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(54) **Reflector antenna with supporting structure.**

(57) An antenna system for a TVRO application includes a supporting superstructure for the main reflector dish which is comprised of a plurality of radial ribs encircled and joined by a peripheral rim with a triangular rib assembly extending between adjacent radial ribs and the included peripheral rim for structural strength. This triangular rib assembly may be either a single stamped member, a flat member folded into a triangle, separate members joined at their ends, or separate members joined between the ribs with tabs and curvilinear tabs mounting them with bolts. Alternately, the supporting superstructure may be formed by a plurality of ribs which have windows formed in their sides and through which other ribs are inserted to form the array of the superstructure. In still another alternate configuration, slots may be formed in the ribs to accommodate the intersection of the ribs in the array. The mesh panels are attached to the supporting superstructure by a plurality of integrally formed tabs which are die stamped i the rib, or part of a separate bracket included as part of the rib, and which are then folded over onto the edge of the mesh panels. A linear actuator and drive linkage is disclosed which provides horizon-to-horizon movement of the antenna dish through the use of a standard linear actuator.

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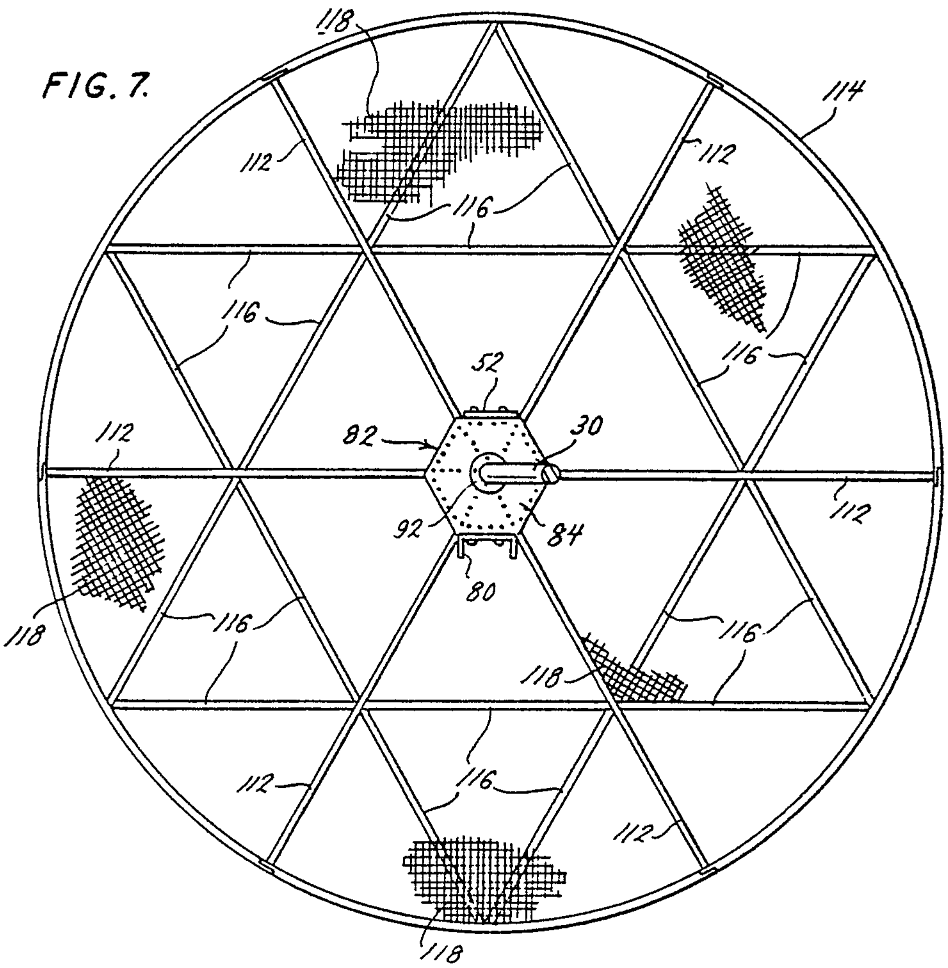
FIG. 7.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ANTENNA SYSTEM

Background and Summary of the Invention

The reception of television programming directly from satellites is becoming increasingly popular as a means of obtaining an incredible array of entertainment, including first run movies, blacked-out sporting events, and many commercial television channels. These systems were first popularized by the residents in remote or rural areas of our country who had very little opportunity to obtain other sources of television programming. However, recently even those in suburban and urban areas have been attracted to satellite television reception systems (TVRO) because of this incredible selection of programs and the dramatically reduced prices of systems presently available. There is even now some economic justification for choosing a TVRO system over cable programming due to the increased costs of cable, and the ability to insulate oneself from the expected price increases.

One of the more important components of a TVRO system is the dish antenna which is now commonly seen in backyards and is used to collect the electromagnetic energy broadcast by the satellites. There are two major design categories of dish antennas, and these include a solid dish antenna which may be made from fiberglass or aluminum, and a mesh-type antenna which generally includes a supporting superstructure which serves as a supporting framework for mesh panels made from expanded die-cut aluminum or the like. Of these two designs, the mesh-type dish antennas are becoming increasingly popular because of their greater strength-to-weight ratio, their lessened wind resistance due to the holes in the mesh, and their ability to better blend in with the surrounding environment.

The supporting superstructure for a mesh-type antenna generally has two purposes: the first is to serve as a skeleton for supporting the mesh in the desired overall shape as necessary to correctly and properly focus the electromagnetic energy from the satellite, and secondly to provide the necessary stability and rigidity to the overall antenna dish to minimize antenna wobble or mispointing which detracts from the electrical performance of the antenna. In the prior art, a typical mesh-type antenna includes a supporting superstructure which is comprised of a center support plate for supporting a "button hook" which is an elongated tube bent in the approximate shape of a button hook at the end of which is mounted a feed horn at the focal point of the dish to receive the electromagnetic energy, with a plurality of radially extending support ribs joined at their ends by a peripheral circumferential rim. Additionally, one or more sets of cross ribs may extend between adjacent radial ribs to form concentric circles about the center support assembly which serve to maintain the proper positioning between the adjacent radial ribs and hold them in parallelism and in their proper shaped configuration to support the mesh panels. As mentioned above, these mesh panels form the surface which reflects and focuses the electromagnetic energy at the feed horn and hence the electrical performance of the dish is dependent upon the ability of the supporting superstructure not only to support these panels in their proper configuration, but also minimize antenna wobble and mispointing. A common overall configuration for the antenna dish is a parabolic shape as that has been found to be optimal for certain well-known feed horn designs.

The expanded die cut mesh panels commonly used in mesh-type antennas are generally secured by sliding the panels into troughs formed in the radial ribs, a process which can be quite difficult and time-consuming in that the mesh panels have to be almost perfectly formed and sized and the ribs have to be perfectly positioned to achieve an easy sliding fit. Once installed, the mesh panels are supported along the edge thereof, but by necessity there must be some clearance between these troughs and the edge of the mesh to facilitate their assembly. Thus, there is the problem of forming the trough to provide a tight fit and thus increase the difficulty and time of assembly versus forming troughs with a loose fit to facilitate assembly but which minimizes the support and control of the shape of the mesh panel after it is installed. As explained above, the shape of the mesh panel directly affects the electrical performance of the antenna and is a critical factor in determining the viewability of the signals actually received from the satellites.

Still another consideration is the number of ribs which are utilized in the antenna design. The greater the number of ribs, the smaller the size of each panel and hence the easier it is to hold the panels in their proper configuration and shape. However, the greater the number of ribs the more expensive the antenna, the greater weight the antenna has without necessarily increasing its stability which therefore reduces its resistance to mispointing, and the greater assembly time required. On the other hand, the fewer number of ribs, the greater the size of each panel which reduces assembly time, but which also increases the problem of holding the panels in their proper shape and configuration. Therefore, it is important to minimize the number of ribs in any particular antenna design while also minimizing the size of each mesh panel and attaching it in such a manner as to ensure its proper assembly and resistance to deformation from its optimum configuration and shape.

Most antennas for TVRO applications also include a drive mechanism of some sort to move the antenna dish through an azimuth direction to facilitate reception of signals from more than one satellite. As is well known in the TVRO industry, there are a plurality of satellites in geostationary orbits over the equator, each satellite having a number of transponders for the rebroadcasting of different television programming. Thus, it is desirable to point the antenna dish at different satellites along this "arc" of satellites by moving the antenna dish through an "azimuth" direction. At present, this is commonly done through the use of a linear actuator which most often is comprised of an electric gear drive and screw mechanism which is attached by a swivel to the mast supporting the antenna and extends to the back of the supporting superstructure. Unfortunately, for most of these installations and designs, the linear actuator is incapable of position ing the antenna dish through the entire 180° arc as is desired to receive signals from all of the presently available and/or future satellites. Although there are horizon-to-horizon drive assemblies, they are generally much more expensive and require much more complicated drive mechanisms including ring gears, drive motors and gear reducers.

To solve these and other problems related to the successful design of a mesh-type antenna for a TVRO application, the inventors herein have succeeded in designing and developing several different antennas with a unique approach to a supporting superstructure which provides optimal solutions to the problems inherent in providing sufficient strength-to-weight ratio for reliable pointing of the antenna while also providing for mesh panels which are suitably sized to achieve accurate and reliable shaping of the desired curvature and maintaining that curvature during use. Additionally, a novel drive linkage has been designed which permits the use of a linear actuator to achieve horizon-to-horizon coverage of the satellite arc, and a technique for attachment of the mesh panels to the supporting superstructure which minimizes assembly time and maximizes accurate and reliable positioning of the mesh.

The inventors' supporting superstructure design includes three general embodiments, with several variations on one of the embodiments. The three embodiments include a first embodiment characterized by a series of radially extending ribs with triangular rib assemblies mounted between adjacent ribs and the circumferential peripheral rim which encircles the radial ribs. This first embodiment is characterized by several variations on the triangular rib assembly which interconnects between the adjacent radial ribs and the peripheral rim. In a first variation, a single stamped triangular rib assembly may be mounted by screws or the like to each of the adjacent radial ribs and peripheral rim. In a second variation, a single stamped rib may be formed in a straight piece and folded over at each of two corners to form the triangular assembly. In a third variation, three separate ribs are formed in the same configuration and nest together at their ends to form the triangular assembly. In a fourth variation, three separate cross beams mount between hinge pins and slots formed in the ribs to achieve the triangular reinforcement.

In a second embodiment of a supporting superstructure, nine cross beams are utilized to provide a geodesic superstructure, with windows formed in the sidewalls of the ribs through which intersecting ribs are inserted to achieve the assembly.

In a third embodiment of a supporting superstructure, slots are utilized at the intersections of the ribs and a fastener comprised of a slotted cylindrical member with a spring clip holds the slotted ribs together at their intersection.

As is known in the art, there is some movement in the industry to convert from C-band to Ku-band frequency. The newer satellites are operating at Ku-band frequencies, and it is believed by some observers that eventually all satellite broadcasting will be at Ku-band. Therefore, it is important to recognize this trend and also adapt existing designs for use at these higher frequencies. In a variation which can be used with any of the three embodiments, the central portion of the dish may be replaced with a solid spun metal construction, or mesh openings which are scaled down in size at approximately a three-to-one ratio, or even a perforated metal surface be provided to enhance the performance of the antenna at Ku-band. With the first embodiments arrangement, it is anticipated that this modification will replace the portion of the dish surface extending between the interior legs of the triangular cross ribs.

A unique triangle and lever drive linkage can be used with any of these antenna embodiments which connects between a standard linear actuator and the antenna superstructure to provide for horizon-to-horizon movement of the antenna dish through the linear actuator presently known in the prior art. This permits retrofitting of existing antenna dishes as well as use with new antennas to achieve horizon-to-horizon pointing of the antenna dish at minimal cost.

Still another feature of the inventors' antenna design includes a unique method of attaching the mesh panels to the supporting superstructure ribs. This technique includes the use of a plurality of upstanding tabs formed in the upper surface of the ribs so that mesh panels may be easily placed adjacent the tabs and the tabs folded over against the mesh which captures it against the upper surface of the rib to tightly hold it in place. The upstanding tabs can be die stamped into the rib channel, or a separate tab bracket may be sandwiched between a pair of C-brackets to form the rib.

As an alternative to the upstanding tabs, slots may be formed in the tops of the ribs, and a plastic extruded "Tee" may be inserted through the slot to capture the edge of the mesh panel on either side of the rib and secure it to the rib. This eliminates the alignment, sliding, and loose fit problem of the pre-formed slots of the prior art. Also, the installation is relatively simple to achieve and re placement of the mesh is also relatively simple by merely cutting off the plastic Tee.

The foregoing has been a brief description of some of the principal advantages and features of the inventors' new antenna design. A more complete understanding and appreciation for this invention may be achieved by referring to the drawings and description of the preferred embodiment which follows.

