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(54) **ILLUMINATED IRRIGATION SYSTEM**

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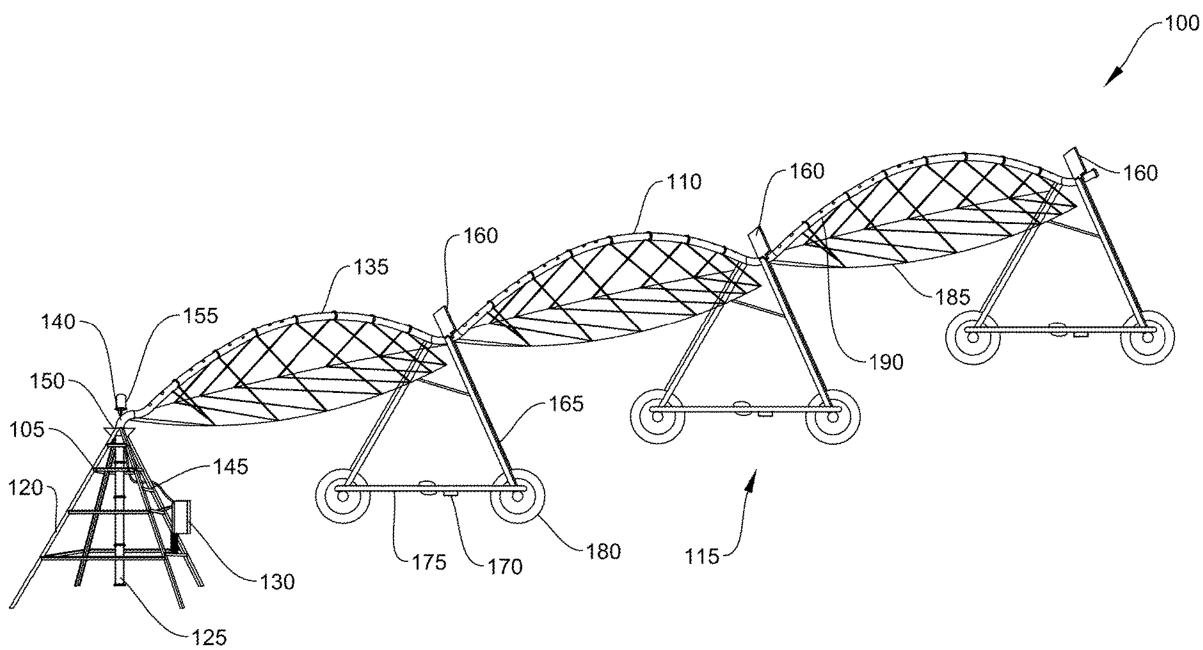
(57) **ABSTRACT**

A light assembly mounted to a span of an irrigation system. The light assembly includes at least one bracket, at least one extension, and a light bar. In one variation, the light assembly is powered by the power supply of the irrigation system. In another variation, the light assembly is powered independent of the irrigation system. In one form, the light assembly is controlled to turn on when natural light is not available and controlled to turn off when natural light is available. As a result, a crops exposure to light during short periods of daylight is increased.



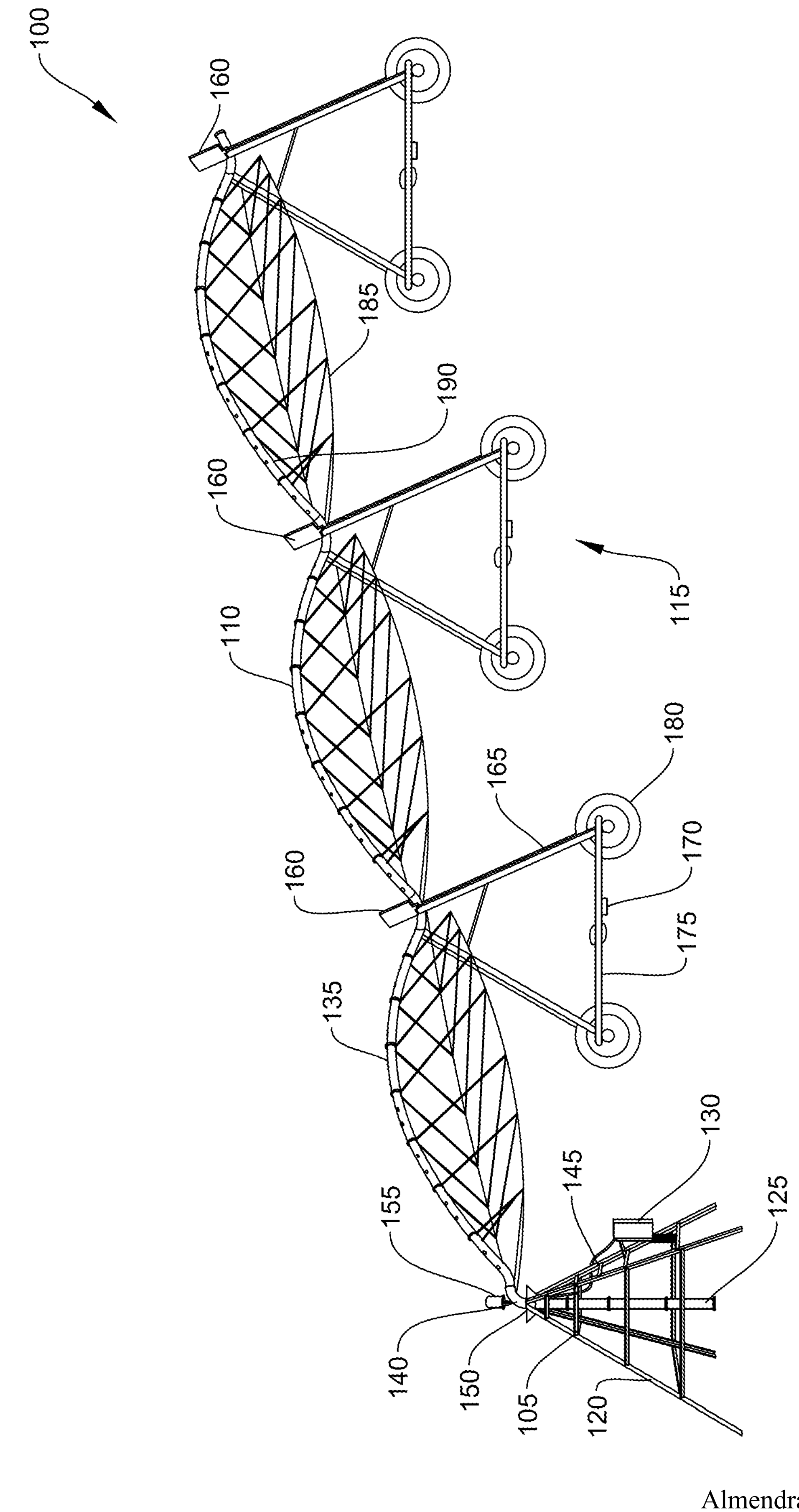

100
160
185
190
160
115
110
180
165
170
160
175
135
130
145
125
155
140
150
105
120

