PCT WORLD INTELLECTUAL PROPERTY ORGANIZATION
International Bureau

INTERNATIONAL APPLICATION PUBLISHED UNDER THE PATENT COOPERATION TREATY (PCT)

(51) International Patent Classification 4 :		(11) International Publication Number:
E04C 1/40	A1	WO 86/ 01245
		(43) International Publication Date: 27 February 1986 (27.02.86)

(21) International Application Number: PCT/US85/01460

(22) International Filing Date: 5 August 1985 (05.08.85)

(31) Priority Application Number: 639,751

(32) Priority Date: 10 August 1984 (10.08.84)

(33) Priority Country: US

(71) Applicant: THE DOW CHEMICAL COMPANY [US/US]; 2030 Dow Center, Abbott Road, Midland, MI 48640 (US).

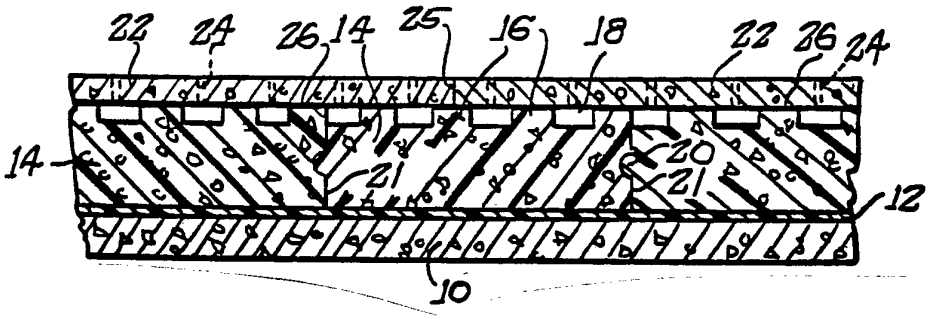
(72) Inventor: ROODVOETS, David, L. ; 151 Shagbark, Westerville, OH 43081 (US).

(74) Agent: JUHL, Nis, H.; The Dow Chemical Company, P.O. Box 1967, Midland, MI 48641-1967 (US).

(81) Designated States: AU, BR, GB, JP.

Published
With international search report.

(54) Title: LIGHTWEIGHT ROOFING SYSTEM



(57) Abstract

An insulated roofing system in which a waterproof membrane (12) is applied to the roof deck (10). Extruded panels of closed cell polystyrene form (14) are provided on top of the membrane (12), thus protecting the membrane (12) from thermal cycling, ultraviolet rays, and physical damage. The foam panels (14) provide excellent insulation and are substantially impervious to water. The foam panels (14) are provided on the upper surface thereof with integral ribs (16) spaced by grooves (18). Lightweight reinforced concrete panels (22) are laid directly on top of the foam panels (14) and are secured thereto, preferably by adhesive (26) spaced along the ribs (16). The concrete panels are provided with holes (24) which are preferably aligned with the grooves (18) between the ribs (16) to provide for ventilation and moisture removal.

FOR THE PURPOSES OF INFORMATION ONLY

Codes used to identify States party to the PCT on the front pages of pamphlets publishing international applications under the PCT.

AT	Austria	**GA**	Gabon	**MR**	Mauritania
AU	Australia	**GB**	United Kingdom	**MW**	Malawi
BB	Barbados	**HU**	Hungary	**NL**	Netherlands
BE	Belgium	**IT**	Italy	**NO**	Norway
BG	Bulgaria	**JP**	Japan	**RO**	Romania
BR	Brazil	**KP**	Democratic People's Republic of Korea	**SD**	Sudan
CF	Central African Republic			**SE**	Sweden
CG	Congo	**KR**	Republic of Korea	**SN**	Senegal
CH	Switzerland	**LI**	Liechtenstein	**SU**	Soviet Union
CM	Cameroon	**LK**	Sri Lanka	**TD**	Chad
DE	Germany, Federal Republic of	**LU**	Luxembourg	**TG**	Togo
DK	Denmark	**MC**	Monaco	**US**	United States of America
FI	Finland	**MG**	Madagascar		
FR	France	**ML**	Mali		

LIGHTWEIGHT ROOFING SYSTEM

For many years it was the universal practice to construct roofs with a waterproof layer or membrane on the outer surface thereof. Such roofing is still used in many installations, but has many disadvantages. The waterproof membrane, which may be built up sheet material and asphaltic or bitumin or which may be a single sheet of waterproof material, is exposed to extreme temperature variations, as much as 99°C, to ultraviolet radiation, and to physical abrasion, all of which have a deleterous effect on the life of the roofing.

