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(54) **INTEGRATED ENERGY-EFFICIENT ROOFING**

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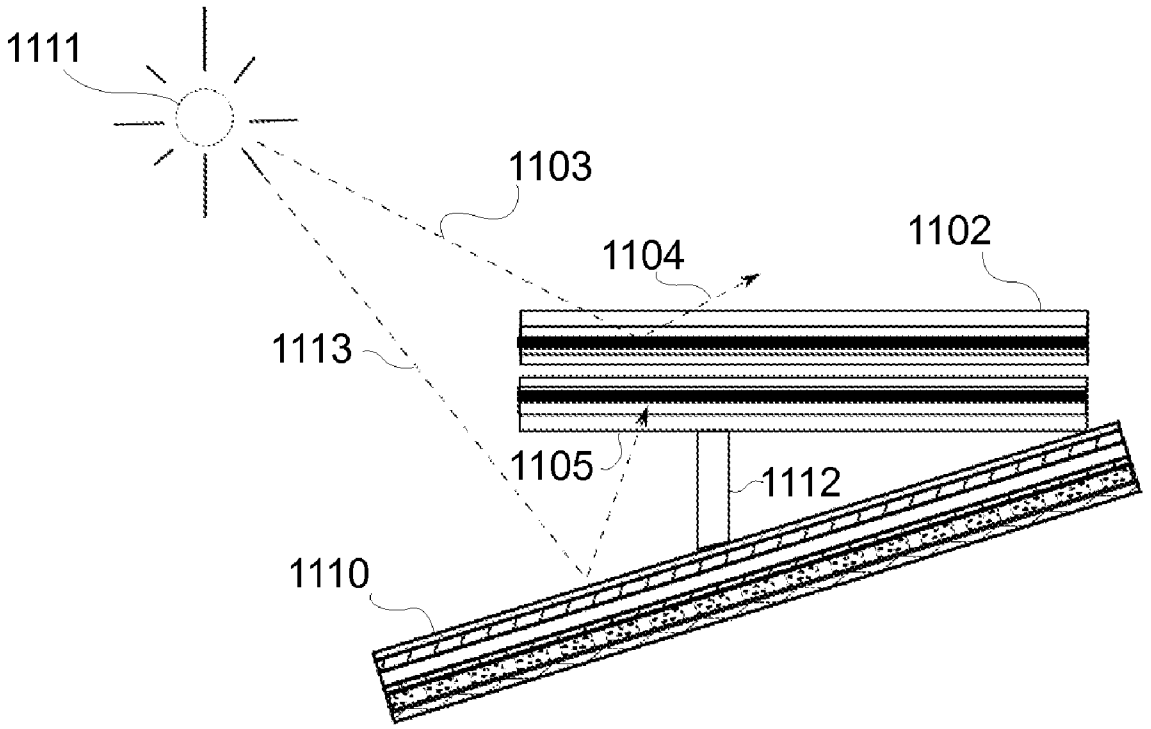
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(57) **ABSTRACT**

Integrated multi-layer roofing that includes energy-conserving reflective layers and insulation can be pre-fabricated in sheets, panels, or even complete pre-sized roofs. Recycled polymers can be used for some or all of the layers, and other recycled materials such as fiberglass can be used in the insulating layer. Some versions of this integrated roofing can be installed directly over roofing beams, greatly reducing the time and expense of installation. The polymer construction makes this roof lightweight and long-lasting. The reflective properties allow for increased energy capture by solar panels and reduce the ground-level effects of greenhouse gases in the atmosphere.



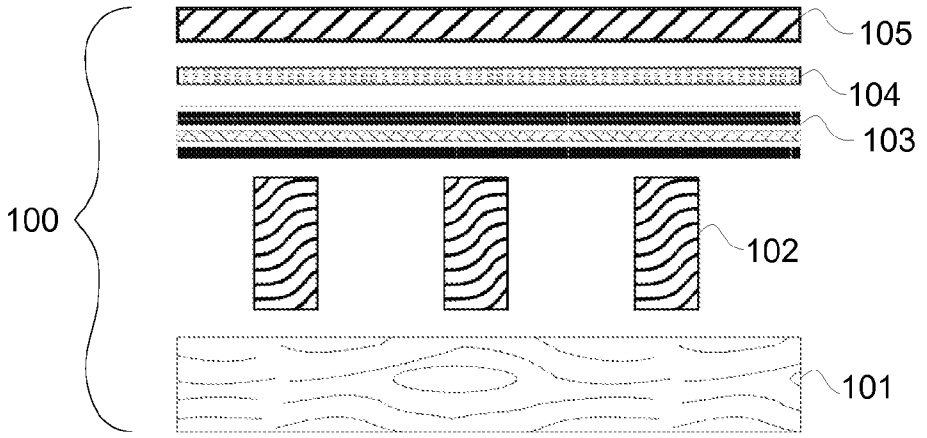


FIG. 1 (Prior Art)