FIG. 1

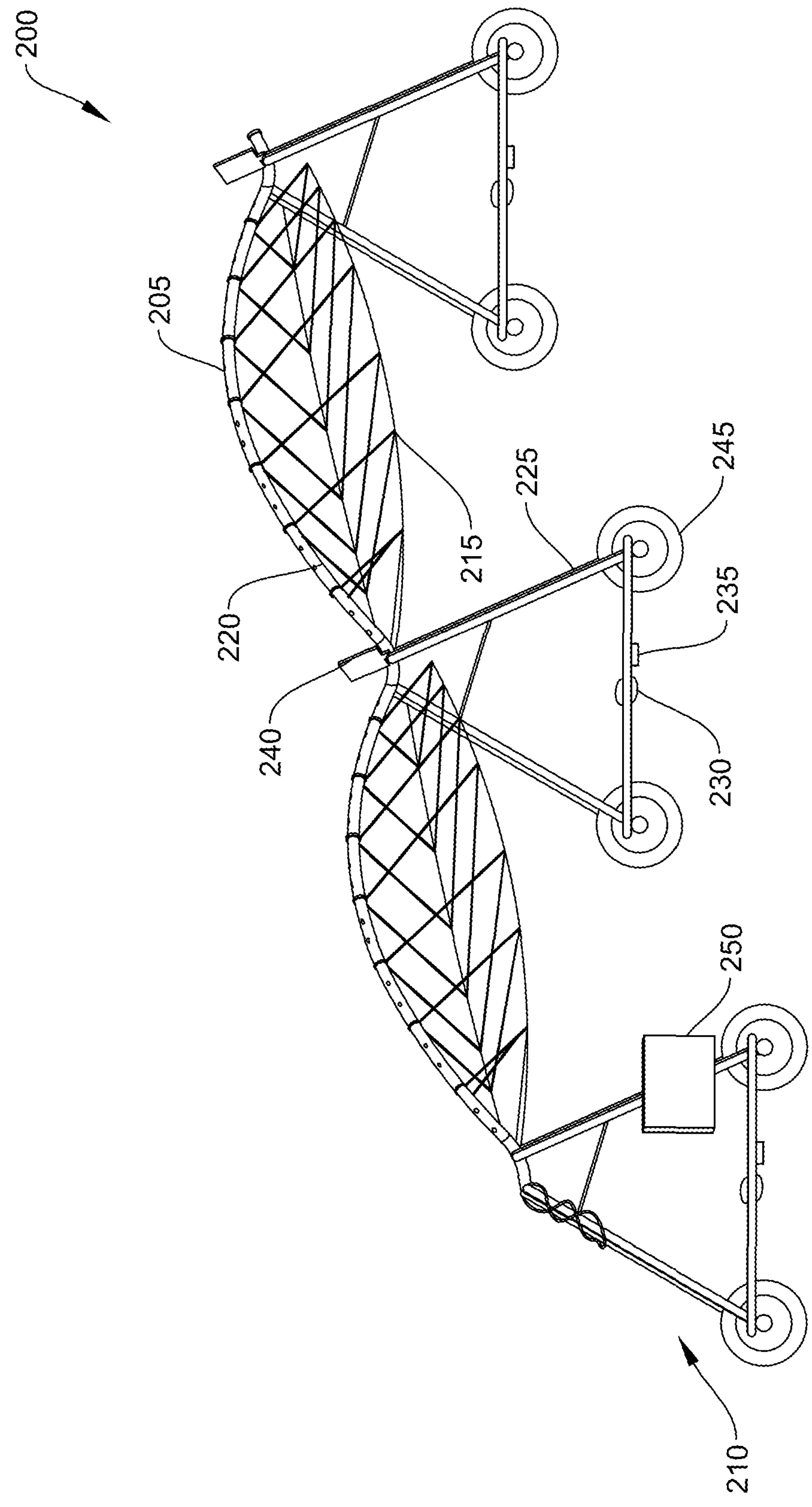


FIG. 2

170

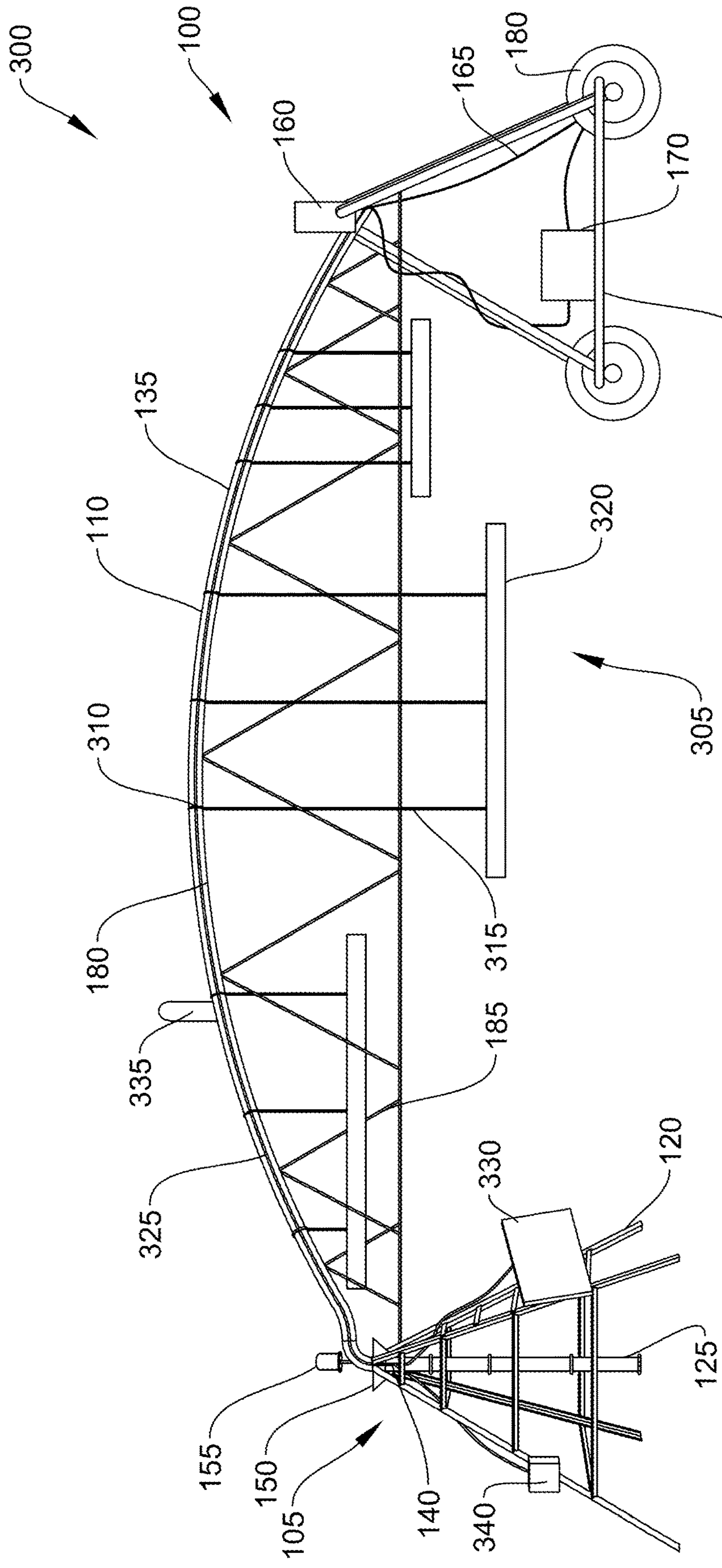

300
100
160
165
180
170
175
135
110
320
310
305
180
315
335
185
325
330
120
125
155
150
105
140
340