It has been common practice for a great many years to provide insulation in roof construction, and when insulation is provided below the waterproof membrane, in the roofing system outlined above, it is necessary to provide a second waterproof membrane below the insulation to prevent moisture from within the building from condensing in the insulation and inhibiting or destroying its insulating qualities.

An alternative upside-down roofing construction is known in which the insulation is applied over the waterproof membrane, see for example U.S.

Patents 3,411,256 and 3,763,614. In this alternative roof construction the waterproof membrane, which may be a built-up membrane or a single waterproof layer such as of thermoplastic, is applied directly to the surface of the roof. Blocks of foam plastic insulation are then applied over the waterproof membrane. STYROFOAM® (trademark of the Dow Chemical Company) brand of foam polystyrene plastic resin is a superior product for such use. It is a tough, closed cell rigid plastic foam having excellent moisture resistance and high compressive strength.

The STYROFOAM® insulation placed over the waterproofing membrane rather than under the membrane, protects the membrane from the effects of thermal cycling, temperature extremes, and physical abuse, thus reducing maintenance costs and prolonging the life of the entire roofing system. It has been found that the membrane so protected remains at stable temperatures below 35°C even in hot summer weather. In fact, under normal conditions, the temperature of the membrane will remain within 15 to 20 °C of the building's inside temperature.

Typically, a polymeric fabric is installed over the foam to stabilize the system, and crushed stone or gravel ballast is applied to counteract the buoyancy of the insulation boards, to provide flammability resistance to the roof surface, and to shield the foam and fabric from ultraviolet radiation. As an alternative, paving blocks may be used in place of stone, particularly if traffic is to be expected on the roof.

When traffic is expected, as in the construction of a plaza deck, pedestals or stone are provided to space the paving blocks above the top of the STYROFOAM® insulation to permit adequate air circulation for drying of the roofing system on warm, dry days. It will be appreciated that a base roof or deck of substantial strength must be provided to support the weight of such a roofing system.

It is now an object of the present invention to provide a lightweight roofing system in which a waterproof membrane is applied directly to the surface of a roof, suitable panels of rigid foam insulation are applied over the membrane, and concrete panels are applied directly to the foam insulation without the necessity of pedestals or stone.

More particularly, it is an object of the present invention to provide such a roofing system in which the upper surface of the foam plastic insulating blocks are ribbed, having alternating ribs and valleys, with the concrete panels supplied directly to the ribbed surface of the foam blocks.

Extruded panels of STYROFOAM® insulation are now available having one surface with integrally formed, alternating ribs and grooves of equal width. It has been found, somewhat surprisingly, that the foam material in the ribs is stiffer, stronger, and more resistant to deformation than the foam material in the valleys. It is believed that this is due to molecular orientation of the material brought about as it foams during extrusion. In accordance with the present invention such foam

insulation material is used on top of a waterproof membrane. Concrete panels which are preferably constructed of a lightweight aggregate are applied to the ribs of the foam panels optionally using a suitable mastic or synthetic resinous adhesive material. Holes are provided in the concrete panels which are aligned with the valleys or grooves in the foam panel to allow air circulation for drying of the roof system on warm, dry days.

More particularly, the present invention resides in a roofing system comprising a roof deck, a waterproof membrane on said roof deck, a plurality of insulating panels of a synthetic resinous foam material positioned on said waterproof membrane, said foam panels having a plurality of raised areas on an upper surface thereof, a plurality of panels of a cementitious material overlying said foam panels and resting on said raised areas, said concrete panels having a plurality of holes extending therethrough for ventilation of said foam panels.

The invention will best be understood from the following detailed description when taken in connection with the accompanying drawings wherein:

Figure 1 is a fragmentary cross-sectional view through a roofing system constructed in accordance with the principles of the present invention; and

Figure 2 is a top view thereof with a portion broken away.

A base roof or deck 10 is shown in Figure 1 comprising a concrete slab which is preferably reinforced. The roof deck could equally be of wood or metal construction. Concrete simply having been chosen, here by way of illustration. A waterproof membrane 12 overlies the roof deck 10. The membrane can be attached to the roof deck, or it can be applied loosely on the top of the deck. The membrane can be a sheet of a polymeric material, or it can be a built-up membrane of a polymeric sheet material with an asphaltic or bituminous material added on top of the sheet.