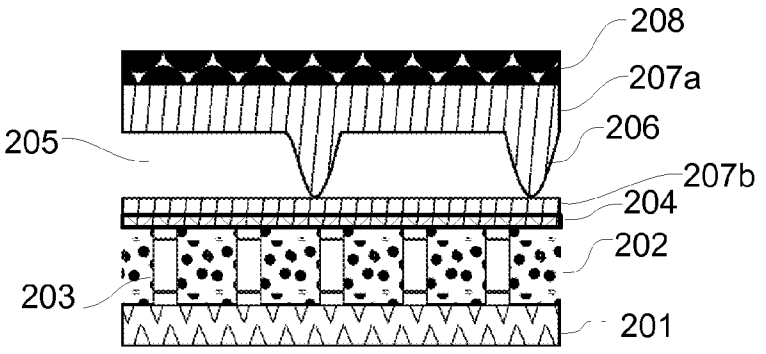


FIG. 2

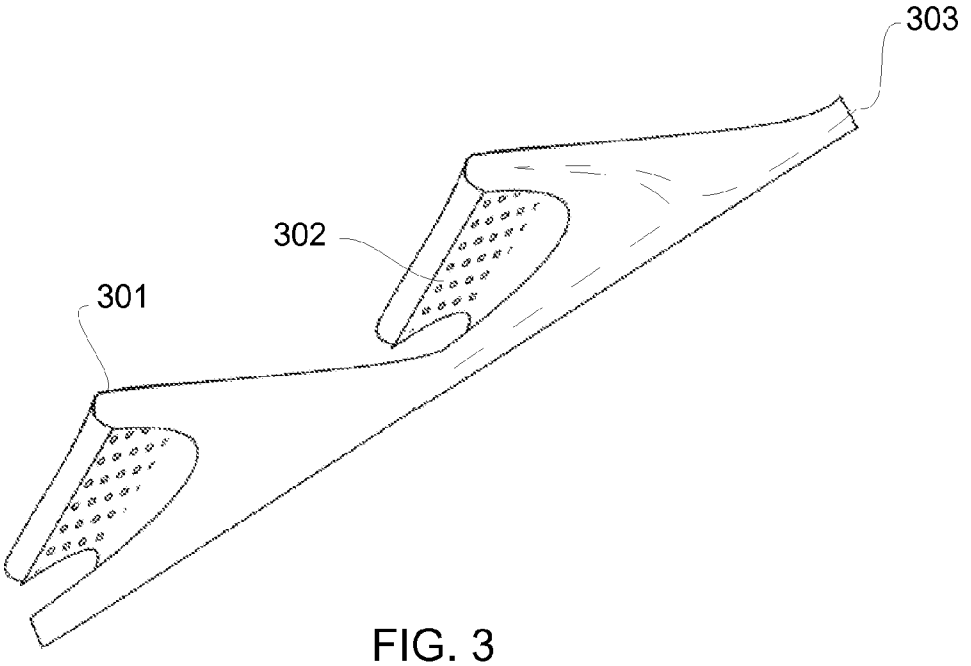


FIG. 3

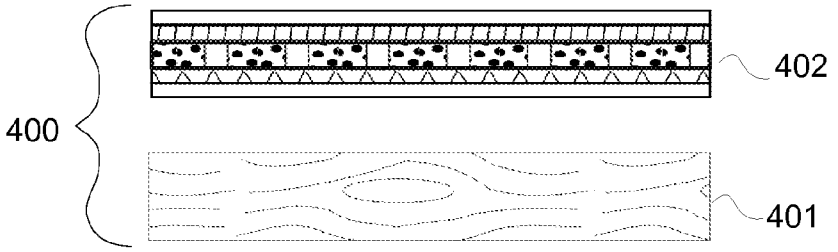


FIG. 4

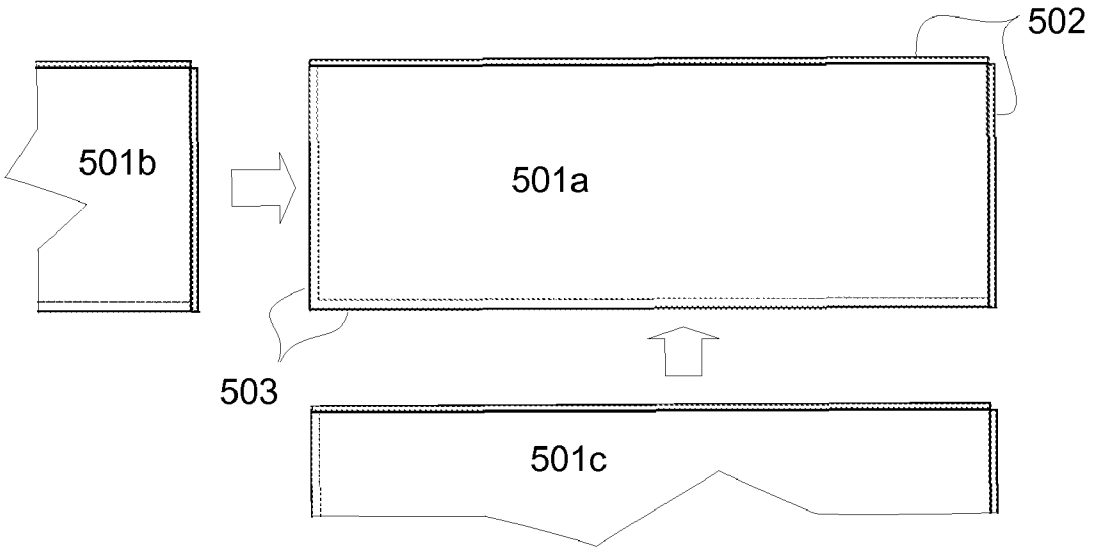


FIG. 5

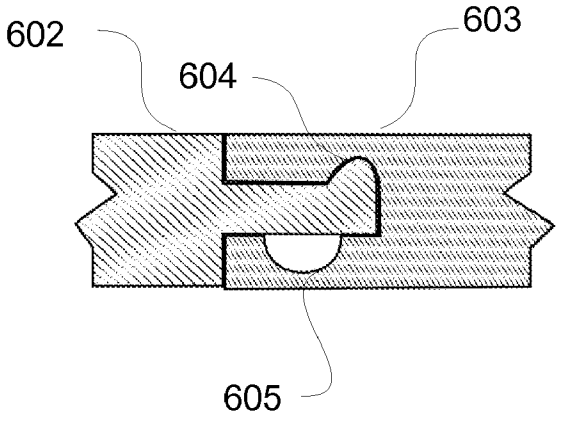


FIG. 6

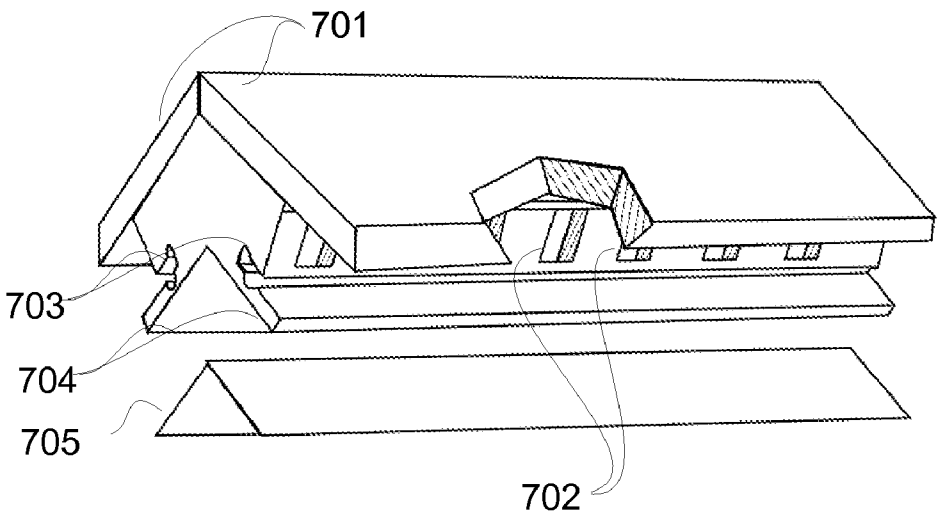


FIG. 7