Brief Description of the Drawings

Figure 1 is a side view of a dish-type an tenna pivotally mounted to a supporting mast;

Figure 2 is a top view taken along the plane of line 2-2 in Figure 1 detailing the horizon-to-horizon interconnecting the linear actuator to the supporting superstructure;

Figure 3 is a rear view taken along the plane of line 3-3 in Figure 2 detailing the mounting of the linear actuator to the supporting superstructure;

Figure 4 is a side view taken along the plane of line 4-4 in Figure 2 further detailing the declination and elevation adjustment for the antenna dish;

Figure 5 is a cross-sectional view taken along the plane of line 5-5 in Figure 4 detailing the declination adjustment and mast mounting of the antenna to the mast;

Figure 6 is a cross-sectional view taken along the plane of line 6-6 in Figure 4 detailing the clamp mounting to the mast;

Figure 7 is a front view of the antenna dish taken along the plane of line 7-7 in Figure 1 detailing the supporting superstructure rib array;

Figure 8 is a side view of the antenna with a standard actuator to drive the dish;

Figure 9 is a top view of the antenna with standard actuator as shown in Figure 8;

Figure 10 is an enlarged partial cutaway view of the center support assembly detailing its construction;

Figure 11 is partial cross-sectional view taken along the plane of line 11-11 in Figure 10 detailing the mounting of the "button hook" to the center support assembly;

Figure 12 is a partial cross-sectional view taken along the plane of line 12-12 in Figure 11 detailing the mounting of the peripheral ribs to the center support assembly;

Figure 13 is a partial enlarged view of a joint between a radial rib and the peripheral rim;

Figure 14 is a partial cross-sectional view taken along the plane of line 14-14 in Figure 13 further detailing the joint of Figure 13;

Figure 15 is a partial cross-sectional view taken along the plane of line 15-15 in Figure 13 further detailing the joint of Figure 13;

Figure 16 is an enlarged partial view of the triangular rib assembly which joins adjacent radial ribs and the peripheral rim;

Figure 17 is a partial cutaway view taken along the plane of line 17-17 in Figure 16 detailing the mounting of the triangular rib assembly to the peripheral rim;

Figure 18 is a partial cross-sectional view taken along the plane of line 18-18 in Figure 16 detailing the mounting of the triangular rib assemblies to the radial rib;

Figure 19 is a partial end view of the one-piece triangular rib assembly shown in Figure 16;

Figure 20 is an enlarged partial view of an alternate version of the triangular rib assembly;

Figure 21 is a partial cross-sectional view taken along the plane of line 21-21 in Figure 20 detailing the mounting of the rib assembly of Figure 20 to the peripheral rim;

Figure 22 is an enlarged partial view of the ends of the rib assembly of Figure 20 as they are folded to complete the triangle;

Figure 23 is a partial cross-sectional view taken along the plane of line 23-23 in Figure 20 detailing the mounting of adjacent triangular rib assemblies to a radial rib;

Figure 24 is an orthogonal view of one of the folded corners of the single piece folded triangular rib assembly;

Figure 25 is a partial cross-sectional view taken along the plane of line 25-25 in Figure 20 detailing the mounting of adjacent triangular rib assemblies to a radial rib;

Figure 26 is an orthogonal view of the second folded corner of the one-piece folded triangular rib assembly version;

Figure 27 is an enlarged partial view of another version of the triangular rib assembly;

Figure 28 is a partial cross-sectional view taken along the plane of line 28-28 in Figure 27 detailing the mounting of adjacent triangular rib assemblies of this version to an included radial rib;

Figure 29 is an orthogonal view detailing the juncture between two members of the three-piece triangular rib assembly version;

Figure 30 is a partial cross-sectional view taken along the plane of line 30-30 in Figure 27 detailing the mounting of the triangular rib assembly to the peripheral rim;

Figure 31 is an orthogonal view detailing the interconnection between two rib members forming the three-piece triangular rib assembly of this version;

Figure 32 is a partial cross-sectional view taken along the plane of line 32-32 in Figure 27 detailing the mounting of adjacent triangular rib assemblies to the included radial rib;

Figure 33 is an enlarged partial view of another version of the triangular rib assembly;

Figure 34 is a partial cross-sectional view taken along the plane of line 34-34 in Figure 33 detailing the mounting of adjacent triangular rib assemblies to the included radial rib;

Figure 35 is an exploded view of the joint between adjacent triangular rib assemblies and an included radial rib;

Figure 36 is a partial cross-sectional view taken along the plane of line 36-36 in Figure 33 detailing the mounting of the triangular rib assembly to the peripheral rim;

Figure 37 is an exploded view of the joint of Figure 36;

Figure 38 is a front view of a supporting superstructure constructed with the nine-rib and intersecting window embodiment;

Figure 39 is an enlarged partial view of a joint between two rib members which form a single rib of the nine-rib supporting superstructure assembly of Figure 38;

Figure 40 is an enlarged view detailing the intersecting ribs and windows of the nine-rib supporting superstructure embodiment;

Figure 41 is a partial cross-sectional view of the intersection of Figure 40 further detailing the windows and ribs at the point of intersection;

Figure 42 is a partial cross-sectional view taken along the plane of line 42-42 in Figure 41 further detailing the dimension of the ribs and windows;

Figure 43 is a partial view of two rib members assembled at an intersection and before the insertion of the third rib;

Figure 44 is a partial view of an intersection of radial ribs having slots and a fastener;

Figure 45 is an exploded view of the intersection of Figure 44 detailing the ribs with slots and the retaining cylinder and spring clip;

Figure 46 is a partial cross-sectional view of the intersection of Figure 44 detailing the cylindrical retainer member and spring clip;

Figure 47 is a partial cross-sectional view taken along the plane of line 47-47 in Figure 46 further detailing the mounting of the retainer cylinder and spring clip to the intersecting ribs with slots;

Figure 48 is an orthogonal view detailing a alternate mounting of mesh panels to supporting rib members with tabs;

Figure 49 is a partial section of a rib member showing the upstanding tabs die stamped in the upper surface of the rib;

Figure 50 is a partial view of a rib member having substantially semi-circular shaped tabs;

Figure 51 is a partial view of a rib member having rectangular tabs;

Figure 52 is a partial view of an alternate rib construction with upstanding tabs;

Figure 53 is a cross-sectional view of the rib construction of Figure 52;

Figure 54 is an orthogonal view of a rib member with slots and the plastic extruded Tee for mounting the mesh; and

Figure 55 is a cross-sectional view of the Tee embodiment of Figure 54 as mounted to a rib and mesh panels.

Detailed Description of the Preferred Embodiment

A satellite television reception only antenna 20 of the mesh-type design is shown in Figure 1 and is generally mounted to a supporting mast 22 which is securely fixed in the ground and may be anchored by concrete or the like and includes a main reflector dish 24 comprised of a plurality of ribs 26 surrounded by a peripheral rim 28, a "button hook" 30 which supports a feed horn 32, support brackets 34 which mount the dish 24 to the mast 22 and a linear actuator 36 with a drive linkage 38 for driving the dish 24 in the azimuth direction.

The linear actuator 36 and drive linkage 38 is best shown in Figures 2, 3 and 4 and includes a linear actuator 36 pivotally mounted by a strap 40 and bolt 42 to an upper bracket 44 extending between support brackets 34. The jack 46 of the linear actuator 36 is pivotally mounted to a corner of an angular bracket 48, a second corner of angular bracket 48 being pivotally mounted to upper bracket 44, and a third corner of angular bracket 48 being mounted to a lever 50. The opposite end of lever 50 is pivotally mounted to the upper declination bracket 52 which is secured such as by welding or the like to the back of the antenna dish 24. Thus, as the linear actuator 36 drives the angular bracket 48, lever 50 moves the dish by moving the upper declination bracket 52. With this drive linkage 38, horizon-to-horizon movement can be achieved with the linear actuator 36.

The mounting details for mounting the antenna dish 24 to the mast 22 are shown in greater detail in Figures 4-6 and include a pair of mast brackets 54, 56 which are mounted on either side of the mast 22 and secured to the mast with a pair of C-clamps 58, 60 and nut and bolt assembly 62, 64. Each bracket 54, 56 has a pair of "smile" slots 66 which permits adjustment of the elevation of the dish 24, as known in the art. A mast cap 68 mounts atop the mast 22 and a nut and bolt assembly 70 further stabilizes brackets 54, 56 atop the mast 22, as shown. An upper and lower cross bracket 72, 74 extend between mast brackets 54, 56 and provide for the mounting of captured bearing assemblies 76, 78 to mount the upper declination bracket 52 and lower declination bracket 80 and permit their adjustment to adjust the declination of the dish 24 with respect to mast 22, as known in the art. The upper and lower declination brackets 52, 80 are secured to a center support assembly 82 which mounts the "button hook" 30 to the dish 24.

The center support assembly 82 is shown in greater detail in Figures 10-12 and include a top plate 84 and a bottom plate 86 which sandwich a cast center ring 88. A plurality of nut and bolt assemblies 90 extend between the flanges of the center ring 88 and a plurality of holes in a collar 92 of "button hook" 30 to secure it in place at the center of the center support assembly 82. A plurality of radially extending ribs 26 are bolted between peripheral bracket members 94 which are mounted between upper and lower plates 84, 86 by screws 96, and are attached to the center ring 88 by nut and bolt assemblies 98. Thus, the center support assembly 82 serves as the central anchoring point for the "button hook" 30 and a plurality of radially extending ribs 26.

As an alternate to the drive linkage 38 ex plained above, a standard actuator 100 may be pivotally mounted to a cross bracket 102, and have its jack 104 pivotally mounted to a drive bracket 106 mounted to the back of the dish 24. As is well known in the art, this standard actuator 100 will drive the antenna dish 24 across the "arc" of satellites, but not to the same degree of movement as is capable with the drive linkage 38 described above.

The supporting superstructure 110 is shown in an overall configuration in Figure 7 and generally includes six radially extending rib members 112 encircled by a peripheral rim assembly 114, and six triangular rib assemblies 116 which extend between adjacent radial rib members 112 and the included arc of peripheral rim 114. At the center of the supporting superstructure 110 is the center support assembly 82 which supports the "button hook" 30, as previously described in greater detail above. A plurality of mesh panels 118 are shaped to mount to the upper surface of the various rib members and assemblies 112, 114, 116. Although it is difficult to show in Figure 7, the supporting superstructure 110 when viewed in cross-section forms the shape of a parabola, or other like geometric surface to optimize the reflection and collection of electromagnetic energy and focus it at a point suitable for reception thereby by a feed horn 32. Thus, each of the rib members and assemblies 112, 116 is shaped to define the surface for mesh panels 118 as the mesh panels 118 form the electromagnetically reflective surface so important to the operation of antenna 20. To enhance the performance of the antenna at Ku-band, the six center panels surrounding the center support assembly 82 and extending to the interior leg of the triangular rib assemblies 116 may be formed from a spun metal, or a mesh which is scaled down from the mesh generally used for operation at C-band and as would by used throughout the rest of the antenna surface. Also, the inner surface may be formed from a perforated metal surface, with holes spaced therethrough as is customary and normal for Ku-band operation. This modification would enhance the performance of the antenna at Ku-band, and would not interfere with performance of the antenna at C-band as well.

A first version of the radial rib and triangular rib assembly embodiment is shown in Figures 13-19, and as best shown in Figure 16 includes a single one-piece stamped triangular rib 120, with a flattened end 122 formed at each of the three corners thereof and a pair of holes 124 formed therein for mounting the triangular rib 120 between the section of peripheral rim 114 and two adjacent radial ribs 112. For this purpose, a pair of nut and bolt assemblies 126 are used to securely fasten the adjacent triangular rib assemblies 120 to an included radial rib 112. As shown in Figures 13-15, each radial rib 112 may be fastened to a joint between adjacent portions of peripheral rim 114 by a pair of nut and bolt assemblies 128, or rivets 130. Additionally, a series of holes 132 may be formed along the upper surfaces of each of the rib and rim members 112, 114, 116, 120 to serve as a point for fastening mesh panels 118. Alternately, upstanding tabs may be used as described in greater detail below.

Still another version 132 of the radial rib and triangular rib assembly embodiment is shown in Figures 20-26 and differs from the first embodiment by the way that the triangular rib member

134 is formed. Instead of being a single stamped triangular rib member, a single stamped straight rib member 134 is folded at each of two corners 136, 138, and the third corner 140 is formed by sliding the two ends together to interlock tabs 142, 144 and align holes 146, 148 for mounting to peripheral rim 114 by nut and bolt assembly 150 as shown in Figure 21. As shown in Figures 24 and 26, mounting tabs 152, 154 with holes 156, 158 are used to mount the other corners 136, 138 to radial ribs 112 by nut and bolt assemblies 160, 162, as shown in Figures 23, 25.

Still another version 164 of the radial rib and triangular rib assembly embodiment is shown in Figures 27-32 and differs from the previous embodiments in the way that the triangular rib assembly 166 is formed. In this version 164, three separate rib members 168, 170, 172 are used to form the triangular rib assembly 166. Because of the geometry of the supporting superstructure 110, and the way that the ends are formed as shown in Figures 29, 31, rib members 168, 170 are the same piece. As shown in Figures 29, 31, one end 174 has a tab 176 bent backward with a smaller circular tab 178 bent forward. At another end 180, a tab 182 is bent forwardly with a semi-circular tab 184 bent backward. With this design, and as shown in Figures 29 and 31, the tabs 176, 182 nest into each other and tab 184 slides within the hole created to form tab 178 and nests there as well to facilitate the interlocking of rib members 168, 170, 172 to form the triangular rib assembly 166. As shown in Figures 28, 30, 32, nut and bolt assemblies 186, 188, 190 are used to secure the triangular rib assembly 166, as with the other versions.

In still another version, 192 of the radial rib and triangular rib assembly embodiment is shown in Figures 33-37 and differs essentially in the way that the triangular rib assembly 194 is formed and mounted to the radial ribs 112 and peripheral rim 114 as in the version 164 of Figure 27, three separate rib members 196, 198, 200. Furthermore, rib members 198, 200 are of the same configuration, just as in the version 164 of Figure 27. However, their ends are formed differently as shown in Figures 34-37. As shown in Figures 34, 35, radial rib 112 has a pair of slots 202, 204, and rib member 196 has a slot 206 to mount the rib members at that intersection. To facilitate that mounting, rib members 194 have their ends formed with matching curved hinges 208, 210 which encircle mounting bolt assembly 212. Rib member 198 has tab member 214 which fits within slot 204. Rib member 200 has tab 216 which fits in slot 206. At peripheral rim 114, rib members 198, 200 have curvilinear tabs 218, 220 which encircle mounting bolt 222 to mount them to peripheral rim 114.

