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United States Patent

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[72] Inventors Peter R. Carney
Lake Forest;
Raymond F. Stevens, Stickney Township, Cook County, both of Ill.

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[73] Assignee Superior Graphite Company
Chicago, Ill.

[54] **THERMALLY CONDUCTIVE CONCRETE WITH HEATING MEANS**
8 Claims, 2 Drawing Figs.

[52] U.S. Cl. **219/213,** 94/2, 106/97, 165/185
[51] Int. Cl. **H05b 1/00**
[50] Field of Search 219/213, 345; 165/185; 252/502, 506; 106/97, 38.28; 94/3, 2, 4, 7

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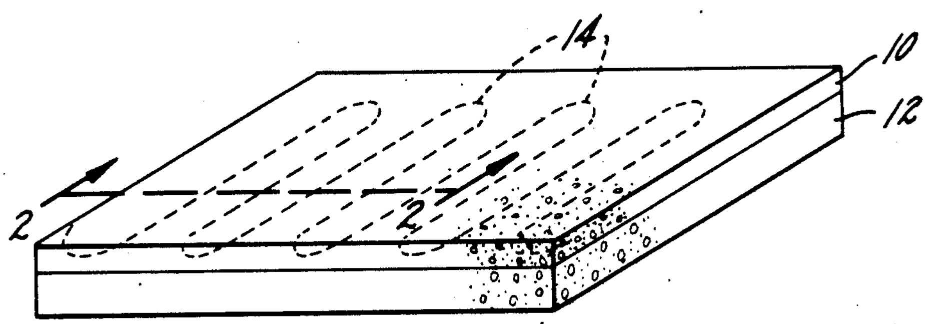
Primary Examiner—C. L. Albritton
Attorney—Hume, Clement, Hume & Lee

ABSTRACT: An improved ground covering and heating means is constructed by formulating graphited concrete containing about 35–85 percent graphite, based on the weight of the dry mix. The concrete is laid in combination with a suitable heating element beneath the upper surface. In the preferred embodiment, the graphited concrete is sandwiched with a lower layer of nongraphited concrete for added strength. In preparing the sandwich, the graphited concrete is preferably poured over the nongraphited concrete while the latter is still in a green state.



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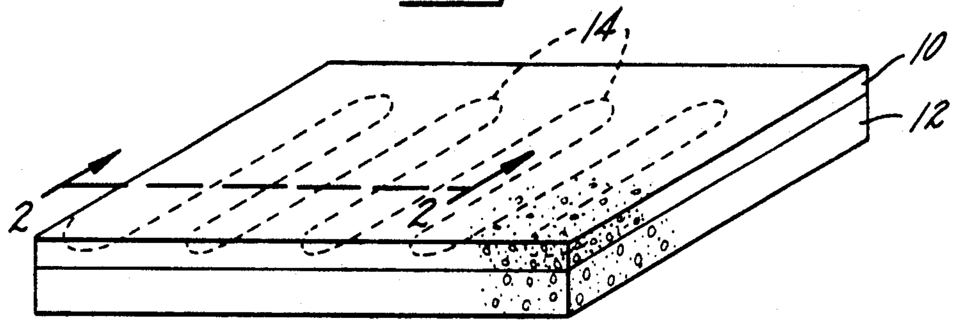

Fig.1.

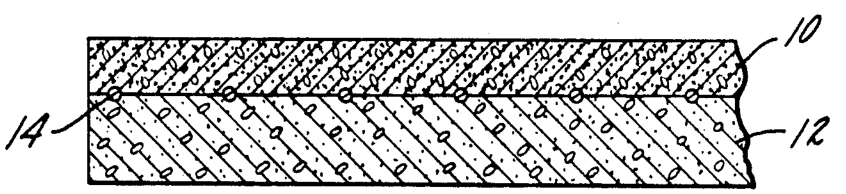

Fig.2.

INVENTORS.
PETER R. CARNEY
RAYMOND F. STEVENS
BY Hume, Clement, Hume & Lee
Attorneys.

THERMALLY CONDUCTIVE CONCRETE WITH HEATING MEANS

The present invention relates to an improved ground covering and heating means, and to a method for making the same.

In recent years there has been an increased interest in the use of ground coverings that incorporate heating means for the melting of snow and ice. Such heated ground coverings are particularly useful at airports where it is imperative that the runways be kept clear during the winter months. Ground coverings with heating means are also useful for sidewalks, driveways, roads, etc., where the need for shoveling or plowing may be eliminated. Finally, the use of a ground covering having a heated means dispenses with the need for the use of salt, which not only is messy, but can also damage the metal parts of vehicles.