FIG. 3

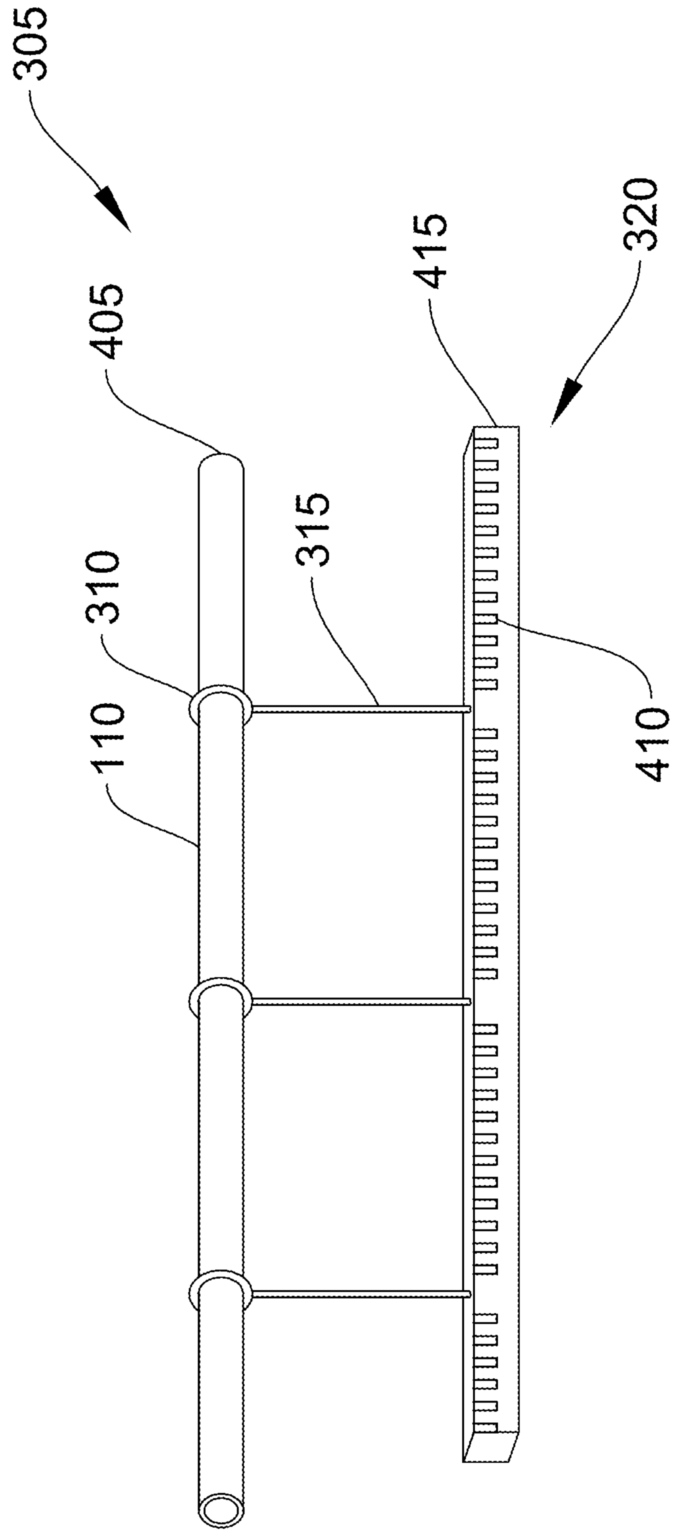


FIG. 4

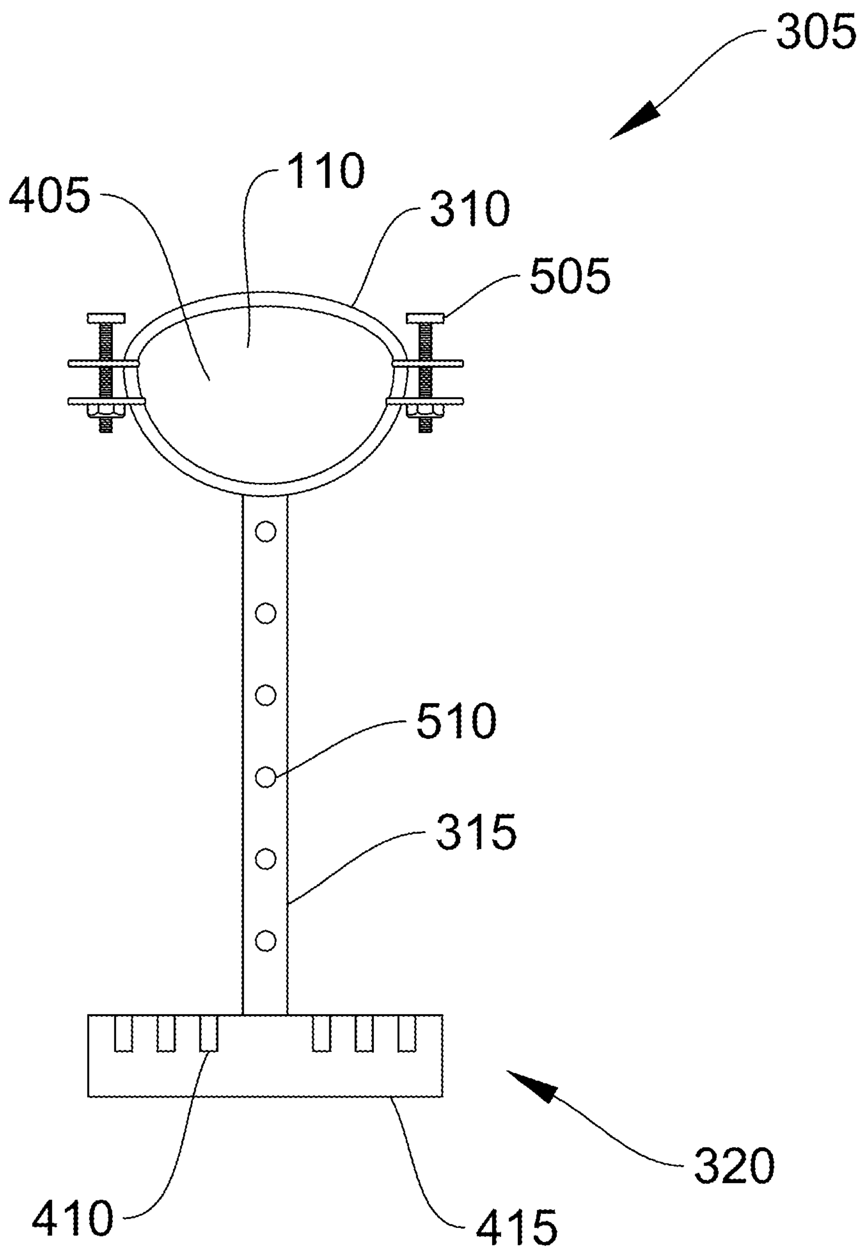


FIG. 5

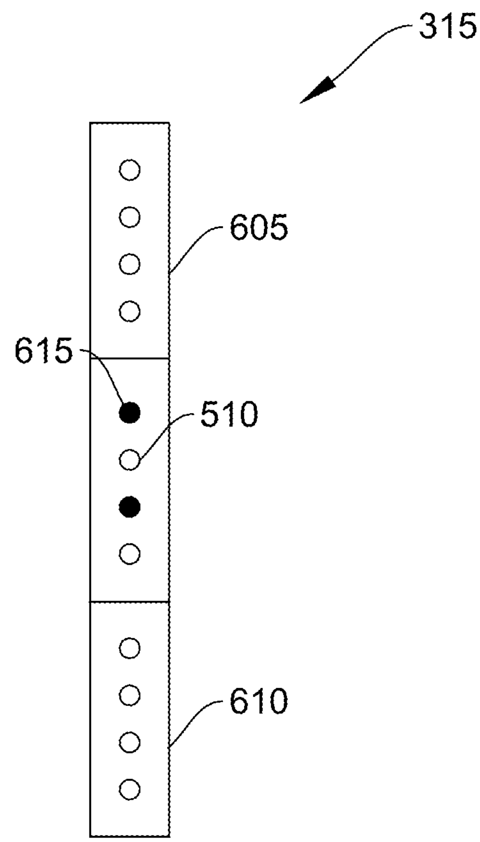


FIG. 6

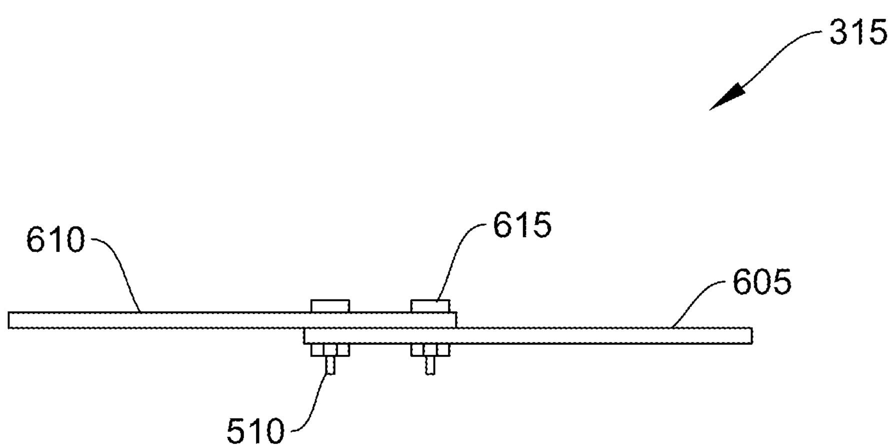


FIG. 7

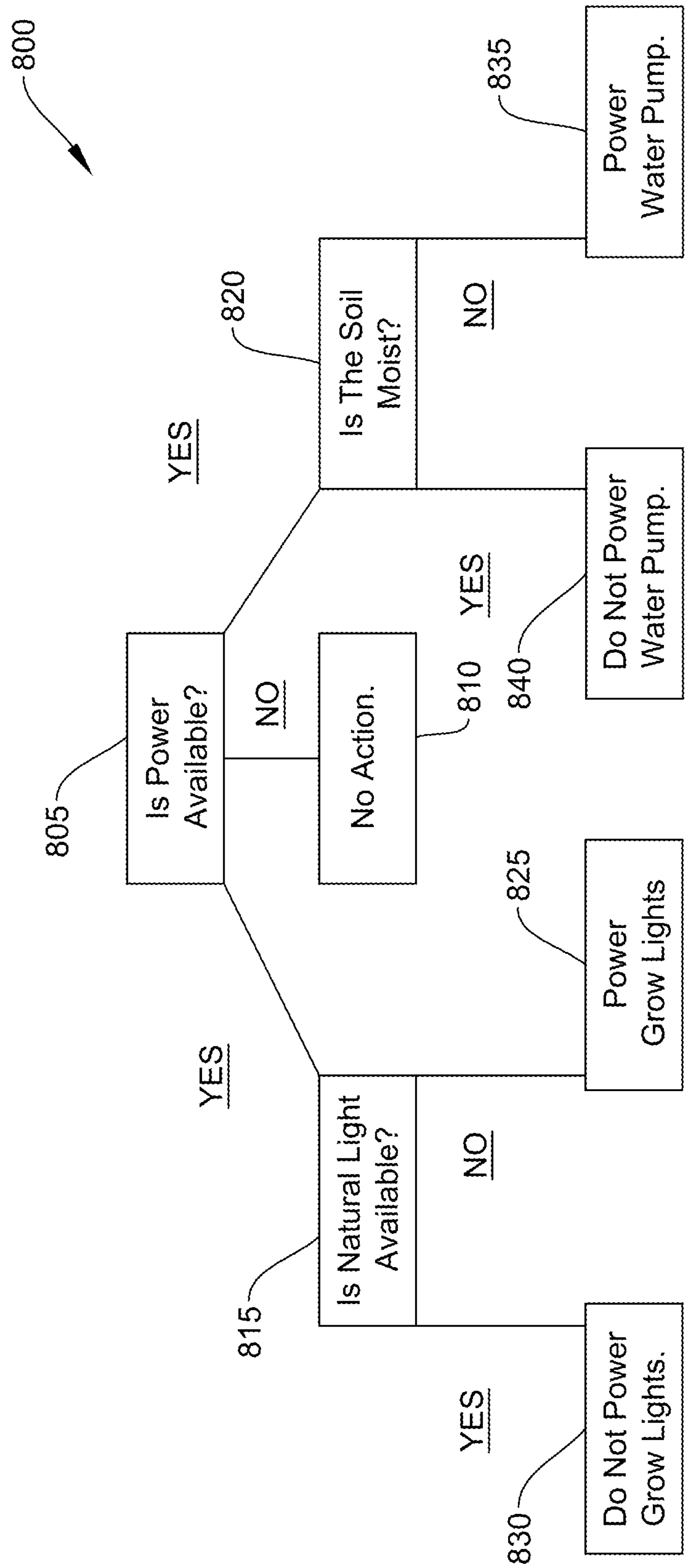

800
805
Is Power Available?
NO
810
No Action.
YES
820
Is The Soil Moist?
NO
835
Power Water Pump.
YES
840
Do Not Power Water Pump.
YES
815
Is Natural Light Available?
NO
825
Power Grow Lights
YES
830
Do Not Power Grow Lights.

