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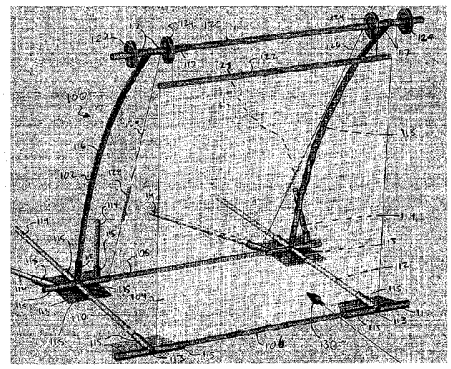

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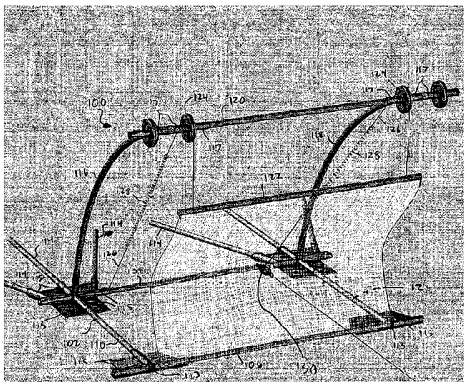

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(57) Abstract: A barrier system acts to gradually decelerate and arrest low-flying projectiles, such as RPGs, to reduce the likelihood of a fuze-detonating impact. The barrier system, which includes a frame-supported net and net suspension, preferably with energy absorbing characteristics, preferably is modular and portable so that similar barrier units can be arranged, and optionally joined together, to form a wider line of defense, such as a defensive perimeter around a potential target area.

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BARRIER SYSTEM FOR PROTECTION AGAINST LOW-FLYING PROJECTILES

This application claims the benefit of U.S. provisional application No. 60/620,353, filed October 21, 2004, which is incorporated herein by reference.

BACKGROUND

[0001] This invention relates to weapons defense, in particular to defense against low-flying projectiles, such as rocket propelled grenades and shrapnel.

[0002] Protective arrangements have been devised to limit the destructive effect of exploding weaponry. For example, the 1943 patent to Wesseler (US 2,326,713) discloses knitted wire shielding fabric "for minimizing the destructive effects of bombs, torpedoes and similar elements of warfare." One form of Wesseler's shielding fabric is described as having "missile deflecting capacity." Deflection systems also are disclosed by Corrado (US 1,204,547) (torpedoes); Fitch (US 4,625,668) (missiles); Feitosa (US 2,100,211) (aerial bombs); Zuckermann (US 2,347,653) (aerial bombs); Hume (US 2,348,387) (aerial bombs); and Schwab (US 2,351,297) (aerial bombs).

[0003] Nowadays armed conflict in various parts of the world often involves the use of manually portable launchers that fire rocket propelled grenades ("RPGs") or similar warheads that are designed to explode upon impact. Such "low-flying" warheads travel at relatively low velocity (as compared to bullets, for example) and typically approach a ground-based target at a relatively low angle of elevation (as compared to aerial bombs, for example, which are dropped from aircraft). Detonation of such low-flying warheads typically is effected by impact pressure on a fuze. Some have a back-up time delay system that detonates the warhead after a preset period of time.

[0004] Often it is necessary to protect personnel and/or materiel at particular locations from the threat posed by RPGs and other low-flying projectiles, which could include non-explosive projectiles as well as explosive warheads. The need for such protection is acute in open terrain and shipboard situations, where there are no natural or man-made barriers (e.g., berms or walls) that would otherwise afford protection. This invention is designed to provide an effective protection system against low-flying projectiles.

SUMMARY OF THE INVENTION

[0005] As RPGs and other low-flying warheads are designed to explode upon impact, the present invention aims to inhibit the likelihood of such explosions preferably by preventing the detonating impact. To prevent the impact, the warhead is "caught" in flight or deflected by a net-like barrier that gradually decelerates the warhead so that it remains intact. If the warhead does explode upon impacting the barrier or after it drops to the ground, substantial blast protection is afforded by the barrier itself, which preferably is deployed at a safe distance from personnel and materiel, thus considerably reducing or eliminating the destructive effect of the blast.

[0006] The projectile is caught or deflected by a barrier that has a net suspended on a ground- or floor-supported frame, which also restrains the bottom margin of the net. Either or both of the top and bottom margins may be resiliently restrained. The side margins of the net preferably are unrestrained, and the net preferably is wider than the frame. Depending on the angle and/or the velocity of the projectile, kinetic energy of the projectile is absorbed by means of net flexion, frame flexion, and/or action of any resilient net restraint. After the projectile is arrested or deflected, the barrier substantially returns to its original position to afford continued protection. The frame preferably has a clear space behind the net to accommodate rearward net deflection by the projectile substantially without interference by the frame. The frame optionally can be adjustable so as to enable adjustment of the angle of the net relative to the vertical in order to tailor the installation to surrounding circumstances for optimum protection, i.e., to minimize the likelihood that warheads fired from particular locations will ride up and over the top of the net.

[0007] The term "net" as used herein is defined as an expanse of any flexible material, e.g., fabric or screening or the like, having sufficient strength and small enough mesh size to at least arrest or deflect (i.e., prevent passage of) an unexploded, low-flying warhead. For optimal protection, the net optionally and preferably should have the properties of a blast curtain, i.e., sufficient strength and small enough mesh size to resist the force of a localized warhead explosion and substantially prevent the passage of small fragments of shrapnel.

[0008] The barrier is modular and is readily portable so that it can be easily transported to and deployed in potentially hostile locations, either on land or on the deck of a ship. Users can erect the barrier system's modular units as needed, e.g., side-by-side to create a wide line of defense or a continuous barrier for perimeter protection around a potential target area, preferably with the nets of adjacent barrier units overlapping. Barrier height can be

customized to suit any application. If desired, the barrier units can be anchored to the ground or floor, or to the deck of a ship, and adjacent units can be connected to one another.

[0009] The above and other features, aspects and advantages of the invention will become more apparent from the following detailed description of exemplary embodiments shown in the accompanying drawing figures.

BRIEF DESCRIPTION OF THE DRAWING

[0010] Fig. 1A is a perspective view of a first embodiment of a barrier unit according to the invention for protection against low-flying projectiles.

[0011] Fig. 1B is a perspective view of the barrier unit shown in Figure 1A, illustrating flexure of the frame and the net as a low-flying projectile is intercepted.

[0012] Fig. 2A is perspective view of a second embodiment of a barrier unit according to the invention.

[0013] Fig. 2B is a perspective view of the barrier unit shown in Figure 2A, illustrating flexure of the frame and the net as a low-flying projectile is intercepted.

[0014] Fig. 3A is perspective view of a third embodiment of a barrier unit according to the invention.

[0015] Fig. 3B is a perspective view of the barrier unit shown in Figure 3A, illustrating flexure of the frame and the net as a low-flying projectile is intercepted.

[0016] Fig. 4 is a perspective view of a fourth embodiment of a barrier unit according to the invention.

[0017] Fig. 5 is a perspective view of a fifth embodiment of a barrier unit according to the invention.

[0018] Fig. 6 is a perspective view of a sixth embodiment of a barrier unit according to the invention.

[0019] Fig. 7 is a perspective view of a seventh embodiment of a barrier unit according to the invention.

[0020] Fig. 8 is a perspective view of a plurality of barrier units of the type shown in Fig. 6, arranged to form a barrier system along a line of defense.

[0021] Fig. 9 is a top plan view of the arrangement of Fig. 8.

[0022] Fig. 10 is a side elevational view of an adjustable frame portion that enables angular adjustment of the net.

DETAILED DESCRIPTION

[0023] The same reference numbers are used throughout the drawing figures to refer to the same or like parts in the different embodiments. In the figures the net is illustrated as being "see-through," i.e., as translucent or transparent. This is done merely to be able to depict structure that is behind the net without having to eliminate or break away substantial portions of the net. The actual light-transmitting characteristics of the net will depend, of course, on the color, mesh size and chemical makeup of the net material.

[0024] A first embodiment of a barrier system unit for protection against low-flying projectiles is shown in Figures 1A and 1B. The barrier unit 100 includes a frame 102 and a net 104. The frame 102 includes a plurality of base members 106, 108, 110, 112 in the form of flexible rods that are interconnected by means of brackets 113. Specifically, there are front 106 and rear 108 base members and left 110 and right 112 side base members. These base members 106, 108, 110, 112 fit into appropriately sized hollow sockets 115 carried by the brackets 113.

[0025] Stabilizers 114 project rearwardly from sockets 115 on the two rear brackets 113. Stabilizers 114 are designed to keep the barrier unit 100 from tipping backwards or flipping over when impacted by a low-flying projectile 130. The underside of each bracket 113 may be provided with a rubbery coating or pad to minimize sliding on hard surfaces, and/or cleats to minimize sliding on sand or soil. At least one hole may be provided in each bracket 113 through which a spike may be driven in order to anchor the barrier unit to the ground. Sandbags may be placed on brackets 113 for stability, irrespective of whether spikes are used.

[0026] Flexible side arch members 116, 118 of the frame 102 project upwardly and forwardly from the rear brackets 113. The upper ends of the arch members 116, 118 support hollow axles 117, each of which carries a pair of pulleys 124. A crossbar 120 interconnects axles 117. As later described, the side-facing sockets 115 on brackets 113, and the hollow axles 117, make this a modular system so that a plurality of barrier units 100 can be interconnected or otherwise juxtaposed to form a wider line of defense.

[0027] The pulleys 124 guide cables 126 that are resiliently extensible by means of elongated coil springs 128, which exert a retractive force on the cables. Each spring 128 can be located intermediate the ends of the cable, or at its lower (rear) end, as shown. The lower end of each spring 128 (or lower end of each cable 126) may be connected to a respective rear base member 108 as shown, or to a rear bracket 113, or to a stabilizer 114. The other (upper) end of each cable 126 is connected to a net bar 122. Net 104 is anchored along its top margin to

net bar 122, which acts as a stiffener for the top margin of the net, and is anchored along its bottom margin to front base member 106.

