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Movable Lawn Irrigation Dripper Array

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ABSTRACT

A form of irrigation device for lawn irrigation is provided including an array of water release outlets for slow release by dripping of water from the water release outlets distributed over a wide area and wherein the irrigation device is of flexible material and construction that allows the irrigation device when used above ground and spread over the wide area to be subsequently collapsed to a linear configuration for portability of movement to a new site and to be rolled for storage.

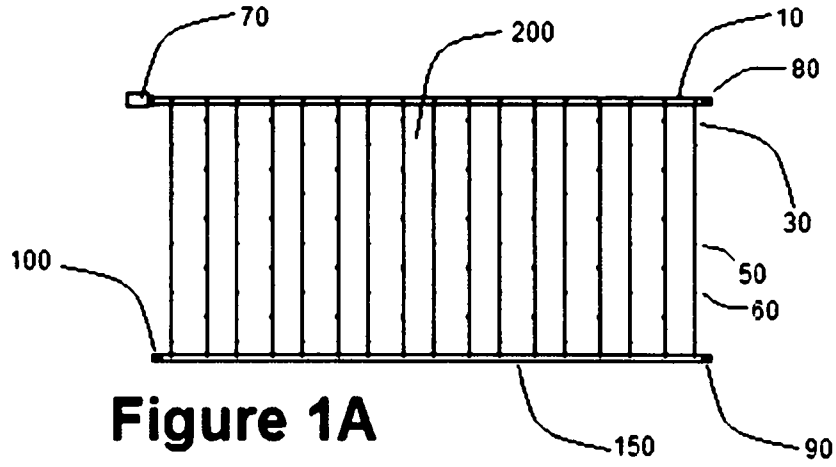

Figure 1A

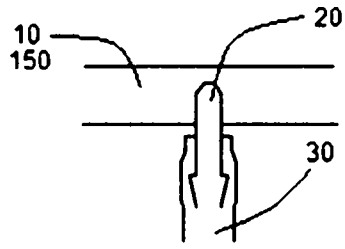

Figure 1B

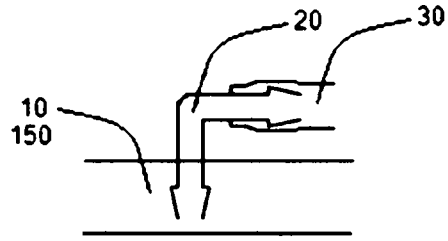

Figure 1C

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AUSTRALIA

Patents Act 1990

COMPLETE SPECIFICATION

STANDARD PATENT

MOVABLE LAWN IRRIGATION DRIPPER ARRAY

The following statement is a full description of this invention, including the best method of performing it known to me:

MOVABLE LAWN IRRIGATION DRIPPER ARRAY

The present invention relates to irrigation systems and more particularly relates to an irrigation device providing a dripper network of the type in which a plurality of drippers are provided in an array for the distribution of water over a wide surface area such as for irrigating a lawn.

The irrigation device described herein may be manufactured as a collapsible array for relocation and for storage, as in an example configuration as a spooled net of connected lines rolled onto a garden hose spool.

BACKGROUND OF THE INVENTION

Modern demands upon water conservation, and particularly efficient utilization of water resources, make it imperative that irrigation systems be operated with a minimum of water loss and provide uniform distribution of water precisely over the area to be irrigated. In order to achieve maximum water utilization efficiency in an irrigation system, the water distribution must be confined to the area which requires watering and must be uniformly distributed over that area. In the prior art, various sprinkler irrigation systems have been used, spraying radial distances away from the sprinkler heads, however the water losses of such systems, due to water waste beyond the needed area, in-air evaporation into dry air, the effect of winds on aerial thrown spray, and wetted surface evaporation losses, of these systems, are in excess of acceptable water use efficiencies of modern times.

This invention relates to irrigation systems and particularly to a lawn area irrigation system that distributes and emits water to the area to be irrigated as large drops which soak directly into the soaking soil in which the lawn is grown so that it irrigates through the soil at root level. The invention also encompasses a portable and storable conduit apparatus for use in the system and a method of irrigating a lawn area by emitting water evenly into the lawn soil.

Many households utilize the traditional garden hose and manually placed hose end sprinkler for garden watering. For others, automated lawn and landscape irrigation systems have become popular in recent years. These utilize smaller variants of the wide area irrigation concepts applied in parks and playing field irrigation systems. Commonly these include a network of underground PVC tubing which supplies irrigating water to sprinkler heads spaced out throughout the area of lawn to be watered.

