Title: TEMPERATURE MODERATING COVER FOR A BUILDING ROOF

Abstract: The present invention provides a multi-purpose moisture-retaining cover utilizing super-absorbent polymer for cooling, insulating, and or protecting a building surface, and can be used on a horizontal, vertical or inclined surface. One embodiment includes a first barrier layer, a layer of non-woven polyester impregnated with a cross-linked super-absorbent polymer, a third layer of non-woven polyester, and a fourth cellululosic layer to support seed germination.
— before the expiration of the time limit for amending the claims and to be republished in the event of receipt of amendments

For two-letter codes and other abbreviations, refer to the “Guidance Notes on Codes and Abbreviations” appearing at the beginning of each regular issue of the PCT Gazette.
TEMPERATURE MODERATING COVER FOR A BUILDING ROOF

Field of the Invention

The present invention relates to the field of roof covering materials with cooling or
insulating properties, including materials adapted to support plant growth.

Background of the Invention

Nearly every material known to man has been used at one time or another as a
roofing material, including metal, glass, plastic, wood, concrete, asphalt, tile and soils,
among others. The primary purpose of a roof is to provide shelter from the elements,
which involves keeping precipitation out of the building interior, but also, and of perhaps
equal importance to most modern building inhabitants, serving as the first layer of
insulation that is required to moderate temperatures inside the building. As demand for
energy rises and supplies of energy-producing natural resources diminish, effective
building insulation becomes more and more important.

Currently, conventional insulation takes the form of non-woven fibrous panels,
foams, slurries or other voluminous, air-trapping materials which line the interior of the
attic space of buildings. In order to provide such insulation, however, sufficient attic
space must be provided, which may substantially increase the construction costs
associated with the building. Thus, there is a need for a low-cost roof covering material
that would not diminish interior spaces or require additional attic space and would serve
to moderate the extreme differences in temperature which often exist between a building
interior and exterior.

Early man-made buildings were constructed from natural materials which by their
composition also provided insulation. In addition, sod, adobe and other primitive
building materials also happened to support plant growth. Grass has also been grown on
roofs in modern times, particularly in Europe, and is generally perceived as aesthetically
pleasing. Such structures also provide a layer of insulation that helps keep the building
interior cool in the summer and warm in the winter. These modern grass-roof systems
use a layer of soil and a complex system of multi-layered materials to protect the
underlying structure from damage; this type of construction is expensive but arguably
justified due to the associated energy savings. Moreover, the insulation provided by these
systems eliminates the need for insulated attic space. However, there are numerous problems associated with these systems, particularly including soil retention.

The cooling effect of water evaporation is well known, and has been used in both primitive and sophisticated cooling systems. A building can be cooled by periodically spraying its roof with water. A layer of ice on a building roof can also provide significant insulation. However, spraying water onto a conventional roof surface for the benefits associated with evaporation or ice melting produces highly variable results because of the difficulty in controlling the amount of water or ice present and the rate of evaporation. There is therefore a need for a roof covering material or structure able to absorb predictable amounts of water quickly and able to slowly release it by evaporation or, in season, permit ice formation.

U.S. Patent No. 5,287,650 to Moriguchi, et al. discloses a structured plant cultivation medium particularly intended for concrete surfaces that has “three layers of synthetic plastic material, a top layer for turf cultivation, a middle layer to protect the roots and a bottom layer to drain water away.” This is underlaid by a root blocking, waterproofing layer, and overlaid by a net to prevent wind damage and protect the other layers from damage by concentrated loads.