In all of the versions of the radial rib and triangular rib assembly, it is readily apparent that the triangular rib assembly is formed from an isosceles triangle and, depending upon the particular dimensions of the dish, can be an equilateral triangle, With some versions, it may be desirable to form the dish with equilateral triangular assemblies as this minimizes the number of pieces which have to be separately stamped or formed to make the triangular rib assembly. With other versions, this is not important as a separate piece must be formed for the base of the triangle anyway so that there are no reduced costs which can be achieved in making the last leg of the triangle the same length as the other two.

In still another embodiment 224 for supporting superstructure 110, the rib array may be formed by nine chord-like cross ribs, each of which may be divided into two rib members. This embodiment 224 is detailed in Figures 38-43. As shown in Figure 38, and as in the previous embodiments, six radial ribs 226 are mounted to center support assembly 228 and their ends are joined by peripheral rim 230. The remaining ribs may be formed by six ribs which are identically configured. To facilitate assembly, each rib may be formed in two parts and are identified by numbers 232, 234. For purposes of description, the supporting superstructure 110 as shown in the embodiment 224 of Figure 38 can be thought of as nine chord-like rib members, with three being substantially horizontal, three being at approximately 60°, and the other three being at approximately 120°, the rib members being substantially equally spaced from the other rib members in each group of three, with the center rib member being thought of as a single rib except that it is interrupted by the center support assembly.

Still another way to envision the supporting superstructure 110 of the embodiment 224 of Figure 38 is that it is comprised of six radial rib members 226 with six chord-like rib members each of which is formed by rib members 232, 234. As shown in Figure 39, the rib members 232, 234 may be joined by three bolt assemblies 236. To facilitate the mutual support between rib members at each of the intersections, rib member 226 may have a window 238 formed therein through which both ribs 232, 234 pass through. Additionally, rib member 234 has a second window 240 through which rib member 232 passes. Windows 238, 240, and ribs 232, 234 are sized to closely fit and thereby provide support at each of the intersections. This is achieved by tapering the rib members as nec essary to fit within the windows 238, 240. Thus, rib 232 has the smallest height, rib 234 the next larger height, and rib 226 the largest height.

Furthermore, the ribs 226, 232, 234 are offset to provide a flush upper surface to support the mesh panels in a smooth parabolic configuration to optimize electrical performance.

Instead of providing windows 238, 240 at the various intersections as shown in the embodiment 224 if Figure 38, slots may be utilized. This embodiment 242 is shown in Figures 44-47. In this embodiment 242, a first rib 244 has an upper slot 246 and a lower slot 248, while rib 250 has only one slot 252 and rib 254 has one slot 256 such that as they are assembled, slots 246, 248, 252, and 256 intersect as shown in Figure 47. To secure ribs 244, 250, 254 together, a cylindrical fastener 258 having six slots 260 formed therein slides over the three rib members 250, 244, 254 and spring clip 262 is inserted therethrough so that its hook ends 264 clip over the lower end of cylindrical fastener member 258 to secure it in place.

Attachment of mesh panel 270 to any rib member 272 may be achieved by a plurality of tabs 274 which can be alternately folded over either side of the rib 272 as necessary to secure the edge of mesh panels 270 as shown in Figure 48. Tabs 274 may be of several different configurations as shown in Figures 49-53. These include the square tabs 276 of Figure 49, substantially semi-circular tabs 278 of Figure 50, and the substantially rectangular tabs 280 of Figure 51. In the rib 272 of each of Figures 49-51, the tabs 276-280 are formed by die stamping them from the upper surface of the rib 272. An alternate construction is shown in Figures 52, 53 and includes a flat tab bracket 282 which is sandwiched between a pair of C-brackets 284, 286. While this construction is somewhat more complicated and hence expensive, it does provide increased structural rigidity and strength over those ribs 272 of Figures 49-51.

An alternative to the tabs as shown in Figures 48-53 is shown in Figures 54, 55 which includes a number of slots 288 which are formed in the upper surface of rib 272 and a plurality of Tee shaped plastic extrusions 290 which capture the mesh panels 270 between the upper head member 292 and the upper surface of rib 272. The arrow portion 294 of the extrusion 290 slips through the slots 288 and springs back to its original configuration which prevents it from being pulled back through the slot 288. To remove the mesh panels 270, the arrow portion 294 may be cut away from the extrusion 290.

There are various changes and modifications which may be made to the inventions herein as would be apparent to those skilled in the art. However, these changes or modifications are included in the teaching of the inventors' disclosure, and it is intended that the invention be limited only by the scope of the claims appended hereto.

Claims

1. An antenna for at least receiving signals broadcast from a satellite, said antenna having a main reflector dish comprised of a supporting frame assembly and a metallic mesh secured to the upper surface thereof, the antenna being characterized by said supporting frame assembly comprising a plurality of n radially extending ribs, a generally circular circumferential rim surrounding said radial ribs and secured to the outer ends thereof, and a plurality of n generally triangular rib assemblies, one of each such assemblies being attached by its corners to each pair of adjacent radial ribs and the included portion of peripheral rim.

2. The device of Claim 1 wherein each triangular rib assembly is formed from a single member.

3. The device of Claim 1 wherein each of said triangles is formed from three rib members, said rib members having interlocking means formed in at least one end of each rib to facilitate attachment of the ends together and to the radial ribs and peripheral rim.

4. The device of Claim 3 further comprising a single fastener means to secure adjacent triangles to their included radial support rib.

5. The device of Claim 3 wherein said interlocking means is formed on each end of each of said triangular rib members, said interlocking means including a tab with means defining a hole therethrough, and further comprising a single fastener means to secure adjacent triangles to their included radial support rib by insertion through said tab holes.

6. The device of Claim 1 wherein each of said triangles is formed from three rib members, said rib members having mounting means formed in each end thereof to facilitate attachment thereof to the radial ribs and the peripheral rim.

7. The device of Claim 6 wherein each of said triangles includes a cross rib extending between adjacent radial ribs, the mounting means at the end of each said cross rib having means to interlock with the mounting means of the adjacent cross rib, and wherein a single fastener means secures adjacent cross ribs to the included radial rib.

8. The device of Claim 1 wherein the number n equals six.

9. An antenna for at least receiving signals broadcast from a satellite, said antenna having a main reflector dish comprised of a supporting superstructure with an upper surface, and an electromagnetically reflective surface secured thereto, said dish upper surface having a predetermined shape to focus the electromagnetic energy impinging on said electromagnetically reflective surface at a desired location, the antenna being characterized

by said supporting superstructure being comprised of a plurality of intersecting cross ribs, and a peripheral rim encircling and joining the outer ends of said cross ribs, at least one of said cross ribs having means defining an opening therein at each intersec tion of said cross ribs for receiving said intersecting cross ribs.

10. The device of Claim 9 wherein at least two cross ribs intersect at each intersection, all but one of said cross ribs having one of said openings therein, said one cross rib without an opening extending through each of said openings at said intersection.

11. The device of Claim 10 wherein at each intersection all but one of said cross ribs extend through one of said openings, the width dimension of each cross rib which extends through an opening being substantially the same as the inside dimension of the opening through which it extends so that said cross rib is securely positioned in said opening.

12. The device of Claim 9 wherein nine cross ribs comprise the supporting superstructure, said cross ribs being substantially equally spaced throughout said superstructure.

13. The device of Claim 12 wherein said nine cross ribs are grouped into three groups of three cross ribs, said cross ribs in each group being substantially parallel to each other, and the middle cross rib of each group being comprised of two members, the superstructure having a center support assembly, and each of said middle cross rib members being mounted to said center support assembly and extending radially therefrom.

14. The device of Claim 11 wherein said cross ribs are grouped into three groups of three cross ribs, said cross ribs in each group being substantially parallel to each other, and wherein each cross rib is comprised of at least two members, the superstructure having a center support assembly, and each of said middle cross rib members being mounted to said center support assembly and extending radially therefrom.

15. An antenna for at least receiving signals broadcast from a satellite, said antenna comprising a main reflector dish, a support, and means pivotally mounting the dish to the support, the antenna being characterized by means to drive said dish about the support, the drive means comprising a linear actuator means pivotally mounted to the support, and a linkage means pivotally mounted to the linear actuator means, support, and dish, said drive means having means to drive said dish through approximately 180° of arc about its support.

16. The device of Claim 15 wherein said linkage means comprises a first member having pivotal mounts in three locations, and a second member pivotally mounted to the first member and the dish.

17. The device of Claim 16 wherein the first member is pivotally mounted to the actuator, the support, and the dish, and wherein the first member comprises an angular bracket, said three pivotal mounts being substantially positioned at the two ends and the center thereof.

18. The device of Claim 17 wherein the second member comprises a lever with its pivotal mounts being substantially positioned near the ends thereof.

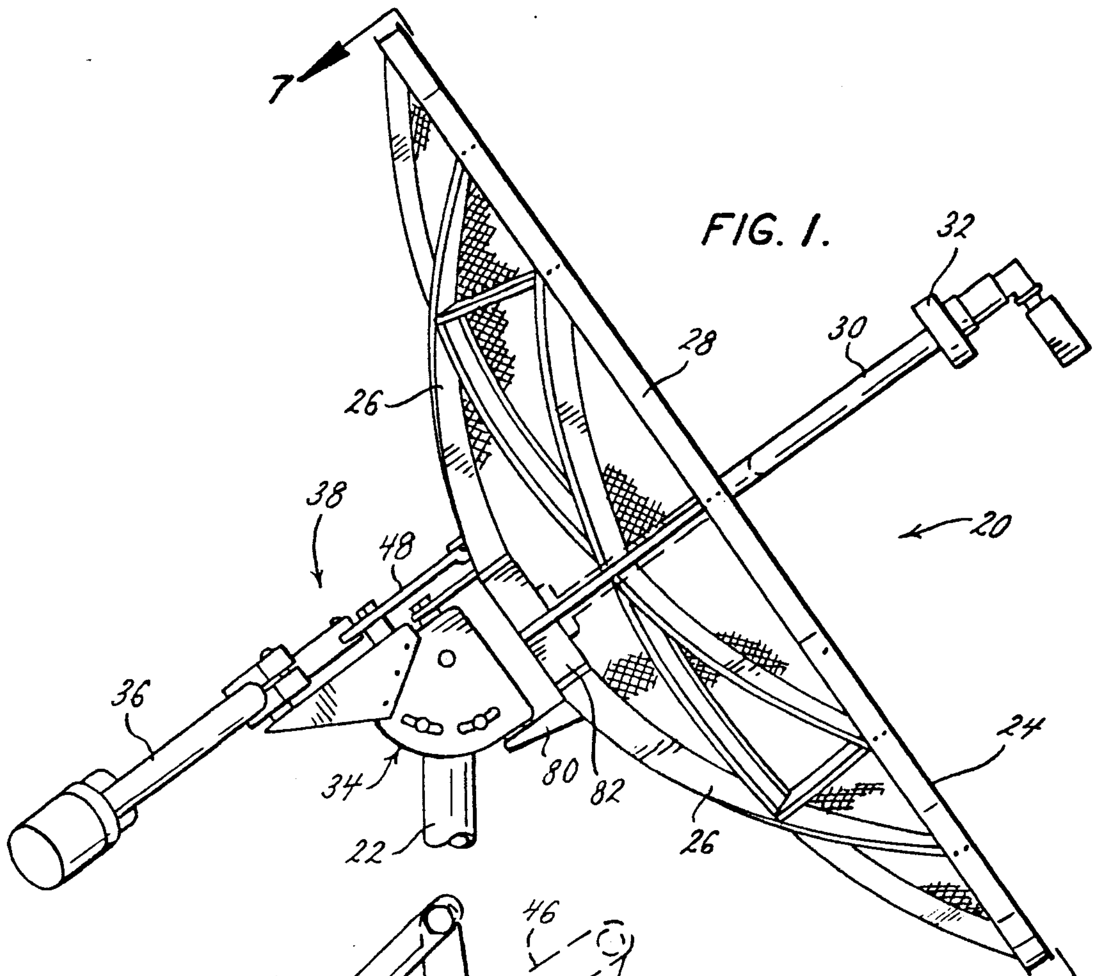


FIG. 1.