Regardless of the system, these methods of watering have many water loss problems associated with them. The most important problem with sprinkler head irrigation systems is that such systems make very inefficient use of irrigation water. Sprinkler head systems need a high water flow rate to throw water away from the sprinkler head, with the result that they commonly deliver water to an area too fast for the surface to absorb and thereby waste irrigation water through runoff. Also, complete coverage of an area requires that the sprinkler heads be spaced such that their coverage areas overlap, as much as sixty percent overlap is common. This coverage overlap causes uneven water distribution and exacerbates the runoff problem. Also, the spray created by the

sprinkler heads results in high evaporation loss, particularly in windy conditions and is often blown outside of the area to be watered and into streets and dry parking areas.

Other problems with sprinkler head irrigation systems include the susceptibility of sprinkler heads to pose hazards to persons using the lawn area and the high evaporation losses that occur from the broad-scale wetting of lawn leaves that do not absorb the irrigation water.

In some areas with salts in the water, the spray from the sprinkler heads can damage the lawn leaves and often discolours fences, paving, building materials and adjacent structures. Furthermore, the deep trenching required for the network of PVC tubing makes installation costs fairly high.

Drip irrigation systems, installed under the lawn to be grown, utilize subsurface water emitters to release irrigating water and avoid many of the problems associated with sprinkler head systems. However, deep drip irrigation systems must be pre-installed before lawn growth commences and are inefficient for use in irrigating lawns. The inefficiency arises because drip emitters deliver a major portion of the water to the area too deep to be useful to lawn grasses. In-ground drippers also suffer the problems of root in-growth into the dripper outlets; blocking them and stopping the intended even water distribution.

The surface array drip grid of this invention will consume much less water than perfectly adjusted traditional sprinkler systems, because it delivers moisture right to the roots of grass and does not waste water on the grass leaves that would evaporate from the surface of the lawn, especially during hot weather days.

It also does not spray outside the lawn area to be irrigated, and its cover area is not compromised by changing winds.

The larger drips of the water distributed by this invention minimize the surface area of the distributed water and this minimizes evaporation loss to winds and dry air.

It offers the further benefit that people do not need to wait for the surface of the lawn to dry, to play or use the lawn for social activities, or to cut the grass.

This invention also allows users to irrigate the lawn at any time, even in the afternoon hot sunny hours when the traditional system can "burn" the grass through broad-scale leaf wetting. The afternoon hours are the most productive in the sense of grass growing rates, as at this time the photosynthesis level is commonly at its highest resulting in the opportunity for optimum moisture to be applied.

As a result of the benefits of this invention, water irrigation loss is brought to a minimum, and the appearance of lawns irrigated with this invention will be much more attractive than the lawns irrigated with the traditional sprinkler systems.

This invention may be manually applied with the garden hose, or it may also be connected to the automated sprinkler system's electrical valve and control panel to allow On or Off mode and water flow scheduling to be used.

For areas where local authorities or governments ban or restrict the use of sprinkler irrigated home lawns and gardens, due to the high water loss inefficiencies of sprinkler use, the system of this invention is less likely to be restricted, due to its greater efficiency of water use by applying drippers, instead of high loss sprinklers as the means of water distribution. This allows the home occupant to water lawns "as needed", with less restraint, so as to immediately address garden stress due to sudden dry conditions, as opposed to the inefficient practice of more excessively irrigating "as allowed" on scheduled "watering days", regardless of the weather conditions on that day, in case a dry day may follow.

These systems are very convenient and efficient, especially for small home lawns yet they can also be applied in larger formats or interconnected modules for wide area parks, bowling greens and playing fields.

Today, when the rapidly increasing water consumption of the community becomes a huge problem for society, these systems can save tremendous amounts of water, and therefore money, with the added benefit of improvement of the environment.

SUMMARY OF THE INVENTION

An irrigation device for lawn irrigation is provided including an array of water release outlets for slow release by dripping of water from the water release outlets distributed over a wide area and wherein the irrigation device is of flexible material and construction that allows the irrigation device when used above ground and spread over the wide area to be subsequently collapsed to a linear configuration for portability of movement to a new site and to be rolled for storage.

In an embodiment an irrigation device is described having water release outlets provided as lengths of in-line dripper tubing having in-line water release drippers distributed along the lengths and wherein a series of lengths of the in-line dripper tubing are connected along the length of one or more water feed lines by connection means that allow for passage of irrigation water.

In an embodiment the irrigation device would be constructed having one or more water feed lines that are of garden hose or similar material.

In an embodiment the connection means consists of right angled elbow hose connectors or a device of equivalent function that provides radial pivotal connection of the in-line dripper tubing to the water feed lines.