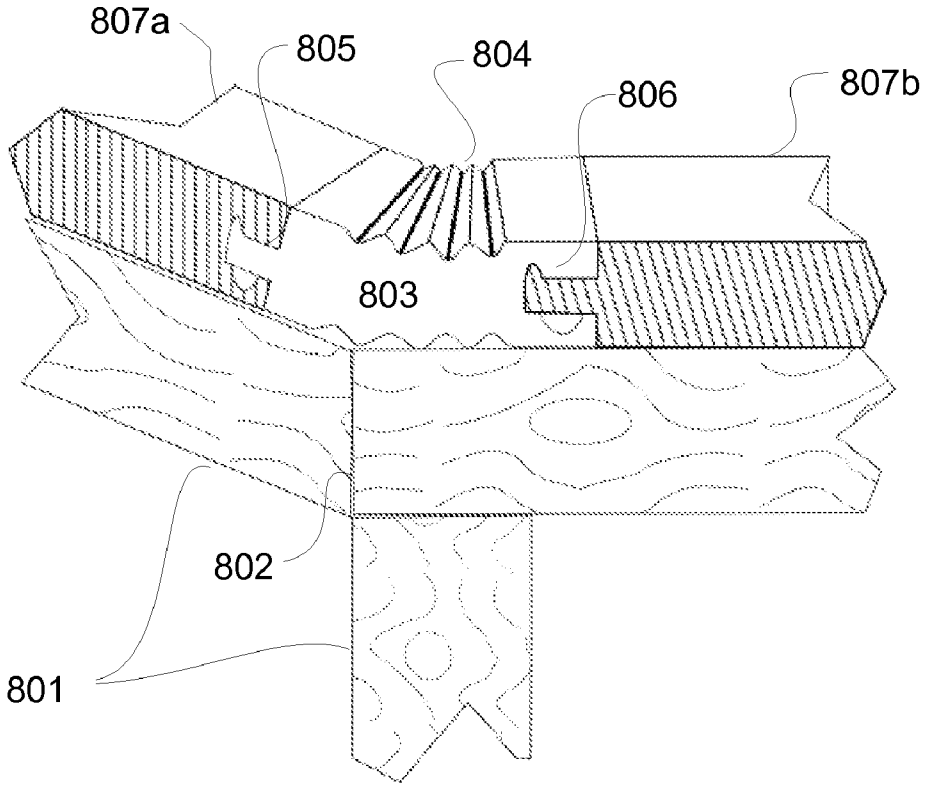


FIG. 8

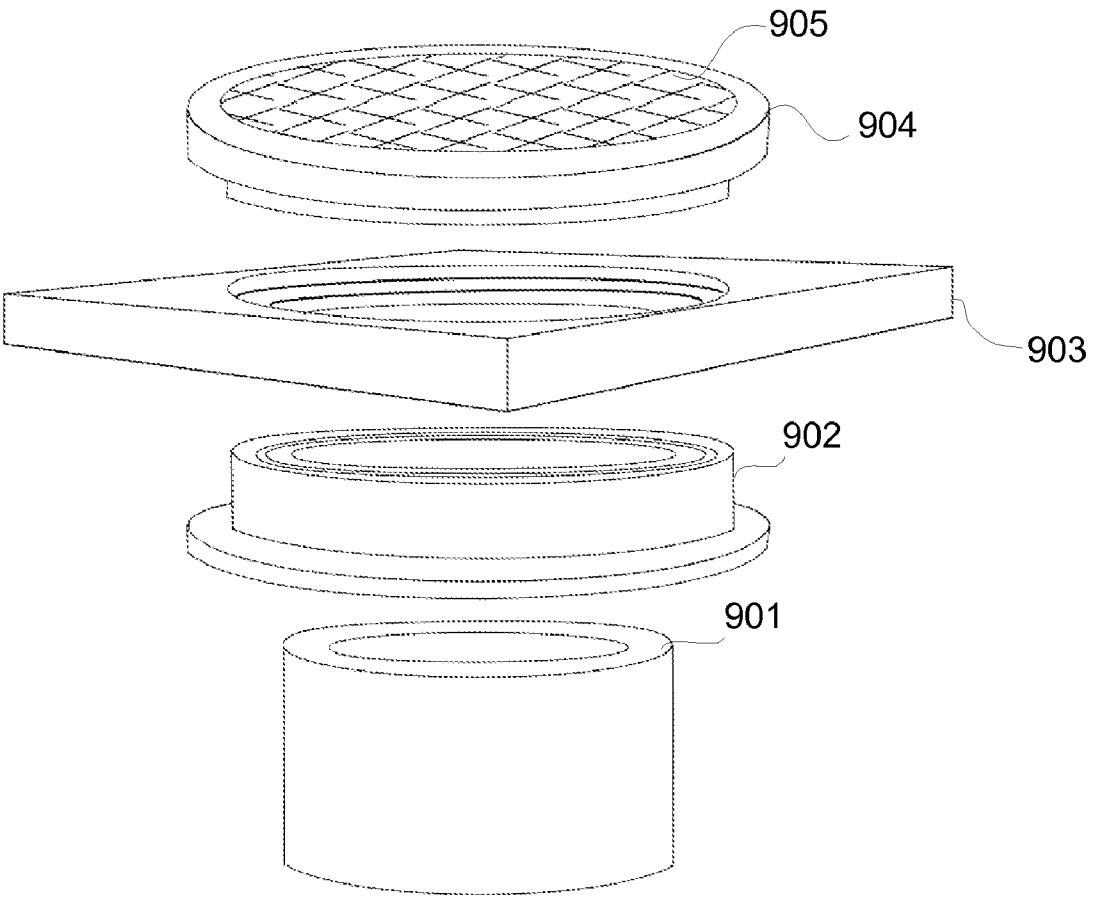


FIG. 9a

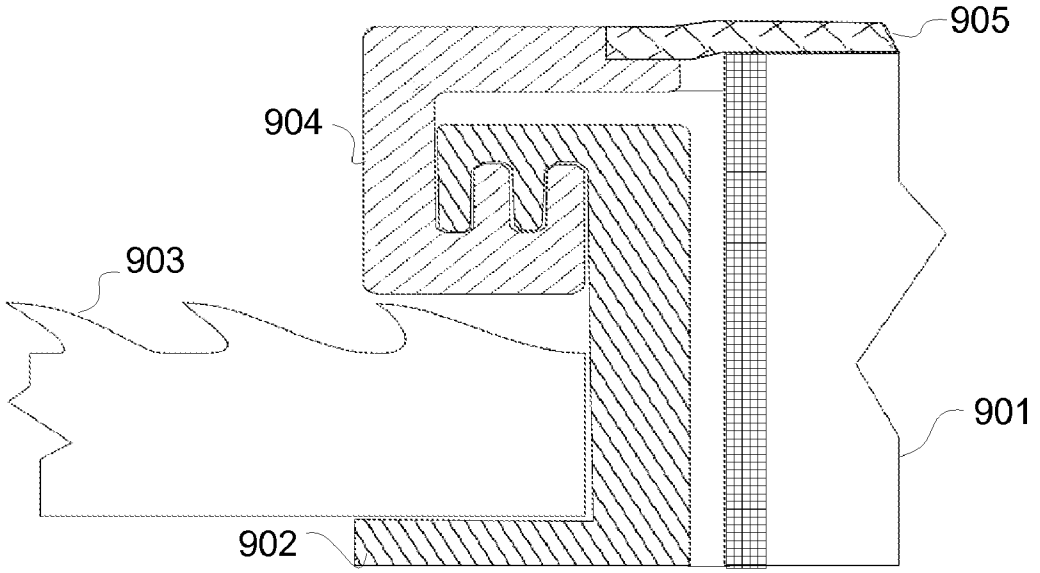


FIG. 9b

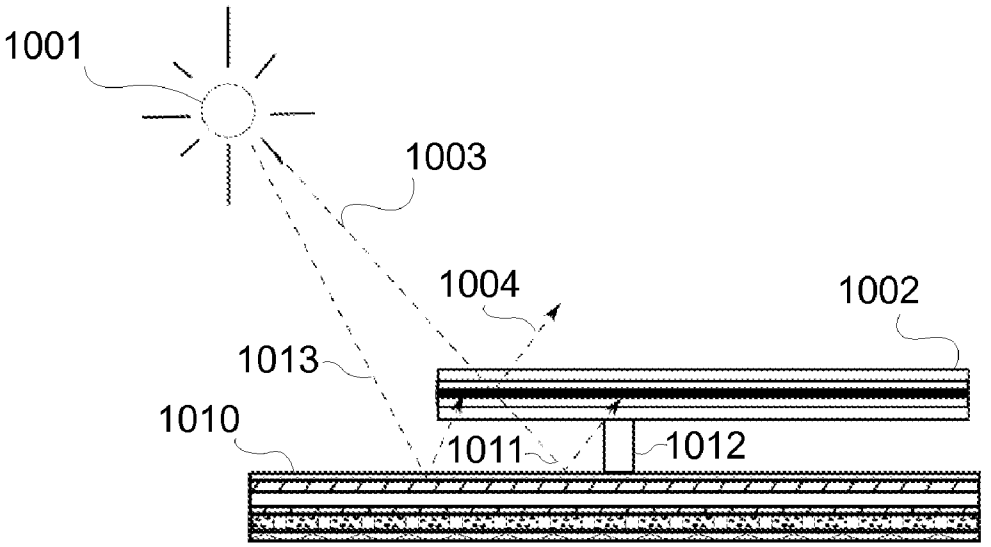

1001
1003
1004
1002
1013
1010
1011
1012

FIG. 10

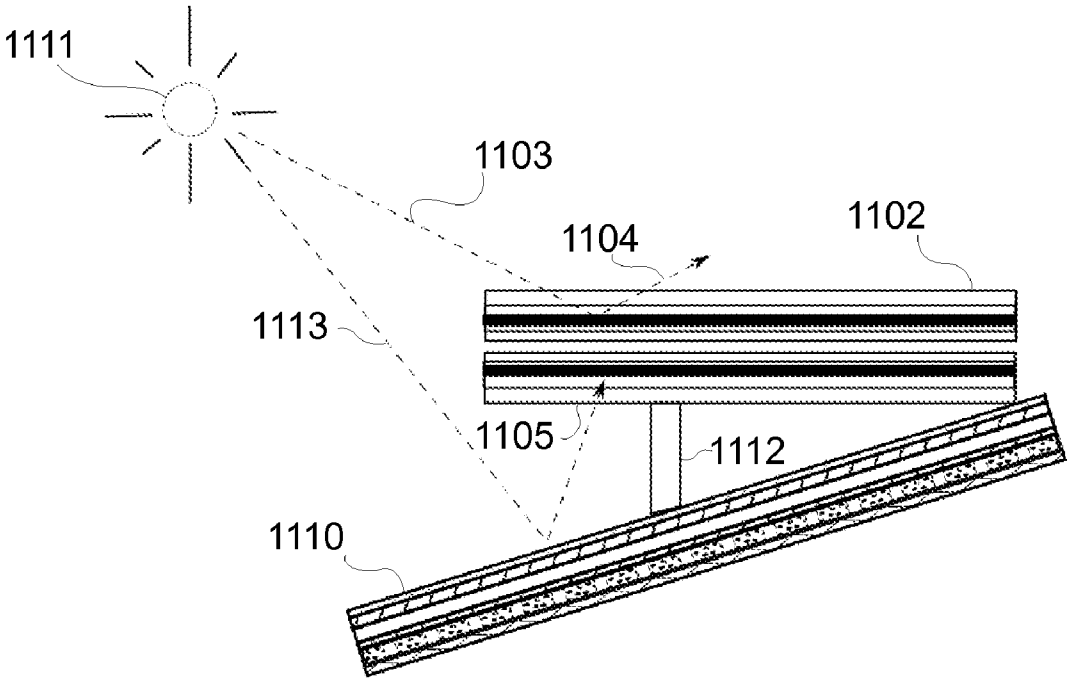

1111
1103
1104
1102
1113
1105
1112
1110

FIG. 11

INTEGRATED ENERGY-EFFICIENT ROOFING

RELATED APPLICATIONS: None

FEDERALLY SPONSORED RESEARCH AND DEVELOPMENT: None

APPENDICES: None

BACKGROUND

[0001] Related fields include roofing material for construction; particularly roofing that includes flexible material and reflective "cool" roofing.

