# United States Patent [19]

**Peterson**

[11] **3,862,527**

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[54] **ROOF CONSTRUCTION**


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[73] Assignee: **Harry S. Peterson Company,** Pontiac, Mich.



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[52] **U.S. Cl.** ..... **52/94,** 52/262, 52/302, 52/309, 52/408, 52/747

[51] **Int. Cl.** ..... **E04d 3/26,** E04d 3/32

[58] **Field of Search** ..... 52/302, 262, 303, 60, 309, 52/409, 410, 94, 95, 408, 747



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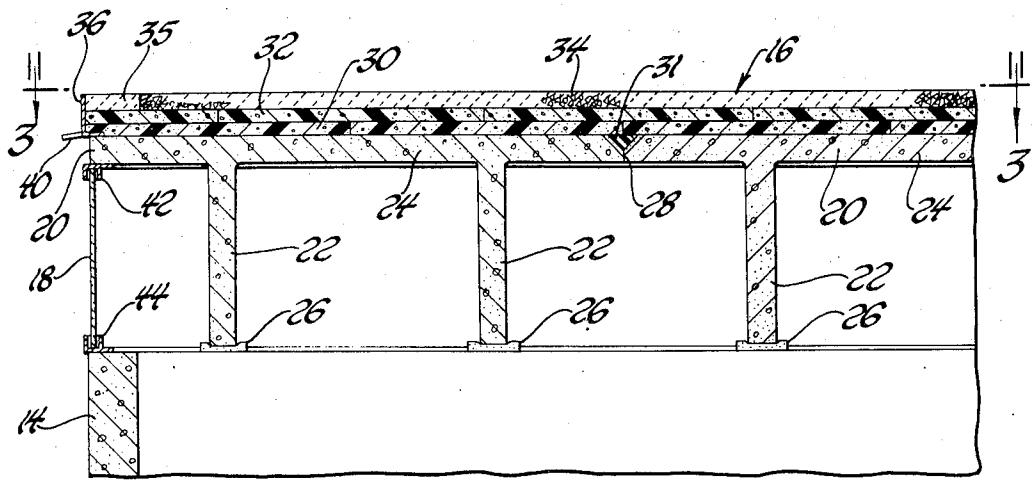
[57] **ABSTRACT**

A roof construction for flat roof industrial buildings and the like wherein the roof deck comprises a plurality of structural members such as prestressed concrete tees or slabs disposed in side-by-side abutting relationship on top of and spanning the walls of a building. Small cracks in and joints between the concrete members are discretely filled and sealed using an elastomeric sealant material. Rigid polystyrene foam boards are placed on top of the concrete members without the use of any adhesive or other sealing membrane. The edges of the polystyrene board may be staggered between layers so that the edges or seams between the adjacent boards do not line up. Finally, a layer of crushed stone is placed on top of the polystyrene boards to weight them down and prevent ultraviolet ray damage. An aluminum angle member is secured around the periphery of the roof deck to maintain the roof construction components in place. In the illustrated embodiment, a line of windows is secured by means of aluminum strips in the space between the tops of the walls and the roof deck.