In an embodiment the pivotal connection may be positioned so that the in-line dripper tubing extends at suitable angles from the water feed lines for the irrigation device to be laid out as a two dimensional array of water release drippers over the wide area being irrigated.

In an embodiment when being moved the pivotal connection may be positioned so that the in-line dripper tubing is parallel to the water feed lines for the irrigation device to be

stretched or collapsed to a one dimensional array of the in-line dripper tubing and the water feed lines for relocation and for rolling or spooling onto a garden hose spool for storage when not in use.

In an embodiment the array of water release outlets is constructed with a hollow mat of pressed sealed plastics sheets positioning the slow release water release outlets wherein infilling water fills a cavity between the pressed sealed plastics sheets and wherein the hollow mat of pressed sealed plastics sheets has large open growth holes to allow sunlight access and ventilation to lawn below the open growth holed hollow mat and wherein the hollow mat walls are of flexible plastics construction that allows the hollow mat to be collapsed when the infilling water pressure is released to a rolled or folded or scrunched linear configuration for portability of movement to a new site and for storage.

In an embodiment the irrigation device may have bending resilient material associated with one or more of the water feed lines, the in-line dripper tubing and the general construction, to assist the irrigation device to self straighten when in use.

In an embodiment tubing or water conduits of large diameter flexible lines are used wherein infilling irrigation water pressure results in stiffening of these lines, and thus assisting self straightening of the irrigation device when it is in use.

In an embodiment peg attachment means are provided to enable the irrigation device to be pegged to the ground to be irrigated.

BRIEF DESCRIPTION OF DRAWINGS

The present invention will be described by way of exemplary embodiments, but not limitations, illustrated in the accompanying figures in which like references denote similar elements, and in which:

Figure 1A illustrates one possible example embodiment of the irrigation device as it would be, laid out in expanded form whilst in use irrigating a lawn area, the irrigation device having incorporated water feed lines and in-line dripper tubing having embedded in-line water release drippers at regular intervals.

Figure 1B illustrates a top view of an example embodiment of a connection means of the irrigation device of Figure 1A illustrating an example right angled elbow hose connector positioned at the end of exampled in-line dripper tubing and pivotally connected along the length of an example water feed line with the pivotal connector position, to connect the flexible dripper line tube, at right angles to the water feed line.

Figure 1C illustrates a side view of the connection means of Figure 1B illustrating the example right angled elbow hose connector of Figure 1B inserted into the length of a water feed line.

Figure 2A illustrates the irrigation device of Figure 1A in transition to being extended into a linear configuration for relocation or storage.

Figure 2B illustrates an example embodiment of a connection means of the irrigation device of Figure 2A illustrating an example right angled elbow hose connector positioned at the end of exampled in-line dripper tubing and pivotally connected along the length of an exampled water feed line, with the pivotal connector position to connect the in-line dripper tubing at 45 degrees to the water feed line, as it is being rotated from its fully right angled expanded array position.

Figure 3A illustrates the irrigation device of Figure 1A extended to an almost linear configuration ready for relocation or storage.

Figure 3B illustrates an example embodiment of a connection means of the irrigation device of Figure 3A illustrating an example right angled elbow hose connector positioned at the end of exampled in-line dripper tubing and pivotally connected, to align along the length of an example water feed line with the pivotal connector position to connect the in-line dripper tubing parallel to the water feed line, so as to bring all lines parallel and into a linear configuration.

Figure 4 illustrates a lawn soil side profile view showing the irrigation water soaking distribution when the irrigation device of Figure 1A is situated above the lawn and in use.

Figure 5 illustrates the irrigation device of Figure 1A extended to an almost linear configuration and in transition being rolled onto a garden hose spool reel for relocation or storage.

Figures 6A to 6D illustrate embodiment of attachment means of the irrigation device for pegging the irrigation device to the lawn to be irrigated.

Figure 7 illustrates another form of embodiment of the irrigation device, wherein the array of lawn irrigation drippers are held in position and fed with irrigation water by means of a hollow mat of flexible pressed sealed plastics sheets providing infilling water to the drippers from a cavity between the pressed sealed plastics sheets and having large open growth holes to allow sunlight access and ventilation to the lawn below the open holed hollow mat when in use.

DETAILED DESCRIPTION OF THE INVENTION

In the following description, various aspects of the present invention will be described. However, it will be apparent to those skilled in the art that the present invention may be practiced with only some or all aspects of the present invention. For purposes of explanation, specific numbers, materials and configurations are set forth in order to provide a thorough understanding of the present invention. However, it will also be apparent to one skilled in the art that the present invention may be practiced without the specific details. In other instances, well known features are omitted or simplified in order not to obscure the present invention. The terms "embodiment" and "embodiments" will be used repeatedly; however re-use of these terms does not necessarily refer to the same embodiment, although it may.