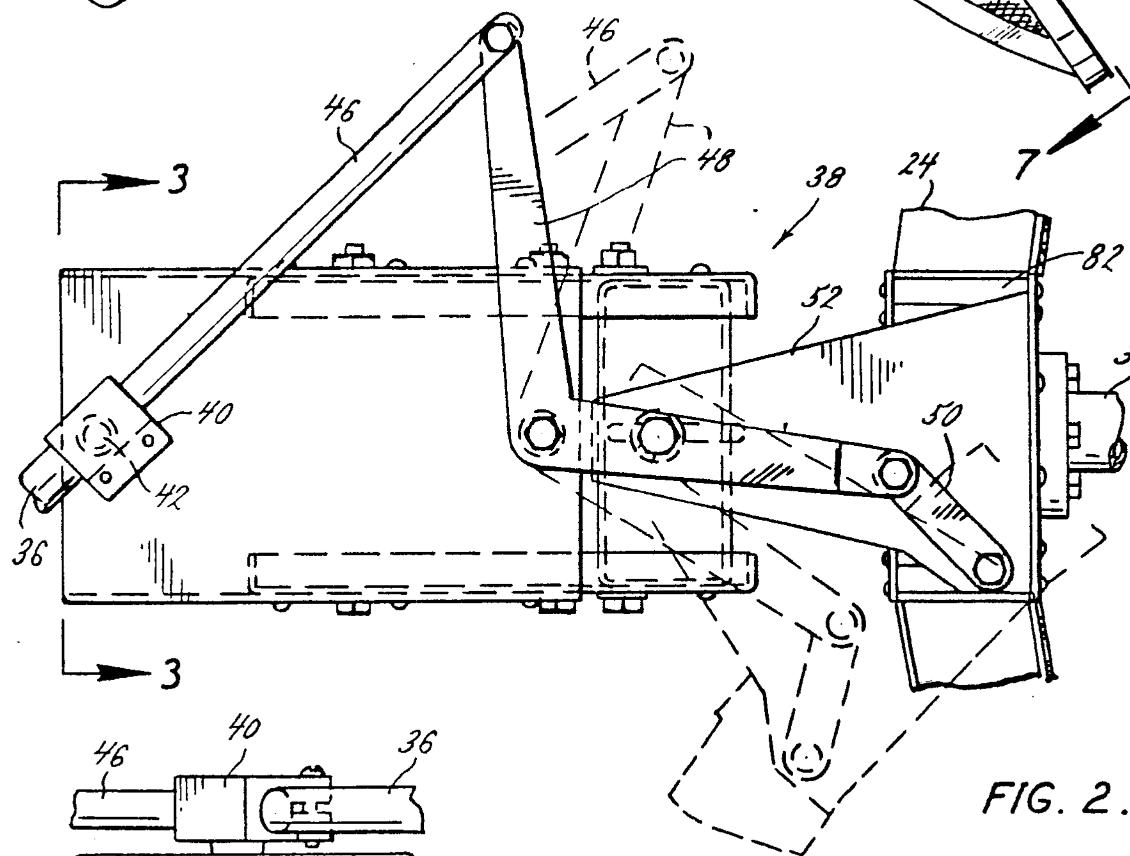


FIG. 2.

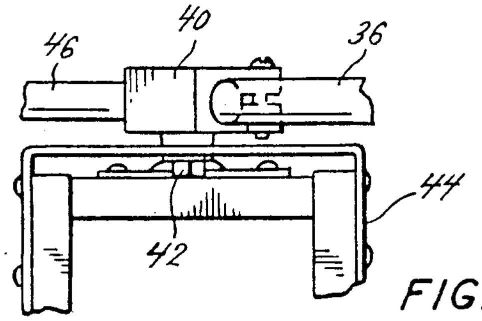
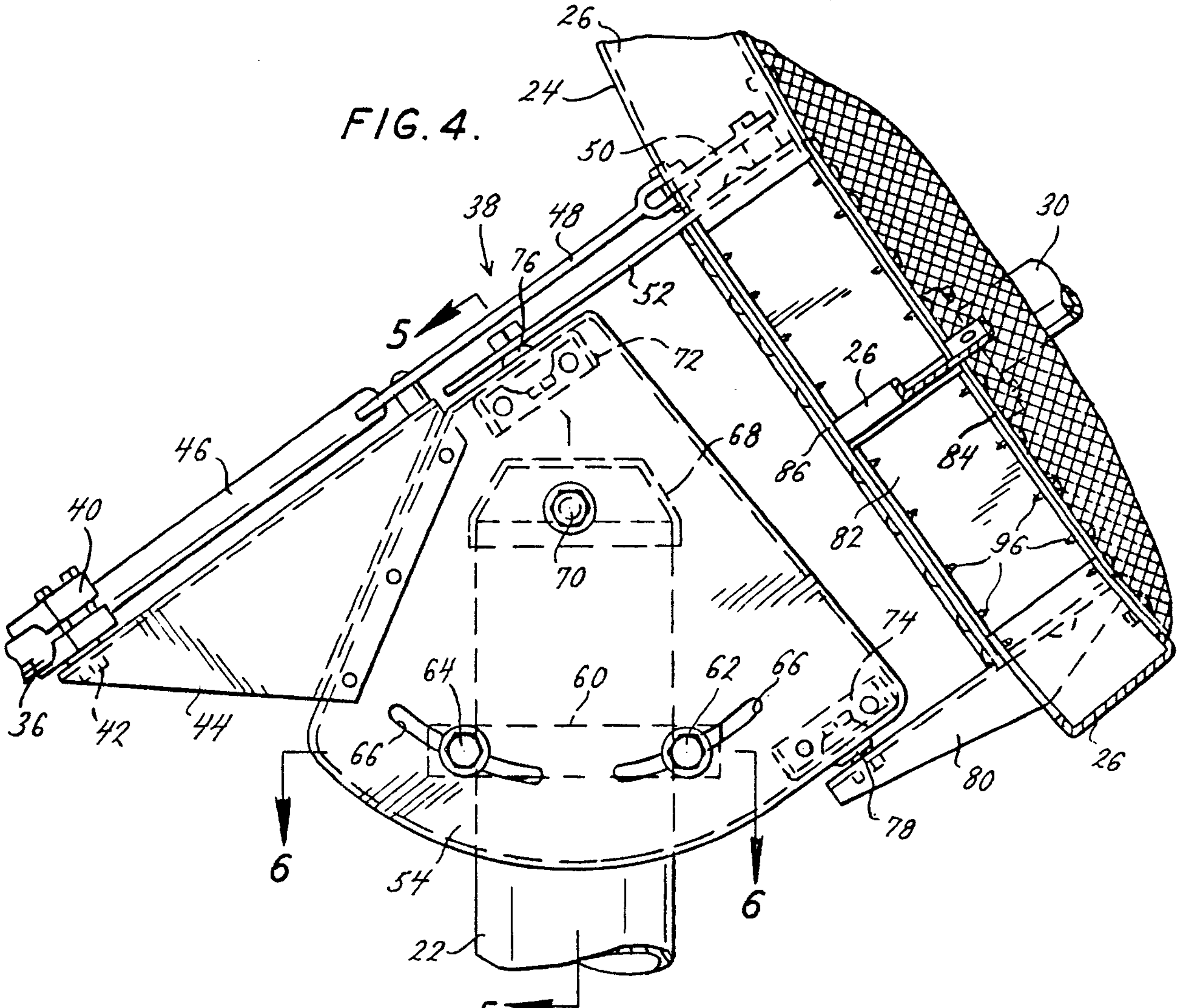
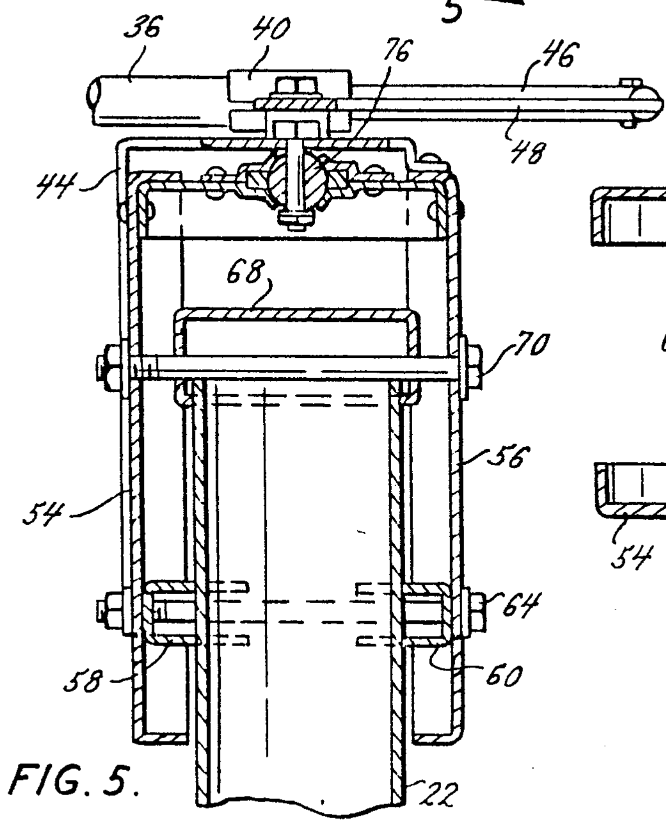


FIG. 3.

FIG. 4.





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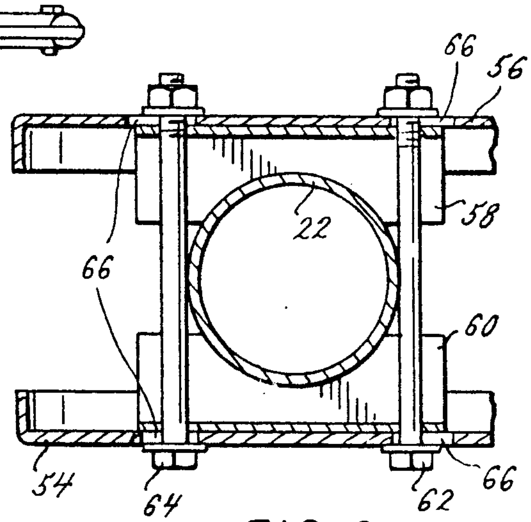
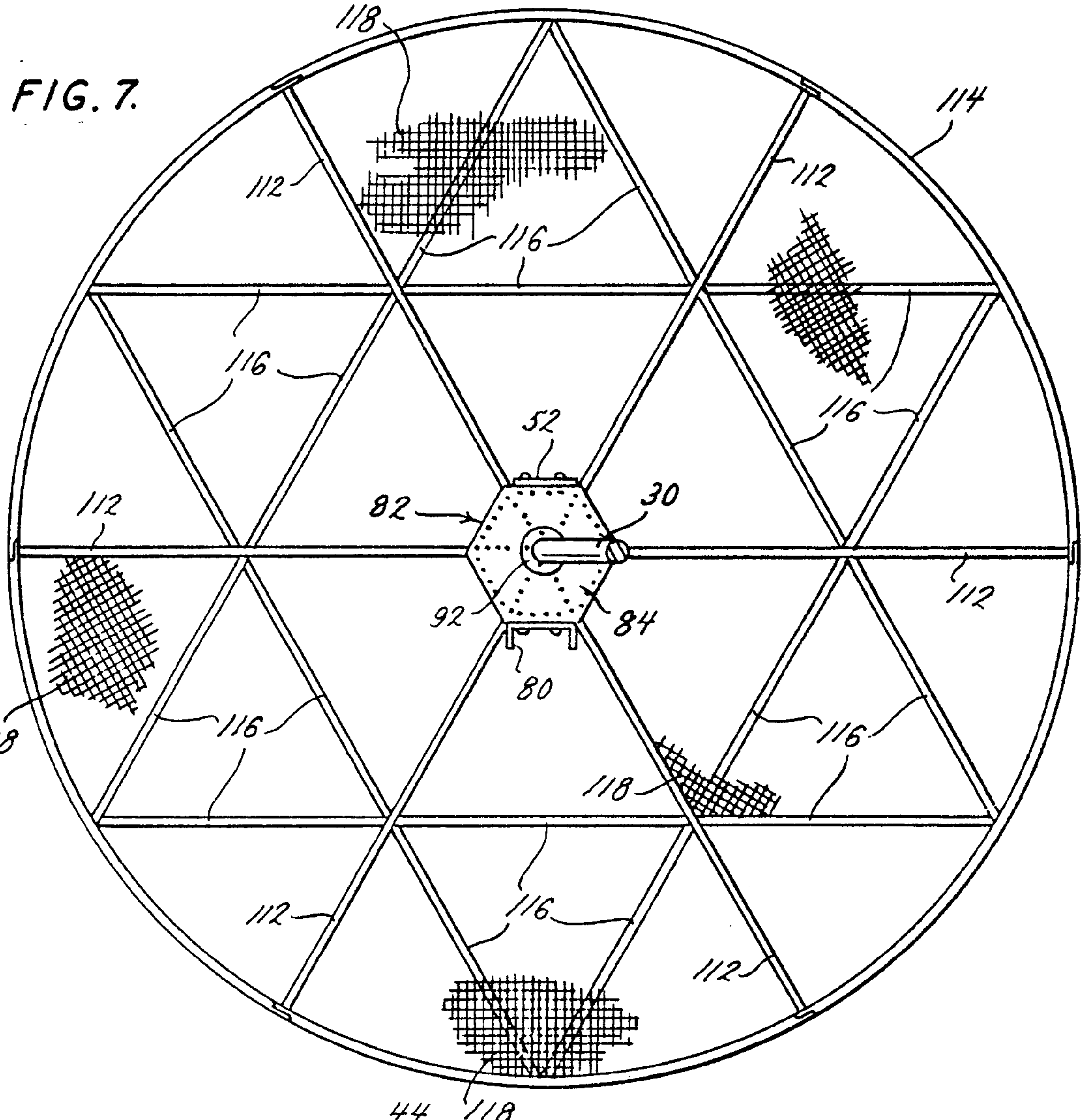
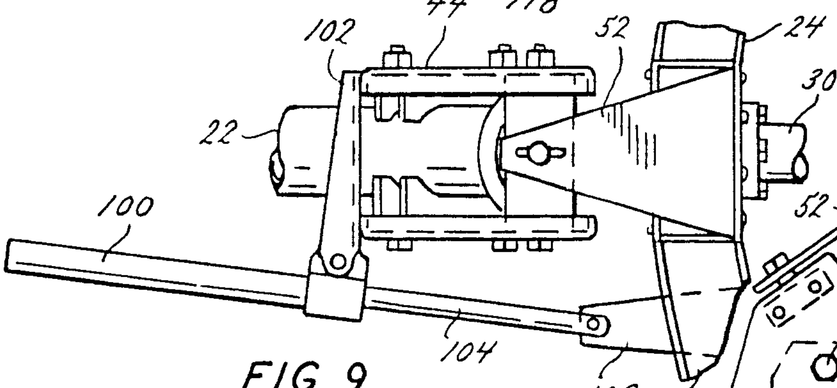


FIG. 6.

