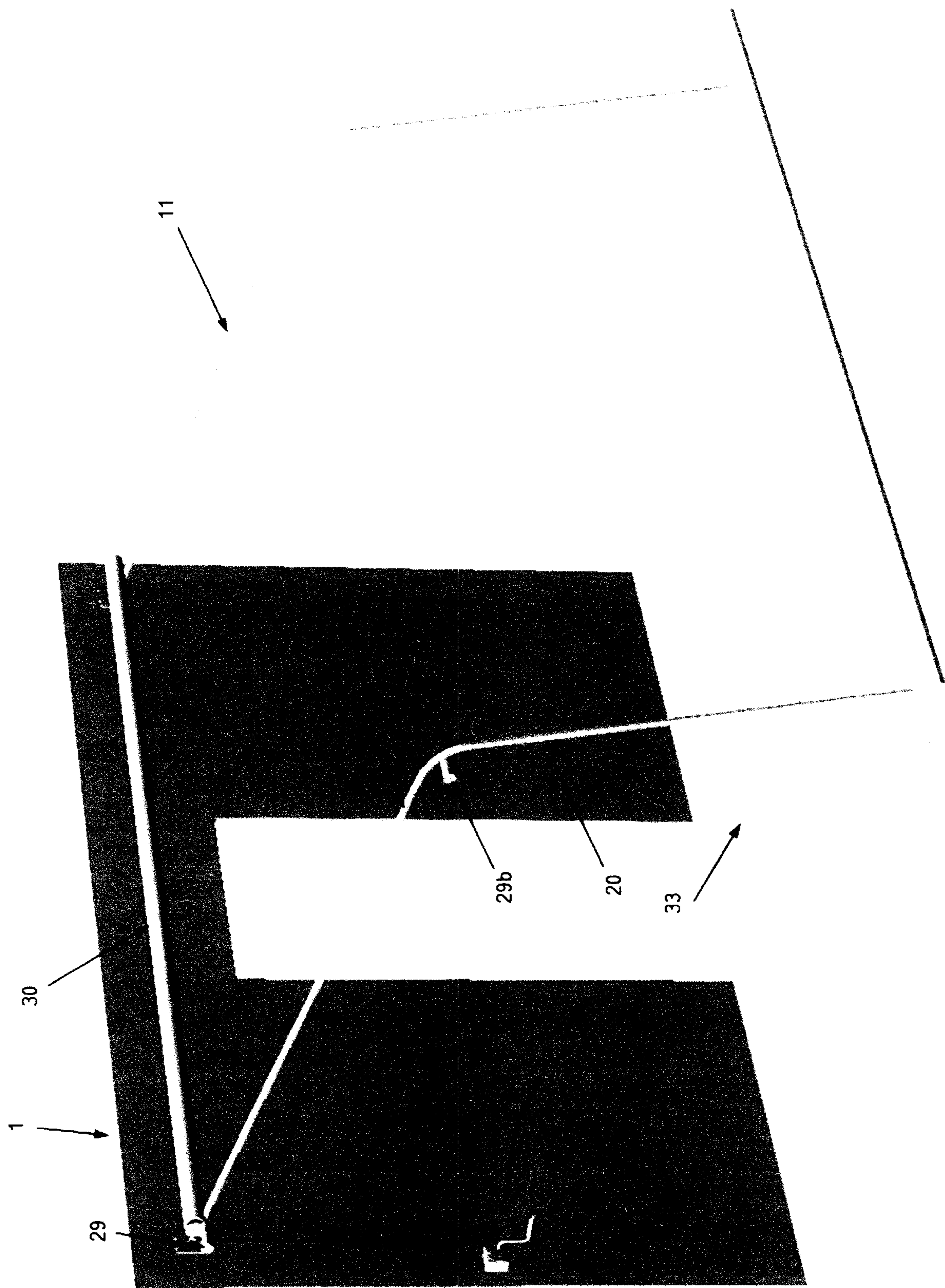


FIG 13B