Referring now to Figures 1A to 3A and 1B to 3B and Figure 1C, wherein embodiments of an irrigation device, incorporated with the teachings of the present invention are shown. As illustrated, in accordance with the present invention, irrigation device [200] is provided with a garden hose connector [70] for connecting to the supply water of a common "garden water supply hose". This garden hose connector [70], which may be connected through a water pressure lowering device, enables connection for ingress of irrigation water to flow into the first "garden hose water feed line" [10]. When in use the irrigation water will flow through each "pivotal connection" [20] and into the "in-line dripper tubing" [30] having embedded "in-line water release drippers" positioned at regular intervals along the lengths of the "in-line dripper tubing" [30].

The "in-line dripper tubing" [30], has at regular intervals along its length, embedded in it, slow water release dripper outlets. This in-line dripper tubing is readily available and is commonly supplied through garden and irrigation stores for a wide variety of agricultural and garden irrigation needs. For lawn irrigation, as applied in this invention, it is preferable that "in-line dripper tubing" be used which has in line drippers positioned at 0.30 meter intervals, which each deliver 2 liters per hour of water flow. In the Figures some of these in-line drippers are sample referenced as [50] and [60].

Irrigation water flow out of the first "garden hose water feed line" [10] can only occur into each of the connected "pivotal connections" [20] as the irrigation water flow is blocked from otherwise exiting the first "garden hose water feed line" [10] by "end plug" [80].

The irrigation water flow into the first end of the "in-line dripper tubing" [30] fills these tubes and flows through the "pivotal connection" [20] at the second end of these "in-line dripper tubing" [30] into the second "garden hose water feed line" [150].

Irrigation water flow out of the second "garden hose water feed line" [150] can only occur into the "pivotal connection" [20] as the irrigation water flow is blocked from otherwise exiting the second "garden hose water feed line" [150] by the "end plugs" [90] [100]. Accordingly the second "garden hose water feed line" [150] acts as an irrigation water pressure equalizer, balancing the water pressure in the multiple lengths of "in-line dripper tubing" [30], by pressurizing these tubes from both ends to accommodate the possibilities of any pinched "in-line dripper tubing" [30] restricting the flow of water along them.

As a result, the irrigation device [200] pressurizes with water causing the in-line drippers to commence irrigation water release at their manufacture designed regular flow rate. The result is an even distribution of irrigation water dripping from the array of in-line drippers, evenly over the area of lawn, over which the irrigation device [200] is positioned.

The irrigation water dripping from the array of in-line drippers, as large droplets, falls into the lawn immediately below each in-line dripper and soaks into the soil which is matted with lawn grass roots. Once the irrigation water droplets reach the soil which is matted with lawn grass roots it spreads throughout the soil under the irrigation device by capillary action, distributing itself evenly through the soil for optimum take-up by

the grass roots. It has been found with the present invention that the preferable positioning of the drippers into a two dimensional array at 0.30 meter interval spacing where each dripper delivers 2 litres per hour of irrigation water will result in an even irrigation of the lawn through capillary action in most conditions within one hour of this slow steady irrigation, the result provides optimum lawn irrigation with minimum water loss.

Figure 4 illustrates a lawn soil side view showing the vertical soil profile and the irrigation water soaking distribution when the "in-line dripper tubing" [30] of the irrigation device, situated in normal use position above the lawn, is in use, distributing irrigation water. The irrigation water drips through the lawn leaves [160] and is soaked throughout the soil of the grass root mat [170] immediately below each dripper by capillary action in the soil. Irrigation water penetration into the soil [180] below the grass root mat is reduced in a healthy lawn by the greater water soaking capillary action of the active grass root mat.

Due to the mobility of the irrigation device [200] and its light weight and height above the grass root mat, as supported by the growing lawn [160], the lawn grass roots are unable to grow into and block the dripper outlets, as is a problem with the prior art of buried piped dripper irrigation devices.

Due to the large droplet size delivered by the irrigation device [200], and it's close and immediate proximity above the grass root mat [170] to be irrigated, evaporation losses are minimized as the droplets are of maximum size for the surface tension of the water, so that the minimum of water surface area is exposed to dry air evaporation. Additionally the speed of droplet transition through the air is minimized as the irrigation water does not need to be thrown through the air as high velocity small sprayed drops for water distribution. Further, as a result, water does not fall to a location where it is wasted or not wanted, as blown by winds whilst moving through the air, or forced to be distributed where it is not optimally needed by the irrigation distribution shape of a water-throwing sprinkler device. Thus drop surface evaporation, and these other wastages are minimized, avoiding the problems with the prior art of water sprinklers.