**5 Claims, 3 Drawing Figures**



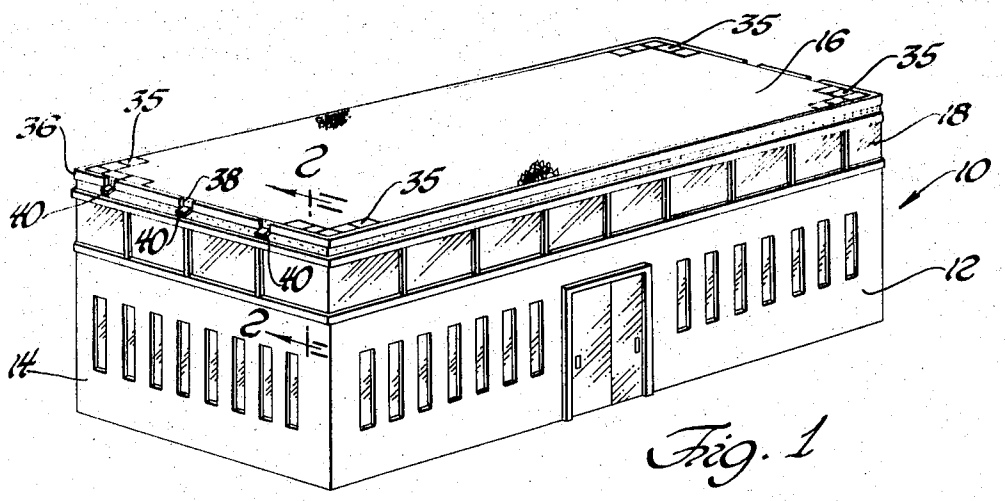



Fig. 1

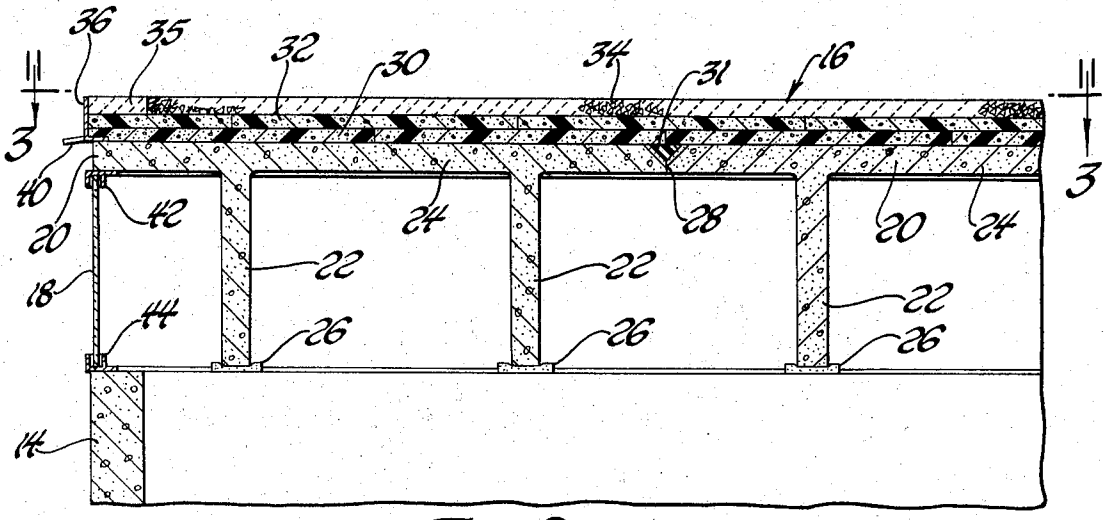



Fig. 2

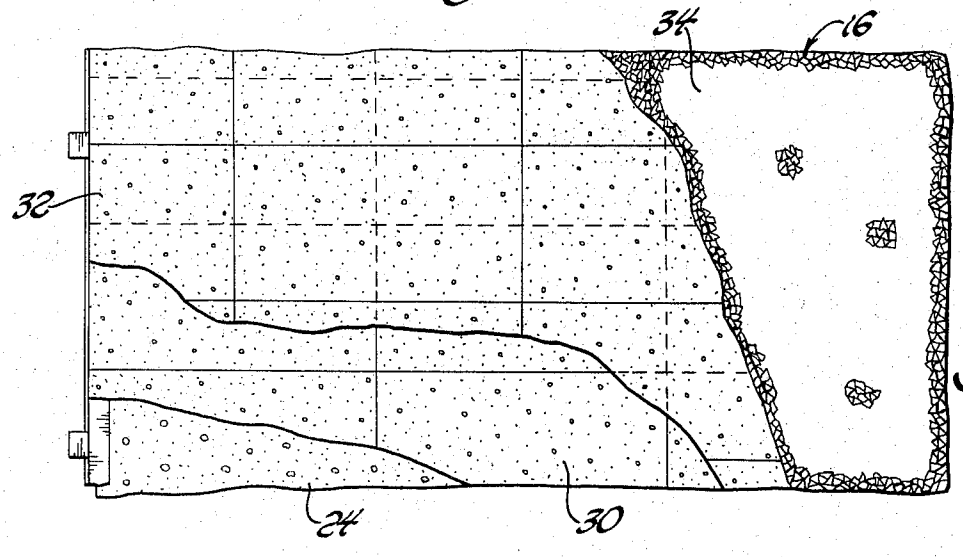



Fig. 3

# ROOF CONSTRUCTION

## INTRODUCTION

This invention relates to a roof construction for industrial buildings and more particularly to a roof construction of the type having external insulation.

## BACKGROUND OF THE INVENTION

The typical industrial roof construction involves the building of structural support systems for wood or steel, the building of a roof deck, sealing the deck with a full covering of asphaltic meterial and the insulation of the deck by disposing heat retaining material over the inside surface of the deck. More recently it has been recognized that insulation may be positioned on the outer surface of the roof deck and covered with stone to weight the insulation down and protect it from ultraviolet ray damage. One of the benefits provided by this "inverted" roof structure is the maintenance of the sealing layer at a relatively even temperature. An example of such an "inverted" roof structure is described in detail in the U.S. Pat. No. 3,411,256 to John S. Best.