[0002] Roofing, an essential element of any type of shelter, presents excellent opportunities for energy conservation in climate-controlled structures. Where the inside of the structure needs to be kept warmer than its surroundings, the roof can be designed to trap internal heat and absorb incident sunlight to convert to heat. Where the inside of the structure needs to be kept cooler than its surroundings, the roof can be designed to dissipate internal heat and reflect incident sunlight.

[0003] Roofing also presents opportunities to reduce the impact of an increasing human population on the natural environment. Use of recycled materials reduces landfill content. Reducing the use of lumber reduces the need for timber harvesting. Reducing the use of lumber may also may reduce the risk of spreading fire among densely packed residences, since wood is naturally flammable and building lumber is often untreated for flame retardance. Eliminating or carefully isolating toxic content keeps toxics out of the local soil and water. Roofing with a longer useful life reduces the demand for replacement. According to a 2008 Lawrence Laboratories study published in the *Climate Change* journal, every 1,000 square feet of solar-reflective roofing can offset 10 tons of carbon-dioxide emission. Energy-saving building design can also reduce greenhouse emissions from the power plants that would otherwise operate at higher capacity to fuel internal climate control.

[0004] Besides reducing the burden on the environment, roofing presents opportunities to reduce the total cost of new construction. If construction materials and/or labor can be made less costly, buildings become affordable to a wider range of would-be homeowners and entrepreneurs, improving the local economy, standard of living, and social stability.

[0005] Typical conventional roofing is fairly complex to install, although the materials and processes are well known. FIG. **1** illustrates an example. A common type of roof **100** is constructed by attaching several layers of different materials to a framework of beams **101**. First a more closely spaced array of supports **102** is installed. Underlayer **103** defines the continuous roof surface and may include insulation, or the insulation may be placed in the gaps between supports **102**. Vapor-seal **104**, typically a flexible membrane, is attached above underlayer **103**. Shingles or roll roofing **105** makes up the top layer, providing durability and esthetic appeal. The installation of these multiple layers is fairly labor-intensive, and its scheduling generally relies on the timing of multiple deliveries from the separate suppliers of the individual layers. Any late delivery can "gate" the whole process; the inner layers because they must be installed first, and the outer layer because some of the inner layers could be damaged by prolonged exposure to weather after unprotected installation.

[0006] Various approaches have been taken to make roofing reflect more solar radiation. So far, the most widely commercialized are light-colored paints or foams. Paints are typically low-cost, though the advertised reflectivity figures of 70-80% may not apply across the entire solar spectrum, particularly under typical dusty outdoor conditions. Foams can also help insulate the roof, but are often fragile and relatively short-lived (needing re-spraying in 5 years, compared to the 9-15 year life of typical conventional roofing. Also, some foams and paints may contain toxic chemicals, requiring extra precautions to keep them contained during installation. Some existing "cool roofs" based on a white or light-colored paint or foam coating lose their solar reflectivity as atmospheric dust builds up, but are too delicate for vigorous or frequent cleaning. Such roofs may also be damaged if stepped on, as for cleaning a chimney or dryer vent, or adjusting an aerial antenna or satellite dish.

[0007] Likewise, roofing made of various recycled materials has been developed. Typically, the materials recycled are other construction materials such as asphalt, bitumen, concrete and fiberglass. While this is beneficial, these materials may not be readily available in new or expanding communities unless demolition on a similar scale has recently happened nearby. Their weight also adds to the expense of transportation to and from the recycling site. It would be more desirable to recycle a problem material that is discarded more continuously and is easier to transport. Lighter weight would also decrease the demands on the strength of the underlying structure, potentially enabling the use of less material or less-expensive material.

[0008] Both reflective roofing and roofing that incorporates recycled material have also encountered acceptance barriers based on esthetics. Apparently, although conserving energy and protecting the environment are popular high-profile goals, strict standards of traditional appearance trump them both in neighborhood-association decisions.

[0009] In light of all the above factors, a more integrated type of roofing that is simpler to install and uses recycled plastics would help conserve energy, protect the environment, and make construction and structure ownership more widely affordable. Leeway for customization of its appearance to meet local community standards would increase its chances of acceptance, thus increasing its economic value.

SUMMARY

[0010] This integrated roofing features reflective, moisture-blocking, insulating, and esthetic layers fabricated into a single sheet or panel. Installation is highly simplified by replacing the usual multiple disparate layers with a single integrated layer that may also be larger in area than conventional roofing components. Reflective features prevent excess solar absorption. A fumed outer surface with heat-release perforations helps the roofing dissipate heat from radiation that is absorbed, or excess heat absorbed from other sources. Some of the layers can be fabricated from recycled plastics.

[0011] The sheets or panels can be designed to be joined and trimmed in various ways during installation. Compatible ancillary fittings such as ridge caps and pipe sealers can be made for this roofing. For applications where large numbers of identical or similar structures will be made (housing developments, business parks, mobile homes, monitoring stations), whole roofs (or subsections sized for transport by truck

or rail) can be manufactured, tested at the factory, then simply hauled into place with cranes or winches and anchored at the site.

BRIEF DESCRIPTION OF THE DRAWINGS

[0012] FIG. **1** illustrates how the components of a common type of conventional roofing are installed on the structure frame.

[0013] FIG. **2** illustrates an example set of layers constituting an integrated roofing sheet.

[0014] FIG. **3** illustrates an example of structural heat-control features in the integrated roofing.