U.S. Patent No. 5,390,442 to Behrens discloses a multi-layer vegetation structure “made up of a culture layer for holding vegetation, and a separation layer, and wherein a fire-retardant layer made of non-combustible material is arranged on top of the separation layer and below the culture layer.” This combination of elements is supposed to “serve the purpose of permitting roof or wall foliation in buildings,” and the fire-retardant layer is supposed to suppress the spread of fire to the building if the vegetation element itself or dry plants on the vegetation element catch on fire. U.S. Patent No. 5,608,989, a later patent also to Behrens, describes a system which includes a substrate for supporting plant growth that has dispersed within it solid activated carbon particles capable of absorbing hazardous substances, and living microorganisms that are capable of converting hazardous substances into non-hazardous substances that are capable of being utilized by growing plants rooted in the substrate. This ‘989 patent to Behrens contemplates the use of “hygroscopic materials such as mineral wool, glass fibers, rock wool, etc. that are capable of holding moisture so as to minimize the frequency at which water must be applied in the absence of natural rainfall.”
Both the Moriguchi and Behrens patents disclose roof covers which are composed of relatively heavy materials. In other words, the dry weight of the cover is relatively high in comparison to the wet weight of the cover. Thus, the total amount of water which may be absorbed by the cover before the weight limit of the roof is met is relatively small. As a result, these covers do not perform well in regions where precipitation is high and inconsistent. This is because high precipitation creates excess water which must be drained, potentially washing away components of the cover, such as soil or hygroscopic materials. Similarly, in periods of no precipitation, the covers tend to dry out quickly because of the limited amount of water that may be stored in the cover. The rapid drying reduces the insulative efficacy of the covers. Artificial watering systems may be provided to maintain the desired moisture content. However, the nature of the materials used in these covers limits the ability of water to migrate through the cover, thus requiring the watering system to be distributed over the entire covered area. Such a large system may significantly increase construction costs of the roof and cover system.

Summary of the Invention

The structure of this invention provides a lightweight covering material for horizontal and moderately inclined roof and similar surfaces that incorporates a non-woven fabric layer with super-absorbent polymer (“SAP”). The SAP is formed in a manner that intermeshes the SAP particles with the fibers of the non-woven fabric. The intermeshing secures the SAP in place and prevents SAP from being washed out of the cover by water. This approach is advantageous because it eliminates the need for additional binders, such as soil, which ordinarily would be used to hold the SAP or other absorbent material in place. This substantially reduces the dry weight of the cover, which in turn allows the cover to be designed to absorb more water.

The SAP absorbs water (from natural precipitation or artificial sources) and then slowly releases the water, by evaporation, into the air. The evaporation moderates the temperature of the roof, substantially reducing the heating and cooling costs of the structure.

Alternatively, the cover may be structured to allow the hydroponic growth of plants. In order to allow plant growth, the cover requires a root barrier layer, to prevent damage to the roof from root growth. A middle layer of non-woven fabric shades the
underlying SAP layer and supports root growth. An upper cellulosic layer holds moisture and seeds. The upper layer also may contain smaller amounts of SAP to maintain moisture. Hydroponic growth is desirable because it eliminates the need for soil, which would add considerable weight to the cover without increasing its ability to absorb water.

Thus, the wet to dry weight ratio of a hydroponic cover is substantially higher than that of a cover which uses soil in which to grow plants.

Both embodiments of the cover also may include a drainage layer under the SAP layer to allow excess water to drain from the roof.

A further benefit of such a roof cover is the significant reduction or elimination of run-off from the roof during normal rain conditions. Run-off is often a major contributor to erosion around and under buildings, a problem which can affect the foundation of a building and cause expensive and time consuming repairs. Furthermore, the concentrated streams of run-off from buildings having large roof areas can erode landscaping and cause other structural and aesthetic problems.

It is therefore an object of this invention to provide a roof covering material that contains SAP for quick absorption of a predetermined volume of water.

A further object of this invention is to provide a roof cover that has a high wet to dry weight ratio.

Another object of this invention is to provide a roof cover that, having absorbed a quantity of water, retains the absorbed water for an extended period of time and releases it slowly into plant roots or by evaporation.

Another object of this invention is to provide a roof covering structure that supports plant growth without the use of soil.

Yet another object of this invention is to provide a roof cover that does not allow the water absorbent element of the cover to be washed away by water.