Due to the slow release of dripping irrigation water from the drippers of the irrigation device [200], the irrigation water release rate is controlled so that its supply is slower than the capillary soaking take-up rate of the soil matted with lawn grass roots [170], to which it is being supplied. As a result, irrigation water wastage by runoff is eliminated. Irrigation water wastage by runoff is a problem of the prior art of distribution by water sprinklers, which can only work when they supply a sufficiently high water flow rate for the water to be thrown over the distribution distance to the lawn by radial centered sprinklers.

The irrigation device [200] is sufficiently flexible so that it can be shaped and positioned to suit a wide variety of garden lawn landscape designed shapes by the user positioning it on the lawn to be irrigated in the shape of the intended irrigation pattern.

Thus the irrigation device [200] solves all of the key problems of the sprinkler prior art to optimize irrigation water distribution with minimized losses due to wind blown wastage, dry air evaporation wastage, thrown spray evaporation wastage, irrigation

distribution shape wastage, higher flow rate runoff wastage, and in addition it eliminates the high cost prior installation and the blockage by root ingress of the buried dripper network prior art.

It is recognized that a key need of home users is to movably reposition the irrigation device [200] between uses, for the irrigation of larger lawns and the coverage of more than one lawn area, such as back and front lawns on larger residential properties. For this purpose, the irrigation device [200] in an embodiment is preferably constructed so that the radial connection angle of the connections between the "in-line dripper tubing" [30] and the first and second "garden hose water feed lines" [10] and [150], at the "pivotal connection" [20], may be pivotally changed.

This enables the irrigation device [200] when in use to be wide area spread, as shown in Figure 1A, and to be transitioned by allowing the "pivotal connections" [20] to pivot, at their interconnection to the first and second "garden hose water feed lines" [10] [150], when one or other of the first and second "garden hose water feed lines" [10] [150] is longitudinally pulled by a user. This radial pivoting of the connectors enables the transition of the wide area spread shape as shown in Figure 1A into the shape illustrated in Figure 2A, and beyond by further radial pivoting of the "pivotal connection" [20], at their interconnection to the first and second "garden hose water feed lines" [10] [150], to transition the irrigation device [200] into the linear shape illustrated in Figure 3A.

This linear configuration of the irrigation device [200] can then be dragged by a walking user, to a new lawn location, or spooled or rolled onto a garden hose spool [110] with simple winding of the spool handle [120], as Figure 5 illustrates, for movement to another lawn or for out of the way storage. The garden hose water feed line based irrigation devices [200] as described herein are generally sufficiently flexible that they will self change to a linear configuration, if this is initially commenced, whilst they are being spooled onto a garden hose spool [110] by the simple winding of the spool handle [120].

This wide array to linear configuration shape changing of the irrigation device [200] is achieved without causing folding pinching of any of the "in-line dripper tubing" [30], or of the first and second "garden hose water feed lines" [10] [150], by the easy radial pivoting of the "pivotal connection" [20] at their interconnection to the first and second "garden hose water feed lines" [10] [150], which pivoting occurs without need for individual connection manual user adjustment. Pivoting occurs with the angle direction change between the respective lines as the irrigation device [200] is moved about by the user moving the first and second "garden hose water feed lines" [10] [150], to lengthen, or spread out the irrigation device [200]. The pivoting of the "pivotal connection" [20] is illustrated in the transitions between the states shown in Figures 1B, 2B and 3B. The connection of the "pivotal connection" [20] to the first and second "garden hose water feed lines" [10] [150], is illustrated in Figure 1C.

It is also recognized that upon movably repositioning the irrigation device there is commonly a need to straighten out the irrigation device tubing for aesthetics and maximum area cover. This can be assisted by utilizing bending resilient material in, or associated with, the first and second "garden hose water feed lines" [10] [150], and for further rigidity and straightening, if needed, bending resilient material can also be

associated with some or all of the lengths of the "in-line dripper tubing" [30], in particular those lengths at the outer edges of the irrigation device [200].

A useful alternative to the use of bending resilient material is to construct the first and second "water feed lines" [10] [150] and possibly the "in-line dripper tubing" [30] lengths at the outer edges of the irrigation device [200] of large diameter flexible lines wherein the water pressure applied when infilling with irrigation water results in stiffening of these lines, and thus assisting the self straightening of the irrigation device, when it is use.