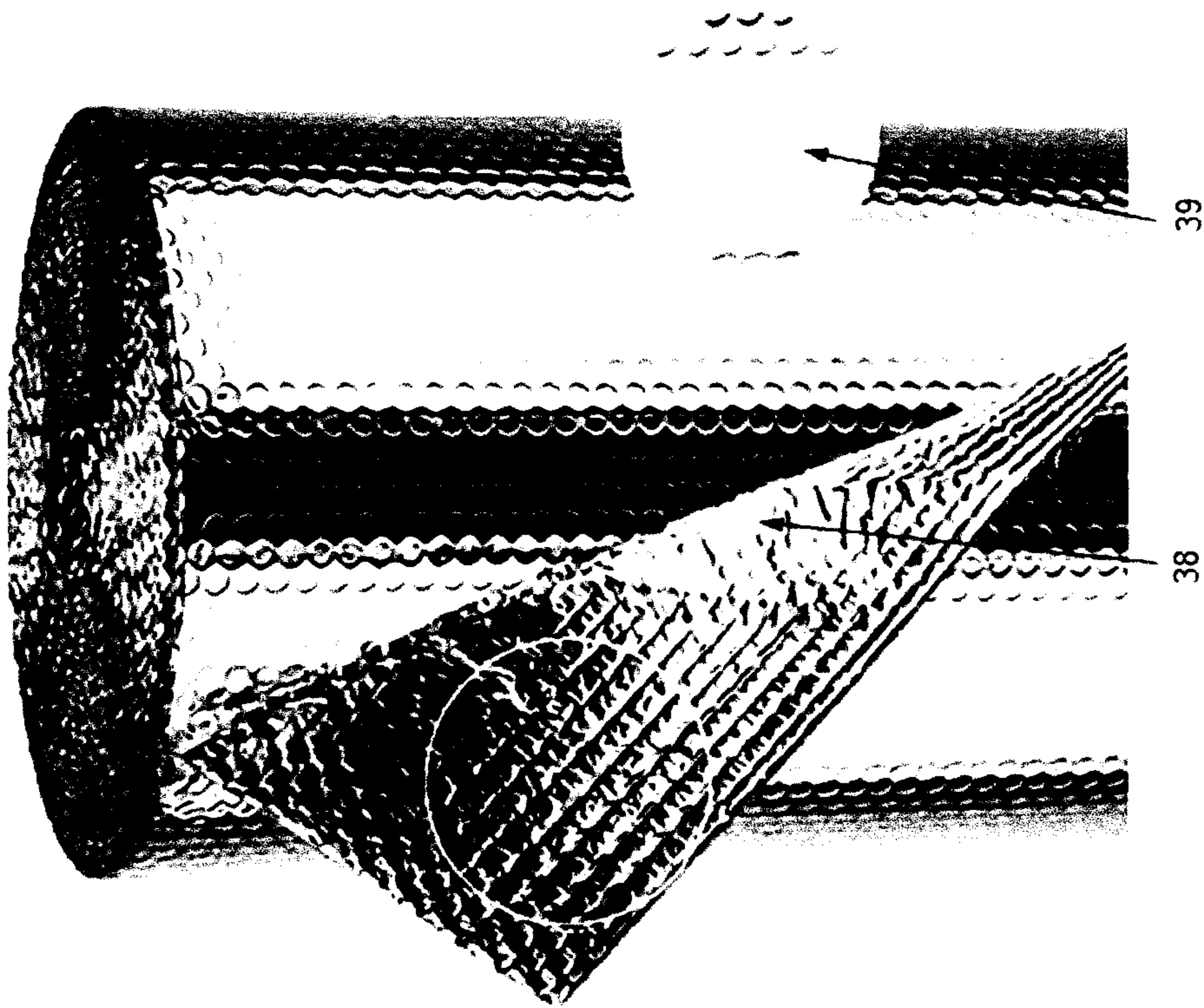


FIG 14B

