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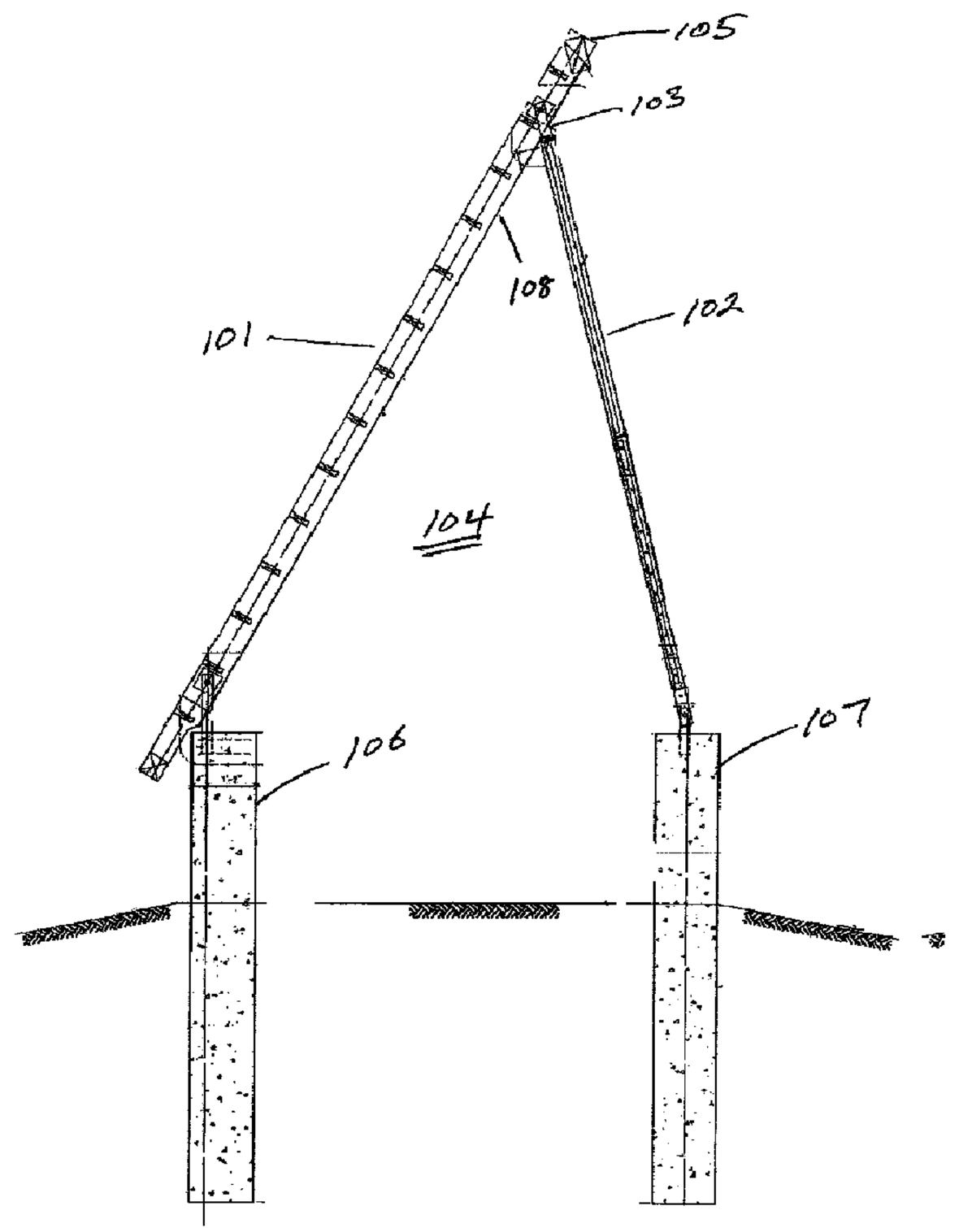
(54) Title: SOLAR ENERGY COLLECTION STRUCTURE



(57) Abrégé/Abstract:
A solar energy collection structure having an articulating south roof comprising solar panels for collection of energy. Together with a north roof, the invention comprises a storage structure for storing items such as hay in an interior space that is shielded from

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(57) Abrégé(suite)/Abstract(continued):
precipitation by the north and south roofs. The pitch of the south roof may be varied by adjustment of variable height supports to track the elevation of the sun over the year. The south roof may be substantially covered by a solar panel array or be constructed of a building-integrated photovoltaic material. The solar panels may also employ multi-axis tracking.

ABSTRACT

A solar energy collection structure having an articulating south roof comprising solar panels for collection of energy. Together with a north roof, the invention comprises a storage structure for storing items such as hay in an interior space that is shielded from precipitation by the north and south roofs. The pitch of the south roof may be varied by adjustment of variable height supports to track the elevation of the sun over the year. The south roof may be substantially covered by a solar panel array or be constructed of a building-integrated photovoltaic material. The solar panels may also employ multi-axis tracking.