[0028] In the ready state (Figure 1A), the net bar 122 is disposed substantially above the front base member 106. In an activate state (i.e., when a low-flying projectile 130 impacts the barrier unit 100 – see Figure 1B), the load applied to the net results in a downward and rearward pull on net bar 122 and, accordingly, a pull on cables 126 and a stretching of springs 128. This causes side arch members 116, 118 to bend downwardly, which moves axles 117, pulleys 124 and crossbar 120 downwardly and forwardly. The result is that net bar 122, although lowered, remains positioned generally above the front base member 106. The projectile thus is kept from riding up and over the top of the net.

[0029] Several mechanisms act to absorb the kinetic energy of the projectile 130 and gradually reduce its velocity until it is arrested so as to reduce the likelihood of an impact-triggered detonation. These include flexion of the net 104, downward motion of net bar 122, bending of the arch members 116, 118, and extension of the springs 128. When the projectile 130 is arrested, it drops to the ground in front of the net 104 with insufficient force to trigger detonation. The barrier unit 100 returns substantially to its ready state by virtue of the restorative nature of the net 104, the flexible arch members 116, 118 and the springs 128.

[0030] In the case of a projectile that has a back-up time delay system, the arrested warhead would be expected to explode after it drops to the ground in front of the net. However, the barrier system still would afford a good measure of protection for personnel and materiel behind the net because the net would act as a blast curtain, and forestall the blast at a reasonably safe distance from the assets to be protected.

[0031] The various components of the barrier unit may be made of a variety of suitable materials, and in suitable sizes, as follows. The net 104 preferably is made of a blast-resistant material, preferably of a mesh size small enough to block the passage of flying fragments from an exploding warhead. Examples include but are not limited to polyethylene or aramid fiber, which may be uncoated, or may be coated with polyvinyl chloride; and polyethylene-wrapped stainless steel cord. A commercial example is that disclosed in US 5,915,449, which is incorporated herein by reference. The net preferably is about 10 to 30 ft. wide by about 10 to 30 ft. high. Brackets 113 are plate-like in form and cover an area about 1.0 ft^2 to 3.0 ft^2. They preferably are made of steel or aluminum. Base members 106, 108, 110, 112; crossbar 120; net bar 122; arch members 116, 118; sockets 115; and axles 117 are about 1½ to 2½ in. in diameter, and are made of any suitably strong and flexible material, such as steel,

aluminum, fiberglass, or carbon fiber. Spring rates are chosen to allow a desired degree of net deflection for the anticipated threat, and will depend on net material, net size, and frame flexion, as will be understood by those skilled in the art. For wider nets one or more intermediate cable and pulley sets could be added to provide added support.

[0032] Figures 2A and 2B show an alternative embodiment of barrier unit 200 in which hanging weights 228 on the rear (lower) ends of the cables 226 are used in lieu of the springs 128 used in the first embodiment. In this embodiment, the arch members 216, 218 are provided with intermediate stub axles 217 that support secondary pulleys 224. The primary pulleys 124 (on axles 117) and the secondary pulleys 224 guide the cables 226 that extend between the net bar 122 and the weights 228. The weights preferably are in the range of 5 to 75 lbs., and may take any form (e.g., sandbags) that can be conveniently attached to cables 226.

[0033] The operation of this barrier unit 200 is similar to the previously described unit 100. Specifically, in the ready state, the net bar 122 is disposed substantially above the front base member 106. In an activate state (i.e., when a low-flying projectile 130 impacts the barrier unit 200), the load applied to the net results in a downward and rearward pull on net bar 122 and, accordingly, a pull on cables 126 and a tendency to raise weights 228. This causes side arch members 216, 218 to bend downwardly, which moves axles 117, pulleys 124 and crossbar 120 downwardly and forwardly. The result is that net bar 122, although lowered, remains positioned generally above the front base member 106 – again to keep the projectile from riding up and over the top of the net.

[0034] In this embodiment, the kinetic energy of the projectile 130 is absorbed by means of flexion of the net 104, downward motion of net bar 122, bending of the arch members 216, 218, and elevation of the weights 228. When the projectile 130 is arrested, it drops to the ground in front of the net 104 with insufficient force to trigger detonation. The barrier unit 200 returns substantially to its ready state by virtue of the restorative nature of the net 104, the flexible arch members 116, 118 and the weights 228. Weight size is chosen to allow a desired degree of net deflection for the anticipated threat, and will depend on net material, net size, and frame flexion, as will be understood by those skilled in the art.

[0035] Figures 3A and 3B show another alternative embodiment of barrier unit 300 in which spring-loaded spools 324 are carried on axles 117. The spools 324 have internal torsion springs 328 (not shown), which are substitutes for the springs 128 of the first embodiment, and for the weights 228 of the second embodiment. These internal torsion springs 328 apply

a retractive force to cables 326, which are wound in or on spools 324 and support the net bar 22 so that the net 104 is held generally upright. Each torsion spring may be in the form of a spiral (i.e., clock-type), but any form of torsion spring may be used. The torsion spring may be supplemented with a damper to help dissipate energy during active use. Commercially available dampers that are suitable include those that employ friction disks, and those that employ a fluid forced through one or more orifices or past a series of vanes.

[0036] The operation of this barrier unit 300 is similar to the previously described barrier units 100, 200. Specifically, in the ready state, the net bar 122 is disposed substantially above the front base member 106. In an active state (i.e., when a low-flying projectile 130 impacts the barrier unit 200), the load applied to the net results in a downward and rearward pull on net bar 122 and, accordingly, a pull on cables 326. As cables 326 pay out from spools 324, torsion springs 328 tighten. This causes side arch members 116, 118 to bend downwardly, which moves axles 117, spools 324 and crossbar 120 downwardly and forwardly. The result is that net bar 122, although lowered, remains positioned generally above the front base member 106 – again to keep the projectile from riding up and over the top of the net.

[0037] In this embodiment, the kinetic energy of the projectile 130 is absorbed by means of flexion of the net 104, downward motion of net bar 122, bending of the arch members 116, 118, and tightening of the torsion springs 328 as the cables 326 pay out. If the spools 324 are equipped with dampers as described above, the dampers serve to dissipate additional energy. When the projectile 130 is arrested, it drops to the ground in front of the net 104 with insufficient force to trigger detonation. The barrier unit 300 returns substantially to its ready state by virtue of the restorative nature of the net 104, the flexible arch members 116, 118 and the torsion springs 328. Torsion spring rates are chosen to allow a desired degree of net deflection for the anticipated threat, and will depend on net material, net size, frame flexion, and the effect of dampers, if present, as will be understood by those skilled in the art.

[0038] Any of the above embodiments can be modified so that the bottom margin of the net, instead of being firmly anchored to the frame, is resiliently restrained, e.g., by cables with springs in the manner of the embodiments of Figs. 4-7. With such an arrangement, the top margin of the net can be resiliently restrained as disclosed above; alternatively the net can be suspended from the frame with its top margin firmly anchored to the frame.

[0039] As noted earlier, the barrier system of the invention is modular so that multiple units can be interconnected to form a wider line of defense. To facilitate this, each of the brackets 113 has a side-facing socket 115 that is designed to be connected to a corresponding element

of an adjacent barrier unit. Similarly, the side-facing portion of each axle 117 is designed to be connected to a corresponding element of an adjacent barrier unit. As a result, multiple barrier units 100, 200, 300 can be joined side-by-side. A degree of flexibility in the base members 106, 108 and the crossbar 120, and in their connections to sockets 115 and 117, respectively, allows a series of interconnected barrier units to arc around an area so as to form a partial or full protective perimeter. Preferably, angled or other types of connectors (not shown) could be used to couple adjacent barrier units together.

[0040] It is possible to stitch or otherwise attach filler nets (not shown) to the adjacent nets of the joined barrier units in order to reduce the likelihood of projectile penetration at the lateral margins of the nets. However, it is preferred to use nets and net bars that are wider than those illustrated and described in the above embodiments. In that case, the cables 126, 226, 326 of the respective embodiments could be guided by the outer pair of pulleys 124 or the outer pair of spools 324; alternatively, the outer pair of pulleys or spools could be dispensed with and the net bar and net would extend laterally outwardly further from the supporting cables. Adjacent barrier units would be staggered so that the nets overlap in a manner similar to that shown in Figs. 8 and 9 and described below in connection with the embodiments of Figs. 6 and 7.

[0041] Further embodiments of the invention are illustrated in Figs. 4-8. These embodiments use a net material as disclosed above, but employ a more robust frame than the previously described embodiments, the frame thus being more suitable for supporting a larger net and/or standing up to harsher conditions.

[0042] The barrier unit 400 depicted in Fig. 4 has a net 402 with a top margin 404, a bottom margin 406, and side margins 408. The top margin 404 is secured to a top net bar 410. The bottom margin 406 is secured to a bottom net bar 412. The net bars 410, 412 are similar in construction to net bar 122 above (Fig. 1A), and serve to stiffen the top and bottom margins 404, 406. The net 402 with its net bars 410, 412 is suspended from a frame 420 by means of three cables 450 that are attached to top net bar 410. The bottom margin of the net is restrained by the frame by means of three cables 470.

[0043] Frame 420 may be made of any of the materials mentioned above in connection with the previously described embodiments. The frame components could be designed to have a degree of flexibility that enables them to be a meaningful factor in energy absorption, but preferably they are more rigid than those of the previously described embodiments. The frame components may be welded or otherwise secured together, but preferably most or all of

them they are knock-down in design (bolted, clamped or otherwise removably connected) so that the unit can be transported compactly and easily and assembled on-site. Frame 420 has a ground- or floor-engaging base portion comprising three laterally spaced longitudinal bottom bars 422 interconnected by two lateral bottom ties 424. Each bottom bar 422 has secured to it a front plate 426, a center plate 428 and a rear plate 430. These plates may have holes through which spikes may be driven in order to anchor the unit to the ground. Each of the front and rear plates 426, 430 has three stabilizers 432 that extend forwardly and rearwardly, respectively, to enlarge the effective footprint of the unit.