[0015] FIG. **4** is an exploded cross-sectional view of how the integrated roofing is installed.

[0016] FIG. **5** is a conceptual top view of individual roofing panels fitting together.

[0017] FIG. **6** is a cross-sectional view of a possible pair of mated panel-edge features.

[0018] FIG. **7** illustrates an example of a ridge cap suitable for joining integrated roofing panels together at the ridge of a pitched roof.

[0019] FIG. **8** shows an example of an adaptor that would allow integrated roofing to be installed where the roof pitch changes.

[0020] FIG. **9***a* is an exploded view of one type of pipe sealer compatible with the integrated roofing.

[0021] FIG. **9***b* is a magnified cross-section of an assembled pipe sealer showing one possible mating feature design.

DETAILED DESCRIPTION

[0022] This description will discuss (1) the structure of the integrated roofing, (2) possible fabrication methods, (3) compatible accessory parts, (4) installation options, and (5) specific benefits of its use.

[0023] FIG. **2** illustrates some example component layers of the integrated roofing. Underlayer **201**, which can include recycled plastic or recycled fiberglass, is textured on the bottom for easy installation over beams; it can slide across the beams when pushed or pulled for exact positioning, but is not so slippery that it will slide out of place by itself on pitched roof beams. Like the plywood it replaces, it adds stiffness to support the sheet or panel between beams (unless the combination of the other layers contributes sufficient stiffness). Underlayer **201** also seals in a layer of insulation **202**, which may include recycled insulating material or phase-change material. If the insulation is easily deformable (e.g. fiberglass batting), an array of sturdy supports **203** can maintain a constant thickness of insulation **202** between underlayer **201** and vapor barrier **204**. Support array **203** can also contribute part of the necessary stiffness in the plane of the roofing sheet; for example, if the support array takes the form of interconnected cells, such as a honeycomb or other grid structure. Above vapor barrier **204**, a reflective layer **207***a* reflects incoming solar radiation and an outer layer **208** protects the rest of the layers from environmental wear. An optional air gap **205** under reflective layer **207***a* adds more insulating value, its width maintained by an array of air gap supports **206**. An optional second reflective layer **207***b* can also be inserted under air gap **205** and above vapor seal **204**. Second reflective layer **207***b* may or may not reflect the same part of the solar spectrum as first reflective layer **207***a*. If desired, outer layer **208** can be textured to resemble any kind of traditional roofing (for example, shingles, tiles, or tar-and-gravel) or to complement modem architecture.

[0024] A number of approaches can be taken to customize the color of this integrated roofing to fit the esthetic needs of architects or neighborhood associations, and render that color durable under prolonged weathering and occasional cleaning. The outer layer **208** can be a clear polymer, transparent across the entire visible spectrum, and the color can be that of reflective layer **207***a*, **207***b*, or a combination if **207***a* is partly translucent. Outer layer **208** can alternatively be a transparent color (for example, the red of Spanish tile) and still allow most sunlight to pass through to be reflected by reflective layers **207***a* and **207***b*. Color in outer layer **208** may also be applied as distributed dots, stripes, or other shapes separated by transparent interstices. Sunlight passing through the interstices is reflected by reflective layers **207***a* and **207***b*. However, an observer looking up at an angle from some distance away (the sidewalk, street, or neighbor's yard) would see a solid-colored roof, similar to the way an array of half-tone dots in a newspaper photo can appear as a solid shade of gray. If the color is mixed or laminated into reflective layer **207***a*, reflective layer **207***b*, or outer layer **208**, it will be impervious to pressure-washing and other low-cost methods of cleaning, and it will stand up to any foot traffic necessary for maintenance, repair, or seasonal decoration An ultraviolet-blocking additive may optionally be added to outer layer **208** to relax the need for inner layers to resist UV degradation and allow a wider variety of recycled plastics to be used in those layers.

[0025] Moreover, if the roof beams will be exposed inside the structure rather than covered with a dropped ceiling or the like, underlayer **201** can also be esthetically colored or textured.

[0026] A number of manufacturing options are feasible. The best choice will depend on the exact nature of the polymers and any other materials, and those with experience in manufacturing with those materials will be able to knowledgeably choose among the candidate methods. Underlayer **201**, made of plastic, fiberglass, or both, can initially be formed by molding, webbing, or other suitable methods. If insulation **202** is loose (e.g., pellets of recycled Styrofoam™ or similar material), then a honeycomb or other cell-based support array **203** can be molded as part of, or initially adhered to, underlayer **201**; insulation **202** can be poured into the cells and any overfill skimmed off; and vapor barrier **204** can be adhered onto the tops of the cell walls, closing the cells and sealing the loose insulation inside. If insulation **202** is a deformable mat such as recycled spun fiberglass with or without included pellets of foam or fragments of polymer, support array **203** may take the form of standoffs to prevent deformation of the integrated roofing. These standoffs can be made as part of underlayer **201**, insulation layer **202**, or vapor barrier layer **204**. If insulation **202** is expected to hold its shape easily for decades under the expected static and dynamic loading (for example, recycled bottle plastic with air bubbles or foam pellets inserted in the melt), then supports **203** may not be needed. Outer layer **208** may be molded or vacuum-formed to provide the desired outer texture. Reflective layers **207***a* and **207***b* may be similarly formed, or may be applied as liquids on the lower surface of outer layer **208** and the upper surface of vapor barrier **204**. If both reflective layers are applied as liquids, air-gap supports **206** could be formed onto, or adhered to, vapor barrier **204** or outer layer **208** and protrude beyond the liquid-coated surface. Layers or sets of layers can be reheated and adhered together by localized surface melt-

ing, or cemented together, in either a continuous process or a batch process. Straps or tabs for attaching the roofing element to the underlying structure's beams may be attached to underlayer **201** by a suitable method at a suitable stage in the manufacturing process.