SOLAR ENERGY COLLECTION STRUCTURE

FIELD OF THE INVENTION

The invention relates to storage structures that collect solar or other energy and more particularly to building integrated photovoltaic (PV) structures having an articulating roof for collection of solar energy.

BACKGROUND OF THE INVENTION

As one of the most environmentally friendly methods of generating electricity, solar panels, or photovoltaic modules, have been widely used for the purpose of collecting solar radiation energy. Such panels may be attached to an existing structure, or may be mounted in an installation in the ground. Different kinds of silicon based modules are known in the prior art: rigid frame modules made with monocrystalline/polycrystaline silicon or flexible modules made with amorphous silicon solar cells also known as thin-film solar cells covering a range of light frequency spectrum and building-integrated photovoltaic's (BIPV) which incorporate PV modules into a static roof shingle, window or wall. The BIPV products are very expensive because they must meet building code, fire code and other requirements and must be absolutely water proof. Hence, the use is very limited to new construction projects because of the high costs and long paybacks. There are other types of materials used for PV modules such as Gallium arsenide (GaAs), Cadmium telluride (CdTe) and Copper-indium-

diselenide (CuInSe2, or CIS), and they are not as popular as silicon in PV module production.

Due to increasing environmental concerns, governments often offer incentives for the use of solar panels. The *Green Energy Act* in Ontario, Canada for example, offers property owners the opportunity to sell electricity harvested on their buildings or land. Farmland is particularly well suited for solar panels, with wide expanses of surface area available. However, farmers and the government are reluctant to use prime agricultural land as it is too valuable to the agricultural business and to society for food production. Also, large ground based systems constructed on flat land have the inherent problem of one PV panel casting a partial shadow on the PV panel behind it unless the PV panels are mounted on large custom racks ("racking") to elevate or separate the rear PV panels above the forward panels. This racking introduces additional costs and reduces the payback and probability that the project will proceed.

Putting the solar panels on the roof of a building is generally the best use of space as it does not interfere with the agricultural land and the roof may be pitched to minimize the shading of one PV panel to the next panel, and reduce the land area required to mount the PV panels without enormous spacing between solar arrays, but the effectiveness of the solar panels on buildings may be compromised by their stationary nature and the fact that more than 80% of existing buildings cannot structurally support the additional weight of a "significant" solar PV system.

A solar tracker is known in the prior art as a device for orienting a PV panel towards the sun. Solar trackers may be single axis or multi-axis, tracking the sun horizontally and/or vertically to allow for the most efficient collection of solar energy. Building a special tracking device for panels that are to be placed on building roofs or on ground based racking increases expense, complexity, maintenance and will increase the energy produced but may not improve the payback. Most roof mounted systems also carry the risk of roof leaks that compromise the warranty of the existing roof and lead to additional costs and disputes that compromise the ability of the land owner to proceed with a project.

Finding effective storage methods that ensure the preservation of a product for as long as possible is a vital aspect of any industry. Hay, for example, is a very important agricultural commodity that is susceptible to moisture, rot and fire when stored outside. Storing hay without a roof overhead exposes it to rain and snow, and leads to the rot of the outer layer and then the inner layers. A loss of up to 56% of total hay weight may result from such exposure. Products may be kept dry through plastic hay wraps, but such wraps result in high financial and environmental costs. Storing the product in an enclosed building, on the other hand, negatively affects the ventilation and air exchange around the product, which also results in moist hay and thus a decrease in quality and quantity. Furthermore, stacking large quantities of a fire-prone product such as hay in one place leads to a greater chance of fire spread and large risk of fire loss, which in turn leads to greater insurance costs. Many farmers use plastic wrap for hay which uses expensive custom wrapping machines and plastic or other wrap to

protect the Hay from the weather. This has a negative environmental impact because the plastic is often not recycled.

Similar issues apply for agricultural and commercial equipment, tractors, combines, boat storage, RV storage and livestock protection.

SUMMARY OF THE INVENTION

This invention allows for protected storage of a Product, such as hay, commercial equipment or livestock, while preserving sufficient ventilation required for PV panels and stored Product. The PV roof is constructed of “standard” PV panels and may be considered a new type of BIPV system because many of the benefits of the BIPV products are incorporated into the invention without significant cost on the structure. The invention is constructed with drainage gutters between PV panels and is tilted so as to allow for further drainage, thus avoiding Product difficulties caused by moisture. The structure is constructed in discrete “kit” sizes to reduce cost and improve flexibility and is further able to support a high wind and snow load by employing broad load bearing supports. The tilting mechanism (automatic, manual, active or passive, single or dual axis) that focuses the solar panels onto the sun so as to efficiently generate energy, may also adjust the angle of the roof so as to allow for efficient access for loading of the product. Additionally, multiple structures may be spaced apart so as to decrease the risk of fire loss and thus reduce the cost of insurance.

A structure that allows for the efficient and clean collection of energy, and that at the same time provides safe and effective storage for products such as hay,

provides a significant synergy of two beneficial systems. It provides for a low cost, environmentally friendly storage structure that allows for greater profitability through the harvesting of electricity and hay.