Another object of this invention is to provide a mat or rug-like material which contains a first SAP layer for quick absorption and retention of water, and a second layer of non-woven polyester which both shades the SAP layer and provides support for root growth.

Another object of this invention is to provide a mat or rug which includes a SAP layer for quick absorption and slow evaporation of water and which cools the underlying
surface in hot weather and provides an insulating cover for the underlying surface in cold weather.

Yet another object of this invention is to provide a roof cover that significantly reduces run-off under normal rain condition.

Other objects, features, and advantages of this invention will become apparent with reference to the remainder of the written portion and the drawings of this application, which are intended to exemplify and not to limit the invention.

Brief Description of the Drawings

Fig. 1 is a schematic cross-sectional view of the cover of this invention shown on a roof.

Fig. 2 is a schematic cross-sectional view of an alternate embodiment of this invention.

Fig. 3 is time-temperature chart showing temperatures below the cover of this invention, above the cover of this invention, and surrounding ambient air temperatures under different conditions.

Fig. 4 is a schematic view of an automatic watering system roof cover in accordance with the present invention.

Detailed Description of the Drawings

Figure 1 illustrates the principal components of a cover 10 of this invention, including a root barrier 12 on top of roof structure 14, a water retention layer 16 on top of the root barrier 12, a shading layer 18, and a top layer 20. In an alternative embodiment, a cover 10 is illustrated in Figure 2 that utilizes a water retention mat 22 on top of roof structure 14. Either embodiment also may include optional drainage layer 15.

Root barrier layer 12 is made up of any water impermeable material that will prevent the penetrate of roots into roof structure 14. For example, polyethylene film having a thickness of about three to four mils will provide the desired protection. Other materials, such as polyurethane modified PDA asphalt, also provide the desired protection and, if desired, additional protection against water penetrate as well.

Optional drainage layer 15 may be any material which allows water to flow freely in a direction parallel to roof structure 14. Drainage layer 15 allows any excess water
which is not absorbed by the upper layers of cover 10 to drain from the upper layers, travel along roof structure 14 and drain from the roof. Drainage layer 15 may, for example, be constructed of any materials suitable for allowing excess water to flow from cover 10 to a desired location, such as the edge of the roof or a drain. Suitable materials include, but are not limited to, woven or non-woven polyester or polyolefin (such as polyethylene or polypropylene) fabrics, non-woven Kevlar, nylon or glass. The thickness of layer 15 is determined by the excess drainage requirements anticipated for the particular installation. For example, in high precipitation areas, where the absorption capacity of the upper layers is expected to be exceeded frequently, a relatively thick drainage layer may be required. In low precipitation areas where excess accumulation is infrequent, layer 15 may be relatively thin or even eliminated altogether.

Top layer 20 is a material that supports seeds during germination and retains moisture to encourage seed growth. Any biodegradable moisture absorbing material, such as cellulosic materials may be used. Layer 20, which may be very thin, need only retain moisture during the germination period of the seeds supported therein.

Middle layer 18 is a non-woven fabric, which may be polyester, polyolefin (such as polyethylene or polypropylene) fabrics, non-woven Kevlar, nylon, glass or any other suitable fiber. Middle layer 18 supports root growth and shades layer 16. Because it may take several weeks for the plants to grow from seed to the point where their roots reach the water stored in layer 16, it may be necessary to provide a source of water to cover 10 during this period to maintain moisture in layers 18 and 20 and ensure proper plant growth. Thus, it may be desirable to impregnate layer 18 with SAP, however, in smaller amounts than that provided in layer 16. The addition of SAP to layer 18, while not required, will assist in retaining moisture in layer 18 during the period of time in which the roots of the plants are growing down from layer 20 to layer 16.