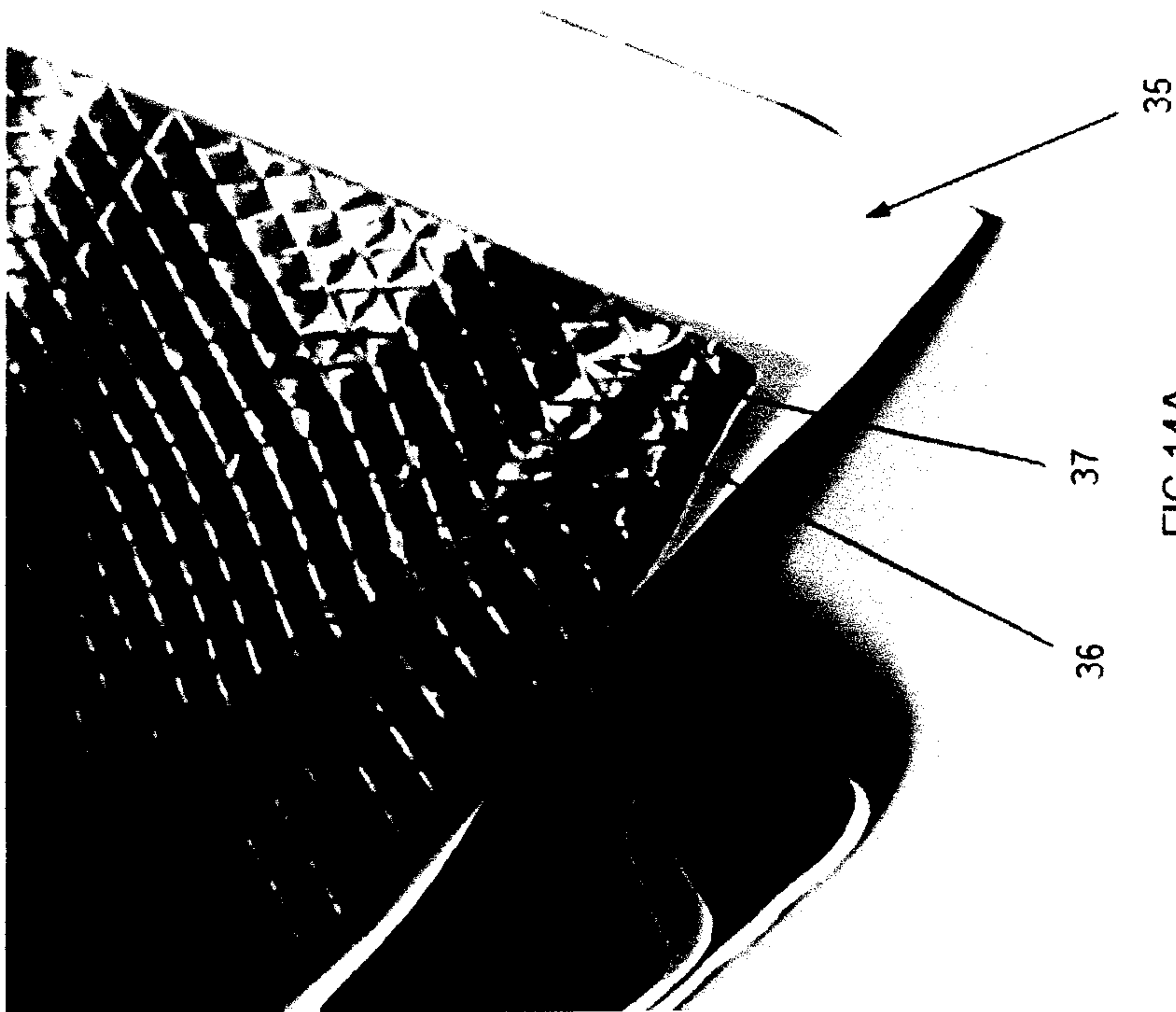


FIG 14A