FIG. 8

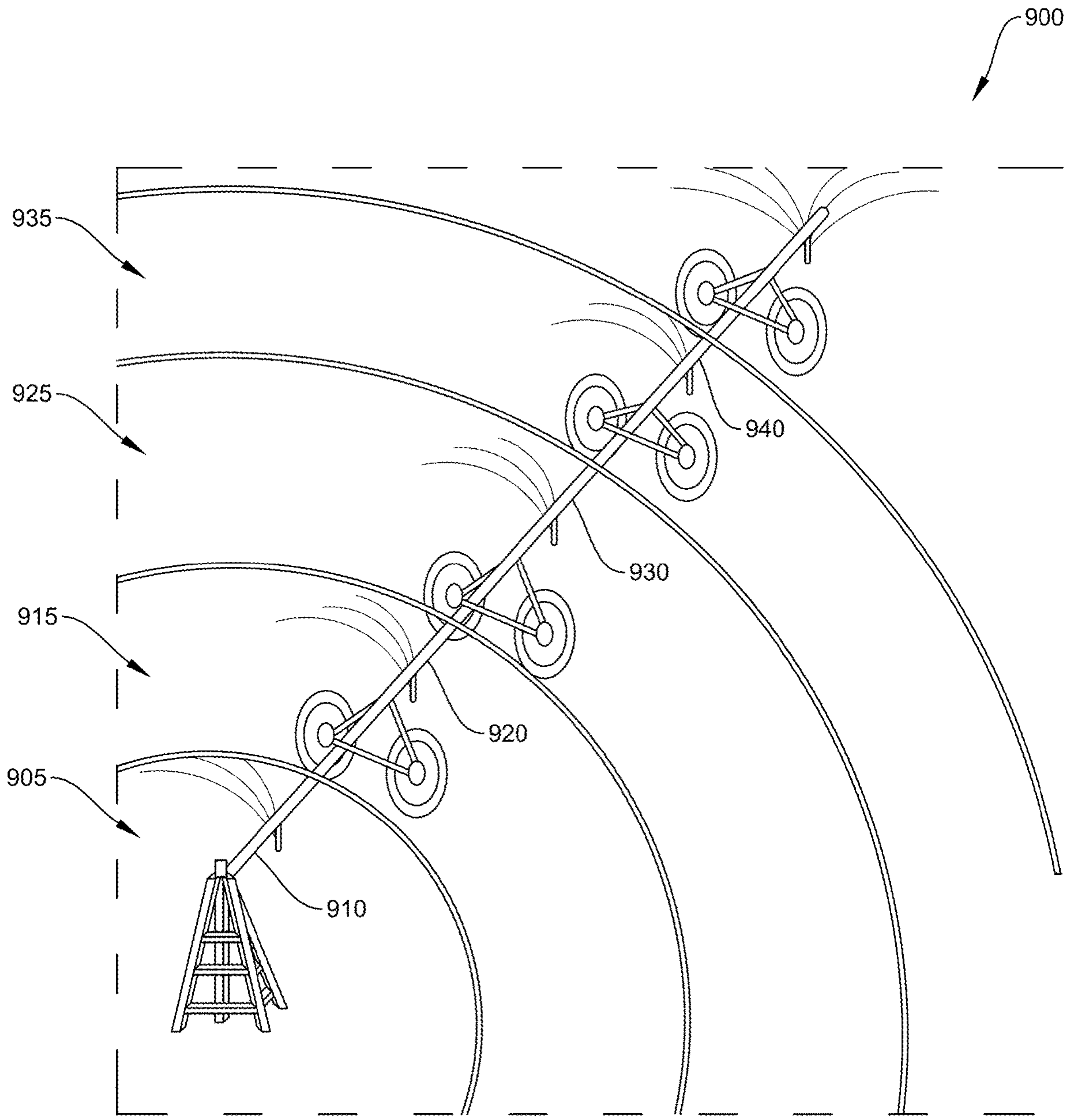


FIG. 9

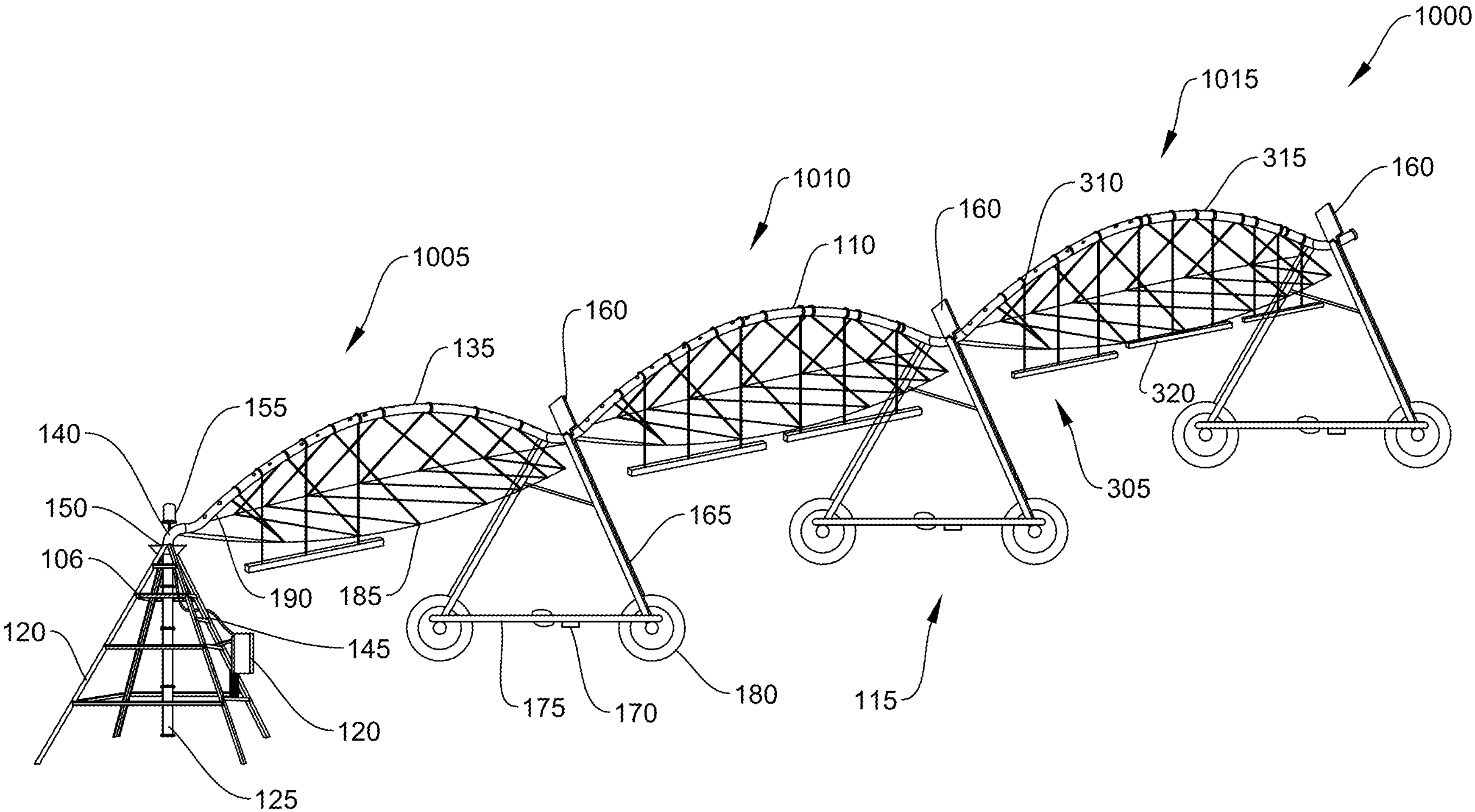

1000
1015
1010
1005
315
160
310
160
110
160
135
155
140
150
106
120
190
185
165
145
120
125
175
170
180
115
305
320

FIG. 10

ILLUMINATED IRRIGATION SYSTEM

CROSS-REFERENCE TO RELATED APPLICATIONS

[0001] This application claims the benefit of U.S. Provisional Application No. 62/951,445, filed Dec. 20, 2019, which is hereby incorporated by reference.

BACKGROUND

[0002] Crop growth depends on four primary factors. Those factors are light, water, temperature, and nutrients. In the spring and fall, temperatures may still be warm enough to support crop growth. However, the lack of adequate sunlight can prevent crops from growing as well as in the summer months. The short days restrict the crops ability to remain in photosynthesis. Photosynthesis is the natural process that occurs when plants use light energy and carbon dioxide to make the food they need to grow. Therefore, increasing the amount of time that the crops are exposed to light will increase the time period for photosynthesis. The more time that a crop is able to be in its photosynthetic stage, the greater the yield will be from that crop.

BRIEF DESCRIPTION OF THE DRAWINGS

[0003] FIG. **1** is a perspective view of a center pivot irrigation system.

[0004] FIG. **2** is a perspective view of a lateral move irrigation system.