According to an aspect of the invention, a solar energy collection structure is provided comprising a framework on which is mounted a north roof and a south roof that meets the north roof at a point, the roofs together shielding an interior space from precipitation, the south roof having energy absorbing material for collecting energy, the south roof further having at least one variable height support to vary the pitch of the south roof between two angles relative to the ground. The energy absorbing material may be a solar panel. The south roof may be constructed from building-integrated photovoltaic material.

The pitch of the south roof may be varied between two angles optimized for summer and winter collection of solar energy respectively. The pitch of the south roof may further be varied between at least four angles and may be varied between 45 and 75 degrees in increments of one degree or less. The pitch of the south roof may further be varied between 30 and 75 degrees.

The south roof may be substantially covered by a solar panel array.

The structure may further comprise a water drainage system that allows melting snow or rain to shed between the solar panels so that the interior space is kept dry.

The structure may be adapted for agricultural use and in particular for the storage of hay.

The solar panels may articulate in the azimuth direction to track the movement of the sun and may employ multi-axis tracking to track the movement of the sun.

BRIEF DESCRIPTION OF THE DRAWINGS

Figure 1 shows a side view of an embodiment of the invention

Figure 2 shows perspective view of an embodiment of the invention.

Figure 3 shows a top plan view of an embodiment of the south roof.

Figure 4 shows a schematic depiction of the water drainage system.

DETAILED DESCRIPTION OF THE INVENTION

As shown in Figure 1, the solar energy collection structure has a south roof 101 supported by at least one variable height support, such as a telescopic post 102. The structure may have two or more supports, with one located near the east and west edges of the south roof 101. Each post 102 may be connected to the south roof via a hinge 103, or other suitable mechanism. The posts 102 and south roof 101 form an A-frame or tent-like framework with an interior space 104 for storing items such as hay.

The south roof 101 may have an upper edge 105 that is substantially parallel to the ground and may have east and west edges that are straight and substantially perpendicular to the ground and the upper edge 105. In that case, the interior

space 104 is the space formed by the south roof 101, a plane through the at least one support and the upper edge 105, a plane intersecting the east edge of the south roof 101 and being perpendicular to the upper edge 105, a plane intersecting the west edge of the south roof 101 and being perpendicular to the upper edge 105, and the ground.

The south roof 101 may rest on south concrete footings 106 near its lower edge. If telescoping posts 102 are used, their bottom ends may be attached to north concrete footings 107.

A typical south roof 101, as shown in Figure 3, may be approximately 48 feet long by 12 feet wide, but there is no limitation on the size. The concrete footings for such a structure are typically founded on native, undisturbed soil capable of sustaining a minimum of 3,000 psf (150 kpa) ultimate soil bearing pressure, or 2,000 psf (100 kpa) allowable soil bearing pressure. The underside of the concrete footings are typically 7 feet minimum below grade. The concrete strength at 28 days may be 35 mpa (4,500 psi) + 6% air entrainment (concrete exposure class c-1).

The structure further includes a north roof 201 as shown in Figure 2 which is connected to the south roof 101 near its highest point and extends downward on top of the posts 102 so that, in conjunction with the south roof 101, it shields much of the interior space 104 from precipitation when the structure is located, for example, in a field on an agricultural farm. The interior space may be used,

for example, for storing items such as bales of hay or other items such as machinery, tools, or livestock.

The structure may be placed in open areas with a line of sight to the sun for at least a portion of the day. The south wall 101 faces generally in a southern direction so that, for example, the line of sight to the sun is approximately perpendicular to the surface of the south roof 101 at mid-day.

The south roof 101 may be rectangular in shape and be constructed using a number of vertical beams, or timbers, 301 as shown in Figure 3, a top beam 302, a bottom beam 303, optionally with additional supporting vertical beams 304 extending between the top beam 302 and bottom beam 303, and a number of horizontal joists 305 extending between the vertical beams. The outside, south-facing surface of the south roof 101 comprises energy absorbing material, which may inlcude at least one solar panel 202 attached thereto. In a preferred embodiment, the south roof 101 is substantially covered with a solar panel array 202, as shown in Figure 2.

The south roof 101 may be made of a building-integrated photovoltaic (BIPV) material that replaces conventional materials so that the photovoltaic (PV) panels themselves form the roof. Standard solar panels are available with various technologies and physical sizes and ratings but they are generally all mounted to some type of rack, strut or fixture for outdoor use. BIPV systems are different in that they form an integral part of the roof (window or wall) and as such need to confirm to building code, fire code and other required regulations.

The south roof 101 may alternately be constructed of some other energy collecting materials such as solar thermal panels or new materials that are yet to be invented.

The solar panels 202 need not cover the entire south roof and need not extend all the way down the ground. For example, the lower edge of the south roof 101 may have multiple feet extending therefrom to connect the south roof 101 to the ground or to a footing that is in turn supported by the ground.

The solar panels collect solar energy that may be fed into the existing electrical grid, thereby generating revenue, via a Feed-In Tariff arrangement by which the power authority will purchase electricity that is fed into the grid.