[0044] Frame 420 also has an upper portion comprising three laterally spaced longitudinal top bars 434 interconnected by two lateral top ties 436. The upper portion is supported on the base portion by means of three spaced upright portions, each comprising a front post 438, an angled and bent rear strut 440, and four stabilizer struts 442. The front ends of top bars 434 are cantilevered and are disposed substantially forward of posts 438 and above front plates 426 so that net 402 hangs substantially vertically, with ample deflection space behind it.

[0045] Each cable 450 suspending top net bar 410 is guided by a frame-mounted front pulley 452 at or near the front end of top bar 434, and a frame-mounted rear pulley 454 at or near the top of post 438. Cable 450 is anchored to the frame via a coil spring 456, which places the cable under initial tension and renders it resiliently extensible. Similarly, each cable 470 restraining the bottom net bar 412 is guided by a frame-mounted front pulley 472 at or near front plate 426, and a frame-mounted rear pulley 474 on bottom bar 422 behind post 438. Cable 470 is anchored to the frame via a coil spring 476, which places the cable under initial tension and renders it resiliently extensible. Spring rates are chosen to allow a desired degree of net deflection for the anticipated threat, and will depend mostly on net material and net size (the frame flexion factor should be minimal given the robust nature of the frame). A suspended weight, a torsion or other type of spring, a gas spring, or any other element or unit that applies a restorative force (and optionally a damping force) to each cable may be substituted for the coil springs in this or any other embodiment.

[0046] The front ends of top bars 434 optionally may be made adjustable in length so as to adjust the fore/aft position of pulleys 452 and, hence, the fore/aft position of top margin 404 of the net, to vary the angle of the net relative to the vertical. This is illustrated by dashed lines and reference number 435 in Fig. 4 for just one of the top bars 434, it being understood that a frame having this adjustment feature will necessarily require that all top bars 434 be adjustable in this manner. This adjustment feature may be incorporated into this or any other

embodiment of the barrier unit. Adjustment of the fore/aft position can be accomplished by any suitable structure. For example, as illustrated in Fig. 10, each top bar 434 may have a movable telescoping front portion 434a that can be extended forwardly from the fixed portion 434 and be secured in a selected position by means of a shear pin or pins (not shown) placed in aligned holes 435b in the fixed (434) and movable (434a) telescoping portions. Other examples of length-adjustable members are well-known to those skilled in the art, and include telescoping members with locking clutch collars; telescoping threaded members; and hinged, foldable extensions, to name just a few.

[0047] When a projectile impacts net 402, the net will deflect rearwardly due to net flexion and the extension of springs 456, 476, all of which serve to absorb the kinetic energy of the projectile in a manner similar to the operation of the embodiment of Figs. 1A, 2A, arresting the projectile and causing it to drop to the ground in front of the net. However, by comparison much less kinetic energy would be absorbed through frame flexion due to the more robust construction of the frame of this embodiment.

[0048] This embodiment and those described below can be modified so that the net is suspended from the frame with its top margin firmly anchored to the frame. Alternatively, the bottom margin of the net can firmly anchored to the frame. In either case, the other margin of the net would be resiliently restrained as disclosed.

[0049] The embodiment of Fig. 5 is similar to that of Fig. 4. The differences reside in the base portion of frame 500, in which each bottom bar 522 has three depending legs 532, which are intended to be buried in the ground to stabilize the unit. One or more apertured plates 528 also may be provided on each bottom bar 522.

[0050] The embodiment of Fig. 6 is similar to that of Fig. 4, but employs a modified net 602 that is wider than the frame 600. Protrusion of the net laterally beyond the sides of the frame facilitates deployment of a more effective multi-unit barrier system because the nets of adjacent units can be overlapped. Top net bar 610 and bottom net bar 612 preferably are as wide as net 602. Note that the lateral cables 650, 670 are located inboard of the ends of the net bars 610, 612. It is possible for the unit to be configured so that only one side of the net projects beyond the frame, but the symmetrical arrangement illustrated in Fig. 6 provides more flexibility in terms of configuring an effective barrier system.

[0051] The embodiment of Fig. 7 has the combined attributes of the embodiments of Figs. 5 and 6. Depending legs 732 can be buried in the ground for stability, while a symmetrical net assembly 702, 710, 712 wider than the frame allows for net overlap in a barrier system.

[0052] Figs. 8 and 9 depict a barrier system deployed with the nets 602 of adjacent units overlapping one another (units 600 according to the embodiment of Fig. 6 are used as an example). The units are shown in alternating positions, which defines a substantially straight barrier. The units could also be placed in stepped positions (each one slightly behind the preceding one) so that the net faces continuously recede. In either case the units can be angled so as to form a generally arcuate barrier. Adjacent units optionally can be joined together by suitable links 902 (only two are shown in Fig. 9) for added stability of the barrier system as a whole. Links 902 can be placed at ground level and/or above ground level. They can take any suitable form that will help keep adjacent units from separating or shifting. Examples include but are not limited to bars clamped or bolted to the frames, and cables or chains encircling or otherwise secured to frame members, to name just a few.

[0053] The invention is not limited to the above-described embodiments, and it will be understood by those skilled in the art that various modifications can be made without departing from the scope of the invention, which is defined by the appended claims.

CLAIMS

1. Apparatus for protection against low-flying projectiles, comprising:

a net having a top margin, a bottom margin and side margins; and

a net-supporting frame comprising a base portion adapted to be supported on the ground or floor, and an upper portion suspending the net with its top margin higher than its bottom margin,

wherein the bottom margin of the net is restrained by the frame, and the net is wider than the frame and projects laterally beyond at least one side thereof.

2. Apparatus according to claim 1, wherein the net projects laterally beyond both sides of the frame.

3. Apparatus according to claim 2, wherein the net is resiliently suspended from the upper portion of the frame.

4. Apparatus according to claim 3, wherein the top margin of the net is stiffened and is resiliently suspended from the upper portion of the frame.

5. Apparatus according to claim 4, wherein the top margin of the net is suspended by resiliently extensible cables.

6. Apparatus according to claim 5, wherein each of the cables is extensible against a force exerted by a retraction element.

7. Apparatus according to claim 6, wherein the retraction element comprises a spring.

8. Apparatus according to claim 6, wherein the retraction element comprises a weight.

9. Apparatus according to claim 6, wherein each cable is guided by at least one pulley carried by the frame.

10. Apparatus according to claim 2 or claim 5, wherein the bottom margin of the net is stiffened and is resiliently restrained by the frame.

11. Apparatus according to claim 10, wherein the bottom margin of the net restrained through resiliently extensible cables.

12. Apparatus according to claim 11, wherein each of the cables is extensible against a force exerted by a retraction element.

13. Apparatus according to claim 12, wherein the retraction element comprises a spring.

14. Apparatus according to claim 13, wherein each cable is guided by at least one pulley carried by the frame.

15. Apparatus according to claim 2, wherein:

the top margin of the net is stiffened and is resiliently suspended from the upper portion of the frame by resiliently extensible cables;

the bottom margin of the net is stiffened and is resiliently restrained by the frame through resiliently extensible cables; and

each of the cables is extensible against a force exerted by a retraction element.

16. Apparatus according to claim 15, wherein each cable is guided by at least one pulley carried by the frame.

17. Apparatus according to claim 16, wherein the retraction element comprises a spring.

18. Apparatus according to claim 2 or claim 15, wherein the upper portion of the frame adjustably positions the top margin of the net in a fore/aft direction so as to adjust the angle of the net relative to the vertical.

19. Apparatus according to claim 2 or claim 15, wherein the base portion of the frame has stabilizer feet.

20. Apparatus according to claim 19, wherein the stabilizer feet extend substantially horizontally for resting on the ground or floor.

21. Apparatus according to claim 19, wherein the stabilizer feet extend downwardly for burial in the ground.

22. A modular barrier system for protection against low-flying projectiles, comprising a plurality of barrier units arranged side-by-side along a desired barrier locus, each of the barrier units comprising:

a net having a top margin, a bottom margin and side margins; and

a net-supporting frame comprising a base portion adapted to be supported on the ground or floor, and an upper portion suspending the net with its top margin higher than its bottom margin,

wherein the bottom margin of the net is restrained by the frame, and the net is wider than the frame and projects laterally beyond at least one side thereof, and

wherein the barrier units are arranged so that each portion of each net that projects laterally beyond a side of the frame overlaps the net of the adjacent barrier unit.

23. A modular barrier system according to claim 22, wherein the net of each barrier unit projects laterally beyond both sides of its frame.

24. A modular barrier system according to claim 23, wherein the upper portion of the frame of each barrier unit adjustably positions the top margin of the net in a fore/aft direction so as to adjust the angle of the net relative to the vertical.

25. A modular barrier system according to claim 23, wherein the net of each barrier unit is resiliently suspended from the upper portion of the frame.

26. A modular barrier system according to claim 23, wherein the bottom margin of the net of each barrier unit is resiliently restrained by the frame.

27. A modular barrier system according to claim 23, wherein in each barrier unit:

the top margin of the net is stiffened and is resiliently suspended from the upper portion of the frame by resiliently extensible cables;

the bottom margin of the net is stiffened and is resiliently restrained by the frame through resiliently extensible cables; and

each of the cables is extensible against a force exerted by a retraction element.

28. A modular barrier system according to claim 27, wherein each cable is guided by at least one pulley carried by the frame.

29. A modular barrier system according to claim 28, wherein the retraction element comprises a spring.

30. A modular barrier system according to claim 23, wherein the base portion of the frame of each barrier unit has stabilizer feet.

31. A modular barrier system according to claim 30, wherein the stabilizer feet extend substantially horizontally for resting on the ground or floor.

32. A modular barrier system according to claim 30, wherein the stabilizer feet extend downwardly for burial in the ground.

33. Apparatus for protection against low-flying projectiles, comprising:

a net having a top margin, a bottom margin and side margins; and

a net-supporting frame adapted to be supported on the ground or floor and suspending the net with its top margin higher than its bottom margin,

wherein the top margin of the net is stiffened and is resiliently suspended from the frame, and the bottom margin of the net is stiffened and is resiliently restrained by the frame.

34. Apparatus according to claim 33, wherein:

the top margin of the net is suspended by resiliently extensible cables;

the bottom margin of the net is restrained through resiliently extensible cables; and

each of the cables is extensible against a force exerted by a retraction element.