Panels 14 of STYROFOAM®, an extruded polystyrene foam, are laid on top of the membrane 12. The foam panels include on the top surface only integrally extruded ribs ±6 interspaced by grooves or valleys 18. The ribs and the grooves are preferably of equal lateral extent, being approximately 2.5 cm wide, and about 0.5 to 1.25 cm deep. It has been observed that the foam material of the ribs is stronger, more rigid, and more deformation resistant than the material of the grooves or valleys, and this is thought to be due to molecular orientation produced by foaming of the plastic material during extrusion. The foam panels preferably are interconnected by a tongue-and-groove construction 20 along the longitudinal edges 21 thereof. Alternatively, the panels could be butt edged or ship lapped. The ends 23 of the panels conveniently are simply butted together. The thickness of the foam panels depends on the degree of insulating quantity desired, but typically would be on the order of from 2.5 to 15 cm

thick. The extruded polystyrene foam is preferably of the closed cell variety for moisture resistance. The foam panels generally are of a size of 0.6 meters by 2.5 meters, but other sizes can obviously be employed in the practice of the invention.

Reinforced concrete panels 22 are positioned on the foam panels 14, lying on top of the ribs 16. The concrete panels can be made of standard aggregate, but preferably utilize a lightweight aggregate. The concrete preferably is reinforced, and the reinforcing can be a continuous web or screen mesh, or preferably chopped strands or fibers. Glass fibers are preferred, although plastic fibers such as polypropylene can also be used. A fiber length of 0.5 to 2.5 cm is preferred. Longer fibers tend not to be practical as they tend to clump or agglomerate. One to two percent by weight of fiber is preferred, although greater amounts could be used. The concrete preferably is modified with a latex, such as styrene-butadiene latex, or ACROSYL® (manufactured by PPG Industries), a latex acrylic. Other latexes could be used.

Each concrete panel 22 is preferably provided with a plurality of holes 24 extending through the panel. These holes can be manufactured at the time that the concrete panels are manufactured, or they can be drilled or punched through the concrete. They are preferably larger than 0.5 cm in diameter and less than 2.5 cm in diameter. The holes are transversely spaced to line up with the grooves or valleys 18 and are spaced along the length of the valleys, preferably at a distance of from 30 to 90 cm. The reinforced concrete panels preferably are on the order of 1 by 2

met. in size so that the longitudinal junctions 25 and the lateral 27 junctions or abutments between the concrete panels and the junctions or abutments between the foam panels can generally be kept from alignment with one another for best moisture resistance. The concrete panels are preferably secured to the foam panels by a suitable adhesive 26 applied to the top surfaces or in discrete patches spaced along the top surfaces of the ribs 16. The adhesive or mastic must be compatible with both the foam material and the concrete, and not chemically weaken or otherwise destroy the foam material or concrete. A water-based latex adhesive is preferred. One preferred adhesive is a STYROFOAM® mastic 11.

The size difference in the panels and the adhesive mounting of the concrete panels to the foam panels causes the entire system to be tied together as an integral or unitary system. Alternatively, mechanical fasteners could also be used to connect the concrete panels and the foam panels together. If mechanical fasteners are used, they are preferably of the expandable type properly to anchor in the foam plastic. The concrete panels act like a ballast or a rafting device, and the holes in the concrete panels serve as a ventilation system to allow moisture to escape from the foam panels on hot, dry days. The air holes also serve to stabilize the roof and to improve its resistance to lift off due to high winds. The design results in a roof with a smooth surface for enhanced foot traffic. The roof is of a lightweight construction and is cost effective. The latex incorporated in the concrete

panels improves the moisture resistance of the concrete, and reduces the quantity of reinforcing fibers needed. With the waterproof membrane beneath the foam panels, a separate moisture and vapor barrier is not required.

The specific example of the invention as herein shown and described is for illustrative purposes only. Various changes will no doubt occur to those skilled in the art, and will be understood as forming a part of the present invention insofar as they fall within the spirit and scope of the appended claims.