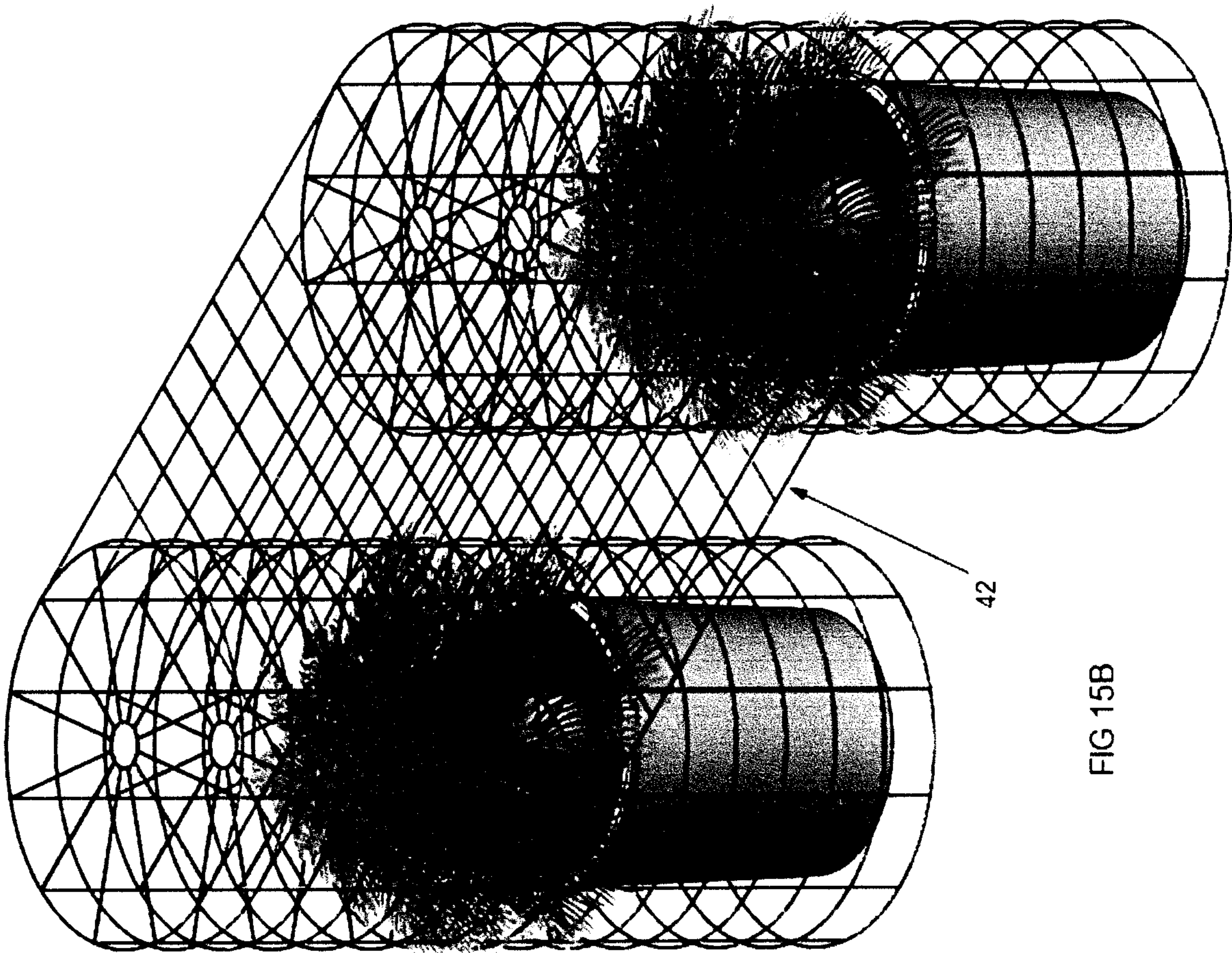


FIG 15B

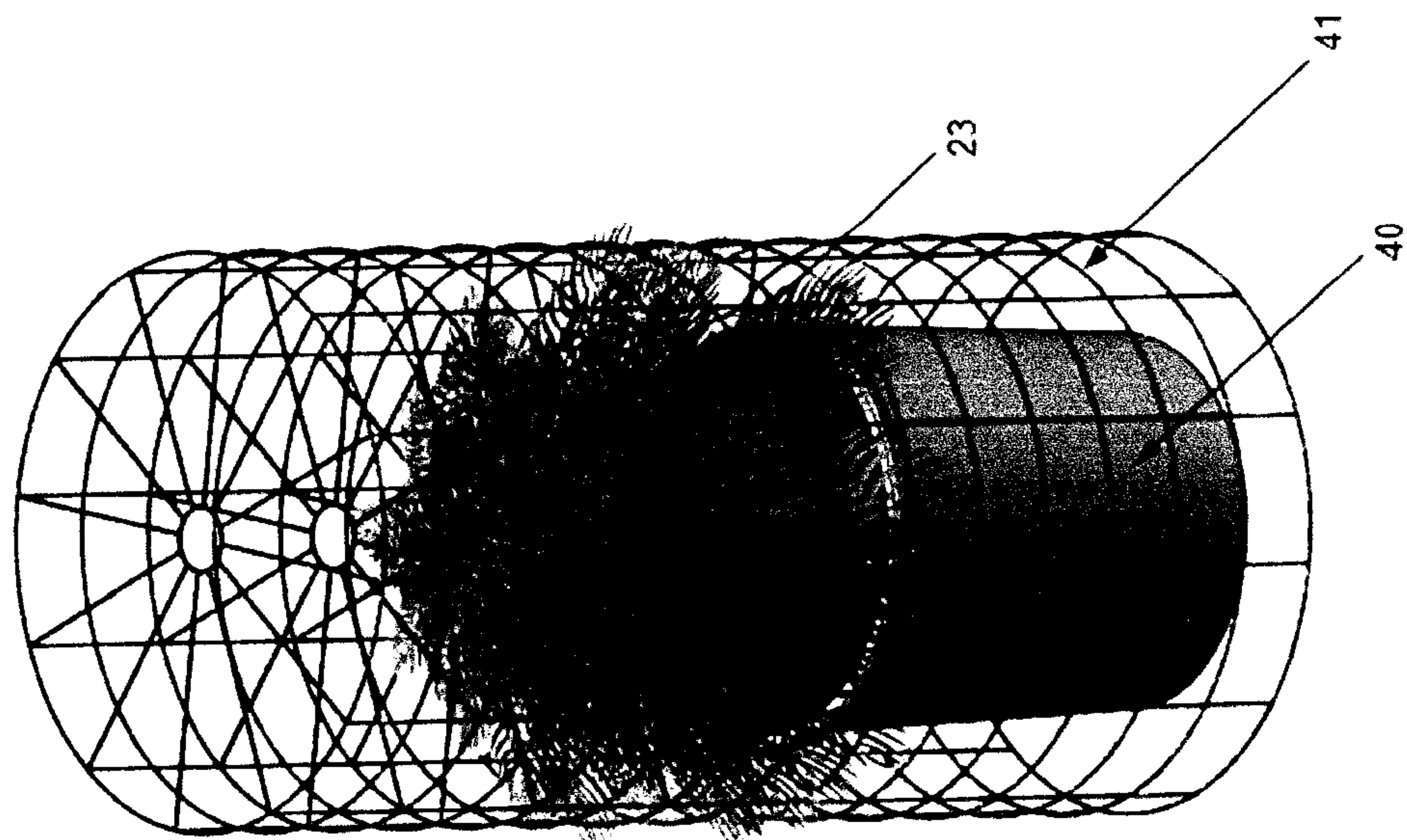