35. Apparatus according to claim 34, wherein each cable is guided by at least one pulley carried by the frame.

36. Apparatus according to claim 35, wherein the retraction element comprises a spring.

37. Apparatus according to claim 33, wherein the portion of the frame from which the net is suspended adjustably positions the top margin of the net in a fore/aft direction so as to adjust the angle of the net relative to the vertical.

38. Apparatus according to claim 33, wherein the frame has stabilizer feet that contact the ground or floor.

39. Apparatus according to claim 38, wherein the stabilizer feet extend substantially horizontally for resting on the ground or floor.

40. Apparatus according to claim 38, wherein the stabilizer feet extend downwardly for burial in the ground.

41. Apparatus for protection against low-flying projectiles, comprising:

a net having a top margin, a bottom margin and side margins; and

a net-supporting frame adapted to be supported on the ground or floor and suspending the net with its top margin higher than its bottom margin,

wherein the bottom margin of the net is restrained by the frame, and the top margin of the net is stiffened and is resiliently suspended from a portion of the frame that adjustably positions the top margin of the net in a fore/aft direction so as to adjust the angle of the net relative to the vertical.

42. Apparatus according to claim 41, wherein:

the top margin of the net is suspended by resiliently extensible cables;

the bottom margin of the net is stiffened and is restrained through resiliently extensible cables; and

each of the cables is extensible against a force exerted by a retraction element.

43. Apparatus according to claim 42, wherein each cable is guided by at least one pulley carried by the frame.

44. Apparatus according to claim 43, wherein the retraction element comprises a spring.

45. Apparatus according to claim 41, wherein the frame has stabilizer feet that contact the ground or floor.

46. Apparatus according to claim 45, wherein the stabilizer feet extend substantially horizontally for resting on the ground or floor.

47. Apparatus according to claim 45, wherein the stabilizer feet extend downwardly for burial in the ground.

48. Apparatus for protection against low-flying projectiles, comprising:

a net having a top margin, a bottom margin and side margins; and

a net-supporting frame adapted to be supported on the ground or floor and suspending the net with its top margin higher than its bottom margin, wherein:

the top margin of the net is suspended from the frame,

the bottom margin of the net is restrained by the frame,

the side margins of the net are unrestrained,

at least a portion of the net is adapted to deflect rearwardly upon frontal impact by a low-flying projectile, and

the frame has a clear space behind the net to accommodate said net deflection substantially without interference by the frame.

49. Apparatus according to claim 48, wherein at least one of the top and bottom margins is resiliently restrained.

50. Apparatus according to claim 49, wherein the top margin of the net is resiliently suspended from the frame.

51. Apparatus according to claim 50, wherein the bottom margin of the net is resiliently restrained by the frame.

52. Apparatus according to claim 50 or claim 51, wherein the top margin of the net is stiffened.

53. Apparatus according to claim 52, wherein the bottom margin of the net is stiffened.

54. Apparatus according to claim 53, wherein:

the top margin of the net is suspended by resiliently extensible cables;

the bottom margin of the net is restrained through resiliently extensible cables; and

each of the cables is extensible against a force exerted by a retraction element.

55. Apparatus according to claim 54, wherein each cable is guided by at least one pulley carried by the frame.

56. Apparatus according to claim 55, wherein the retraction element comprises a spring.

57. Apparatus according to claim 48, wherein the portion of the frame from which the net is suspended adjustably positions the top margin of the net in a fore/aft direction so as to adjust the angle of the net relative to the vertical.

58. A method of protecting an area from low-flying projectiles, comprising erecting a modular barrier system adjacent the area to be protected on a barrier locus along which there is a potential threat from low-flying projectiles, the modular barrier system comprising a plurality of ground- or floor-supported barrier units each having a net suspended from a frame with the top margin of the net higher than the bottom margin of the net, wherein the barrier units are arranged so that a side marginal portion of each net overlaps a side marginal portion of each adjacent net.

59. A method according to claim 58, wherein the net of each barrier unit is wider than the frame and projects laterally beyond both sides of the frame, and the barrier units are placed in a staggered arrangement.

60. A method according to claim 58 or claim 59, comprising anchoring the frame of each barrier unit to the ground or floor.

61. A method according to claim 60, wherein the floor comprises a deck of a ship.

62. A method according to claim 61, comprising anchoring each frame to the deck using mechanical fasteners.

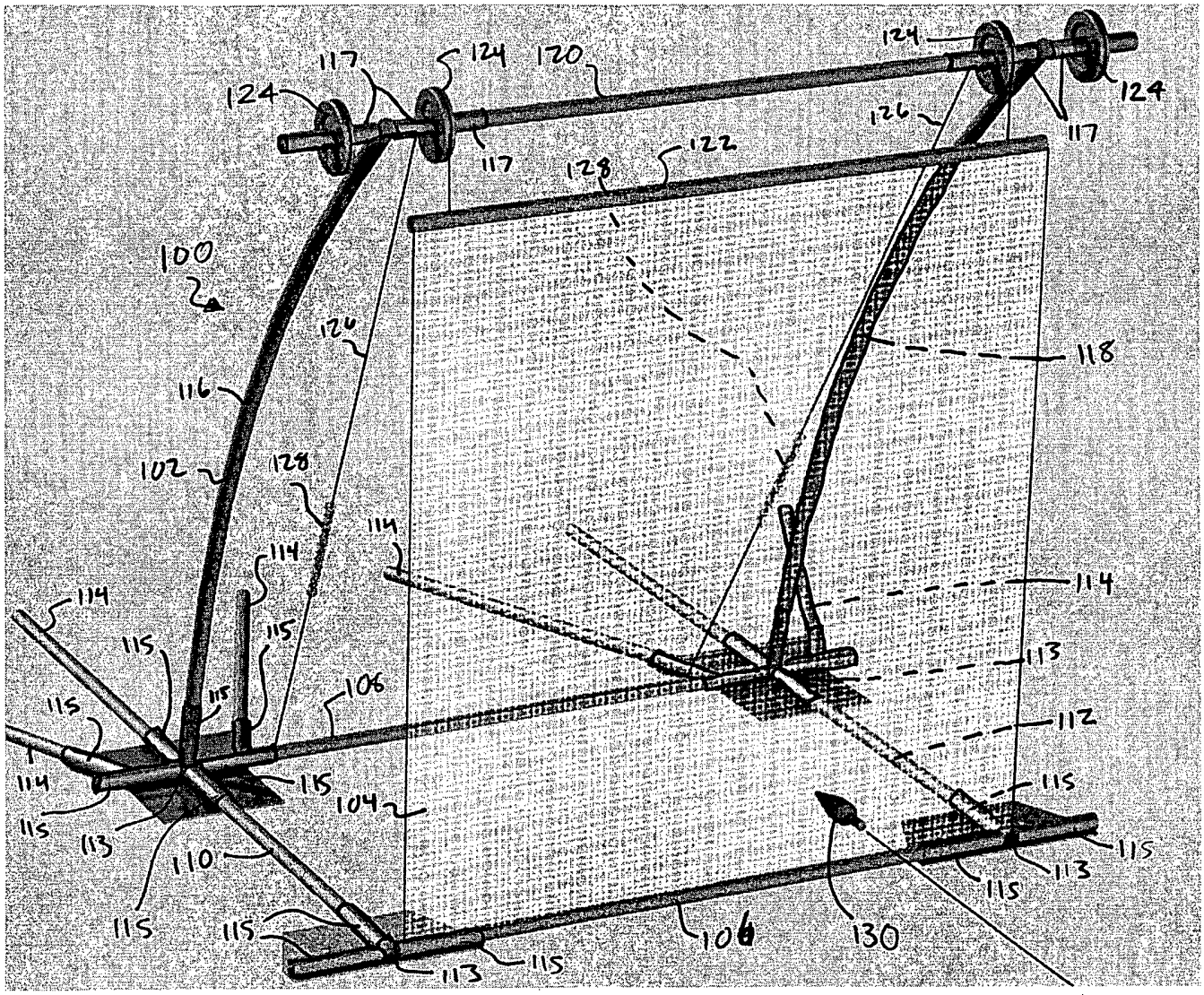
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FIG. 1A

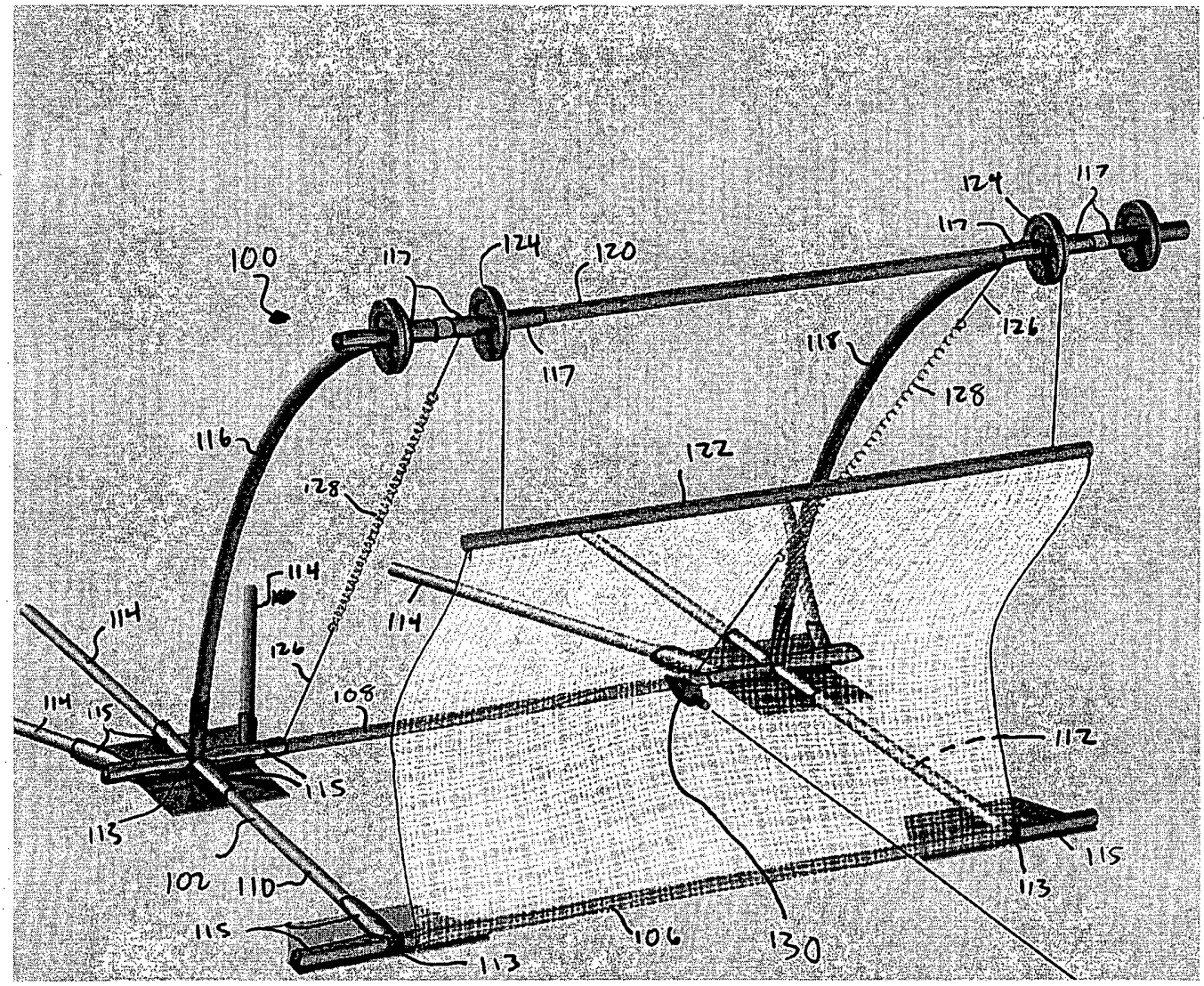
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FIG. 1B