In the Best patent, the roof deck is first covered with a water-impermeable membrane comprising a plurality of alternating layers of felt and bituminous material. This water-impermeable membrane is then covered with blocks of rigid polystyrene or the like. The polystyrene is adhesively secured to the membrane and is in turn covered with stone. According to the Best patent, the disposition of the insulation over the water-impermeable membrane maintains the membrane at a relatively constant temperature and, thus, avoids the temperature cycling which often gives rise to cracking and the resulting deterioration of the roof construction.

## BRIEF SUMMARY OF THE INVENTION

In accordance with the present invention, an "inverted" roof construction is provided wherein the heat insulating material is on the outside of the roof deck but wherein the mass sealing of the deck with an asphaltic membrane is eliminated. The elimination of the asphaltic membrane itself results in a number of advantages including substantial cost savings, reduced fire hazard, greatly facilitated leak location and repair, and other advantages hereinafter made apparent. In place of the sealing membrane, the present invention contemplates the use of prestressed concrete members in the formation of the deck, and the discrete or selective sealing of any cracks in and joints between such members, thus, providing a moisture-proof roof structure having all of the aforementioned advantages and the further advantage of readily accommodating the unevenness often found in jointed roof decks. Moreover, the selective sealing of the roof structure is perferably carried out using a high-recovery, chemically curing sealant of the polymeric type, thus, providing substantial improvement over asphaltic materials from the standpoints of increased flexibility and resistance to long-term dillution from water immersion.

In general, the objects of the present invention are accomplished by constructing the roof deck from prestressed concrete members which, in the typical situation, span the walls of the building to be roofed, the prestressing being along a single axis and eliminating all shrinkage cracks so as to effectively render the concrete structure impervious to moisture and to permit long spans. Where two or more prestressed concrete



structural members are required to form the deck, such members are disposed in abutting relationship and the joint between such member is permanently sealed using a resilient polymeric sealing compound of a type hereinafter described in detail. The insulating material, preferably in the form of one or more layers of extruded, closed-cell polymeric foam material, such as polystyrene, is placed directly on the prestressed concrete structural member and is then weighted down and protected from ultraviolet ray damage by a layer of crushed stone.

In the preferred embodiment of the invention, the prestressed concrete structural members which form the deck take the form of unidirectionally prestressed concrete "tees" which are placed in side-by-side relationship and sealed along the joints thereof. Any cracks in the members are discretely sealed rather than by mass coating. According to this preferred construction, a space is defined between the upper extremities of the building wall and the surface of the roof deck, this space being such as to readily accommodate a line of windows or other structural elements as suits the designer. Moreover, the preferred embodiment comprises a rigid L-shaped angle disposed around the periphery of the roof deck so as to retain the insulation material as well as the crushed stone. As hereinafter described in greater detail, the retainer angle is periodically interrupted by scuppers to permit water to flow from the roof deck.

## BRIEF DESCRIPTION OF THE DRAWINGS

FIG. **1** is a perspective view of an industrial building having a flat roof constructed in accordance with the invention;

FIG. **2** is a cross-sectional view of a portion of the roof construction in the building of FIG. **1**; and,

FIG. **3** is a plan view with layers broken away of the roof construction of FIGS. **1** and **2** to illustrate the various layers and the disposition of the elements thereof.

## DETAILED DESCRIPTION OF THE SPECIFIC EMBODIMENT OF THE INVENTION

Looking now to FIG. **1**, there is shown an industrial building **10** having concrete walls **12** and **14** and a flat roof construction **16** of the "inverted" type as hereinafter described in detail. In the building **10** of FIG. **1**, a peripheral line of windows **18** is disposed between the top of the walls **12** and **14** and the roof construction **16**. This structural arrangement affords excellent interior lighting conditions, but it is to be understood that other structural components, such as brick, wood, and other materials can be substituted for the windows **18**.