FIG 15A

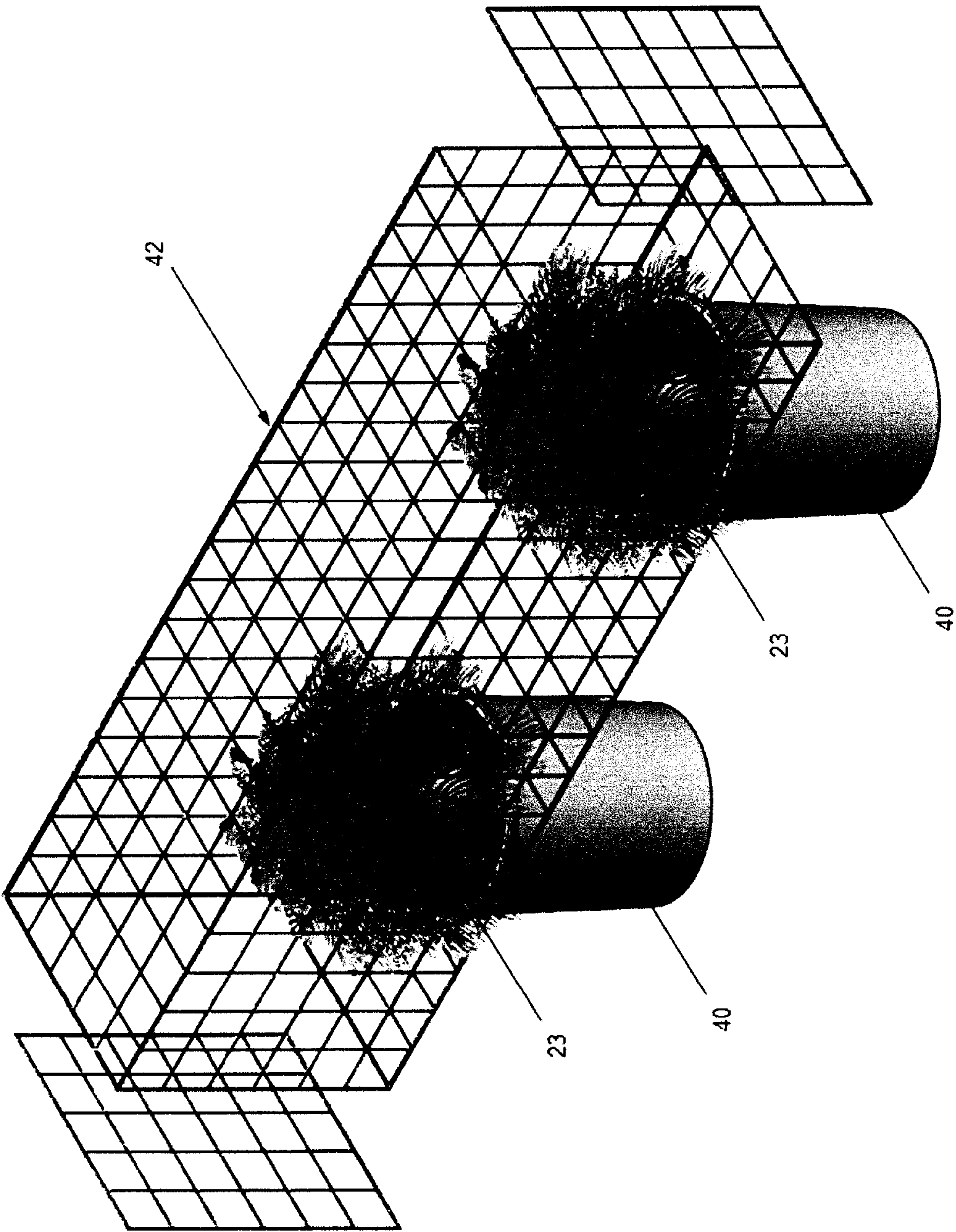