FIG. 7.





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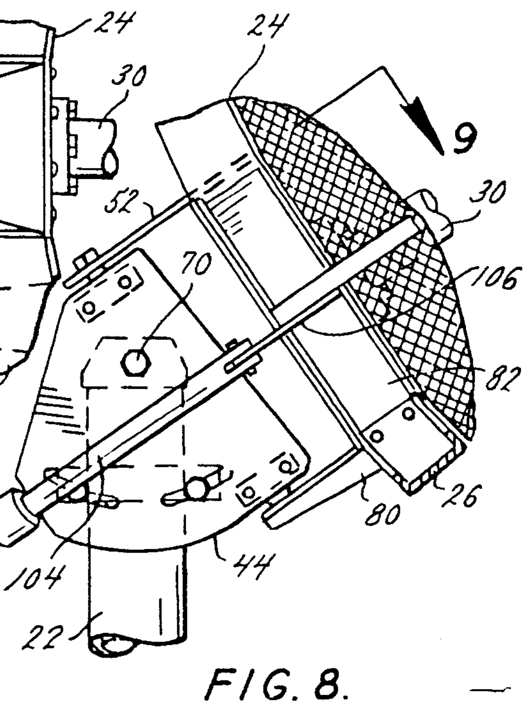


FIG. 8.

FIG. 10.

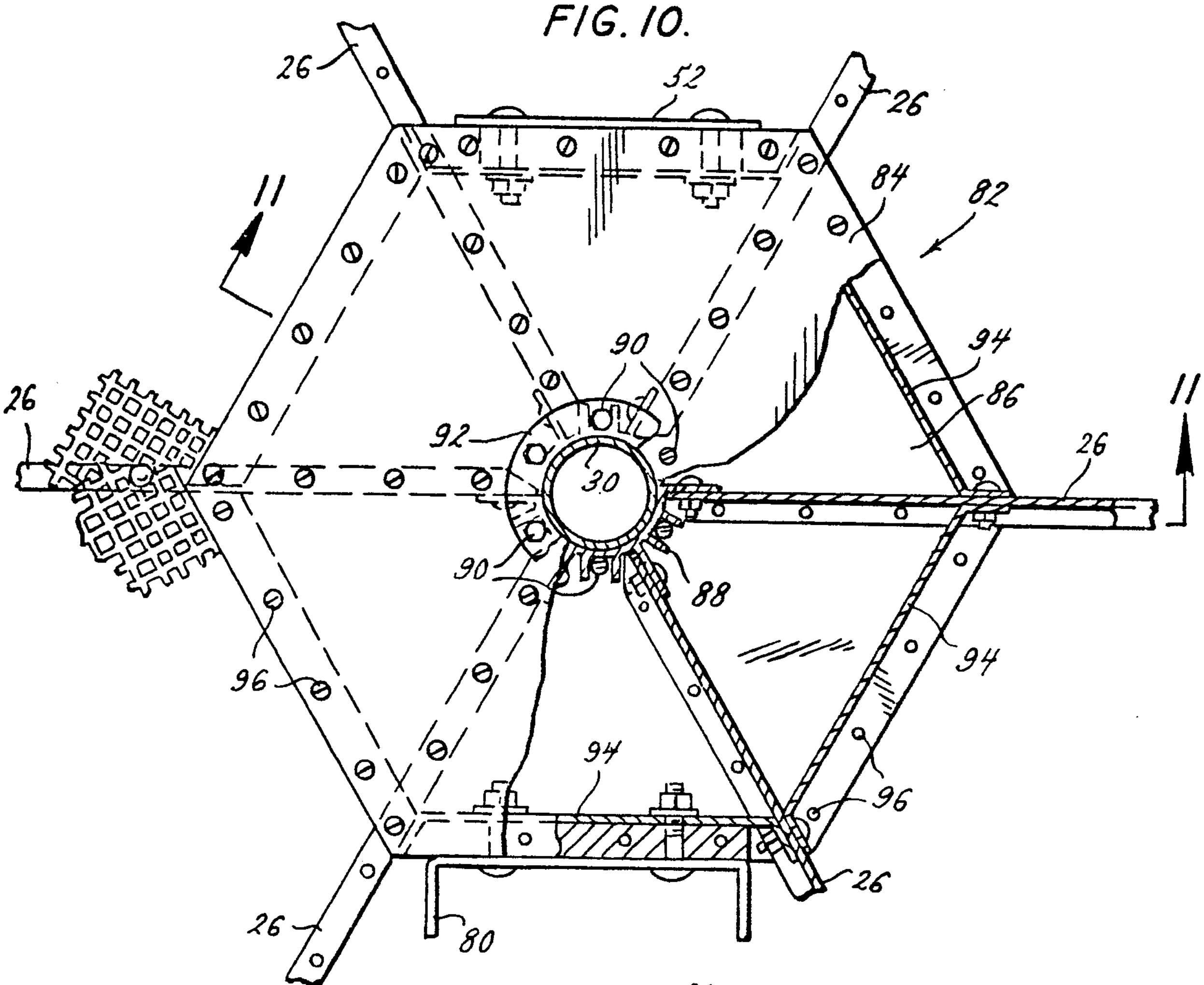
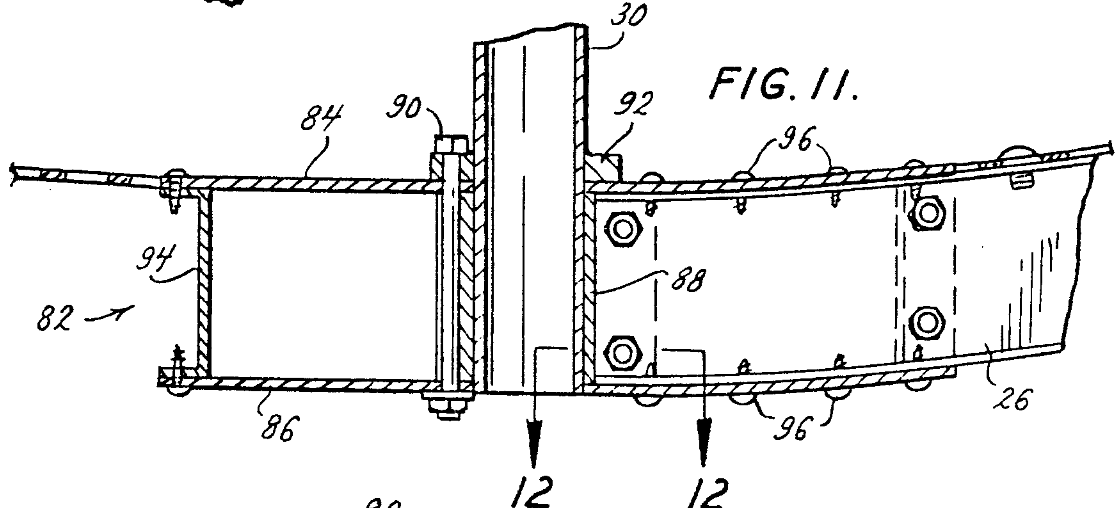


FIG. 11.



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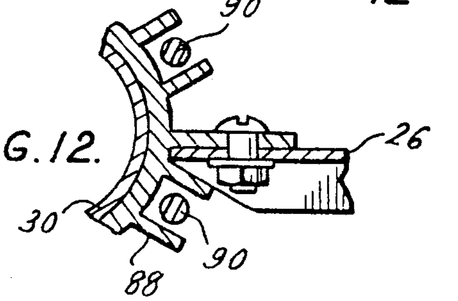

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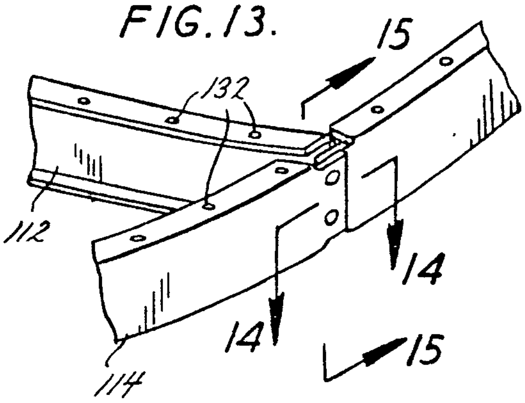


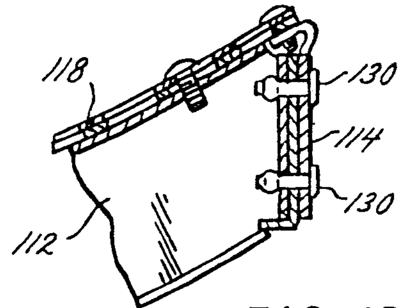


FIG. 15.

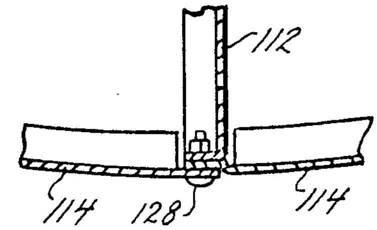
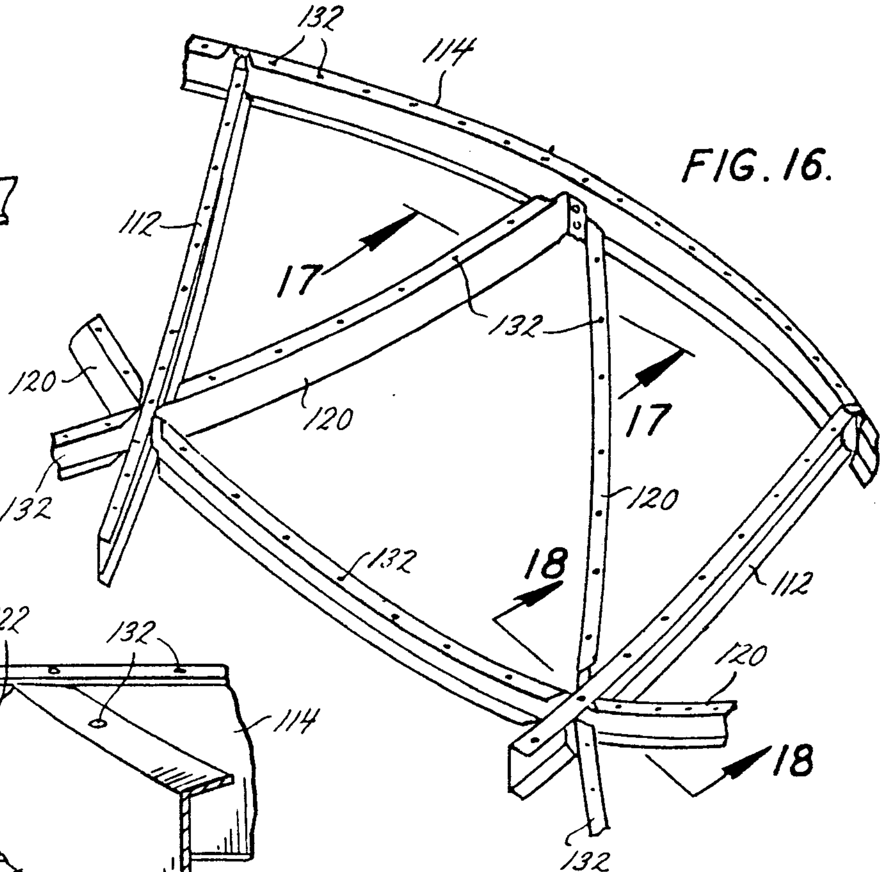


FIG. 14.