WHAT IS CLAIMED IS:

1. A roofing system comprising a roof deck, a waterproof membrane on said roof deck, a plurality of insulating panels of a synthetic resinous foam material positioned on said waterproof membrane, said foam panels having a plurality of raised areas on an upper surface thereof, a plurality of panels of a cementitious material overlying said foam panels and resting on said raised areas, said concrete panels having a plurality of holes extending therethrough for ventilation of said foam panels.

2. The roofing system of Claim 1, wherein the raised areas on said foam panels comprise a plurality of ribs spaced apart by grooves.

3. The roofing system of Claim 1 or 2, wherein said ribs and said grooves are of substantially equal width.

4. The roofing system of Claim 1, 2, or 3, wherein said cementitious panels are secured to said foam panels.

5. The roofing system of Claim 4, wherein said raised areas comprise ribs spaced apart by grooves, and wherein the cementitious panels are secured to the foam panels by an adhesive spaced along said ribs.

6. The roofing system of any one of the preceding claims, wherein said cementitious panels are fiber-reinforced.

7. The roofing system of any one of the preceding claims, wherein said cementitious panels and said foam panels are of different longitudinal and lateral dimensions.

8. The roofing system of any one of the preceding claims, wherein said foam panels are extruded and said ribs are parallel, and wherein said cementitious panels are made of a reinforced concrete and said plurality of holes extending through the concrete panels are disposed between the raised areas of the foam panels.

FIG. 1

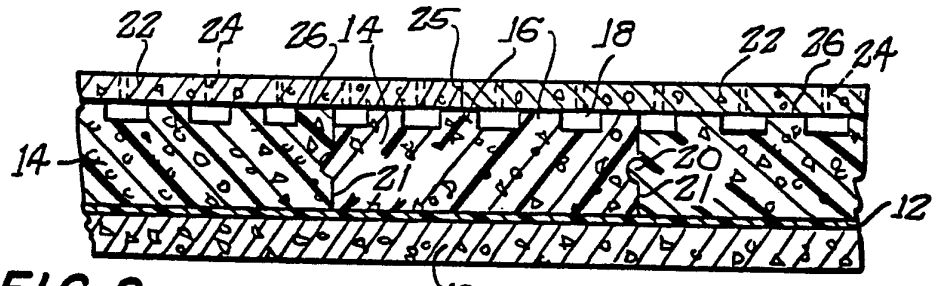
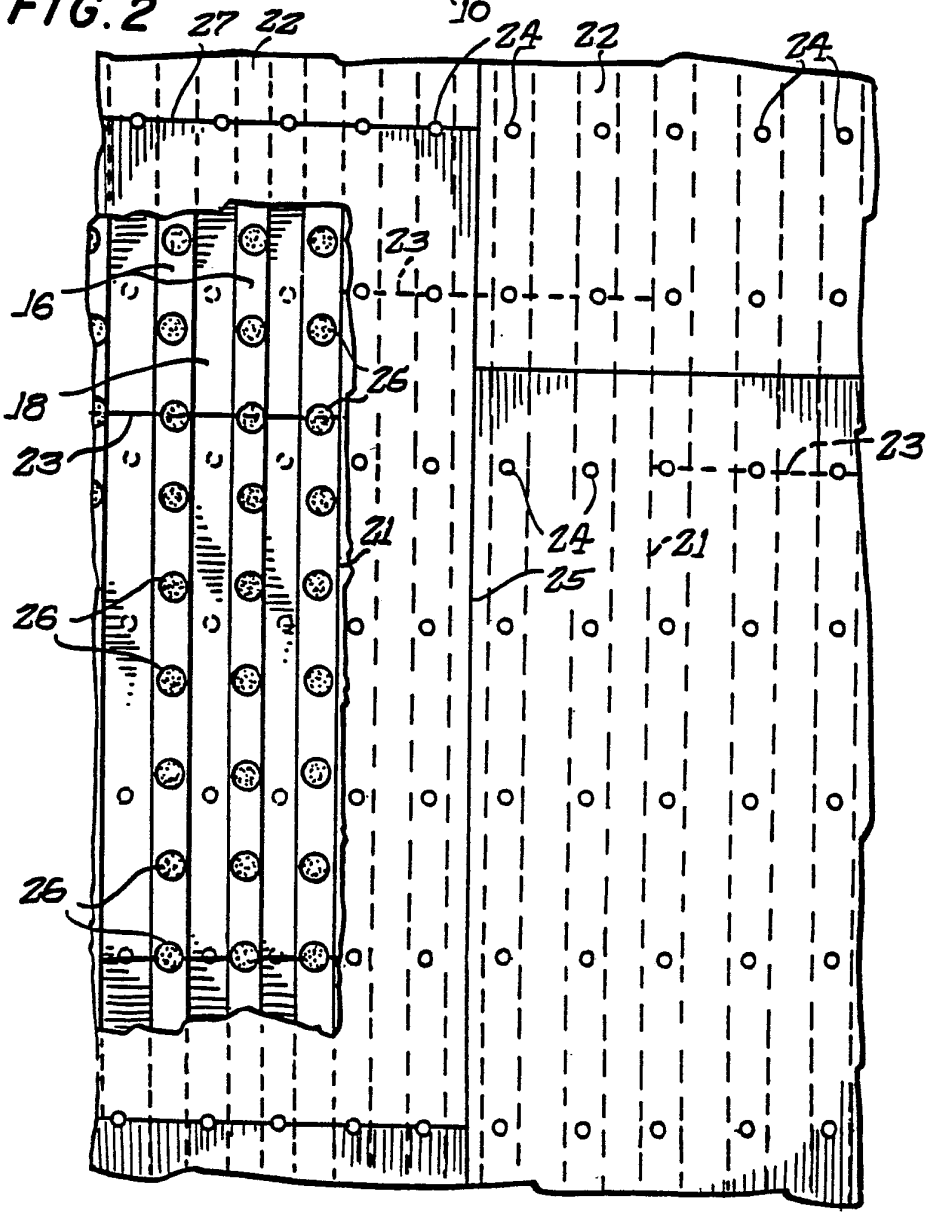