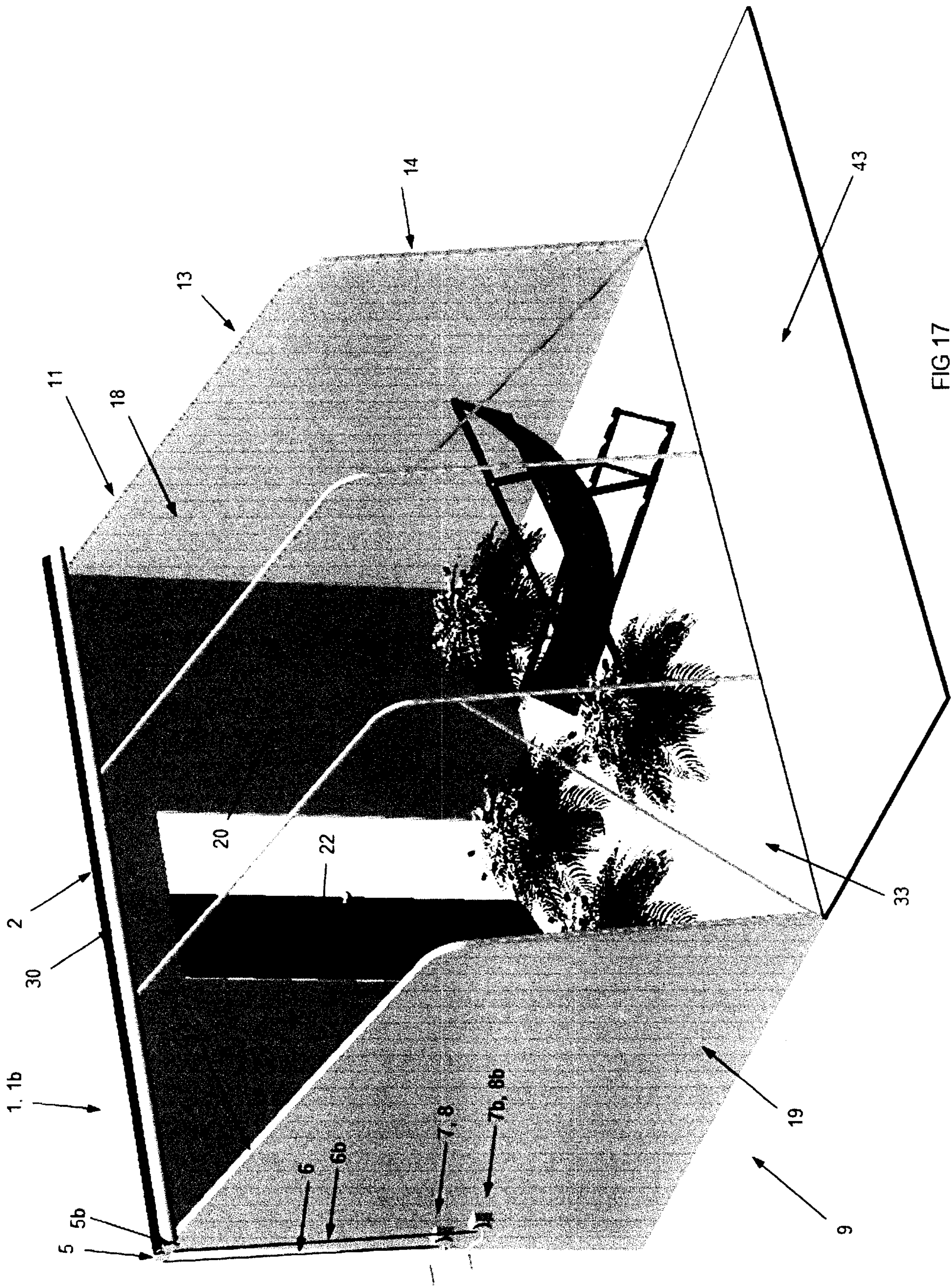