An alternative to bending resilient material or internal pressure straightening lines is to provide an attachment means at the ends of the first and second "garden hose water feed lines" [10] [150] as shown in Figure 6A and 6B so that pegs [400] as shown in Figure 6C and 6D may be used to peg the irrigation device to the ground at these points. Suitable attachment means may be looped ends [310] [320] [330] [340] which may be associated with the end plugs [80], [90] and [100] as shown in Figure 6A, so that pegs [400] may be inserted through them, as shown in Figure 6C, or the simpler widening of the ends [360] [370] [380] as shown in Figure 6B, so that the pegs [400] may hook over the ends of the first and second "garden hose water feed lines" [10] [150] as shown in Figure 6D without the ends [350] [360] [370] [380] being pulled through.

Figure 7 illustrates another form of embodiment of the irrigation device, wherein the array of lawn irrigation drippers are held in position and fed with irrigation water by means of a hollow mat of flexible pressed sealed plastics sheets wherein the drippers gain infilling water from a cavity [210] between the pressed sealed plastics sheets and having large open growth holes [220] to allow sunlight access and ventilation to the lawn below the open holed mat when in use. This hollow mat of flexible pressed sealed plastics sheets, is in use, pressurized with infilling irrigation water through garden hose connector [70], and when depressurized of irrigation water can be longitudinally folded to a long linear form and spooled onto a garden hose spool, or rolled or folded to a compact form for relocation and storage.

CLAIMS

1. An irrigation device including

an array of water release outlets for slow release by dripping of water from the water release outlets distributed over a wide area and wherein;

the irrigation device is of flexible material and construction that allows the irrigation device when used above ground and spread over the wide area to be subsequently collapsed to a linear configuration for portability of movement to a new site and to be rolled for storage.

2. The irrigation device of claim 1 wherein the water release outlets are provided as lengths of in-line dripper tubing having in-line water release drippers distributed along the lengths and wherein;

a series of lengths of the in-line dripper tubing are connected along the length of one or more water feed lines by connection means that allow for passage of irrigation water.

3. The irrigation device of claim 2 wherein the water feed lines are of garden hose or similar material.

4. The irrigation device of claim 2 or claim 3 wherein the connection means consists of right angled elbow hose connectors or a device of equivalent function that provides radial pivotal connection of the in-line dripper tubing to the water feed lines.

5. The irrigation device of claim 4 wherein the pivotal connection may be positioned so that the in-line dripper tubing extends at suitable angles away from the water feed lines for the irrigation device to be laid out as a two dimensional array of water release drippers over the wide area being irrigated.

6. The irrigation device of claim 4 wherein when being moved the pivotal connection may be positioned so that the in-line dripper tubing is parallel to the water feed lines for the irrigation device to be stretched or collapsed to a one dimensional array of the in-line dripper tubing and the water feed lines for relocation and for rolling or spooling onto a garden hose spool for storage when not in use.

7. The irrigation device of claim 1 wherein the array of water release outlets is constructed with a hollow mat of pressed sealed plastics sheets positioning the slow release water release outlets wherein infilling water fills a cavity between the pressed sealed plastics sheets and wherein;

the hollow mat of pressed sealed plastics sheets has large open growth holes to allow sunlight access and ventilation to lawn below the open growth holed

hollow mat and wherein the hollow mat walls are of flexible plastics construction that allows the hollow mat to be collapsed when the infilling water pressure is released to a rolled or folded or scrunched linear configuration for portability of movement to a new site and for storage.

8. The irrigation device of any of the preceding claims wherein bending resilient material is associated with one or more of the water feed lines, the in-line dripper tubing and the general construction to assist the irrigation device to self straighten when in use.

9. The irrigation device of any of the preceding claims wherein tubing or water conduits of large diameter flexible lines are used wherein infilling irrigation water pressure results in stiffening of the large diameter flexible lines, and thus assisting self straightening of the irrigation device when it is in use.

10. The irrigation device of any of the preceding claims wherein peg attachment means are provided to enable the irrigation device to be pegged to the ground to be irrigated.

11. An irrigation device substantially as hereinbefore described with reference to the accompanying figures.

ALLEN WILLIAM BROWN
(Name of Applicant)