Looking specifically to FIGS. **2** and **3**, it can be seen that the roof construction **16** of the building **10** comprises a plurality of prestressed concrete tees **20** having depending vertical leg portions **22** and flat deck portions **24**. The two concrete tees which are shown in FIG. **2** span the entire distance between a pair of opposite walls **12** and are supported on the walls by means of neoprene bearing blocks **26**. In addition, the deck portions of the two concrete tees **20** are placed in side-by-side abutting relationship so as to form a linear butt joint **28**. Any cracks formed in the tees **20** during shipping are discretely filled with sealant after being dressed and primed as necessary. The joint **28** is preferably formed such by dressing into a V-shape and filled with a weather resistant sealer **31** to prevent moisture

from penetrating the roof deck. The sealant material used in the cracks and joints is preferably a durable, elastomeric, one or more component sealant conforming to federal (G.S.A.) specifications TT-S-00230C (one component) or TT-S-00227E (two component). Such sealant materials should exhibit long-term flexibility to withstand differential expansion and contraction of the tees **20,** and long-term adhesion to concrete after extended water immersion; thus, the sealant should contain no water-extractable ingredients. Suitable sealant materials include chemically-curing polyurethanes and polysulphides having extension recovery properties of 15 to 100 percent, based on a 25 percent extension test. A suitable sealant material is available from the Harry S. Peterson Company of Pontiac, Michigan, and is marketed under the trade name "ISO-FLEX". The V-shaped slot in the joint **28** may be formed and sealed in accordance with the teachings of the copending U.S. patent application, Ser. No. 292,019, filed Sept. 25, 1972 in the name of Harry S. Peterson, Charles M. Peterson, and Robert King.

In accordance with the present invention, the concrete tees **20** are prestressed in the conventional fashion by means of tension cables which extend unidirectionally from one end thereof to the other, thereby placing the tees in compression over the span between the walls **12.** This prestressing places the concrete in uniform compression eliminating shrinkage crack formation and renders it substantially impermeable to moisture and, in addition, permits long spans of unsupported roof deck to be utilized. As hereinafter described, any cracks which might develop in shipment are discretely filled and, assuming a good quality sealant is used, good results may be expected since such cracks are non-moving in character. Moreover, uneven joints resulting from differential camber and loading are filled with the flexible sealant so as to provide a smooth ramp like surface from one tee surface to the next, the ramp of the sealant filler bridging the tees being preferably extended out to overlap the lower tee surface.

In accordance with the invention, the flat deck surface which is formed by the upper or external surfaces of the perstressed concrete tees **20** is covered with two or more loosely disposed plies **30** and **32** of rigid closed-cell polymeric material, such as extruded polystyrene board, so as to provide heat insulation in the roof construction. The present invention does not contemplate the use of any adhesives, as required in the prior art, to be applied to the insulative material during installation. Rather the blocks **30** are laid directly upon the sealed flat deck surface **24** of the concrete tees **20.** Additional layers **32** are similarly disposed directly upon the preceding layer **30** without bonding the layers together. As shown in FIGS. **2** and **3,** the plies **30** and **32** comprise two-by-eight foot boards of ½ to 4 inches in thickness and are overlayed such that the edges or seams do not line up. This staggering overlay maximizes heat insulation by reducing leakage at the butt joints. It is to be understood that a single ply or more than two plies of insulating material may be employed without departing from the substance of the present invention, the dimensions previously given as well as the use of two or more staggered plies being preferred, but not critical to the invention. It is, however, important that a rigid, extruded closed cell material be used to endure the exposure to weather. It has been found, for example, that the compressed bead insulation board deteriorates rapidly when exposed to intermittent water immersion and, thus, is not suitable for use in the present invention.

Next a layer **34** of crushed stone or aggregate is placed over the polystyrene insulation board plies to prevent damage from ultraviolet rays and to prevent movement of the insulation board due to wind. The size and weight of the aggregate to be used may vary according to building design, wind force and whether or not any adhesive is used between the roof deck and insulation board plies. Wind may cause variable amounts of uplift force at various points over the roof, the most severe forces tending to occur at the corners of the building. Accordingly, it is desirable to place an arrangement of heavy cast concrete or stone blocks **35,** commonly called "patio blocks" over the insulation board at the building corners as shown in FIGS. **1** and **2.** This also eliminates the erosion-like effect of wind and weather which sometimes occurs in the aggregate at the corners. The stone blocks **35** may alternatively be placed all around the perimeter of the roof.

In general, an aggregate weight of 10 to 15 pounds per square foot is normally adequate to weight down the insulation board. Patio blocks of about 2 inches in thickness are also adequate. In an actual embodiment, the following aggregate specification was used and has been found satisfactory in a system using two plies of Styrofoam board which are not adhesively bonded to the roof deck or to one another; cut limestone having a composition or gradatious as listed below:

| | | |
|---|---|---|
| 100% | passing a screen size | 1½ in. |
| 92–100% | passing a screen size | 1 in. |
| 40– 75% | passing a screen size | ¾ in. |
| 15– 35% | passing a screen size | ½ in. |
| 0– 15% | passing a screen size | ⅜ in. |
| 0– 5% | passing a screen size | No.4 |

1% maximum passing a screen size Wash.