[0005] FIG. **3** is a perspective view of a light assembly mounted to a center pivot irrigation system.

[0006] FIG. **4** is a front view of a light assembly.

[0007] FIG. **5** is a side view of a light assembly.

[0008] FIG. **6** is a side view of a light assembly extension.

[0009] FIG. **7** is a front view of a light assembly extension.

[0010] FIG. **8** is a flowchart depicting a logic process for a light assembly.

[0011] FIG. **9** is a top view of a crop coverage area divided into one or more individual crop areas.

[0012] FIG. **10** is a perspective view of a center pivot irrigation system with varying levels of radiant flux.

DESCRIPTION OF THE SELECTED EMBODIMENTS

[0013] For the purpose of promoting an understanding of the principles of the invention, reference will now be made to the embodiments illustrated in the drawings and specific language will be used to describe the same. It will nevertheless be understood that no limitation of the scope of the invention is thereby intended. Any alterations and further modifications in the described embodiments, and any further applications of the principles of the invention as described herein are contemplated as would normally occur to one skilled in the art to which the invention relates. One embodiment of the invention is shown in great detail; although it will be apparent to those skilled in the relevant art that some features that are not relevant to the present invention may not be shown for the sake of clarity.

[0014] FIG. **1** shows an example of a center pivot type irrigation system **100**, the center pivot type irrigation system **100** has a pivot point **105**, one or more spans **110**, and one or more drive units **115**.

[0015] The pivot point **105** has one or more pivot legs **120**, a riser pipe **125**, and a control panel **130**. The pivot legs **120** serve to support the pivot point **105** and provide a solid base for the center point irrigation system **100**. The riser pipe **125** is connected to a first span **135** through a pivot swivel **140**. The riser pipe **125** serves to transport water from a source to the first span **135**. The control panel **130** is mounted to the pivot point **105**. The control panel **130** serves to command the center pivot irrigation system **100** to start, stop, move in reverse, and/or pump water. Optionally, the control panel **130** may command auxiliary equipment, such as lighting, to power on or off.

[0016] The control panel **130** further includes an irrigation wiring system **145**. The irrigation wiring system **145** runs from the control panel **130** through a J-pipe **150** and into a collector ring **155**. The collector ring **155** includes brass rings with contact brushes that allow for a continuous flow of electricity even as the machine rotates around the pivot point **105**. From the collector ring **155**, the irrigation wiring system **145** runs across the one or more spans **110** to one or more tower boxes **160**. The tower boxes **160** work to support and control the movement of the center pivot irrigation system **100**. The tower boxes **160** are configured to work with the one or more drive units **115** to control movement.

[0017] The drive units **115** include one or more span supports **165**, a drive motor **170**, a driveshaft **175**, and one or more wheels **180**. The span supports **165** serve to support the spans at or above the crop level. The drive motor **170** is commanded by the tower box **160** to move in a certain direction at a certain speed. The drive motor **170** spins the driveshaft **175** which in turn spins the one or more wheels **180**. The connection between the tower box **160** and the drive motor **170** keeps the irrigation system moving in the proper direction at a consistent speed.

[0018] The one or more spans **110**, including the first span **135**, have at least one supportive truss **185**. The supportive truss **185** serves to support the spans to reduce drooping as a result of the contained water. Furthermore, the supportive truss **185** works to maintain the integrity of the spans in the event of high winds or inclement weather. The one or more spans **110**, including the first span **135**, further include at least one sprinkler **190**. The sprinkler serves to distribute the water that is pumped through the riser pipe **125** to the spans **110**.

[0019] FIG. **2** shows a lateral move type irrigation system **200**. The lateral move type irrigation system **200** operates similarly to the center pivot type system discussed in FIG. **1**. For ease of understanding the similar components will not be discussed in great detail, for reference see FIG. **1**.

[0020] The lateral move type irrigation system **200** includes one or more spans **205** supported by one or more support structures **210**. Similar to FIG. **1**, the spans **205** are supported by a truss system **215**. The truss system **215** serves to distribute the weight of the spans **205** when the system is operating and the spans **205** are full of water. Additionally, the truss system **215** adds durability to the irrigation system. This reduces the cost of maintenance and increases the life of the irrigation system. Located on the spans **205** are one or more sprinklers **220**. The one or more sprinklers **220** serve to distribute the water from inside the spans to the surrounding crops.

[0021] The support structures **210** serve to maintain the span height needed by supporting the spans **205**. The support structures **210** include one or more span supports **225**, a drive motor **230**, a drive shaft **235**, and one or more wheels **245**. The span supports **225** serve to provide a solid mounting location for the spans **205** and a control panel **250**. The control panel **250** serves as the location to power the irrigation system on or off and also to set the speed and direction of movement. To begin locomotion a command tower **240** sends a movement signal, indicating the speed and direction of movement, to the drive motor **230**. The drive motor **230** then begins to rotate the driveshaft **235**. The rotation of the driveshaft **235** in turn creates a rotation of the one or more wheels **245** which moves the irrigation system. In the lateral move system the command towers **240** communicate with one another in order to maintain consistency in the speed and direction of movement. This allows the irrigation system to move uniformly and avoid putting undue stress on the spans.

[0022] A distinction between the center pivot type irrigation system discussed in FIG. **1** and the lateral move type irrigation system **200** is the method for obtaining water. The center pivot system has water pumped through the riser pipe **125** whereas the lateral move system must either drag a hose connected to a water source or have a water channel running parallel with the movement of the lateral move system to draw water from.

[0023] FIG. **3** shows one example of an illuminated irrigation system **300**. The illuminated irrigation system **300** shown in FIG. **3** includes the center pivot type irrigation system **100** and a light assembly **305**. For the sake of clarity, the individual aspects of the center pivot irrigation system **100** will not be discussed again in great detail. Instead, see FIG. **1** for a detailed explanation of the center pivot irrigation system.

[0024] The light assembly **305** includes one or more brackets **310**, one or more extensions **315**, and a light bar **320**. The bracket **310** is configured to surround the span **110** and attaches via clamping force. Descending from the bracket is the extension **315**. The extension **315** is variable along its length. For example, the extension may be set to allow for the light bar **320** to hang anywhere from 1-10 meters above the ground. In an example embodiment, the light bar **320** is hung approximately 3.5 meters above the ground. In another embodiment, the light bar **320** is hung approximately 3.5 meters above the top of the crop. At the end of the extension **315** opposite of the bracket **310** is the light bar **320**. The light bar **320** is generally connected to the extension **315**. However, the light **320** bar may optionally be connected directly to the brackets **310**. The light bar **320** includes multiple grow lights to aid in crop growth when sun exposure is low. The grow lights may be of the Light Emitting Diode (LED) type, the High Intensity Discharge (HID) type, the fluorescent type, and/or the plasma type. Light bar **320** is generally configured to emit light in a generally downward direction and may optionally include reflectors to divert light emitted in other directions in the generally downward direction.

[0025] The light assembly **305** is generally powered by the irrigation systems existing power grid. For example, a light assembly wire **325** is attached at one end to the control panel **330** and at the other end to the light bar **320**. This configuration allows for the light assembly **305** to be activated when the irrigation system is active. However, this configuration may be modified by the addition of a light timer **335**. The light timer **335** connects between the control panel **330** and the light assembly **305**. The light timer **335** serves to prevent the flow of power into the light assembly until a certain pre condition is met. For example, the sun sets at 6 PM and rises at 8 AM, the light timer **335** may be set to allow power flow from 6 PM to 8 AM when the sun is down. This increases the crops exposure to light and increases the time of photosynthesis. Additionally, multiple light assemblies **305** and light timers **335** may be connected together in order to cover multiple span lengths.