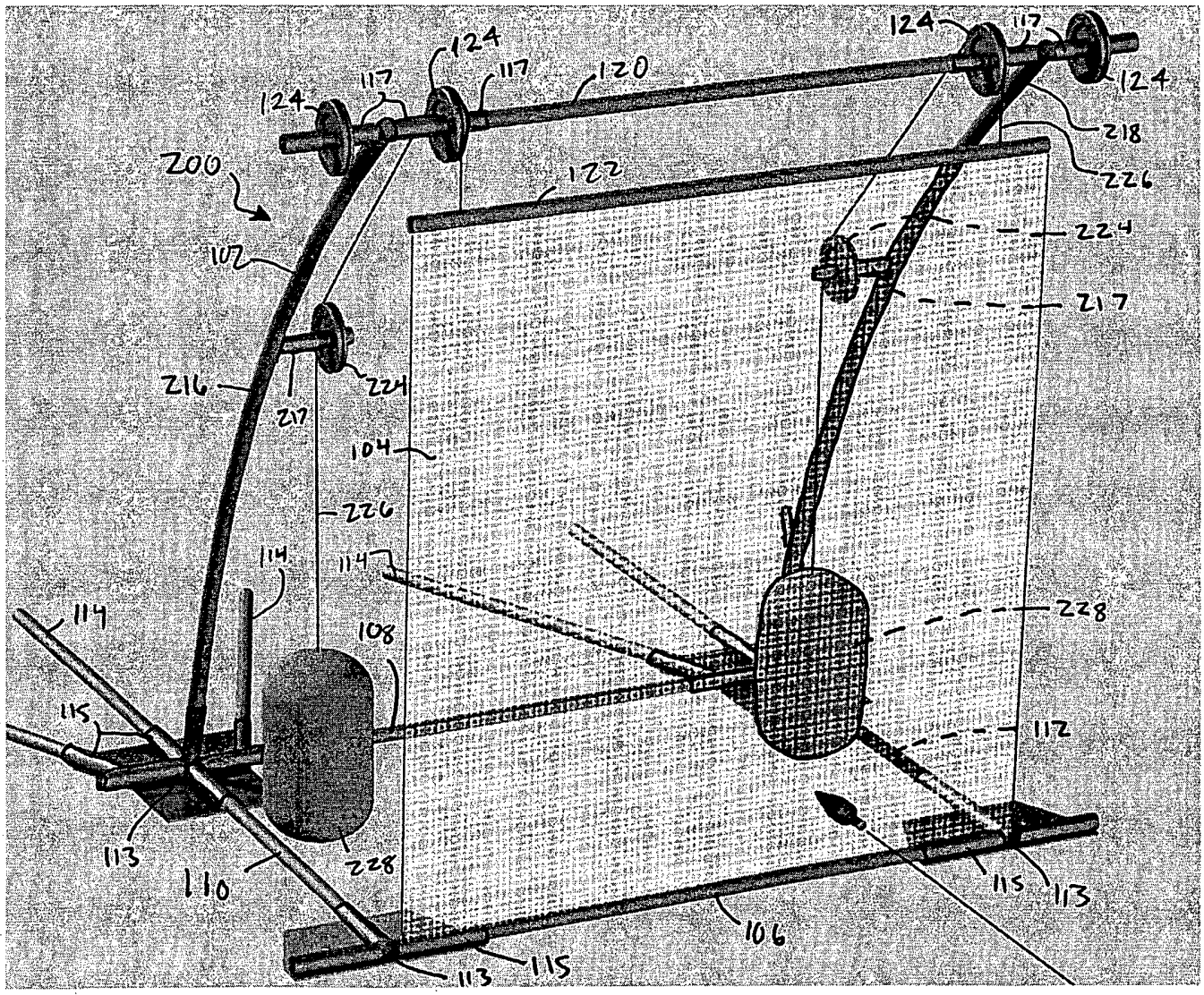
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FIG. 2A

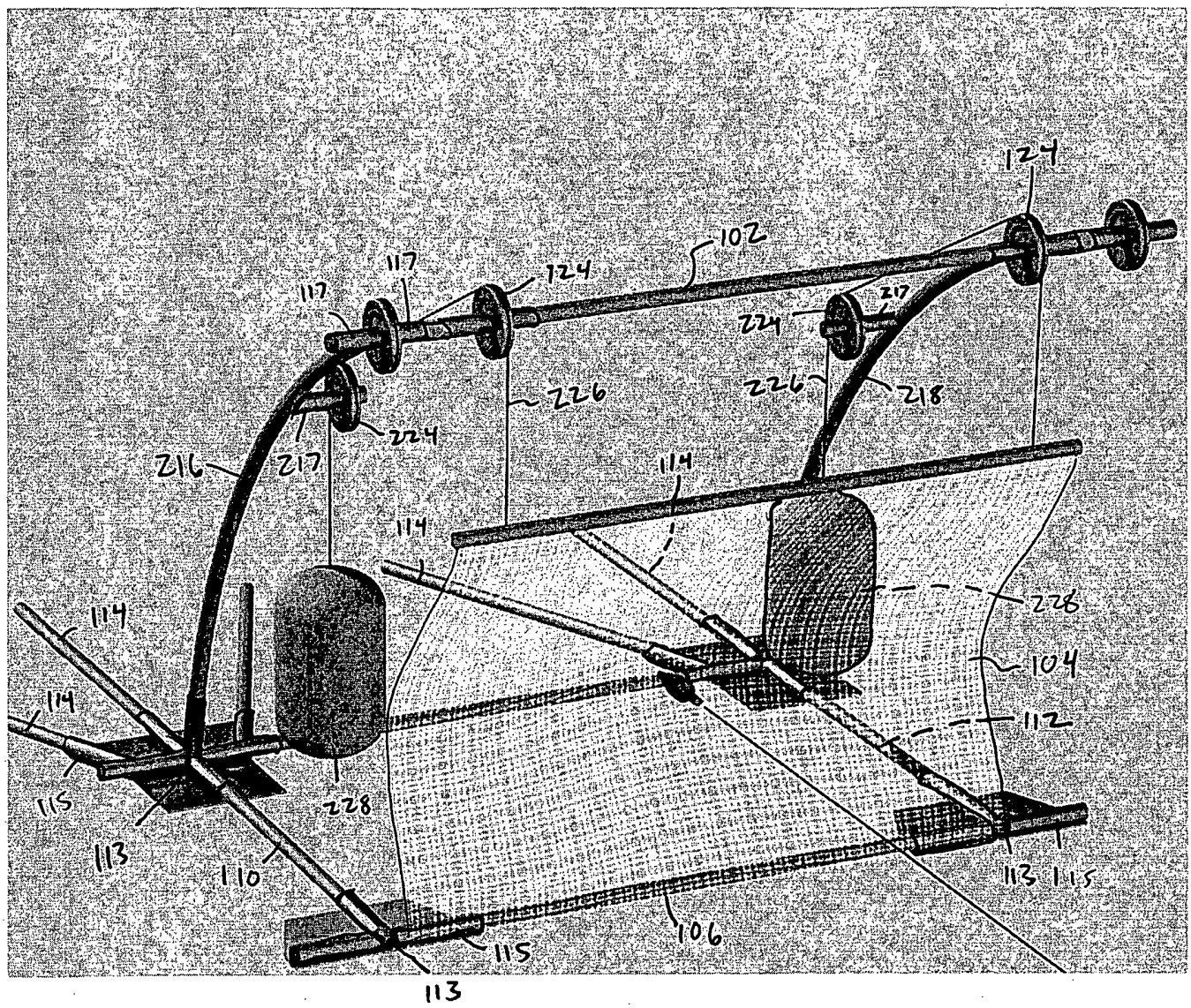
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FIG. 2B