FIG 16



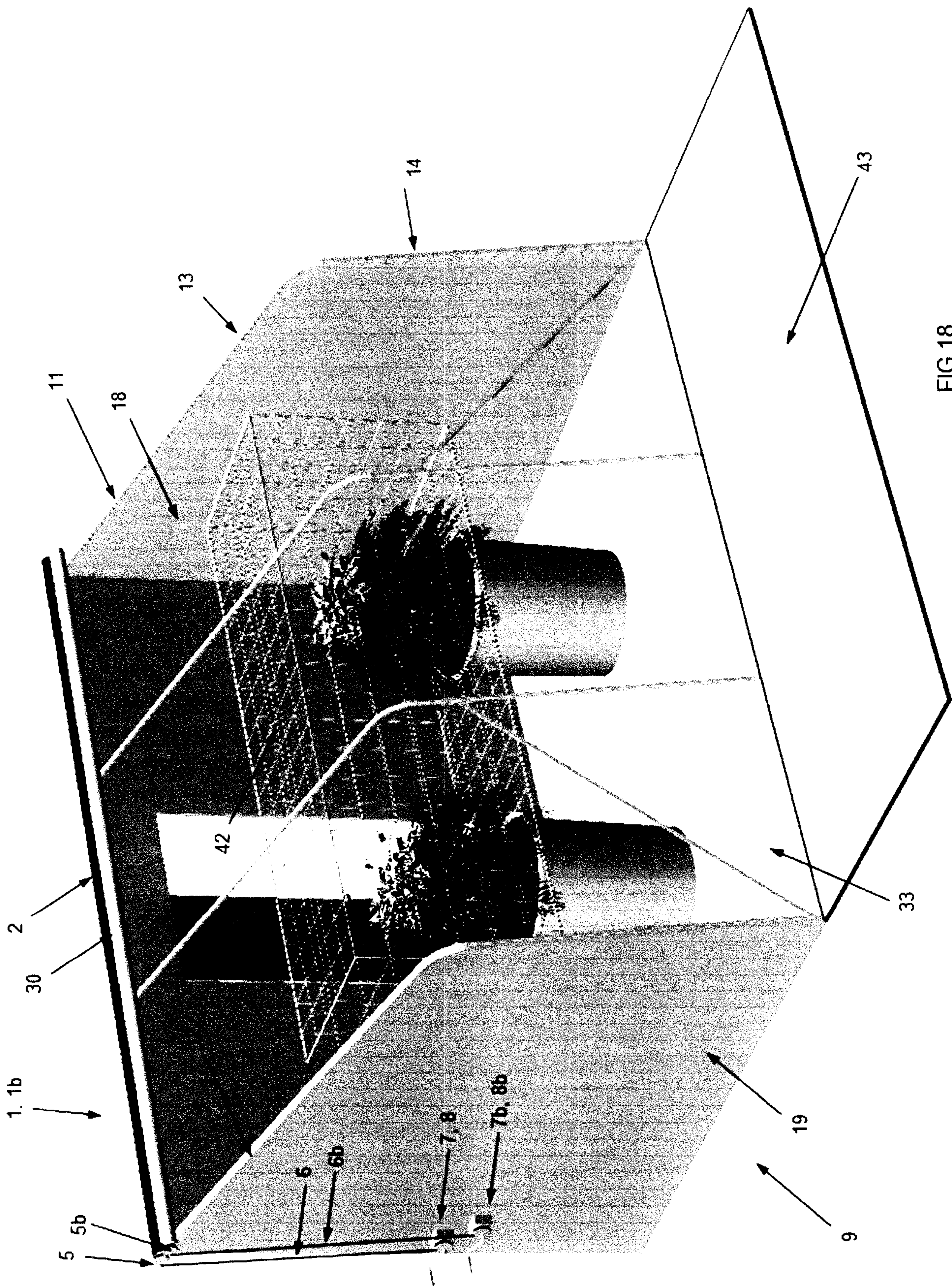


FIG 18

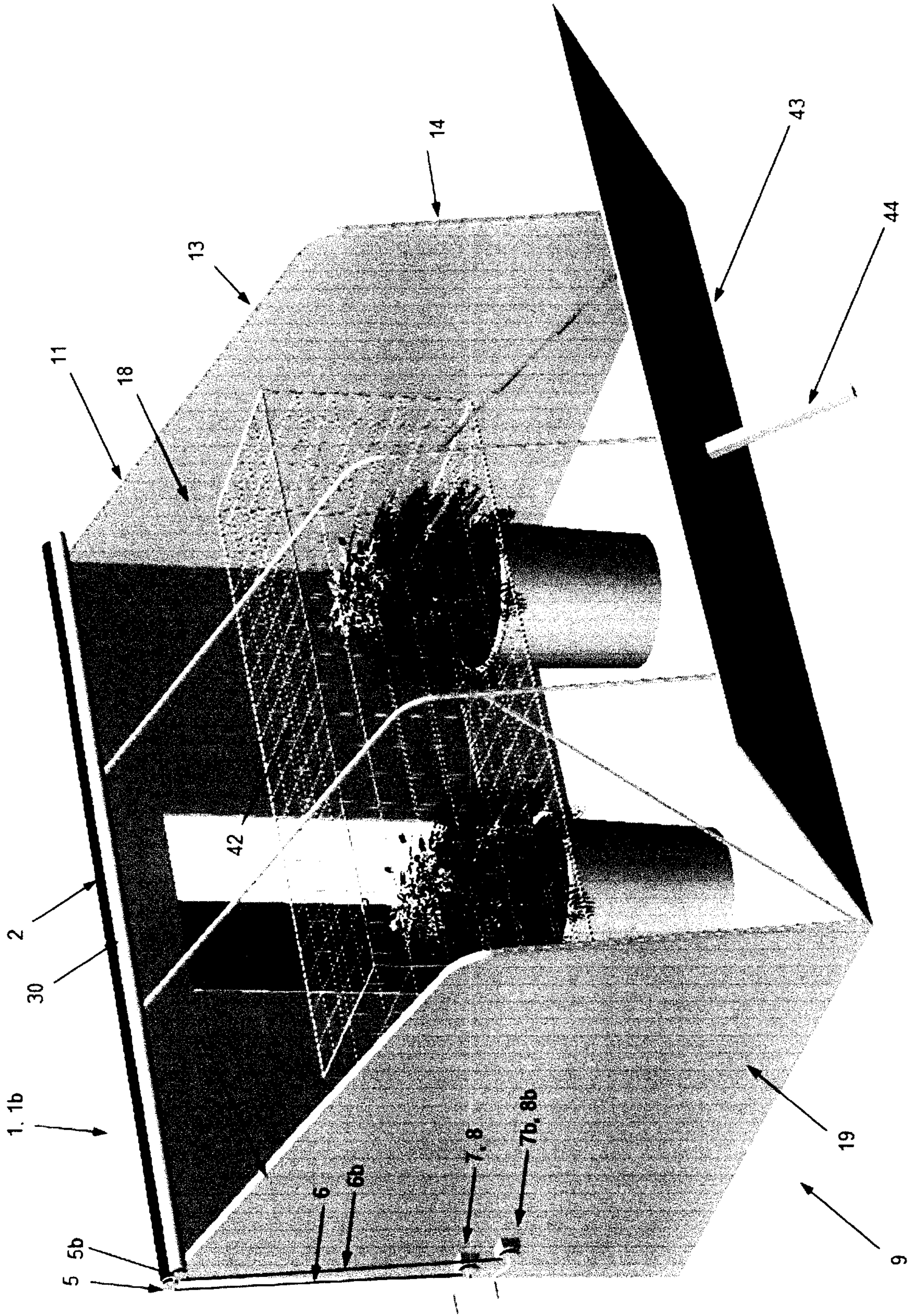