[0026] In a different configuration, the light assembly **305** may be powered independent of the irrigation system. For example, the light assembly wire **325** is attached at one end to the light assembly control panel **340** and at the other end to the light bar **320**. In this configuration, the light assembly does not rely on power from the control panel **330**. Additionally, logic may be implemented into the light assembly control panel **340** to monitor the environment for sunlight. When sunlight is not available the logic may command that power be applied to the light assembly **305**. In this configuration the light timers **335** are unnecessary and the process becomes more autonomous.

[0027] The light assembly of FIG. **3** is shown in more detail in FIG. **4**. The light assembly **305** includes the brackets **310**, the extensions **315**, and the light bar **320**. The bracket **310** is operationally coupled to the span **110** of the irrigation system. In another embodiment, the bracket **310** is operationally coupled to the supportive truss system **185**. Enclosed within the span **110** is a water pipe **405**. The water pipe **405** serves to transport and distribute water throughout the irrigation system. The bracket **310** may be in the form of a pipe clamp. Some options for the type of pipe clamp may be rigid clamps, adjustable clamps, cushioned clamps, and/or U-bolt clamps. Attached to the bracket **310** is the extension **315**. The extension **315** is adjustable in terms of length. For example, the extension may be set to allow for the light bar **320** to hang anywhere from 1-10 meters above the ground. In an example embodiment, the light bar is hung approximately 3.5 meters above the ground. Additionally, the extension **315** is able to be operationally coupled to another extension **315** in order to extend the operational length beyond that of a single extension component.

[0028] At the end of the extension **315** opposite the bracket **310** is the light bar **320**. The light bar **320** is generally connected to the extension **315**. However, the light **320** bar may optionally be connected directly to the brackets **310**. The light bar **320** includes one or more grow lights **410** to aid in crop growth when sun exposure is low. The grow lights **410** may be of the Light Emitting Diode (LED) type, the High Intensity Discharge (HID) type, the fluorescent type, and/or the plasma type. The grow lights **410** are contained inside of a light housing **415**. The light housing **415** serves to protect the grow lights **410** from inclement weather, debris, and to focus the emitted light in the intended direction. The light housing **415** may be made of a metallic or polymeric material and sized according to the individual needs of the user. For example, the light bar may be anywhere from 1-20 meters long depending on the application.

[0029] The light assembly of FIG. **4** is shown in more detail in FIG. **5**. The bracket **310** is secured around the span **110** by one or more fasteners **505**. The fasteners **505** serve to secure the bracket **310** on the span **110** by creating a clamping force. The fasteners **505** may be of any type. For example, the fasteners may be screws, bolts, welds, glues, magnets, clamps, and/or rivets.

[0030] Attached to the bracket **310** is the extension **315**. The extension **315** is adjustable in terms of length. For example, the extension may be set to allow for the light bar **320** to hang anywhere from 1-10 meters above the ground. In an example embodiment, the light bar is hung approximately 3.5 meters above the ground. Additionally, the extension **315** is able to be operationally coupled to another extension **315** in order to extend the operational length beyond that of a single extension component. The adjustability of the extension **315** is accomplished by one or more adjustment holes **510**. The adjustment holes **510** allow for the light bar **320** to be placed higher up towards the span **110** or lower down towards the crops. The adjustment of the light bar **320** allows for the optimal light exposure for the particular crops being grown. For example, placing the light bar **320** close to the top of the crops results in a very narrow coverage area. As a result, this creates an inefficient lighting system. However, placing the light bar **320** far from the top of the crops allows the light to disperse and lose strength. As a result, there is less light absorption by the crops and therefore less photosynthesis and growth. Therefore, adjusting the light bar **320** allows for the distance from the top of the crops to the light bar to be variable. This variability allows for ideal light exposure conditions to be created where the light bar **320** is close enough to the crops to supply additional light, but, also far enough from the crops to cover a broad area and remain efficient.

[0031] Moving to FIG. **6** the extension **315** is shown in connection with a second extension **315** in order to increase the operational length. To combine multiple extensions, a process is completed as follows. A first extension **605** and a second extension **610** are adjusted to the intended operational length. The extensions are then further adjusted until the holes **510** of the first extension **605** and the second extension **610** are in alignment. Following the alignment of the holes **510**, one or more fasteners **615** are inserted through the holes **510** in order to secure the first extension **605** and the second extension **610** together. The fasteners **615** may be of any type. For example, the fasteners may be screws, bolts, welds, glues, magnets, clamps, and/or rivets.

[0032] FIG. **7** shows the extensions of FIG. **6** from a front view. As shown in FIG. **7** the first extension **605** and the second extension **610** are connected together by the fastener **615** in a sandwich configuration. The sandwich configuration allows the fastener **615** to exert a clamping force on the first extension **605** and the second extension **610**. This clamping force maintains the positioning of the extensions in the event of strong winds or other inclement weather.

[0033] An example of a logic flowchart **800** is shown in FIG. **8**. The logic flowchart **800** gives an example of the operational logic behind the intended light assembly usage. The logic flowchart **800** has separate pathways for grow light applications and sprinkler applications. The individual pathways allow the grow lights and the sprinkler system to run independently of each other. For example, the logic begins with a step **805**. Step **805** tests power flow to see if the breaker is closed and allowing power into the irrigation system. If no power is entering the irrigation system then a step **810** commences.

[0034] If power is available, the irrigation system moves on to a step **815** and a step **820**. In step **815** the irrigation system tests for available sunlight. Testing for light may be done by using a light sensor. For example, photo-conductive cells may be used to determine if sunlight is available. Additionally, other types of light sensors may be used such as photo-emissive cells, photo-junction devices, and/or photo-voltaic cells.

[0035] If natural light is not available, the logic moves to a step **825**. Step **825** instructs the irrigation system power supply to apply power to the grow lights. The addition of the grow lights results in more light exposure for crops. The longer light exposure creates a longer period for photosynthesis and crop growth.

[0036] If natural light is available, the logic moves to a step **830**. Step **830** instructs the irrigation system power supply to withhold power from the grow lights. Withholding power from the grow lights during times where natural light is available prevents wasted electricity. Additionally, withholding power saves costs in electricity and wear and tear on the light assembly equipment.

[0037] In step **820**, the irrigation system tests for proper soil moisture levels. Testing soil moisture levels may be done using tensiometers and resistance or neutron probe methods. Additionally, some irrigation systems are set on a timer. The timer starts the water flow and irrigation based on a constant time of day or week.

[0038] If the soil is not moist, the logic moves to a step **835**. Step **835** instructs the water pump to begin working to force water through the spans of the irrigation system and out of the sprinklers. The sprinklers then move over the crop area and moisten the ground to the proper levels. The added moisture gives the crops the water needed for growth and increases yield.

[0039] If the soil is moist, the logic moves to a step **840**. Step **840** instructs the water pump power supply to withhold power from the water pump. Withholding power from the water pump, during times where the crops have already been watered by rain or other means, prevents over watering. Additionally, withholding power from the water pump, when not needed, creates a more efficient system. The more efficient system saves money in operation costs, electricity, and wear and tear on the pump and associated equipment.