22
24
26
14
25
16
18
22
26
24
14
20
21
21
12
10

FIG. 2


27
22
24
22
24
23
16
26
18
23
23
21
24
21
25
26
26

INTERNATIONAL SEARCH REPORT

International Application No PCT/US85/01460

I. CLASSIFICATION OF SUBJECT MATTER (if several classification symbols apply, indicate all) [3]

According to International Patent Classification (IPC) or to both National Classification and IPC

INT. CL.4 E04C 1/40

U.S. CL. 52/309.12

II. FIELDS SEARCHED

Minimum Documentation Searched [4]

Classification System	Classification Symbols
U.S.	52/309.12,408,410

Documentation Searched other than Minimum Documentation to the Extent that such Documents are Included in the Fields Searched [5]

III. DOCUMENTS CONSIDERED TO BE RELEVANT [14]

Category *	Citation of Document, [16] with indication, where appropriate, of the relevant passages [17]	Relevant to Claim No. [18]
A	US, A, 3,411,256, Published 19 November 1968 (Best) See Column 2, lines 16-19	1-2
Y	US, A, 3,763,614, Published 9 October 1973 (Hyde et al.) See Column 2, lines 41-51	1-8
A	FR, A, 2,359,942, Published 24 February 1978 (Sommer) See Figure 3	1,8
A	US, A, 4,349,398, Published 14 September 1982 (Kearns et al) See Figures 2 and 6	1,8
Y,E,	US, A, 4,492,064, Published 8 January 1985 (Bynoe)	1-8
A,E,T	US, A, 4,512,126, Published 23 April 1985 (Walston) See Figures 3 and 4	1,8

* Special categories of cited documents: [15]

"A" document defining the general state of the art which is not considered to be of particular relevance

"E" earlier document but published on or after the international filing date

"L" document which may throw doubts on priority claim(s) or which is cited to establish the publication date of another citation or other special reason (as specified)

"O" document referring to an oral disclosure, use, exhibition or other means

"P" document published prior to the international filing date but later than the priority date claimed

"T" later document published after the international filing date or priority date and not in conflict with the application but cited to understand the principle or theory underlying the invention

"X" document of particular relevance; the claimed invention cannot be considered novel or cannot be considered to involve an inventive step

"Y" document of particular relevance; the claimed invention cannot be considered to involve an inventive step when the document is combined with one or more other such documents, such combination being obvious to a person skilled in the art.

"&" document member of the same patent family

IV. CERTIFICATION

Date of the Actual Completion of the International Search [2]	Date of Mailing of this International Search Report [2]
18 September 1985	17 OCT 1985
International Searching Authority [1]	**Signature of Authorized Officer [20]**
ISA/US	Lynn M. Sohacki

Form PCT/ISA/210 (second sheet) (October 1981)