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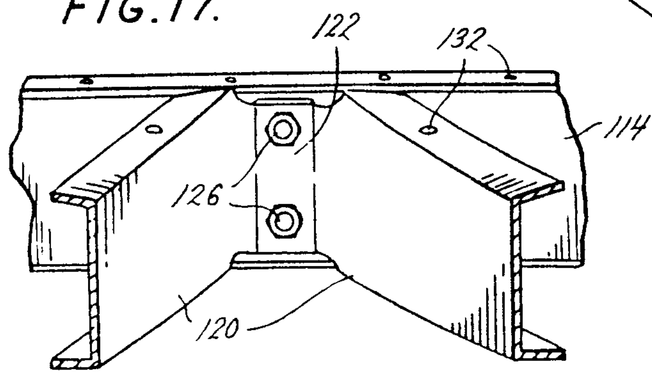

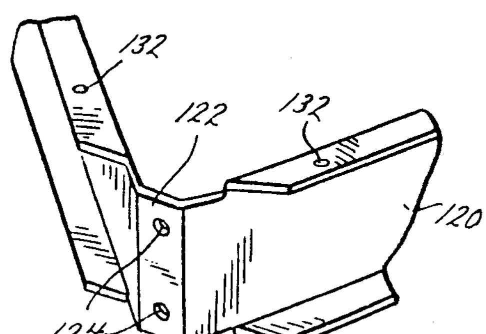

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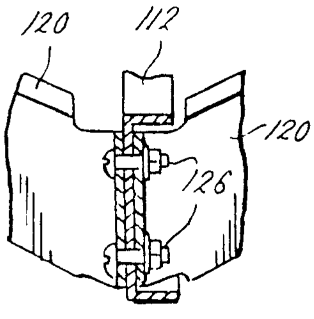

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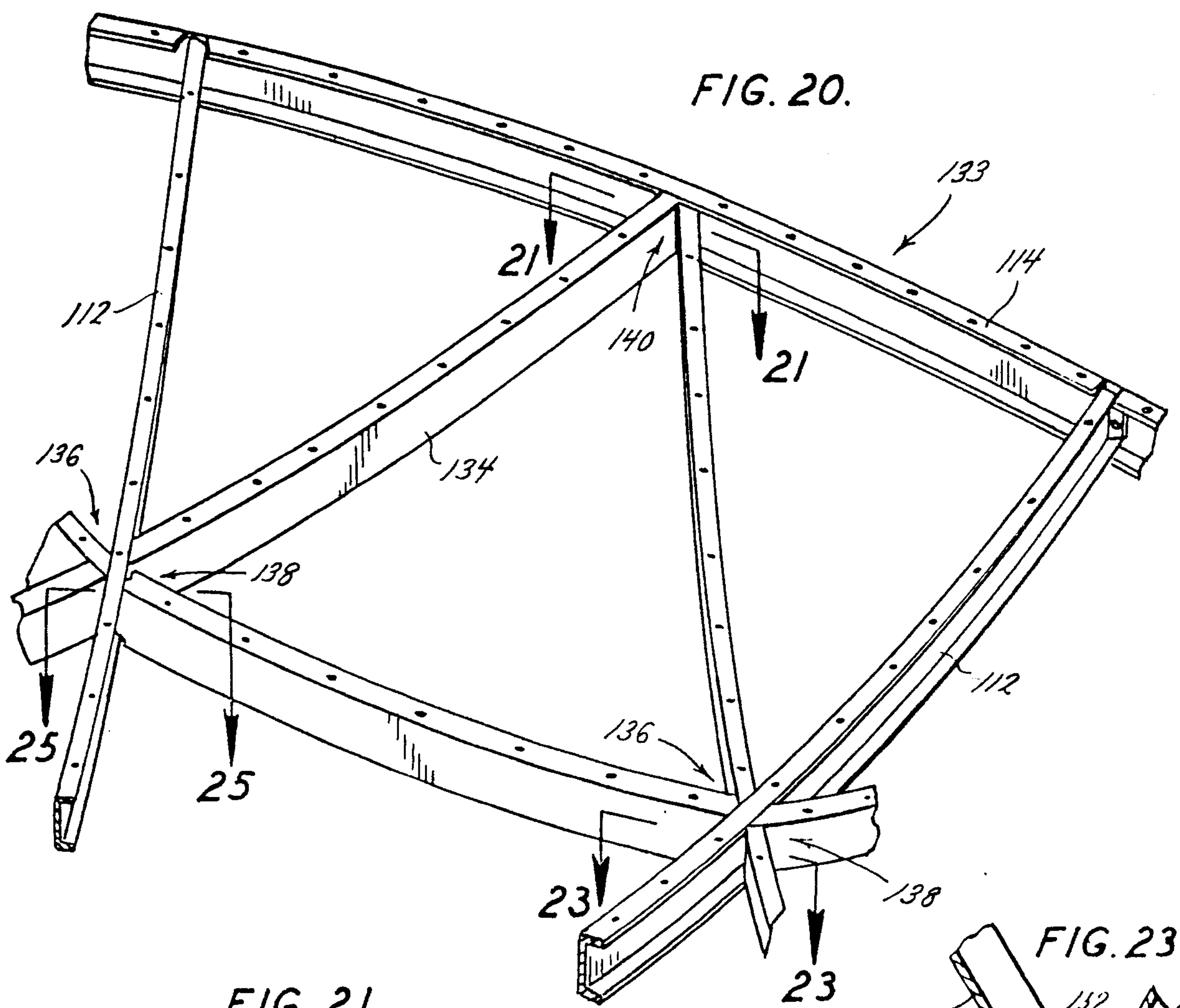
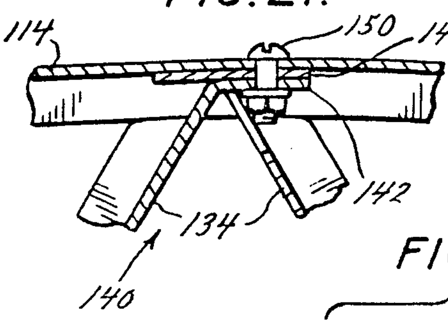


FIG. 20.

FIG. 21.



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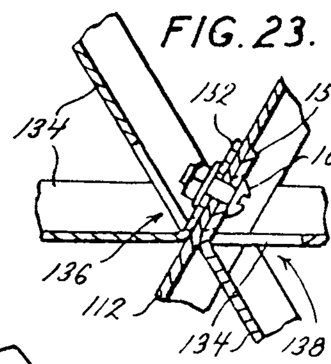

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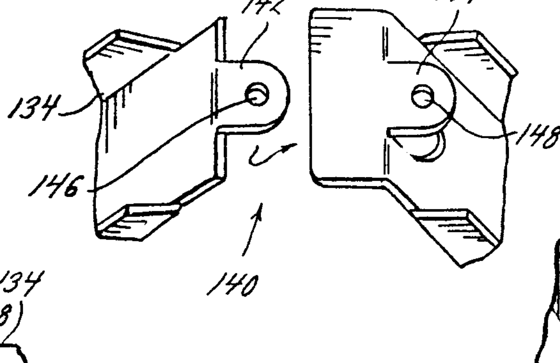

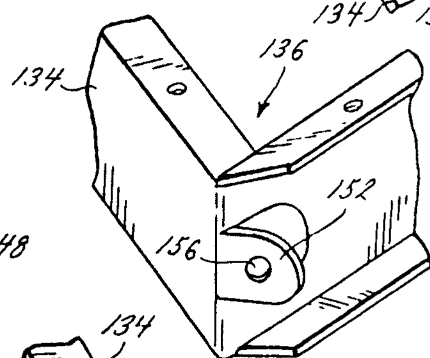

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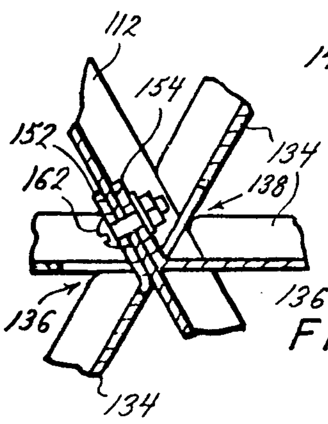

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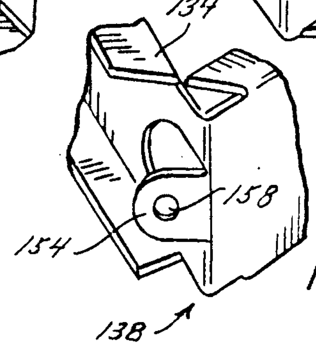

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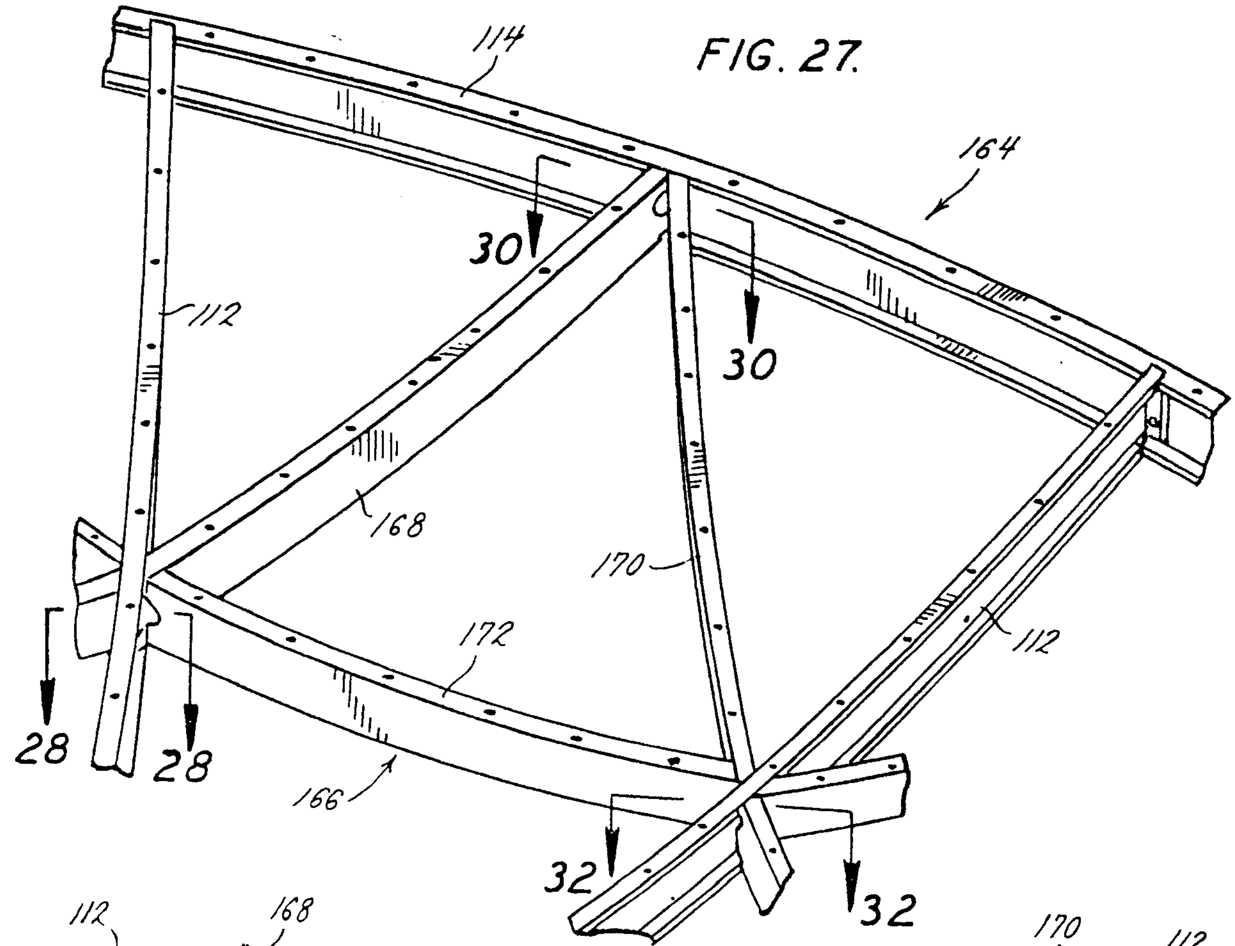

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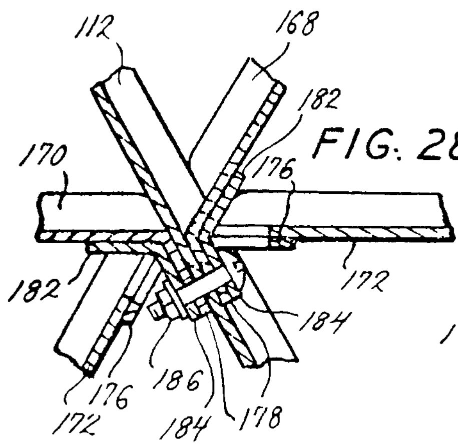

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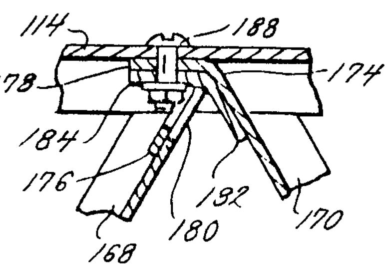

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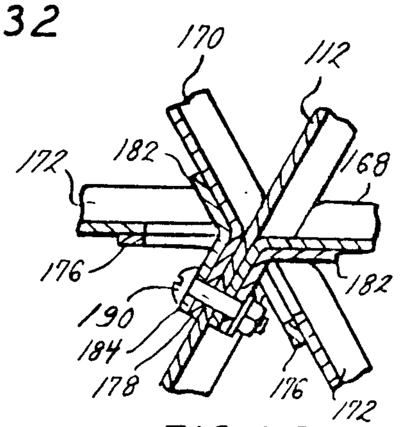

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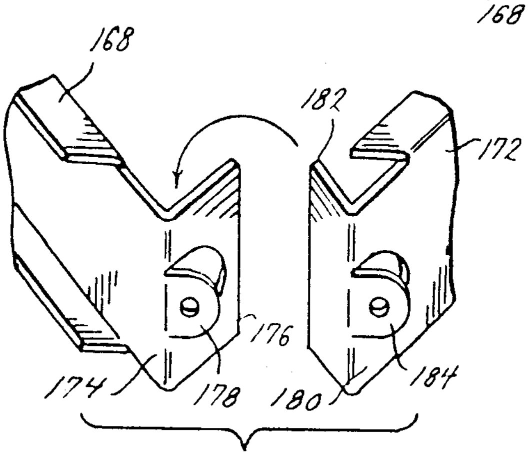

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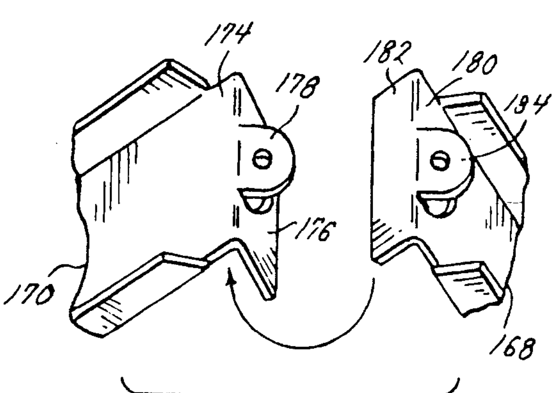