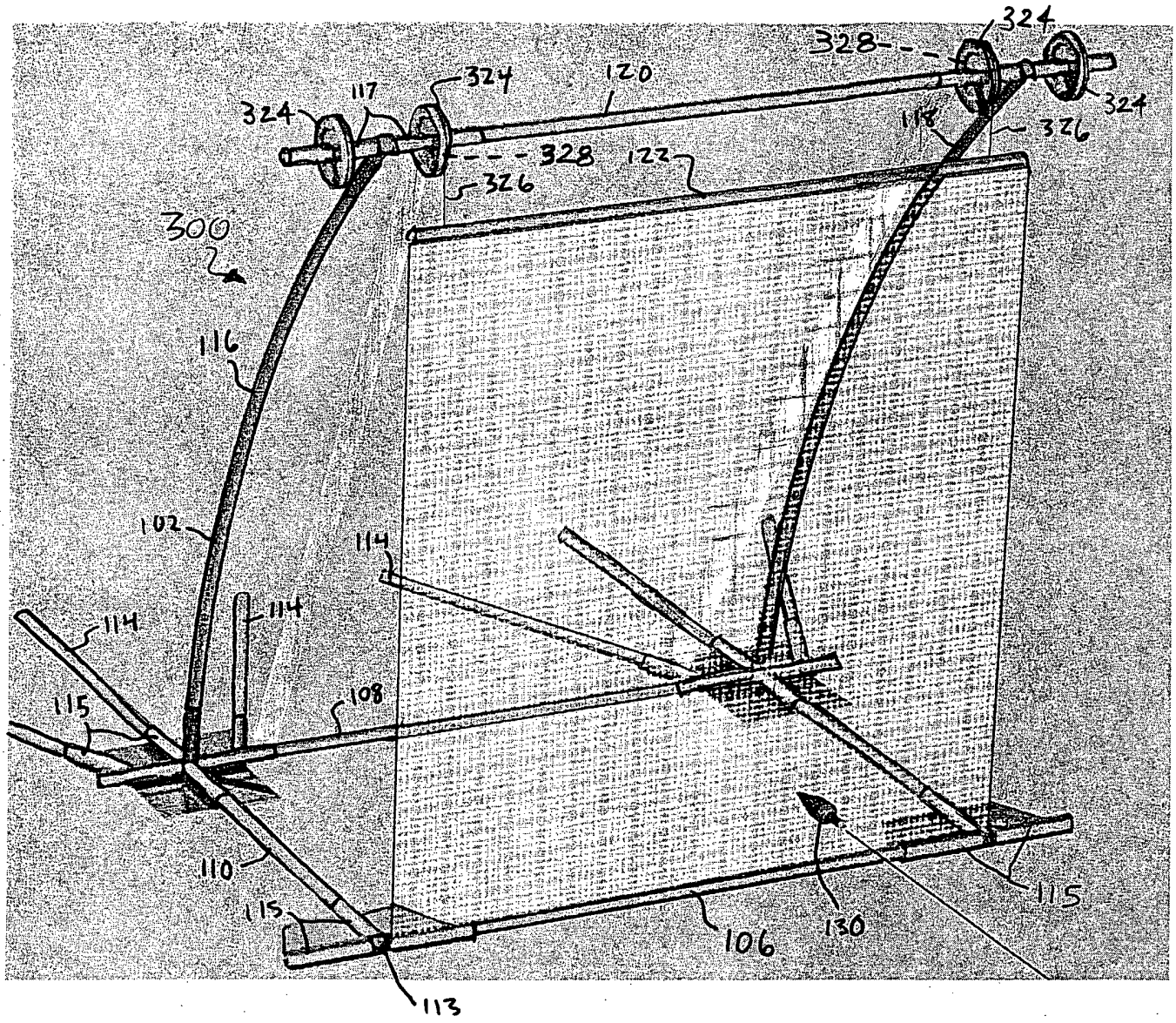
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FIG. 3A

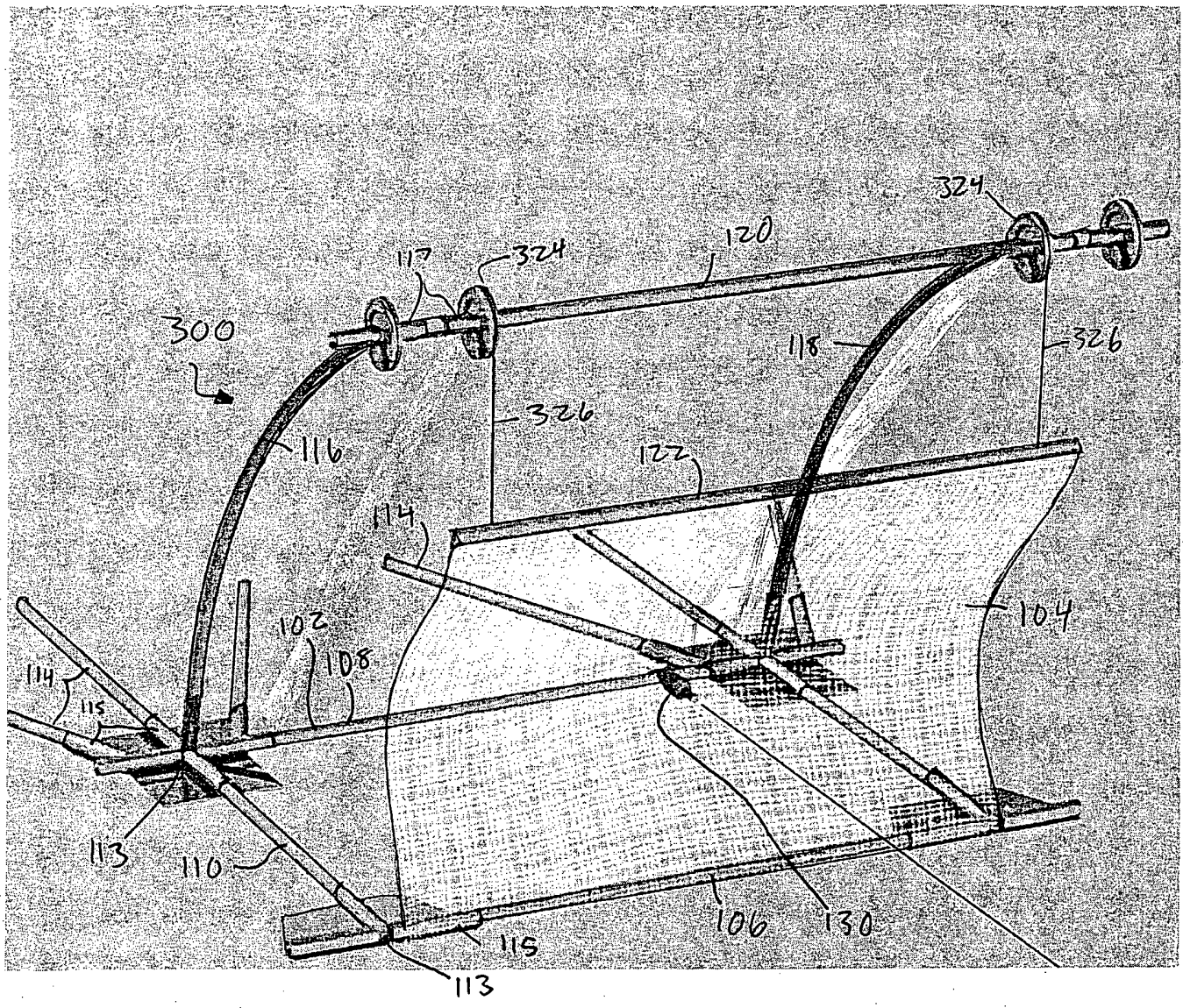
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FIG. 3B

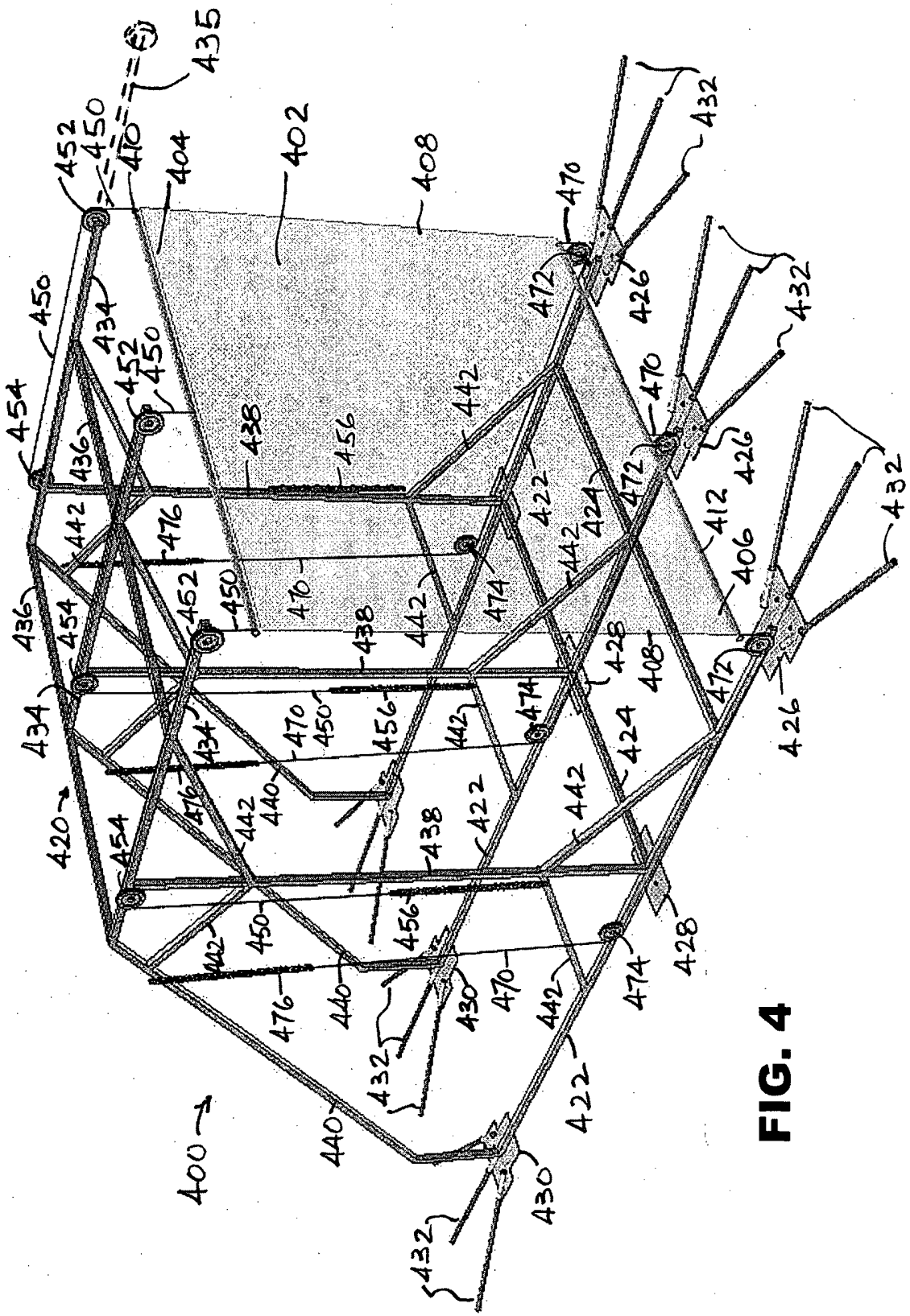
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FIG. 4