FIG 19

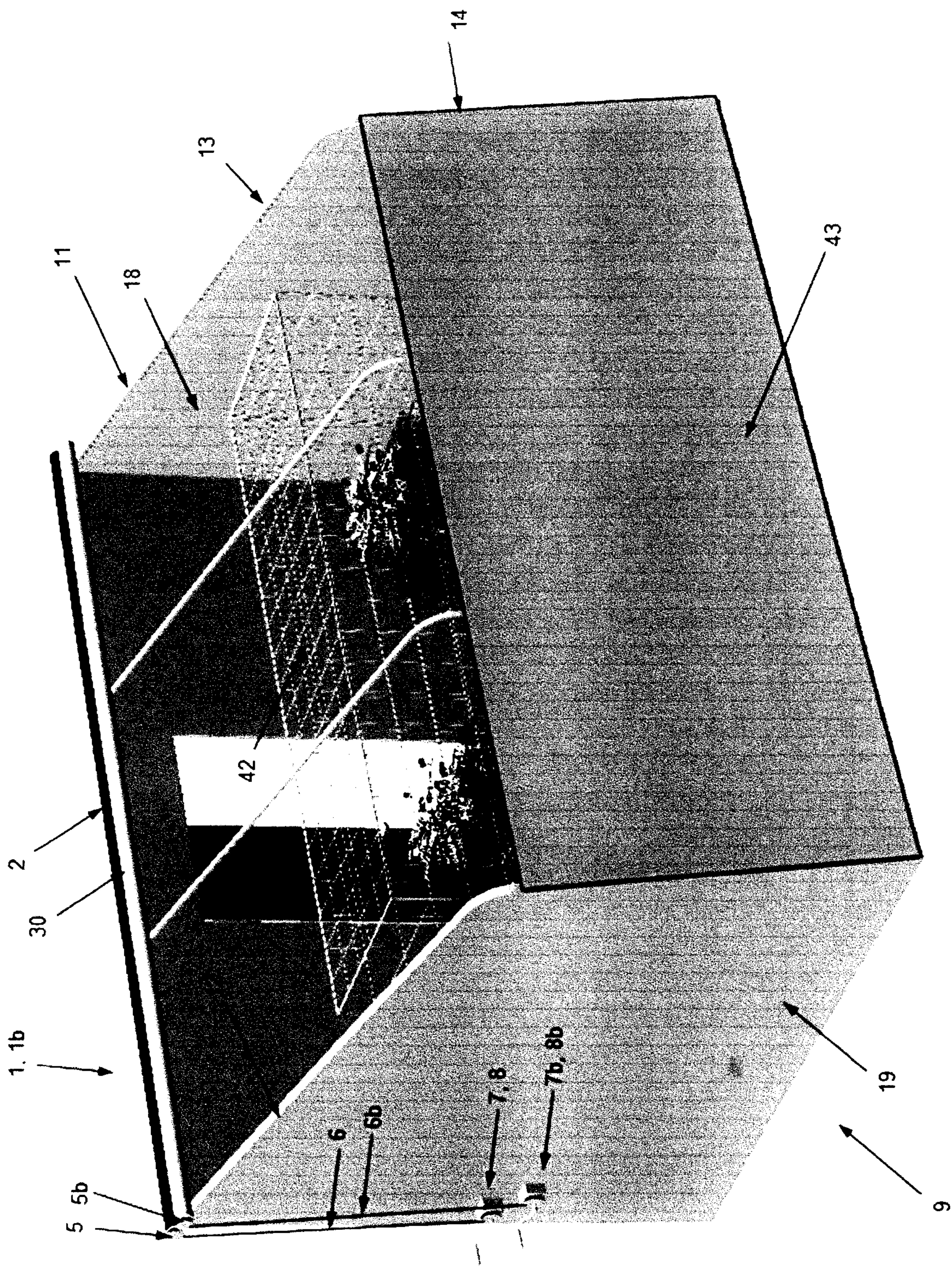


FIG 20