The illustrated and other embodiments of the present invention use a water retention layer 16, 22 that includes SAP, which may be non-woven polyester fiber impregnated with cross-linked SAP. The SAP is polymerized in the presence of the non-woven fiber, thereby embedding and immobilizing the fiber in the SAP in accordance with the teaching of U.S. Patent No. 5,614,269, which is incorporated in its entirety by this reference. In contrast to the disclosure of U.S. Patent No. 5,614,269, it is desirable to select a SAP having an absorption level of approximately 30 grams of water per gram
of SAP and provide for more cross-linking of SAP to ensure the SAP is firmly held within the non-woven fiber. Furthermore, other materials including, but are not limited to, woven or non-woven polyester or polyolefin (such as polyethylene or polypropylene) fabrics, non-woven Kevlar, nylon or glass may be used. Also, other methods (than use of ultraviolet light) for cross-linking the SAP that also result in the SAP interpenetrating with the fibers of water retention layer 16, 22 may be used. For example, heat might be used. As will be understood by those skilled in the art, any such alternative methods must result in adequately capturing the SAP within a non-woven polyester fabric or other suitable structure that retains the SAP within the roof covering structure described herein.

Although the thickness of water retention layer 16, 22 may vary depending on the quantity of water to be absorbed, layer 16, 22 may, for instance, be approximately one-fourth inch (1/4") thick. A square yard of cover 10 using a one-fourth inch thick layer 16, 22 would weigh approximately one pound, but could absorb between thirty and one-hundred-and-fifty pounds of water, depending on the amount of SAP embedded in layer 16, 22. Thus, the wet to dry weight ratio of cover 10 may be between 30 and 150. Also, this ratio may be increased or decreased by modifying the thickness of layer 16, 22, or the amount or absorption level of SAP used in layer 16, 22. In contrast, conventional structures such as that disclosed by the Moriguchi patent, described above, have a wet to dry ratio of about 1.1 to 1.2.

The layers of cover 10 need not be affixed to each other or to roof structure 14. Clips 92 or staples 90 at the edges of cover 10 are generally sufficient to stabilize cover 10 during installation. Once cover 10 is saturated with moisture, the weight of the water is typically sufficient to hold cover 10 in place. If grass or other plants are grown on cover 10, the root structure of the plants also serves to hold together the layers of cover 10. In areas where high winds may occur, heavy weights may be placed at strategic locations on cover 10 to prevent cover 10 from being blown off roof structure 14. Other means for preventing cover 10 from blowing off of roof 14 or sliding off a slanted roof may be provided as appropriate.

Cover 10 may be provided in roll form, either pre-assembled, partially assembled or in separate sheets which may be placed on roof structure in the appropriate order. For example, layer 16 may be provided already affixed to root barrier 12 with staples or adhesives. Once this partially assembled layer is positioned on roof structure 14,
additional layers 18 and 20 may be positioned thereon. Rolls may be provided in any convenient width.

Experiments have shown that use of cover 10 illustrated over a roof surface 14 exposed to direct sunlight during much of the day has a significant effect in moderating the temperature of the roof 14 as compared to the air temperature immediately above the cover 10. Figure 3 graphically charts the temperature over a six day period, at the times and conditions shown, measuring the temperatures at three locations: (a) the temperature of a portion of the roof adjacent to but not covered by the cover 10 is shown by line 30, (b) ambient air temperature is shown by line 32, and (c) the temperature of cover 10 water retention layer 16 is shown by line 34.

As can be seen by reference to Figure 3, the temperature of the unprotected portion of the roof fluctuates widely and, significantly, becomes quite hot (as high as approximately as 150° F. during the middle of the day) during sunny, mid-day periods. By contrast, the portion of the roof protected by the cover 10 fluctuates in temperature much less and remains below the air temperature and the unprotected roof temperature during periods of peak temperatures on the unprotected portion of the roof. The protected roof temperature is lower than the ambient air temperature because of evaporational cooling, and thermal mass provided by the water-containing cover. The protected roof temperature is also lower than it would be with a water layer, since the SAP has more exposed surface to air and does not tend to heat up as water would.