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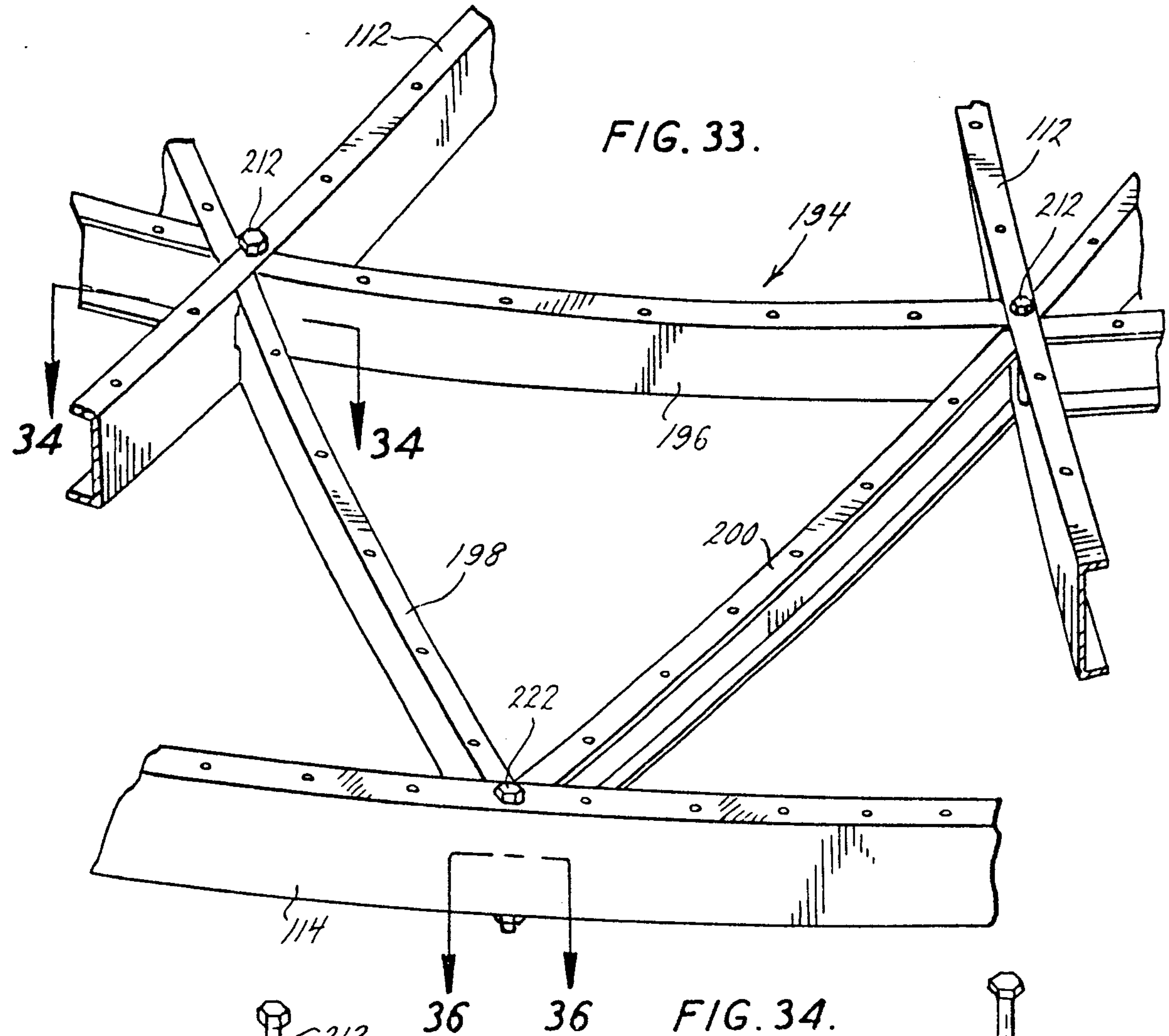

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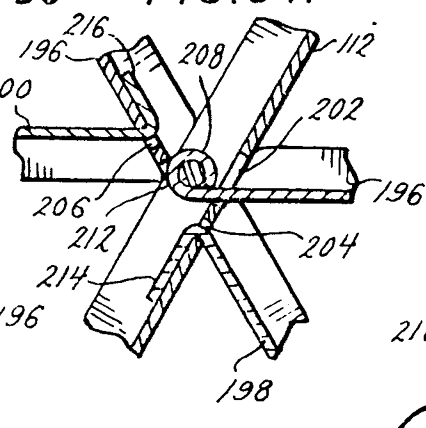

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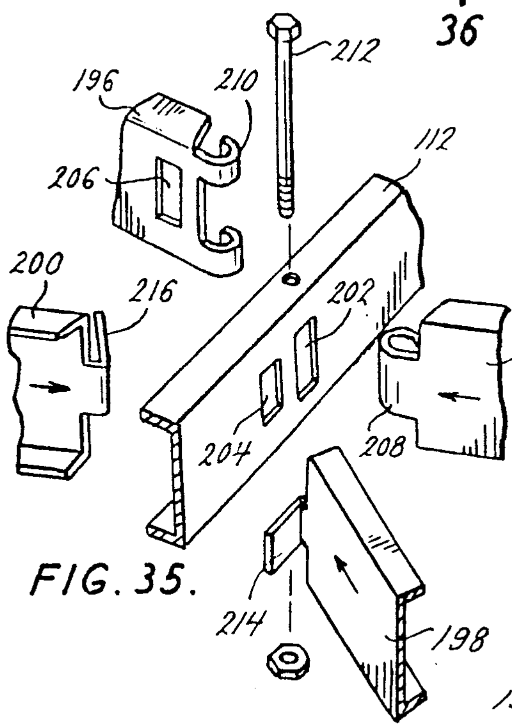

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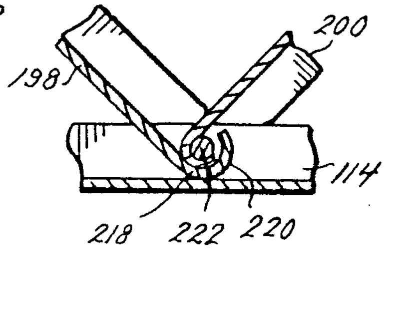

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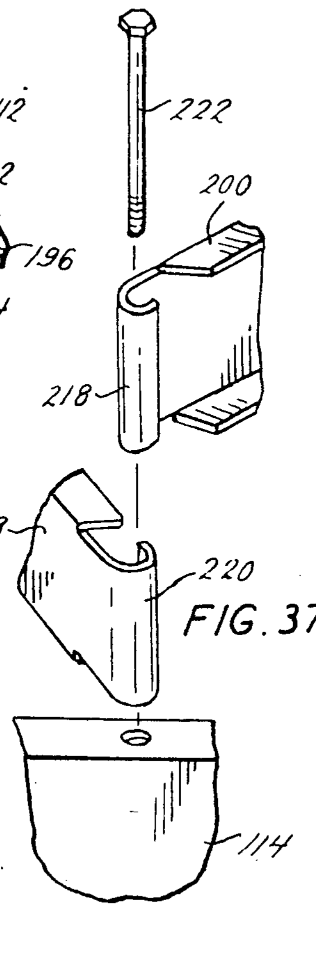
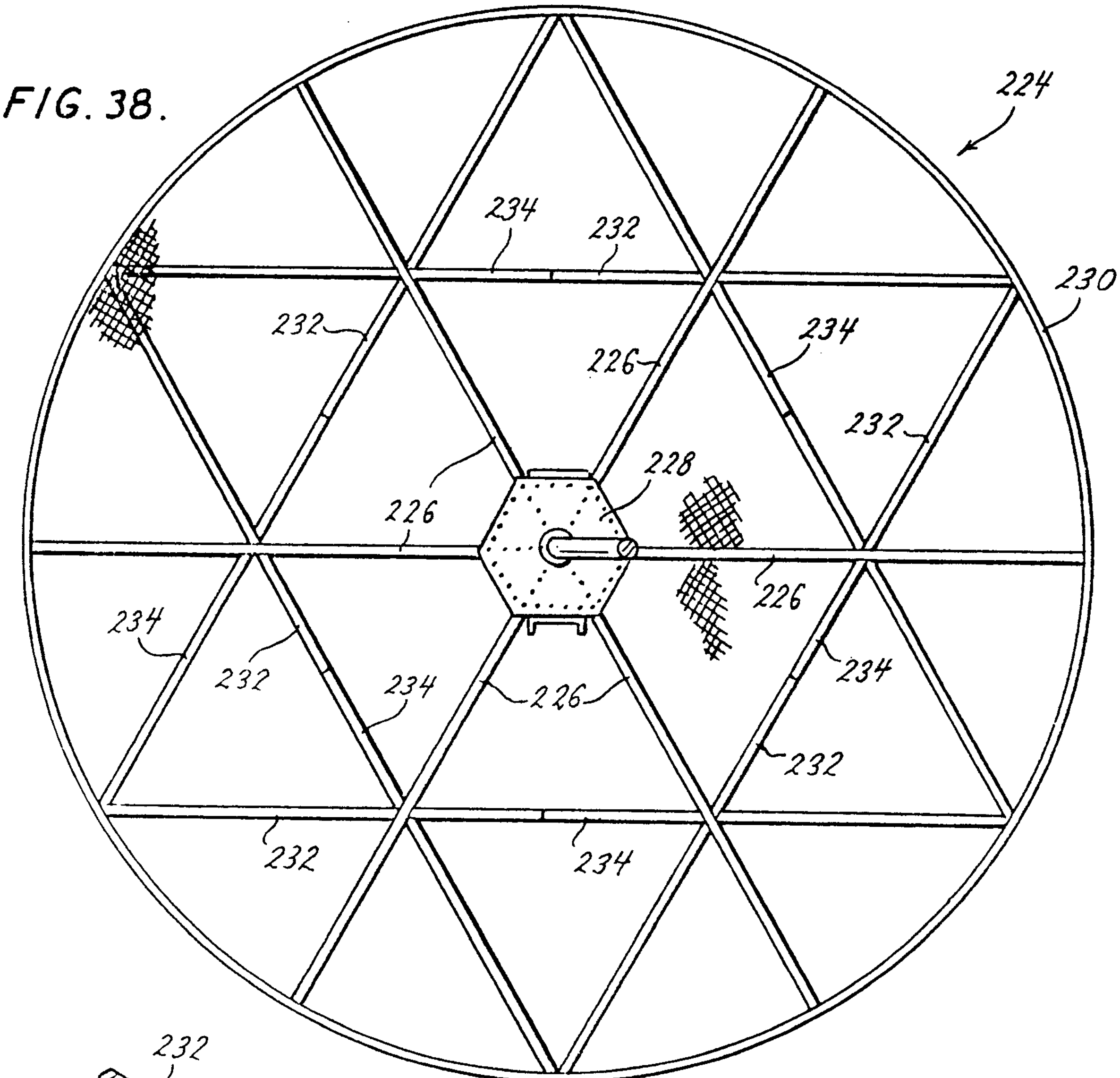
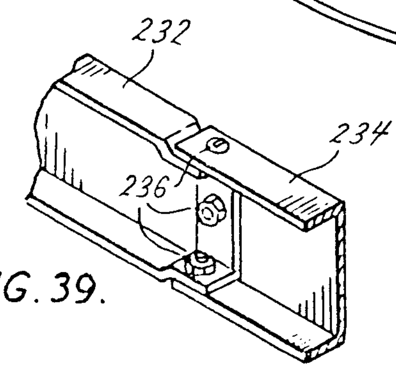


FIG. 37.

FIG. 38.





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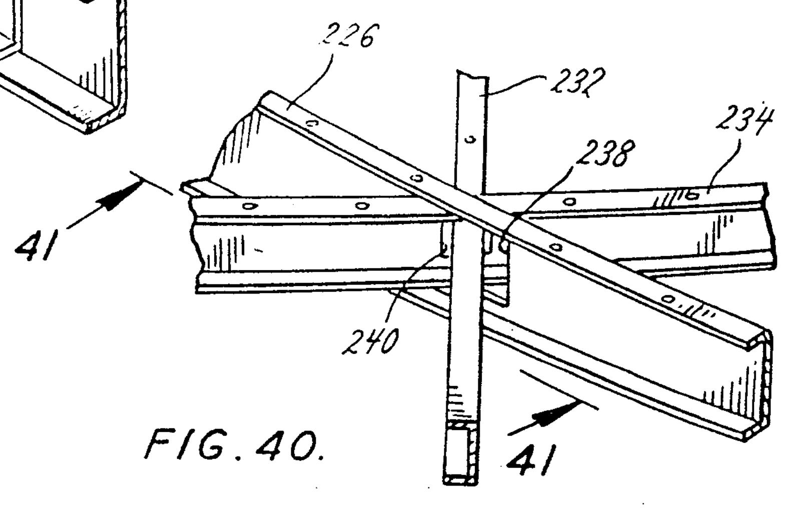
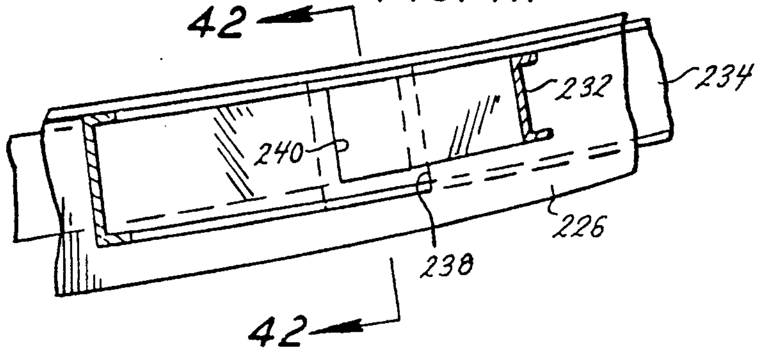


FIG. 40.

FIG. 41.