9 NOVEMBER 2006
(Date)

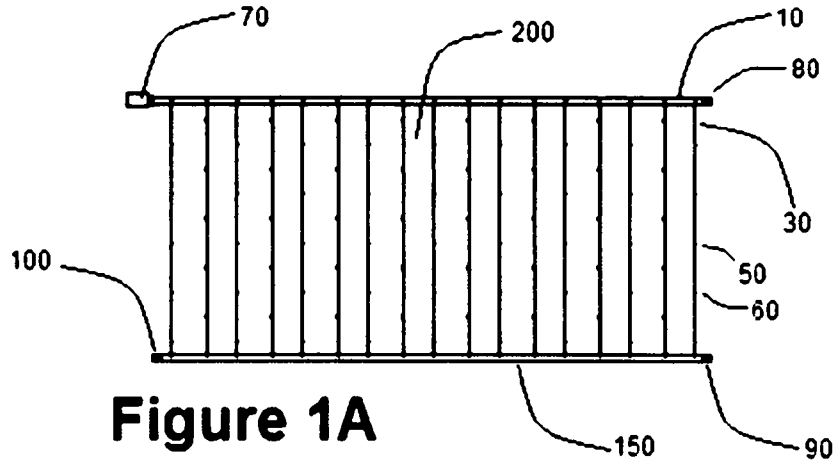

Figure 1A

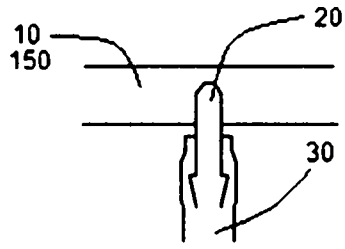

Figure 1B

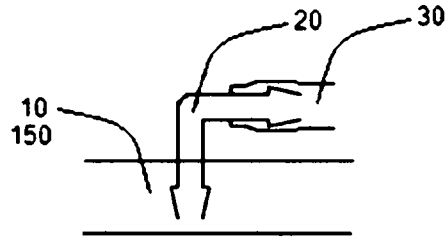

Figure 1C

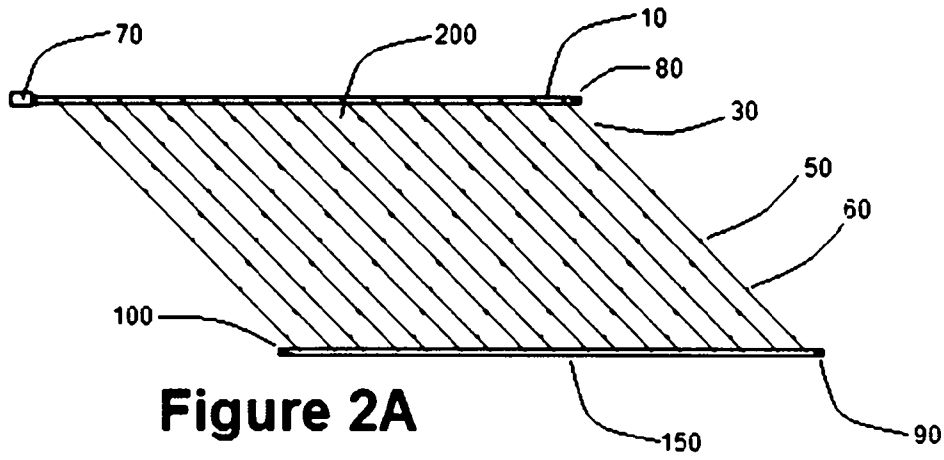

Figure 2A

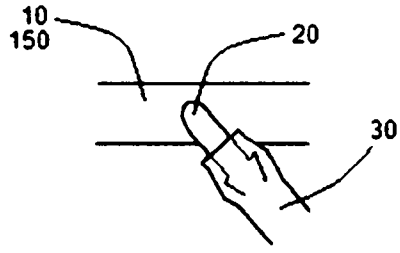

Figure 2B

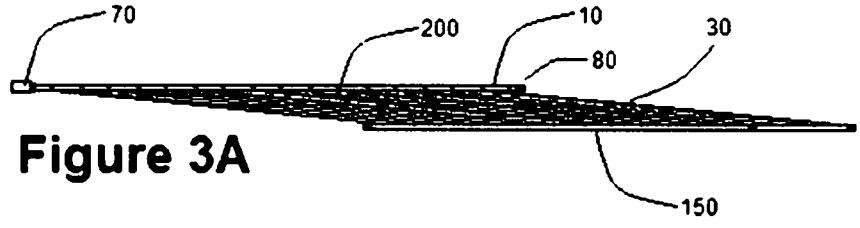

Figure 3A

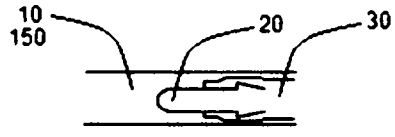