[0040] The separation of the logic for the operation of the grow lights and the sprinklers allows for the independent operation of each. For example, the sprinkler system may not be running, but, the grow lights may be on. In another example, the sprinkler system may be running, but, the grow lights may be off. In yet another example, both the sprinkler system and the grow light may be operating. This flexibility allows for the systems to operate in the most efficient manner possible in order to maximize the crops growth potential.

[0041] FIG. **9** depicts a crop coverage area **900** that is broken up into sections. In this example, the crop coverage area **900** is broken into sections based on the span locations. However, in other embodiments the crop coverage area **900** may be broken into sections based on crop type, section area, and/or natural environmental factors.

[0042] The crop areas can be calculated using a simple equation. For a first crop area **905**, the equation used is $A=pi*r^2$ where A is area, pi is a constant, and r is radius. However, when calculating the areas surrounding the first crop area **905**, a different equation should be used. The equation for a second crop area **915** and subsequent areas is $A=pi*(r_2^2-r_1^2)$ where A is area, pi is a constant, r_2 is the radius from the center to the outer rim of the second crop area **915**, and r_1 is the radius from the center to the outer rim of the first crop area **905**.

[0043] In this example, each crop area is covered by a corresponding span. For example, the first crop area **905** is covered by a first span **910**, the second crop area **915** is covered by a second span **920**, a third crop area **925** is covered by a third span, and a fourth crop area **935** is covered by a fourth span **940**. It should be appreciated that any number of spans may be connected to achieve the length needed to cover the crop area. For example, anywhere from 1-100 spans may be connected together to reach the required length.

[0044] As a result of the difference in crop areas, due to different distances from a pivot point, different levels of radiant flux (light intensity/radiant energy emitted per unit time) may be necessary in order to provide consistent growth conditions in each crop area. In the illustrated example, the first crop area **905** is smaller than the fourth crop area **935**. As should be appreciated, a smaller crop area will not require as much radiant flux as will a larger crop area. To create different levels of radiant flux, one or more light assemblies and/or light assemblies with different radiant flux output may be mounted to individual spans.

[0045] FIG. **10** shows an example of an irrigation system with varying levels of radiant flux **1000**. As discussed previously in FIG. **9**, different crop areas may have a need for different light intensities to achieve optimal growth conditions. Generally, as the length of the irrigation system grows longer the area covered by each span section grows larger. The result is a need for greater radiant flux with each span distance away from the pivot point **105** to obtain similar radian flux compared to closer span sections. Shown in FIG. **10** is a method of maintaining the optimal radiant flux by adding or subtracting light assemblies **305**. For example, the first span **135** has a first radiant flux **1005** that corresponds to the area covered by the first span **135**. The span **110** that follows the first span **135** has a second radiant flux **1010** that is greater than the first radiant flux **1005**. The larger radiant flux corresponds to the larger area and maintains the optimal grow conditions. The subsequent span **110** has a third radiant flux **1015** that corresponds to the greater area and continues to maintain the optimal grow conditions. It should be appreciated that the light assemblies **305** are removable and may be added or removed as the situation warrants in order to maintain the optimal grow conditions.

[0046] In another example, the radiant flux may optionally be controlled by regulating the power flow into the light assembly **305**. Modulating the radiant flux by regulating the power flow would allow for a uniform number of light assemblies **305** while still controlling the light output. In a further example, the radiant flux may be regulated by using different light sources. For example, one light bar **320** may be of the LED type while another light bar **320** may be of the HID type. In yet another example, the radiant flux may be regulated by using light sources with different radiant flux output (power).

[0047] It should be noted that the methods described in FIGS. **9** and **10** generally pertain only to center pivot type irrigation systems. With the lateral move type irrigation system the area covered is uniform and as a result a uniform radiant flux is generally preferred.

1. An illuminated irrigation system, wherein the irrigation system includes one or more vertical supports, one or more horizontal spans supported by the one or more vertical supports, a fluid transport system attached to or extending through at least a portion of the one or more horizontal spans, and a water distribution system operationally coupled to the fluid transport system to distribute water below the one or more horizontal spans, the light assembly comprising:

a light assembly;

a bracket mounting said light assembly to the irrigation system; and

an extension positioning said light assembly a predetermined distance from an intended surface.

2. The illuminated irrigation system as in claim **1**, wherein the bracket is mounted to a horizontal span of the irrigation system.

3. The illuminated irrigation system as in claim **1**, wherein the irrigation system is a center pivot type irrigation system.

4. The illuminated irrigation system as in claim **1**, wherein the irrigation system is a lateral move type irrigation system.

5. The illuminated irrigation system as in claim **1**, wherein the light source comprises Light Emitting Diode (LED) type grow lights.

6. The illuminated irrigation system as in claim **1**, wherein the light source comprises High Intensity Discharge (HID) type grow lights.

7. The illuminated irrigation system as in claim **1**, wherein the light assembly is powered by an existing electrical power from the irrigation system.

8. The illuminated irrigation system as in claim **1**, wherein the light assembly is powered independently from the irrigation system.

9. The illuminated irrigation system as in claim **1**, wherein the light assembly extension has a first end and a second end, wherein the distance between the first end and the second end defines a length, and wherein the length is adjustable.

10. The illuminated irrigation system as in claim **1**, wherein a minimum length of a horizontal span is 100 feet, and wherein the minimum length is measured as the unsupported horizontal span distance between two vertical supports.

11. The illuminated irrigation system as in claim **10**, wherein a maximum length of a horizontal span is 400 feet, and wherein the length is measured as the unsupported horizontal span distance between two vertical supports.

12. The illuminated irrigation system as in claim **1**, wherein a plurality of the horizontal spans are operationally coupled together, in an end to end configuration, in order to reach a predetermined length.

13. A system comprising:

an irrigation system comprising:

one or more vertical supports,

one or more horizontal spans supported by the one or more vertical supports,

a fluid transport system attached or extending through at least a portion of the one or more horizontal spans, and

a water distribution system operationally coupled to the fluid transport system to distribute water below the one or more horizontal spans;

a light assembly comprising:

a bracket for mounting said light assembly to the irrigation system, and

a light source removably secured to said bracket, wherein said light source comprises LED type grow lights.

14. A system as in claim **13**, wherein the bracket is mounted to a horizontal span of the irrigation system.

15. A system as in claim **13**, wherein the irrigation system is a center pivot type irrigation system.

16. A system as in claim **13**, wherein the irrigation system is a lateral move type irrigation system.

17. The system of claim **15**, wherein the plurality of light assemblies are arranged so that the emitted radiant flux increases approximately proportionately to a square of the distance of a particular light assembly from a pivot point.

18. The system of claim **15**, wherein the plurality of light assemblies have variable emitted radiant flux and wherein the plurality of light assemblies are arranged so that the emitted radiant flux increases approximately proportionately to a square of the distance of a particular light assembly from a pivot point.

19. A method of increasing crop light absorption by retrofitting an irrigation system with grow lights comprising:

attaching grow lights to one or more horizontal spans of the irrigation system, wherein the grow lights are attached to the one or more horizontal spans using one or more brackets,

connecting said grow lights to a power control box, wherein the power control box also controls the movement of the irrigation system, and

powering the grow lights during specified time periods to extend the time period for light absorption.

20. The method of claim **19**, wherein the grow lights have variable emitted radiant flux and wherein the grow lights are arranged so that the emitted radiant flux increases approximately proportionately to a square of the distance of a particular light assembly from a pivot point of a center pivot type irrigation system.

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