The structure may be used for storage of hay, but may be used for many other purposes, such as for keeping chickens or other livestock, growing mushrooms, and equipment storage. Embodiments could be used for residential use, even temporary housing as the structure can be readily set up in a new location, or as a workshop.

The pitch of the south roof 101 may be varied over time to optimize the collection of solar energy by varying the height of the variable height supports. This may be done manually by using a portable device to raise or lower the south roof 101. The length of the telescoping posts 102 can then be adjusted to support the roof at a new pitch angle. For example, depending on the latitude, the pitch may be set to be between 60 and 75 degrees with respect to the ground in the winter and between 30 and 45 degrees in the summer. The posts 102 may allow adjustment

of their height so that the pitch angle can be varied in approximately one degree or smaller increments. The pitch of the roof can then be varied as frequently as desired to optimize the collection of solar energy, but preferably at least four times per year. In any case, the pitch should be varied at least twice per year to optimize for summer and winter collection of solar energy: once at or near the autumnal equinox to establish the best position for the winter and once at or near the vernal equinox to establish the best position for the summer. Alternatively a motor could be employed to automatically adjust the pitch based on the time of year so the south roof 101 is periodically moved into a near optimal position.

This simple design, using manual pitch adjustment, results in a very inexpensive structure but is capable of achieving about 50% of the benefit of full solar tracking, which would be very expensive. As a result the cost of the structure may be more than offset by the value of the energy collected, thereby providing a storage facility at little or no net cost.

The variable height supports may be telescoping posts 102, or may alternately be fixed length posts where the height of the post above the ground is varied by changing the connection point to the south roof 101 or changing the points that the posts contact the ground or footing.

The north roof 201 typically employs two portions. The first portion may be made of sheet metal and is fixed, while a second overlapping portion travels and may be raised and lowered to permit access to the interior space 104. The second portion may be made of canvas and may be motorized. Many variations are

possible, and extensions to the north roof 201 allow many uses of the structure. For example, the north roof 201 may be extended with steel to enclose a chicken barn, machine shop, or storage building.

While the basic design discussed above employs single-axis solar tracking by adjustment of the pitch of the entire south roof 101, the invention can readily employ multi-axis tracking. Using multi-axis tracking, the solar panels are moved such that the angle of incidence of the sun is approximately, and ideally always, 90 degrees to the panel at all times. This can be done in single or multiple degrees of freedom and the technology is well understood. This technology may be incorporated into an agricultural or commercial building embodiment of the invention such that the roof (and hence solar panels) will track the sun. In the most basic embodiment, the solar panels would move above the axis indicated as “A” in Figure 2 and the axis indicated as “B” in order to track the movement of the sun during each day.

The motion may be manual, automatic, passive or active tracking based on many available existing technologies.

In order to prevent melting snow or rain to the contents of the contents of the interior space 104 by leaking between solar panels, particularly when multi-axis tracking is employed, the south wall 101 may utilize drainage pans or gutters 402, as shown in Figure 4, attached to the lower side 108 of the south wall 101 located at the points where individual solar panels 404 vertically abut to form a water drainage system (WDS). The WDS allows rain or snow 401 melt to pass

over the solar panels 404 and fall between panels to be collected in vertical collection pans or gutters 402 located beneath the solar panels 404 (but wider than the gaps in the solar panels 404) and these may be made of plastic, galvanized steel or aluminum, for example. Under the force of gravity, the collected water flows down the gutter 402 to the edge of the roof and then fall harmlessly to the ground. When horizontal axis 403 tracking is employed, the use of a WDS is very important.

The structure may be designed to meet the applicable building codes, such as any applicable agricultural building code. The structure is optimized to be a hybrid structure that maximizes the use for both hay storage (or general agricultural storage) and also for providing a large south facing (articulating) surface that optimizes solar energy collection through any conventional or new solar technology. The solar PV array may be any existing technology or may also be solar thermal (to heat hot water for agricultural or commercial or residential use). As such, this may be a very viable option for mass produced residential applications (single family homes) for producing PV energy, hot water and providing residential storage in place of a “garden shed”.

The foregoing is considered as illustrative only of the principles of the invention. Further, since numerous modifications and changes will readily occur to those skilled in the art, it is not desired to limit the invention to the exact processes, components and applications shown and described, and accordingly, all suitable modifications and equivalents may be resorted to, falling within the scope of the invention and the appended claims and their equivalents.

CLAIMS

What is claimed is:

1. A solar energy collection structure comprising a framework on which is mounted a south roof that shields an interior space from precipitation, the south roof having energy absorbing material for collecting energy, wherein the structure is adapted for agricultural use.

2. The structure of claim 1 wherein the south roof further has at least one variable height support to vary the pitch of the south roof between two angles relative to the ground.

3. The structure of claim 1 further comprising a north roof that meets the south roof at a point, the roofs together shielding an interior space from precipitation.

4. The structure of claim 1 wherein the energy absorbing material is a solar panel.

5. The structure of claim 1 wherein the south roof is constructed using building-integrated photovoltaic material.

6. The structure of claim 2 wherein the pitch of the south roof may be varied between two angles optimized for summer and winter collection of solar energy respectively.