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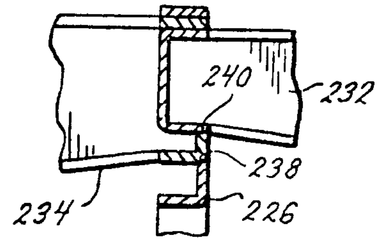

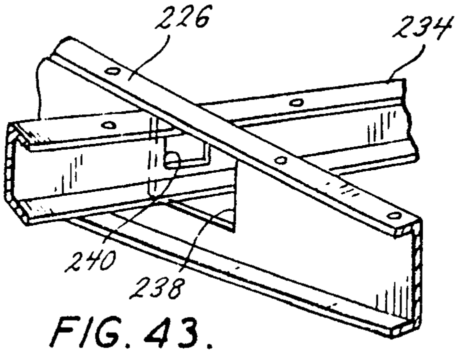

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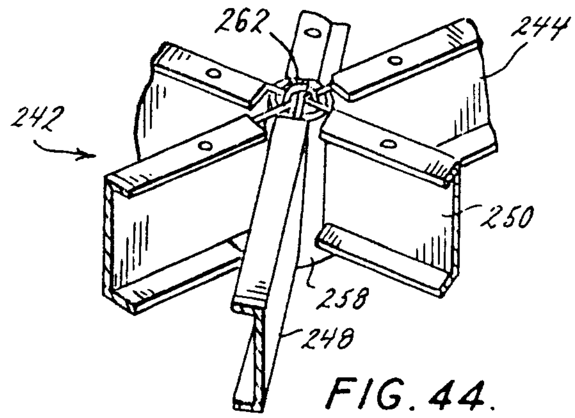


FIG. 44.

FIG. 45.

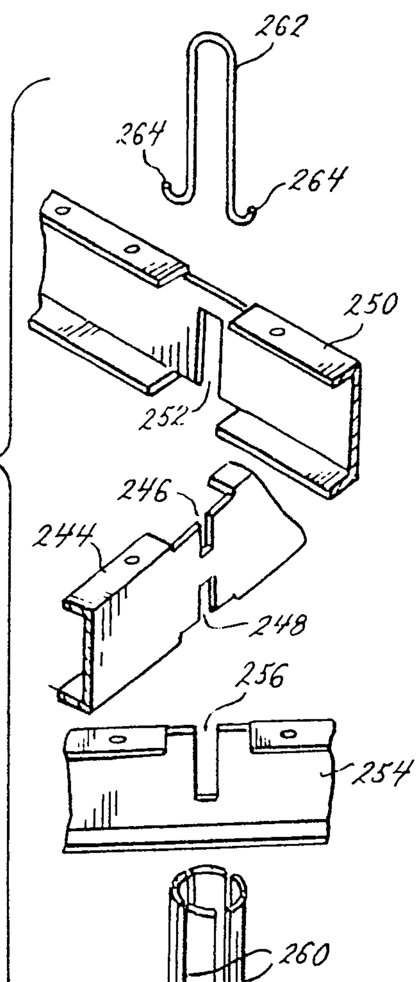
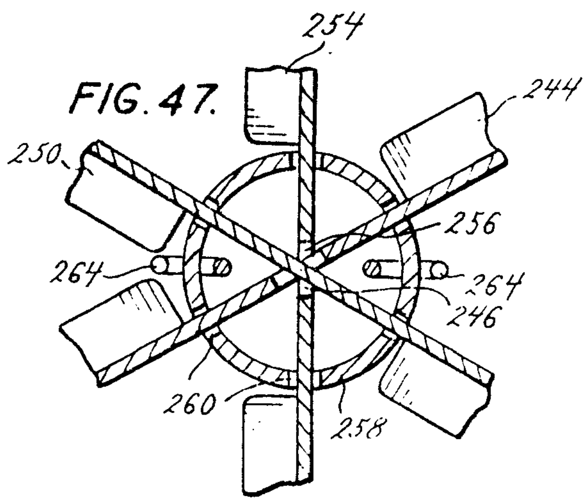


FIG. 47.



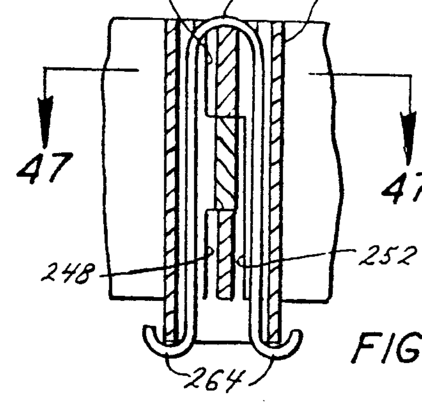


FIG. 46.

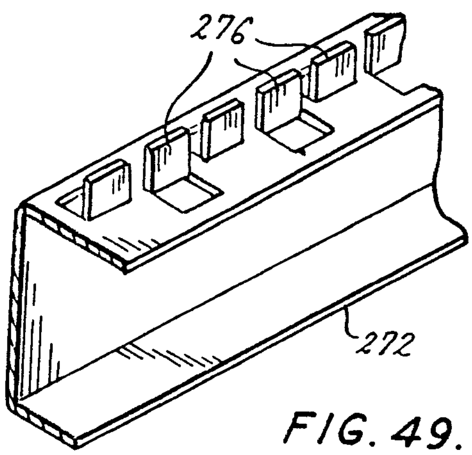


FIG. 49.

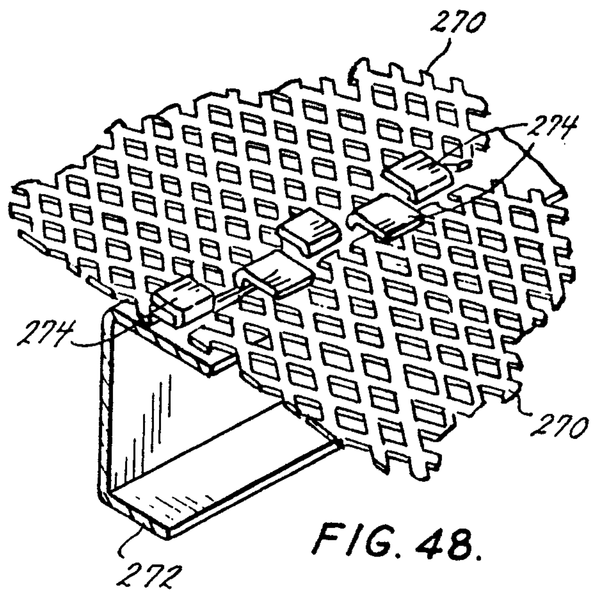
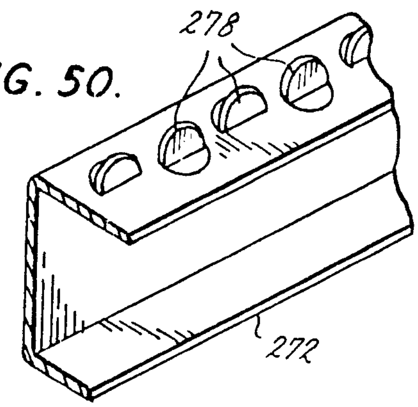


FIG. 48.

FIG. 50.



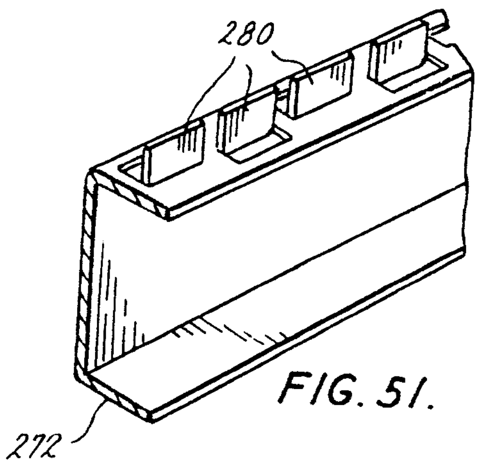
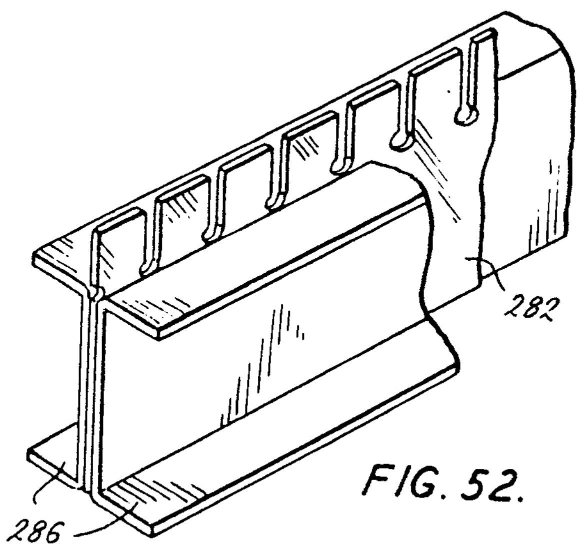


FIG. 51.



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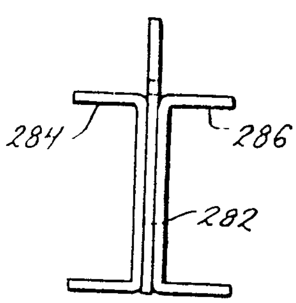

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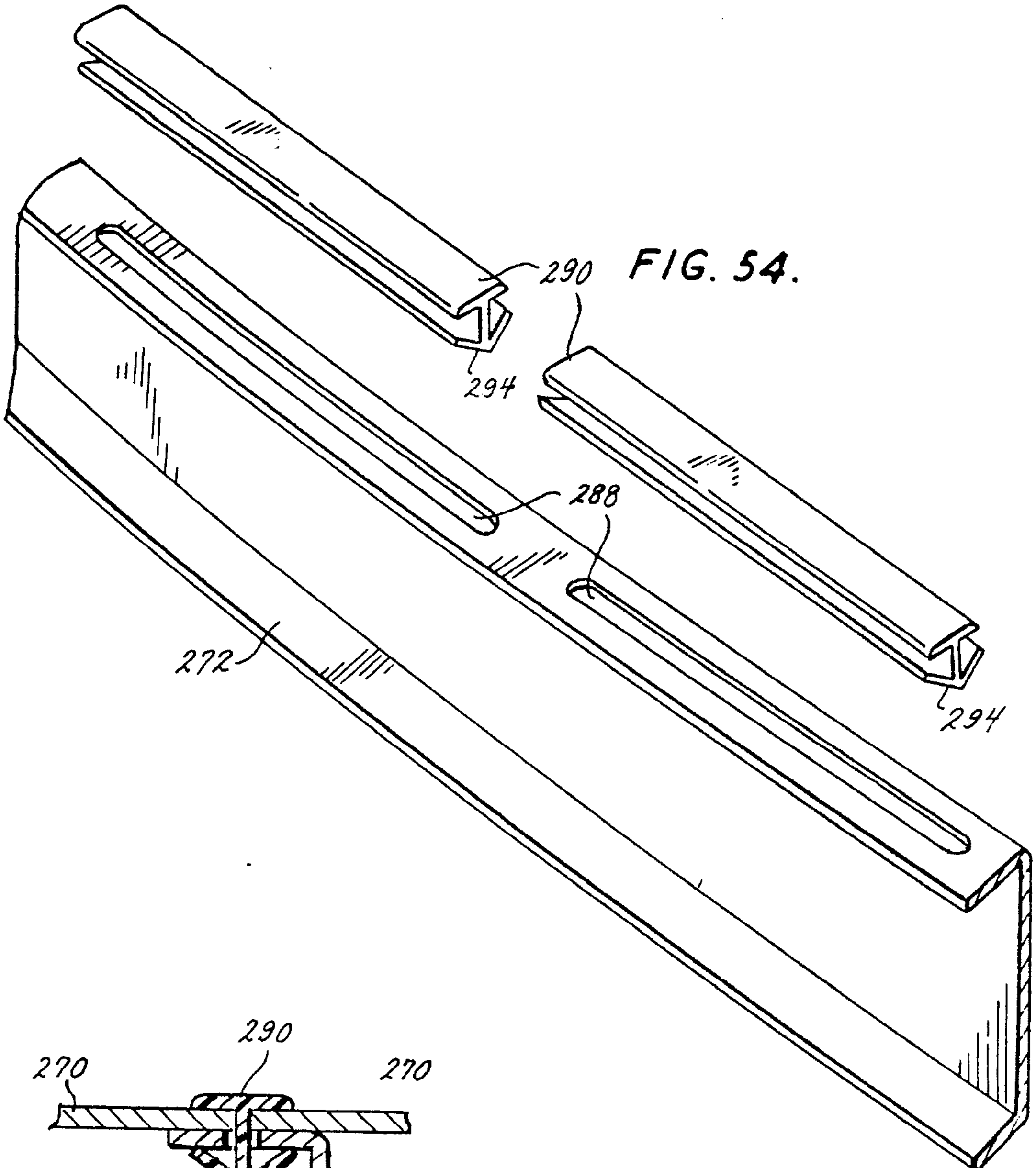

FIG. 54.

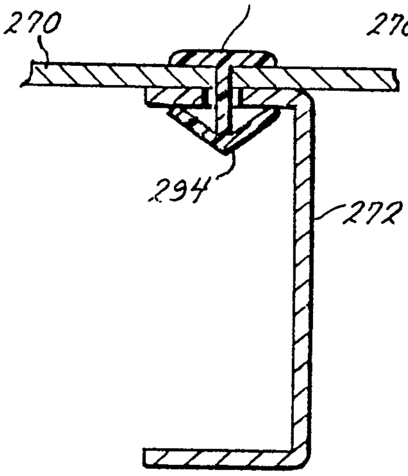

FIG. 55.