Figure 3B

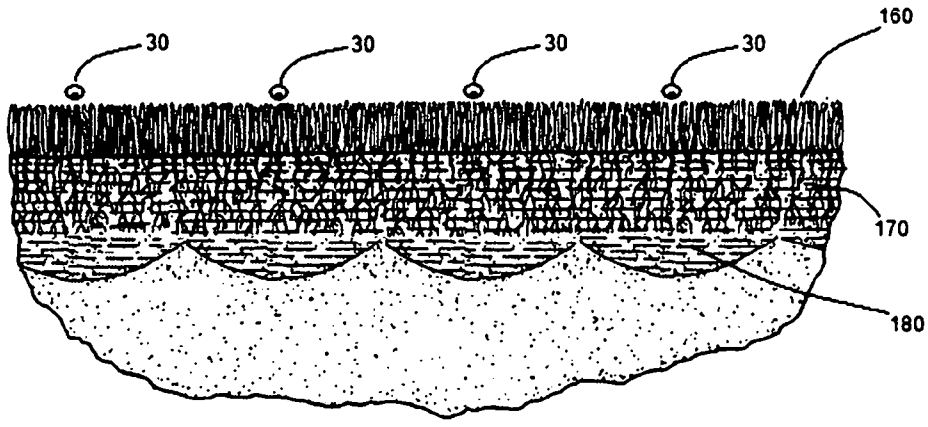

Figure 4

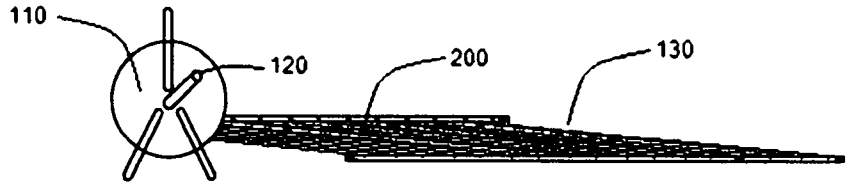

Figure 5

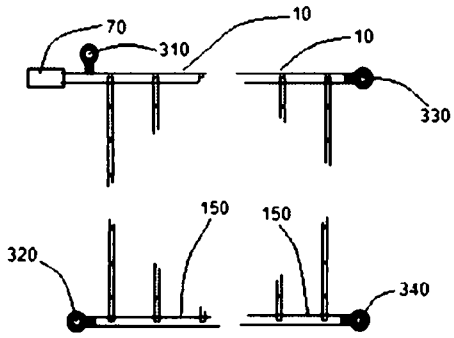

Figure 6A

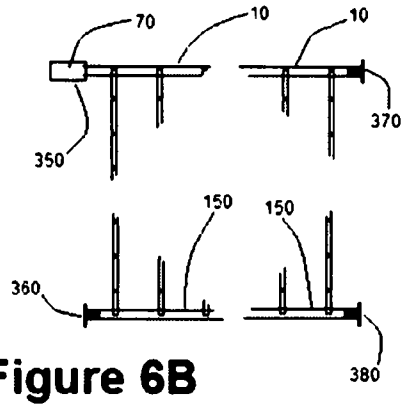

Figure 6B

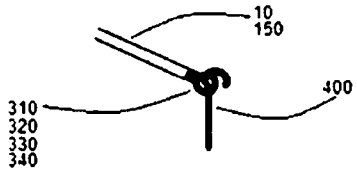

Figure 6C

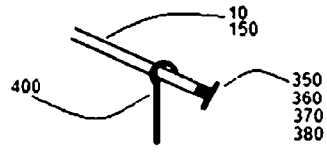

Figure 6D

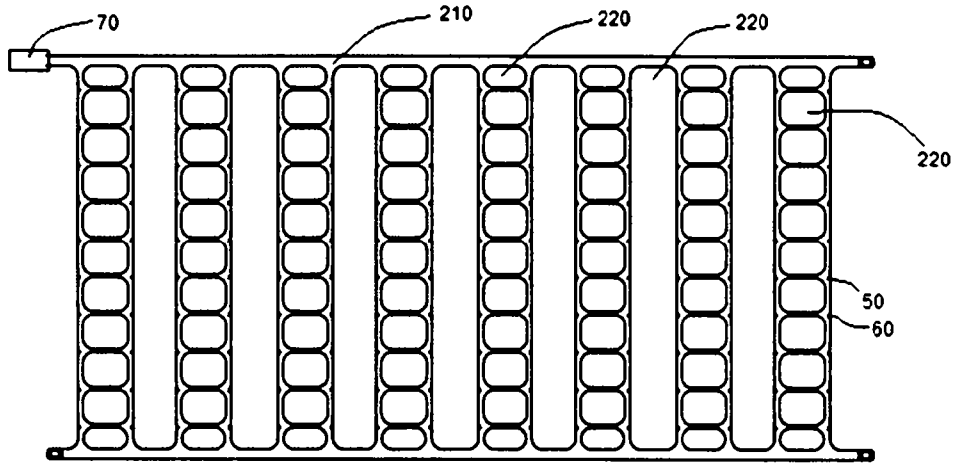

Figure 7