Of course, the data in Figure 3 reflects a cover 10 that is moist. If cover 10 is allowed to dry out, its thermal regulating properties are diminished to the point of being insignificant. Thus, it is important to maintain an adequate moisture level in cover 10. Artificial water sources, such as sprinklers or drip systems may be used to maintain moisture. Also, condensation from air conditioning systems may be used. Provided that the air conditioning system generates adequate moisture, use of air conditioning condensation alone can maintain adequate moisture in a cover 10 to achieve desired temperature moderation even over a two week period with no rain or other source of moisture. Use of air conditioner condensation is desirable as it does not incur any additional costs for water usage. Water need only be delivered to the apex of a sloping roof structure. Because of the exceptional absorption characteristics of the SAP, water introduced on only a portion of cover 10 will migrate to saturate the entirety of layer 16,
22. Of course, on flat roofs, other distribution schemes, such as sprinklers may be necessary.

Watering of the cover 10 may be automated. For example, as shown in Figure 4, moisture sensor 100 may be placed in layer 16, 22. When moisture levels below some predetermined threshold are detected by control system 102, water source 104 may be activated, delivering water through line 106 to drip system 110 and/or sprinkler 108. Alternatively (not shown), a temperature sensor, such as a thermocouple, may be placed between cover and roof structure. The watering system may be activated when temperatures exceed some pre-determined threshold temperature measured by the thermocouple.

Figure 3 reflects an embodiment of cover 10 on which grass or plants are grown. If cover 10 includes only an SAP layer 22, similar results are obtained; however, cover 10 dries out more quickly, thus requiring more frequent application of moisture.

Both the thickness of and the amount of SAP incorporated in layer 16, 22 may be varied to increase or decrease the amount of water absorbed per unit of cover 10. In either case, the limiting factor is the maximum allowable load on roof structure 14. The thickness of layer 16, 22 may have relatively little effect on overall insulation value of cover 10. For example, quarter- and half-inch thicknesses can exhibit nearly identical insulating characteristics. Layer 16, 22 may be as thin as on-eighth of an inch or less to as thick as one-half inch or more. Thickness does affect, however, the tolerance of layer 16, 22 for intervals without addition of moisture. The thicker the layer 16, 22, the longer cover 10 can go without drying out. Thickness also affects the ease of installation. Layers 16, 22 between one-quarter and one-half inch thick are easily manipulated for installation purposes.

The foregoing is provided for purposes of illustrating, explaining and describing preferred embodiments of the present invention. Modifications and adaptations to the described embodiments will be apparent to those of ordinary skill in the art and may be made without departing from the scope or spirit of the invention and the following claims
What is claimed is:

1. A roof cover comprising one or more fibers impregnated with a cross-linked super absorbent polymer.

2. The roof cover of claim 1 in which the wet to dry weight ratio of the cover is about 30.

3. The roof cover of claim 1 in which the wet to dry weight ratio of the cover is between about 30 and 150.

4. A water retaining mat for use on a substrate, the mat comprising:
   a) a first layer comprising a first fabric comprising one or more fibers impregnated with a cross-linked super-absorbent polymer;
   b) a second layer positioned adjacent to the first layer, and comprising a fabric; and
   c) a third layer comprising a cellulosic material and positioned adjacent to the second layer.

5. The mat of claim 4, in which the third layer further comprises plant seeds.

6. The rest of claim 4, wherein the fabric of the second layer comprises a non-woven fabric.

7. The mat of claim 6, wherein the second layer further comprises a cross-linked super-absorbent polymer, impregnated into one or more fibers of said non-woven fabric.

8. The mat of claim 4, further comprising a layer of water impermeable material positioned on a side of the first layer opposite the second layer.
9. The mat of claim 8 wherein the layer of water impermeable material is impermeable to the growth of the plant roots.

10. The mat of claim 8, further comprising a drainage layer interposed between the first layer and the water-impermeable layers.

11. The mat of claim 4 wherein the first fabric is selected from a group consisting of woven polyester, non-woven polyester, woven polyolefin, non-woven polyolefin, non-woven Kevlar, non-woven nylon and non-woven glass fabrics.