[0027] FIG. **3** illustrates an example of structural heat-control features in the integrated roofing. Fin shapes **301** dissipate heat by increasing the effective surface area of the roofing, like fins on a heat-sink. Heat-escape perforations **302** prevent heat from being stored in the roofing and allow the air pressure in the air gap layer to equilibrate with the outside. The fins need not be esthetically distracting to a viewer passing by; they need only be a few inches or cm high, on the order of the thickness of a traditional shake shingle. The characteristics of the fins, along with the texture of the top layer, can be varied to resemble many types of traditional roofing such as Spanish or Oriental tile, asphalt, slate, shake, etc. The fins and perforations can be molded or vacuum-formed into the outer and/or reflective layers, or the upper layers (outer and/or reflective) can be formed as a longer sheet, perforated at intervals, then folded along a fold line such as **303** to form the fins, and the finned structure attached to non-folded lower layers A wide variety of recycled plastics can be incorporated in the various layers, including some of those already encumbering landfills.

[0028] FIG. **4** is an exploded cross-sectional view of how the integrated roofing is installed. Roof **400** is constructed by attaching integrated sheet or panel **402** directly to beams **401** using aluminum straps or fiberglass tabs attached to or integrated with the underlayer, or using construction glue. This is a much faster and less laborious process than constructing the conventional roof of FIG. **1**; the entire roof would be installed in the same time it now takes to install the traditional plywood underlayer and vapor-seal membrane. Also note that the only lumber used is in the underlying beams. These beams need not be as strong as those under a traditional roof because the integrated roofing is significantly lighter in weight; this can reduce the demands on the thickness or grade of lumber in the beams as well, or make aluminum beams a more practical option. Both these factors reduce the demands for timber harvesting that causes deforestation.

[0029] FIG. **5** is a conceptual top view of individual roofing panels fitting together. Preferably they should not need an adhesive liquid such as tar or silicone, because of containment issues during installation and also because such sealants often fail well before the surrounding components. In the illustrated version, panel **501***a* is pre-fabricated in a convenient size, for example 1×2 m or 4'×8'. Two adjoining edges have one type of mating feature **502** (for example, a ridge) and the other two adjoining edges have a complementary mating feature **503** (for example, a channel into which ridge **502** drops, presses, slides, or snaps). When other panels **50** lb and **501***c* are positioned with the same orientation of mating features as **501***a*, the ridges of **501***b* and **501***c* can be mated with the channels of **501***a*. The vapor-barrier layer of the roofing panel extends into all the mating features, so that a double-layered vapor barrier is produced at the join. The outer and reflective layers extend over the topmost mating feature (in this example, the top of channel **503**) so that neither the solar reflectivity nor the visual texture is interrupted at the join.

[0030] FIG. **6** is a cross-sectional close-up view of a possible pair of mated panel-edge features. Ridge **602** includes locking tongue **604**. Channel **603** includes a locking groove to accommodate tongue **604** and a drainage groove **605** to channel any runoff, condensation, or other moisture that may enter the interface. Small variances to allow for thermal expansion and contraction are designed into the mating features to prevent buckling or leaking as external temperatures change.

[0031] In other embodiments, the mating features can be identical on all four edges to minimize the need for maneuvering panels into a particular orientation. A solid mating strip, which may also be fabricated from recycled plastic, can be used in some designs to help exclude and/or channel moisture.

[0032] Various compatible fittings can be made to finish off the roof and accommodate roof-mounted features. FIG. **7** illustrates an example of a ridge cap suitable for joining integrated roofing panels together at the ridge of a pitched roof. Top flanges **701** shed runoff and conceal underlying heat-escape channels **702** for a smooth appearance. Interlock features **703**, shown here as channels similar to FIG. **6**'s channels **603**, enable attachment to roofing sheets. Bottom flanges **704** may optionally be flexible to conform to different angles of roof ridge **705**.

[0033] Some roofs change pitch in places other than the peak ridge, for example over dormers or verandas. FIG. **8** shows an example of an adaptor that would allow integrated roofing to be installed where the roof pitch changes. Beams **801** change angle at vertex **802**. Adapter **803** is placed with flexible section **804** over vertex **802**. Adapter **803** has mating features such as ridge **805** and channel **806** to mate with complementary features on adjacent roofing sheets or panels **807***a* and **807***b*.

[0034] Other fittings, such as edge caps or gutter interfaces, can be constructed similarly to the edge caps and angle adaptors.

[0035] Pipes extending through roofs must often be accommodated. FIG. **9***a* is an exploded view of one type of pipe sealer compatible with the integrated roofing. Over pipe **901** fits rigid flange **902**, which may be sealed around the pipe with outdoor silicone or any other construction-grade sealant compatible with plastic. Rigid flange **902** extends through and beyond a hole in roofing sheet or panel **903**. Flexible flange **904** fits over the end of pipe **901** and mates to rigid flange **902**. Self-sealing gasket **905**, flush with the top of flexible flange **904**, seals the end of pipe **901**. Weatherstripping, silicone, or other types of sealant can be used between the pipe sealer and adjoining roof panel(s).

[0036] FIG. **9***b* is a magnified cross-section of an assembled pipe sealer showing one possible mating feature design. The part numbers in FIG. **8***b* correspond to the same parts as the like numbers in FIG. **9***a*. The stem of rigid flange **902** extends past the fin features of roofing **903**, and is sealed to the roofing with exterior-use silicone or a similar compatible seal. Flexible flange **904** flexes to snap over rigid flange **902**. Self-sealing gasket **905**, which is even more flexible than flexible flange **904**, deforms to seal top of pipe **901**.

[0037] An alternate mating feature design enables a flexible flange with a diameter about the same as that of the rigid flange, saving space where other roof features are close to the pipe. This type of flexible flange would have one or more bottom ridges that press-fit down into corresponding channels in the rigid flange. Weatherstripping or an equivalent extra seal can be added if needed.

[0038] Besides being installed directly over the beams of a new structure as has been described, this integrated roofing can also be installed over a worn-out or damaged traditional roof without needing to strip and dispose of all the existing

materials. Also, as briefly mentioned earlier, a complete roof (or the largest subsections that can be easily transported) can be pre-fabricated with no seams or with factory-sealed seams. Installation then consists of merely winching the roof into place and anchoring it, and the opportunities for leak formation are minimized. This approach can be low-cost if economy of scale is available, as with planned developments or movable structures where a single design will fit a large number of constructed units.

[0039] Because this integrated roofing is both reflective and durable, it can enhance the efficiency of solar panels positioned to receive either direct sunlight or sunlight reflected from the roof.