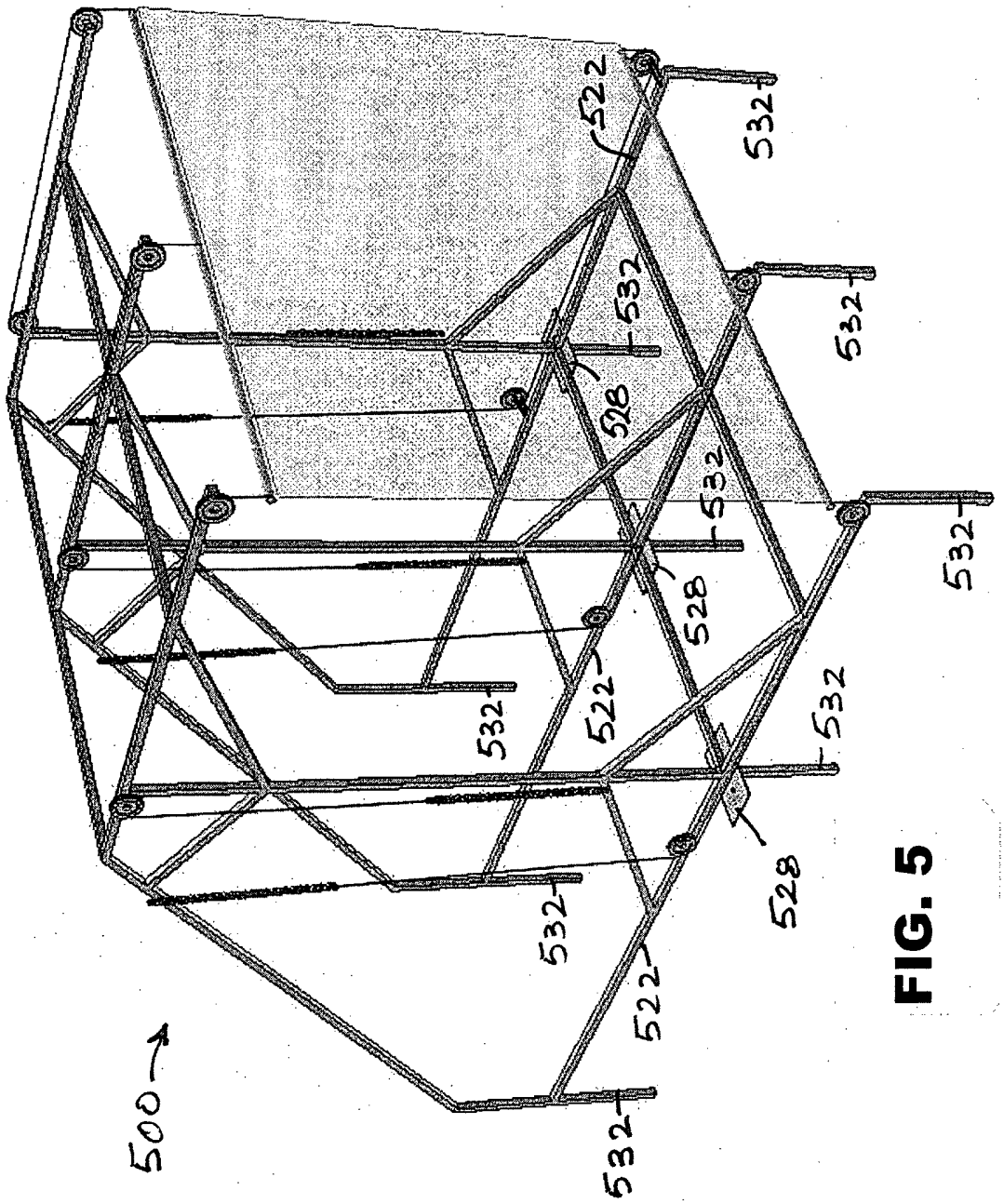

FIG. 5

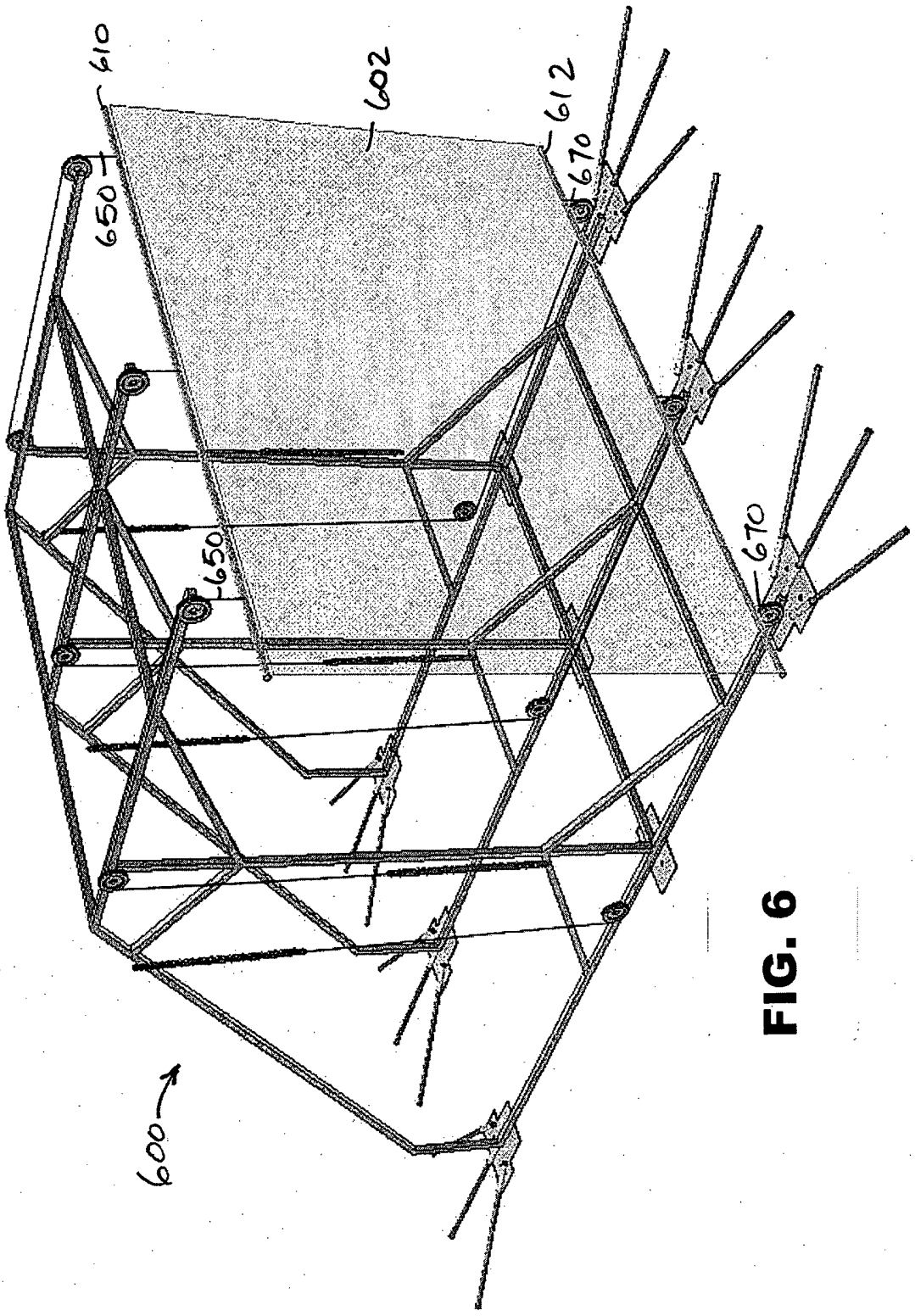

FIG. 6

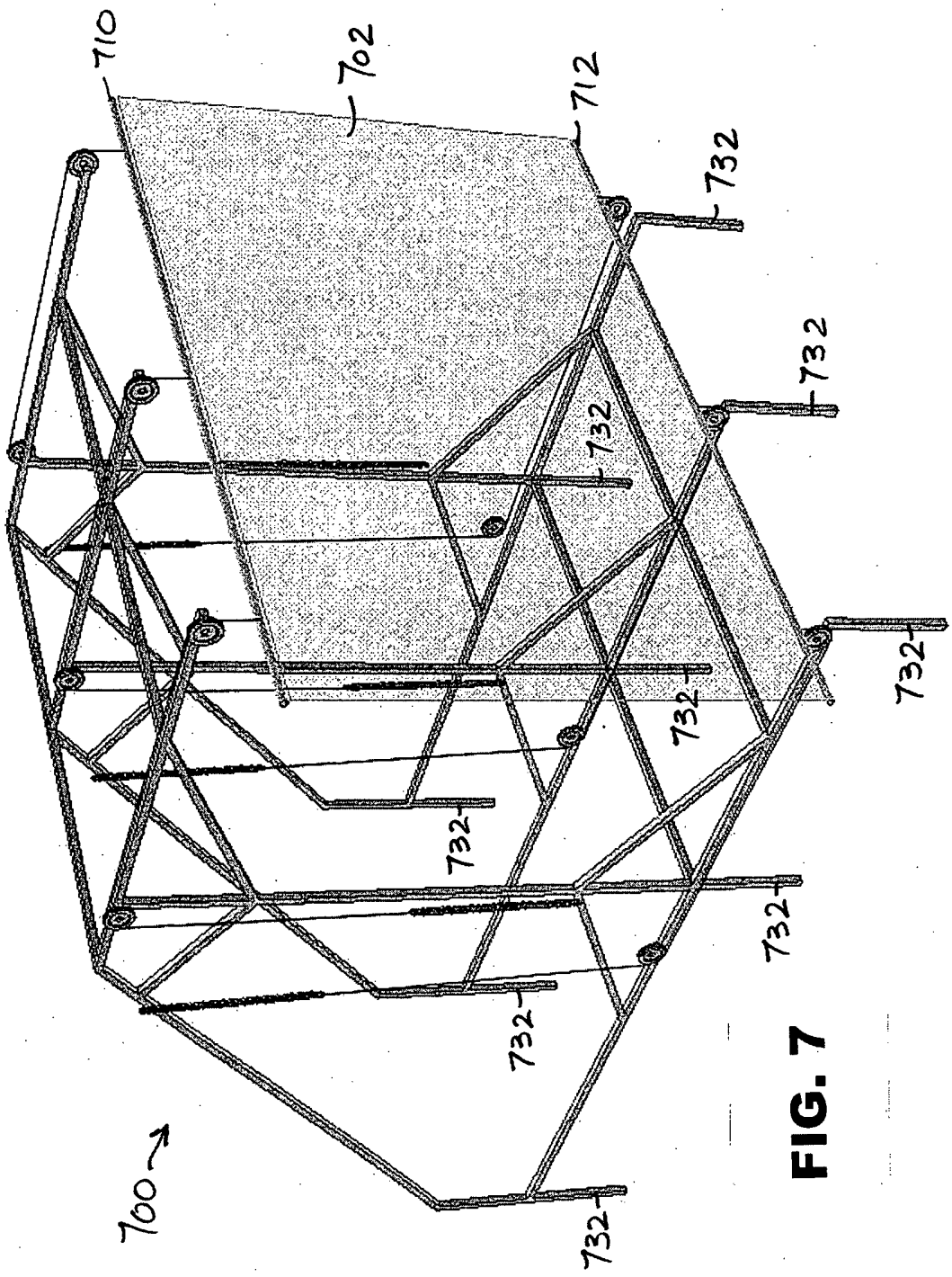

FIG. 7