7. The structure of claim 2 wherein the pitch of the south roof may be varied between at least four angles.

8. The structure of claim 7 wherein the pitch of the south roof may be varied between 45 and 75 degrees in increments of one degree or less.

9. The structure of claim 8 wherein the pitch of the south roof may be varied between 30 and 75 degrees.

10. The structure of claim 4 wherein the south roof is substantially covered by a solar panel array.

11. The structure of claim 10 wherein the structure further comprises a water drainage system that allows precipitation to shed between the solar panels so that the interior space is kept dry.

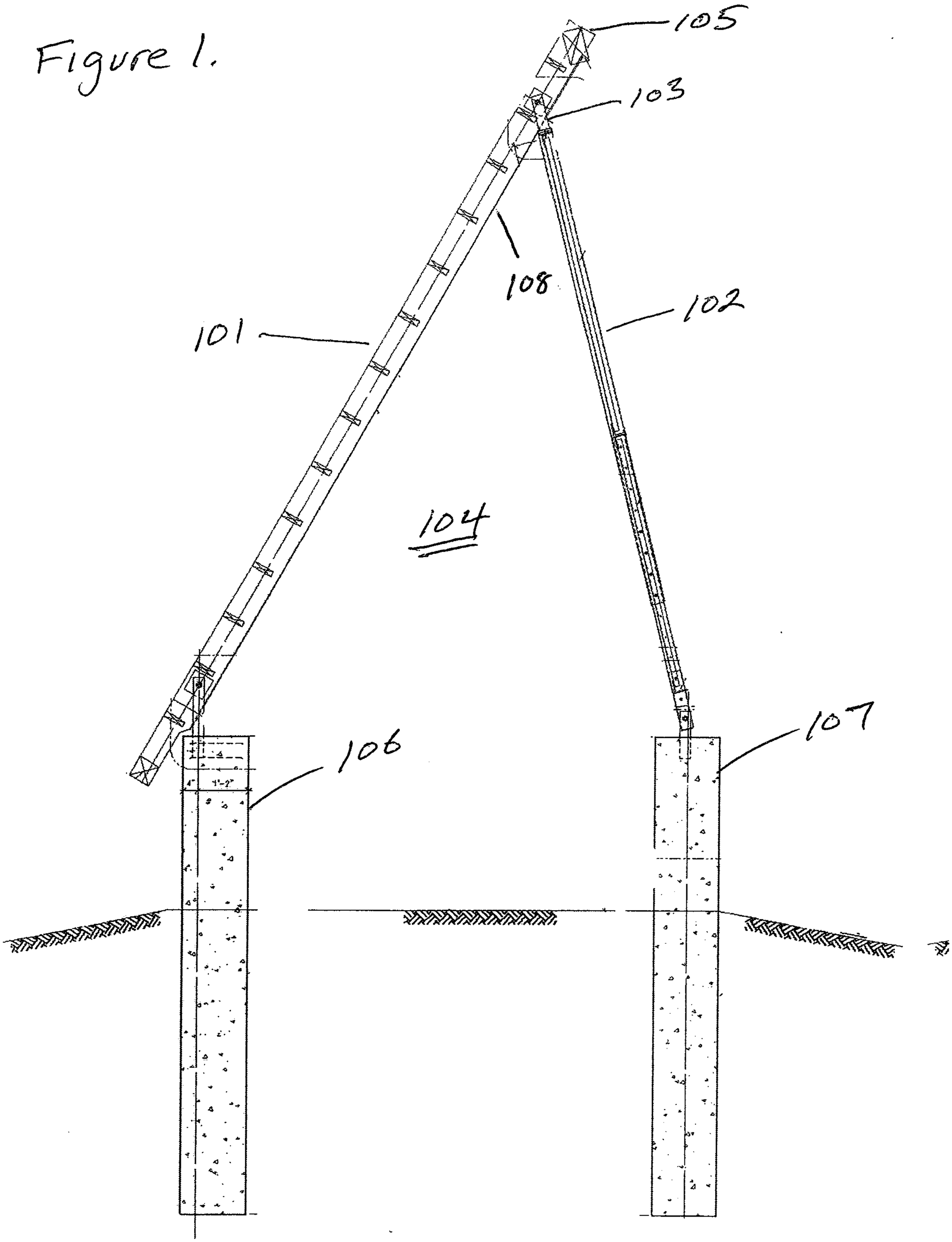
12. The structure of claim 1 wherein the structure is adapted for the storage of hay.

13. The structure of claim 10 wherein the solar panels articulate in the azimuth direction to track the movement of the sun.

14. The structure of claim 13 wherein the solar panels employ multi-axis tracking to track the movement of the sun.

15. The structure of claim 1 wherein the structure is offered to owners of farmland at no cost.

Figure 1.