[0040] One advantageous combination is a reflective roof with a partially transparent thin-film solar panel. Thin-film-based solar panels are less expensive and make better use of diffuse sunlight than wafer-based panels, but they are not as efficient because not all the sunlight is absorbed on a single pass through the film. This is mainly because the film is so thin; the absorption spectrum of the material would convert more light to electricity if the light could travel a longer distance through the material. If the solar panel is at least partially transparent, for example if both the front and back electrodes are fabricated from a transparent material such as a tin oxide or zinc oxide, unabsorbed light passing through the back of the solar panel bounces back off the reflective roof surface and into the panel again, where more of it can be absorbed and converted to useful electricity.

[0041] FIG. **10** conceptually illustrates how the roof could increase efficiency in a semitransparent thin-film solar panel. Although the illustrated roof **1010** is flat, this configuration can also be effective with a pitched roof. Sun **1001**, in the illustrated position, illuminates semitransparent solar panel **1002** in the usual way with, for example, ray **1003**. Some of the light is converted to electricity, some is reflected as ray **1004**, and some passes through the panel as ray **1011**. Ordinarily, transmitted light such as ray **1011** would be lost, but reflective roof **1010** bounces ray **1011** back into panel **1002** where it has a second chance to be converted, Now consider ray **1013** that would ordinarily miss panel **1002** entirely. If panel **1002** is offset from roof **1010** by standoff **1012**, the reflection of ray **1013** from roof **1010** bounces into panel **1002** where it can be converted. From this diagram, one skilled in the art can infer that there will be some times of day when, due to the angle between the sun and the roof, more of the light will behave like ray **1013**, initially missing panel **1002** but being reflected toward it by roof **1010**. The reflective roof thus increases the productivity of the solar panel over the course of the day without requiring an expensive "sun-tracking" panel mount.

[0042] "Back-to-back" mounting of solar panels is another way to leverage the roof reflectivity into more solar power from a smaller area. In the example of FIG, **11**, a back-to-back pair of panels **1102** and **1105** is mounted at a pitch angle shallower than that of the reflective roof **1110**, by using stand-off **1112**. This enables the use of the more common opaque-backed panels. Top panel **1102** picks up the direct light **1103** from sun **1111**; some of this light is reflected as ray **1104** and some is converted. Bottom panel **1105** picks up the light **1113** reflected from roof **1110**. This configuration allows top panel **1102** to be a different type of panel from bottom panel **1105**. For example, if roof **1110** is a diffuse reflector (acting more like a movie screen than a mirror), top panel **1102** could be a crystalline photovoltaic panel that is very efficient at converting direct light, while bottom panel **1105** could be a thin-film panel that captures diffuse light more effectively. One or both of the panels might even be solar-thermal, with the heat-exchange pipes being sandwiched between panels **1102** and **1105**.

[0043] Besides being economical to manufacture, unburdening the environment by incorporating recycled plastics, offsetting greenhouse gas effects by reflecting sunlight, installing quickly and inexpensively, and being adaptable to local community architectural tastes, this integrated roofing has a potentially longer useful life than many traditional roofs. The same very slow rate of decomposition that makes plastics so burdensome in landfills is an advantage in structural components. Plastic is not subject to rot and will not support the growth of toxic mold as wood does. Every year that the roof remains functional prevents the material and energy expenditure of replacing it, as well as the environmental impact of disposing of it. The built-in interlocking features allow individual sheets or panels to be replaced in the field if they are damaged, without needing to replace the entire roof If the owner wishes to change the look, a new top layer can be applied to the existing sheets or panels. Furthermore, part or all of this roofing can be recycled again when it does finally reach its end-of-life.

[0044] Those skilled in the art will recognize that many variations of this integrated roofing are possible by minor variations on the descriptions and drawings presented here. Therefore, the reader should note that only the claims, rather than any other part of this document, limit the scope of the invention.

We claim:

1. A roof, comprising:
an underlayer,
an insulation layer above the underlayer,
a vapor barrier layer above the insulation layer,
a first reflective layer above the vapor barrier layer, and
an overlayer above the first reflective layer,
where:
all the layers are integrated into a single sheet during manufacturing,
the composition of at least one layer comprises a recycled polymer,
the upper surface of the sheet comprises a plurality of fins, and
a surface of at least one of the fins is perforated with holes.

2. The roof of claim **1**, where the integrated sheet is sufficiently stiff to keep its shape when installed directly over standard roofing beams.

3. The roof of claim **1**, further comprising a solar panel mounted above the roof at an angle to receive and process sunlight reflected from the first reflective layer at an expected position of the sun relative to the roof

4. The roof of claim **1**, further comprising
a second reflective layer between the first reflective layer and the outer layer, and
an air-gap layer between the first and second reflective layers.

5. The roof of claim **4**, where the air gap is maintained by an array of stand-offs.

6. The roof of claim **4**, further comprising a solar panel mounted above the roof at an angle to receive and process sunlight reflected from at least one of the first and second reflective layers at an expected position of the sun relative to the roof.

7. The roof of claim **1**, where the insulation layer comprises an insulative filling enclosed in insulation cells.

8. The roof of claim **1**, where

the layers comprise a sheet with interlocking features, and

the interlocking features are designed to mate with interlocking features on other sheets and additional fittings.

9. The roof of claim **8**, where the dimensions and materials of the interlocking features are chosen to accommodate the expected thermal expansion and contraction of the interlocked sheets and fittings without leakage or buckling

10. The roof of claim **9**, where at least one of the interlocking features comprises a drainage channel.

11. The roof of claim **9**, where the fittings comprise at least one of

a ridge cap comprising vents that allow heat to escape;

a pipe sealer comprising

a rigid bottom section,

a flexible top section, and

self-sealing gasket; and

an angle adapter comprising at least one flexible section capable of flexing in at least one dimension.

12. The roof of claim **1**, where the outer layer has at least one of:

an additive to protect the roof from ultraviolet damage,

a pigment to provide esthetic coloration, and

an esthetic texture.

13. The roof of claim **12**, further comprising a separately manufactured outer layer configured for installation on top of the existing roof.

14. The roof of claim **1**, where the layers are fabricated into a complete roof with dimensions to fit a predetermined structure.

15. The roof of claim **1**, where at least one of the layers is recycled at the end of the useful life of the roof.

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