12. The mat of claim 6 in which the non-woven fabric is selected from a group consisting of polyester, polyolefin, Kevlar, nylon and glass fabrics.

13. The mat of claim 4, having a wet to dry weight ratio of at least about 30.

14. The mat of claim 13 in which the wet to dry weight ratio of the mat is between about 30 and about 150.

15. A cover for insulating a roof comprising a first layer of a fabric impregnated with a cross-linked super absorbent polymer.

16. The cover of claim 15, wherein the fabric is non-woven.

17. The cover of claim 15 further comprising a drainage layer positioned on one side of the first layer.

18. The cover of claim 15 in which the fabric of the first layer is selected from the group consisting of woven polyester, non-woven polyester, woven polyolefin, non-woven polyolefin, non-woven Kevlar, non-woven nylon and non-woven glass fabrics.
19. The cover of claim 16 wherein the non-woven fabric is selected from the group consisting of polyester, polyolefin, Kevlar, nylon and glass fabrics.

20. The cover of claim 15 having a wet to dry weight ratio of at least about 30.

21. The cover of claim 20 in which the wet to dry weight ratio of the cover is between about 30 and about 150.

22. The cover of claim 15 further comprising a fastener, whereby the cover can be fastened to the upper surface of a roof.

23. The cover of claim 15 wherein the fastener is a staple.

24. The cover of claim 15 in which the fastener is a clip.

25. The cover of claim 15, further comprising plant seeds disposed therein, with the proviso that the cover does not contain substantial quantities of soil.

26. A system for applying and maintaining a predetermined moisture level on a roof, comprising:
   a) cover comprising fiber impregnated with a cross-linked super absorbent polymer positioned on a surface of a roof;
   b) a sensor in communication with a control unit; and
   c) a water distribution system in electronic communication with the control unit.

27. The system of claim 26 in which the sensor is a temperature sensor.

28. The system of claim 26 in which the sensor is a moisture sensor.
29. The system of claim 26 in which the water distribution system comprises at least one water sprinkler.

30. The system of claim 26 in which the water distribution system comprises a water drip system.

31. The system of claim 26, further comprising plant seeds disposed in the cover, with the proviso that the system does not contain substantial quantities of soil.

32. A method for producing a water retaining mat comprising:
   a) providing a first layer of a fabric; and
   b) impregnating one or more fibers of the first layer with a cross-linked super absorbent polymer.

33. The method of claim 32 further comprising:
   c) providing a layer of water-impermeable root barrier material adjacent to a first surface of the first layer.

34. The method of claim 33 further comprising:
   d) providing a layer of non-woven fabric; having a first surface thereof adjacent to a second surface of the first layer.

35. The method of claim 34 further comprising:
   e) providing a fourth layer of cellulosic material adjacent to a second surface of the layer of non-woven fabric.

36. The method of claim 32 further comprising sensing the amount of moisture present in the first layer.

37. The method of claim 36 further comprising delivering water to the first layer.
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FIG. 3
### A. CLASSIFICATION OF SUBJECT MATTER

**IPC 7** E04D11/00 E04D13/16 E04D5/10

According to International Patent Classification (IPC) or to both national classification and IPC

### B. FIELDS SEARCHED

Minimum documentation searched (classification system followed by classification symbols)

**IPC 7** E04D B32B

Documentation searched other than minimum documentation to the extent that such documents are included in the fields searched

Electronic database consulted during the international search (name of data base and, where practical, search terms used)

EPO-Internal

### C. DOCUMENTS CONSIDERED TO BE RELEVANT

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**X** Further documents are listed in the continuation of box C.  
**X** Patent family members are listed in annex.

* Special categories of cited documents:

- **A** document defining the general state of the art which is not considered to be of particular relevance
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Date of the actual completion of the international search: 21 December 2001

Date of mailing of the international search report: 04/01/2002

Name and mailing address of the ISA

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Authorized officer: Righetti, R
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3 November 1998 (1998-11-03)  
column 3; figures ____ | 1,4 |
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