It is to be noted that the ply **30** of insulation board is not bonded or otherwise adhered to the upper surface of the concrete tees **20,** the top ply **32** is not bonded to the lower ply, and that the concrete tees are not sealed by a full surface coating of asphaltic or similar material. The use of uniaxially prestressed deck spans eliminates the need for an adhesive bond or full surface sealant layer between the insulation and the prestressed concrete tees. The elimination of the asphaltic sealer membrane improves the fire rating of the subject roof over prior art roofs by elimination of the possible melting and combustion of the asphaltic or coal tar type ingredients of prior art roof-sealing membranes. It also facilitates the location of any leaks which might develop in the roof deck since such leaks will show through the underside of the tees almost directly beneath the acutal leak point. In a membrane covered roof deck, leaks can travel horizontally a great distance. In addition, the loose construction illustrated herein greatly facilitates repair as the aggregate and insulation board plies may simply be removed to bare the surface of the roof deck.

As illustrated in the drawings, an L-shaped aluminum angle **36** is secured such as by drilling and/or nailing around the periphery of the roof deck. The angle **36** serves to retain the layers **30** and **32** of insulation board as well as the layer **34** of crushed stone. The angle **36** is discontinuous; i.e., is provided with breaks **38** in the upstanding or vertical portion thereof to provide water

runoff from the flat roof. Small scuppers **40** may be provided simply by striking out the breaks **38** and bending the material downwardly. Alternatively, the channel **36** may be made up of sections which are simply left a small distance apart and a spout or spillway-shaped scupper may be brazed or welded into the gap.

As best shown in FIG. **2**, aluminum angles **42** and **44** may be secured, such as by bonding with a bead of the polymeric sealant material, around the periphery of the vertical opening between the top of the walls **12** and **14** and the lower surface of the concrete tees **20** to accommodate the glass window panel **18**. As previously mentioned, this is an optional structural arrangement and may be replaced with other forms of structural means where such means are preferred by the designer.

It is to be understood that the present invention provides many advantages in fabrication, maintenance, repair, and disassembly not expressly listed herein. It is to be further understood that various modifications and additions to the subject invention as illustratively described herein may be made. It may, for example, be preferred to build the roof deck from single leg concrete tees or hollow core concrete slabs or to form the walls **12** and **14** from materials other than concrete. In addition, the aesthetic appearance of the building **10** of FIG. **1** in no way forms a part of the present invention except to the extent that it results from the structural arrangement hereinbefore described in connection with the preferred embodiment of the invention.

The embodiments of the invention in which an exclusive property or privilege is claimed are defined as follows:

**1.** An insulated roof construction for a building having walls and a roof structure characterized by the absence of a mass waterproofing membrane covering the roof structure and comprising: at least two precast concrete members spanning the walls and defining at least one intersection joint wherein the members are in reasonable proximity to one another, a flexible polymeric sealant spanning the joint and substantially adhering to the concrete structures on opposite sides thereof, a layer of relatively light and substantially non-sealing thermally insulative material freely disposed directly on the concrete members, and a layer of particulate weighting material disposed over the insulative material layer and of such thickness as to protect the insulative material from exposure and to prevent the insulative material from movement due to wind.

**2.** The insulated roof structure defined in claim **1** and further including an angle member disposed around the perimeter of the roof to contain the insulative material and particulate material.

**3.** The insulated roof structure defined in claim **2** wherein the angle member is discontinuous to allow water to escape the surface of the roof.

**4.** The insulated roof structure as defined in claim **1** wherein the insulative material is a rigid foamed polymeric material such as polystyrene.

**5.** A method of fabricating a roof structure characterized by the absence of a mass sealing membrane covering the structure and comprising the steps of: constructing a roof structure by placing a plurality of prestressed concrete deck members in side-by-side relationship between support means with the axes of prestress in parallel alignment to define at least one intersection joint between said members, discretely filling any cracks in said members, sealing the joints between said members with a moisture-impermeable flexible polymeric sealant material, curing the sealant material to adhere to the members on opposite sides of each of such joints, placing at least one ply of substantially rigid polymeric insulation material on the outer surface of the deck members and covering the insulation material with a particulate weighting material.

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