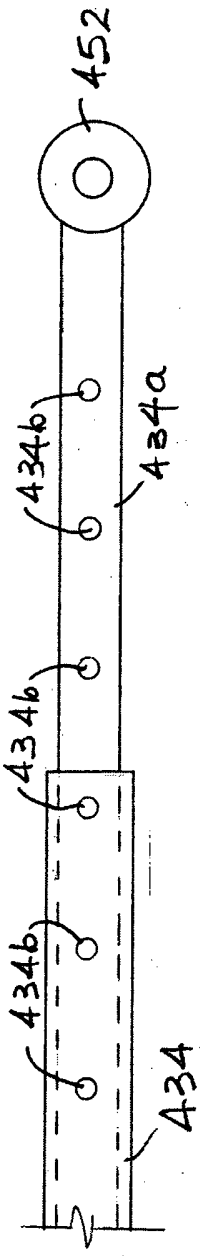

FIG. 10

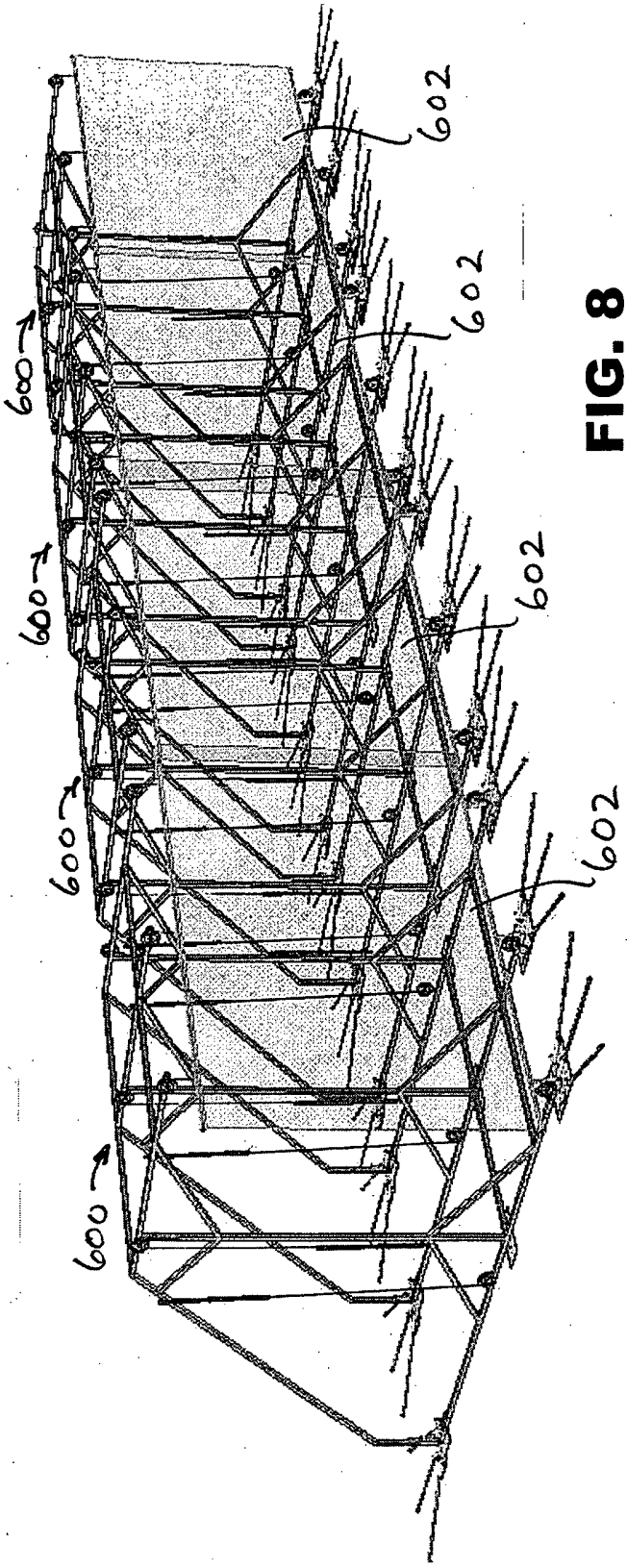

FIG. 8

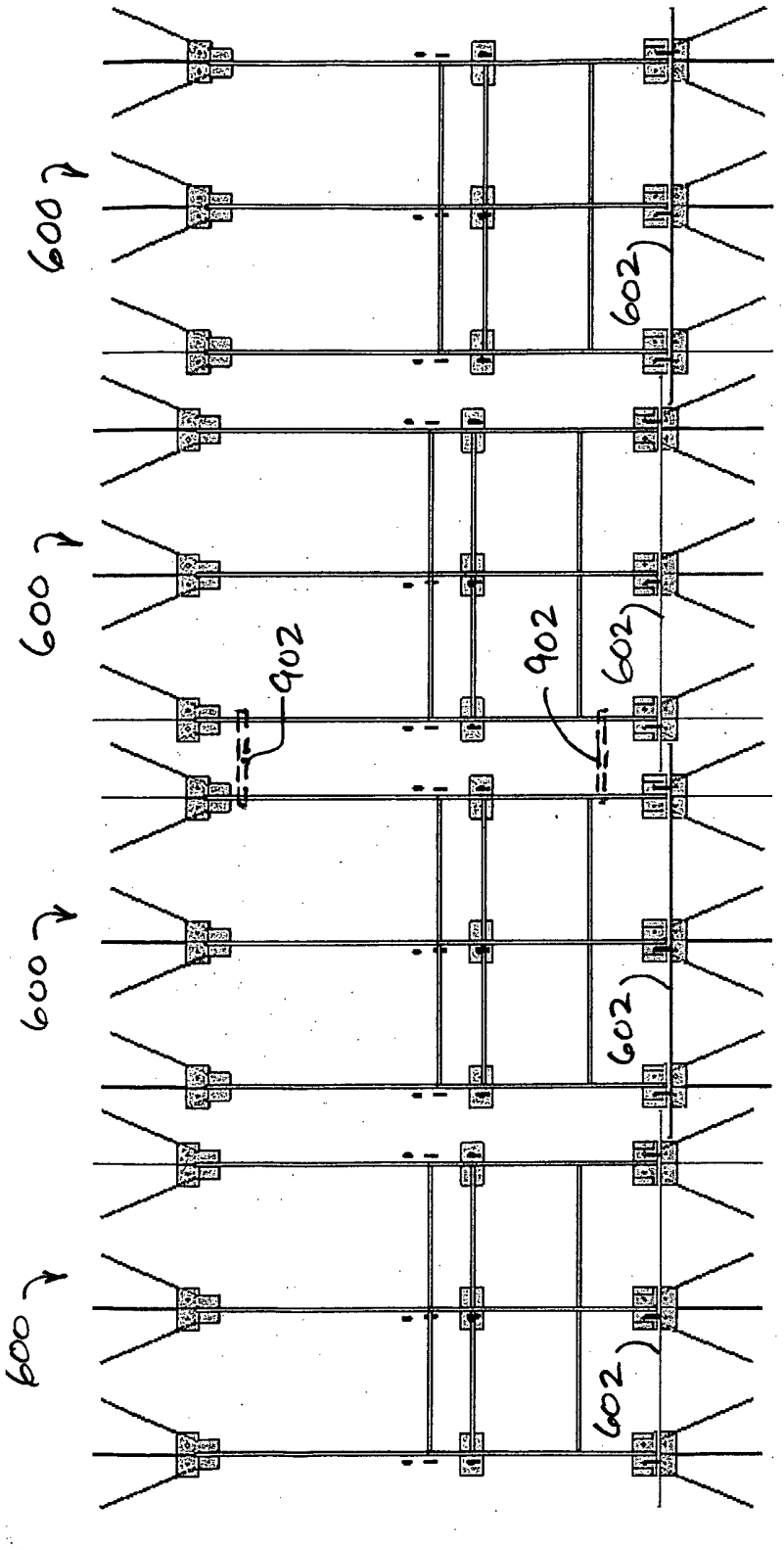

FIG. 9