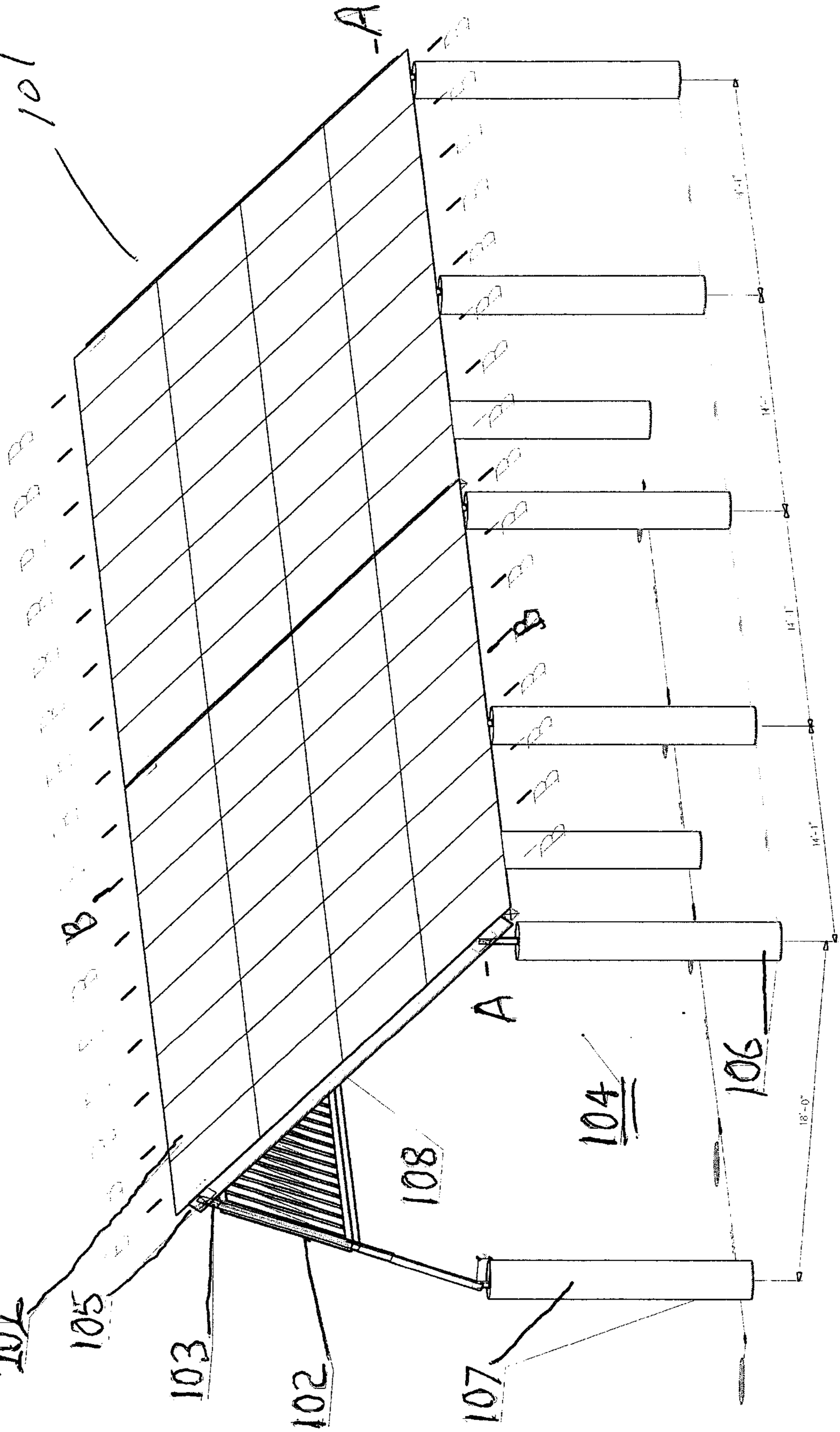


Figure 2

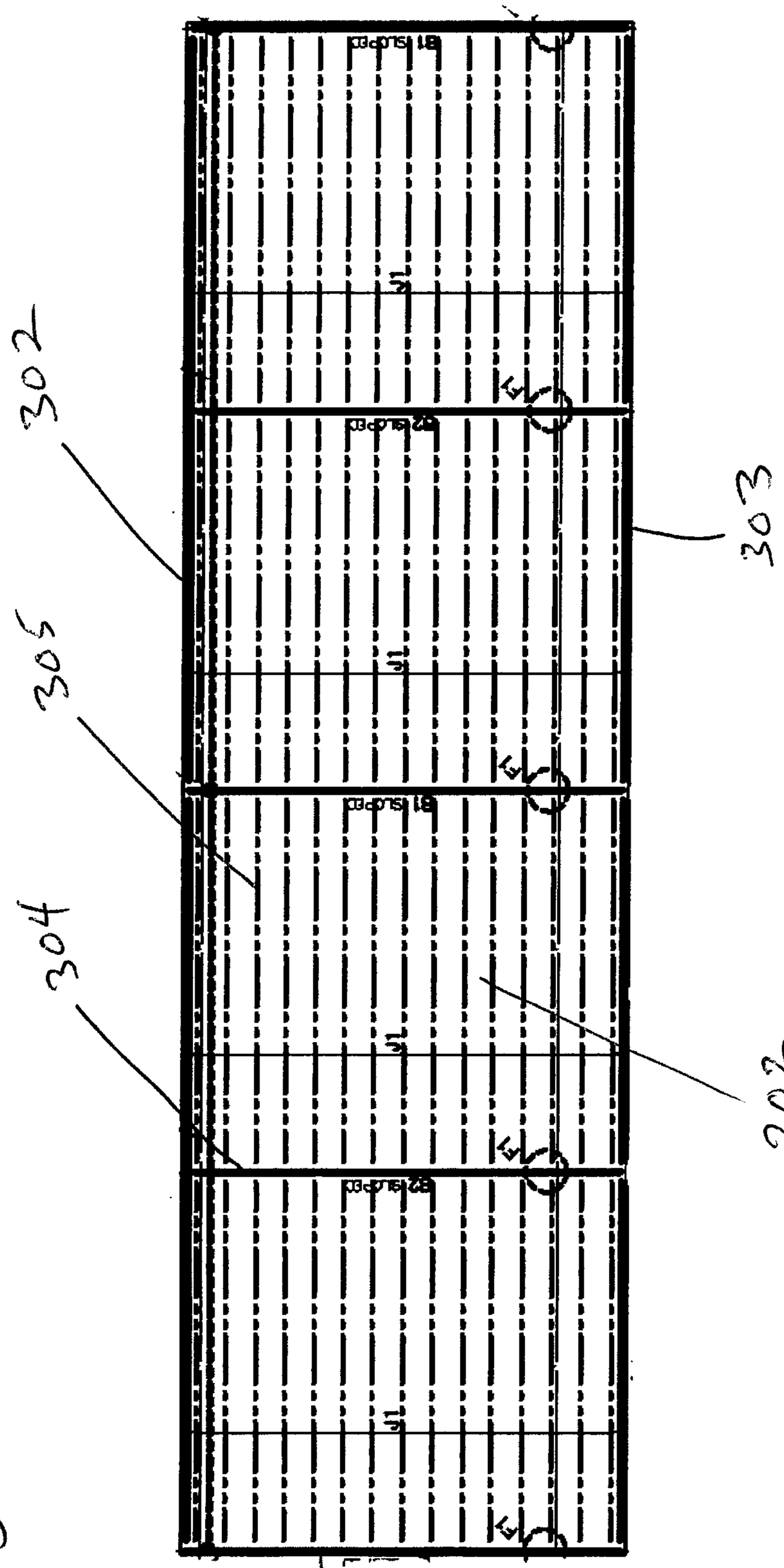
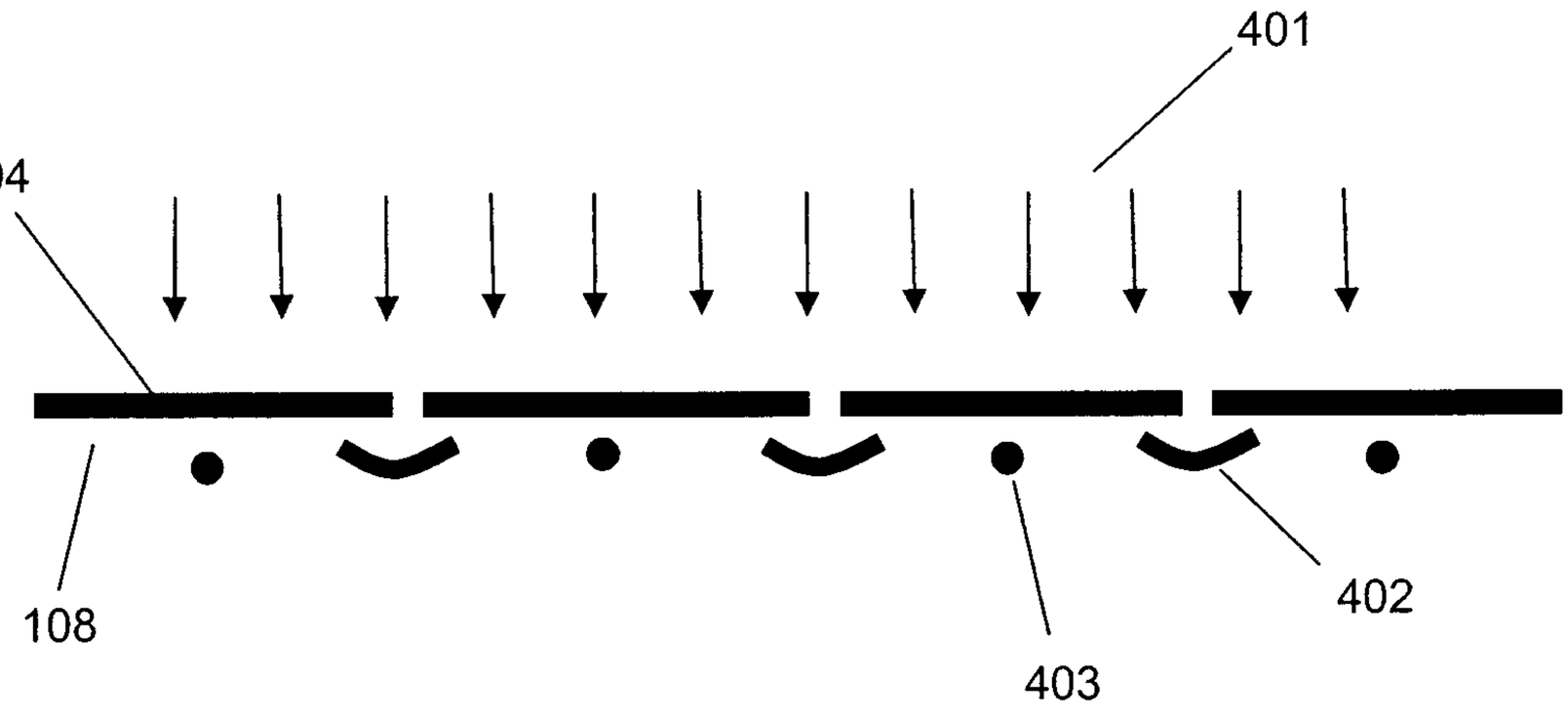
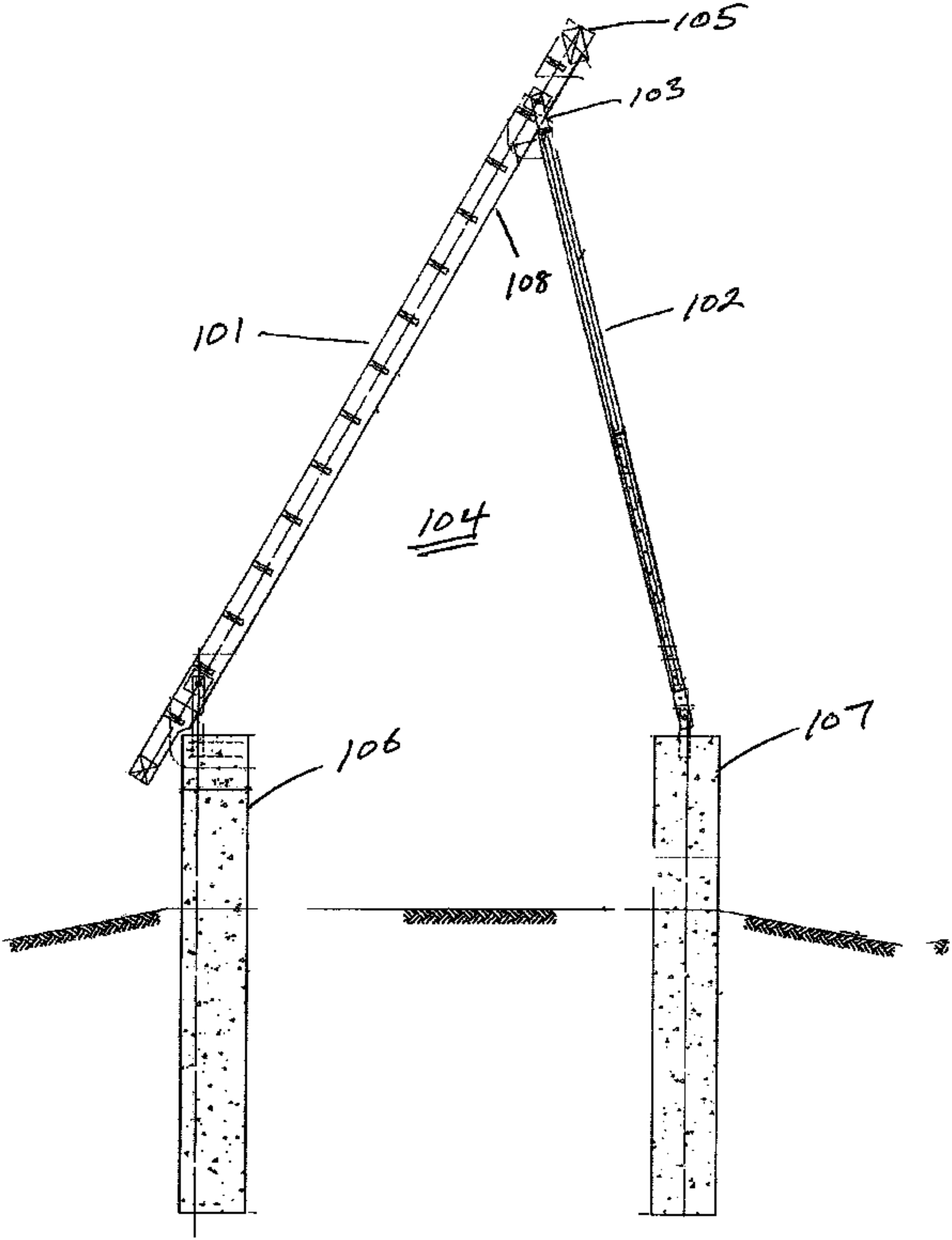


Figure 3

Figure 4

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