Concrete having heating means such as electric wires or steam pipes imbeded therein has long been known. However, a problem with use of an ordinary concrete is the low-thermal conductivity of the material, which requires the positioning of wires or pipes very close together, and which results in the wastage of a great deal of heat energy. Thus, the melting of snow and ice through the use of heating means imbedded in ordinary concrete is a very expensive way to achieve snow and ice removal.

In addition, when ordinary concrete is repeatedly heated to high temperatures, as are produced by an imbedded electrical resistance element, the thermal conductivity is even further reduced. This reduction in thermal conductivity is believed to result from the dehydration of the tricalcium silicate at the concrete-heater interface.

A number of solutions to these problems have been proposed. Among them is the use of electrically conductive concrete, so that the concrete itself may be connected to electric wires to form a resistance element. For example, iron filings may be incorporated into the concrete, permitting the concrete itself to form a resistance element. One problem that is created by such a method arises from the difficulty of achieving a uniform distribution of the conductive material throughout the concrete, together with the difficulty in controlling the resistance of such a concrete to an appropriate level.

Generally, the present invention relates to a ground covering and heating means which utilizes a concrete slab incorporating graphite for improved thermal conductivity. The concrete slab comprises Portland cement and about 35 to 85 percent graphite based on the dry weight of the concrete mix. Heating means for heating the slab are positioned below the upper surface thereof. The graphite incorporated into the slab produces high thermal conductivity, while the concrete retains adequate strength.

The present invention also provides a method for forming a heated ground covering and heating means wherein the layer of ordinary, nongraphited concrete is first poured. Heating means are positioned on the concrete, and a layer of graphited concrete is poured over the nongraphited concrete and heating means while the nongraphited concrete is still in a green state. As indicated above, the graphited concrete dry mix comprises Portland cement and about 35 to 85 percent graphite by weight. By pouring the graphited concrete over the nongraphited concrete while the latter is still wet, a sandwich of very high strength is obtained.

The invention, its construction and method of operation, together with the preferred embodiments thereof, will be best understood by reference to the following detailed description, taken together with the drawings in which:

FIG. 1 is a perspective view of a concrete slab incorporating the features of the present invention; and

FIG. 2 is a cross-sectional view taken along line 2—2 of FIG. 1.

In formulating thermally conductive concrete, as previously stated, it has now been found that the incorporation of graphite is most advantageous, and that a graphited concrete together with suitable heating means forms a ground covering upon which snow and ice may be melted and removed with relative ease and economy.

Concrete in accordance with the present invention is formulated in a conventional manner, except that graphite is substituted for a part or all of the sand. Thus, a concrete prepared in accordance with the invention will comprise Portland cement and graphite, and may optionally include sand and/or stones. The concrete is prepared, mixed and laid in a conventional manner, the only difference from ordinary concrete being that somewhat less water is required in order to mix green concrete of the proper consistency.

The proportion of graphite to be employed in the graphited concrete of the present invention must be sufficiently high to give a significant improvement in thermal conductivity as compared to that of ordinary, nongraphited concrete; but it must not be so high that it destroys the strength of the concrete. As previously mentioned, the portion of graphite in the overall concrete mixture should range from about 35 to 85 percent. Concretes containing less than 35 percent graphite exhibit very little improvement in thermal conductivity as compared to ordinary, nongraphited concrete. On the other hand, above 85 percent the strength of the concrete becomes unacceptably low for most applications. In the most preferred embodiment, the graphite is present in a proportion of about 50 to 85 percent, based upon the overall weight of the concrete components. It is noted that the percentages given here are all based upon the concrete dry mix, before addition of water.

In addition to increasing the thermal conductivity of concrete, the addition of graphite in accordance with the present invention also darkens the color of the concrete. This darker color aids in the melting of snow and ice when thin layers are involved, since the darker color aids in the absorption of radiant solar energy.

Referring to the drawings, in the most preferred embodiment the present invention comprises a sandwich of graphited and nongraphited or ordinary concrete. The graphited concrete **10** forms the upper layer while the nongraphited concrete **12** forms the lower layer. Heating means, in this instance an electrical resistance element **14**, is positioned at the interface between the graphited and nongraphited concrete **10, 12**, respectively. It is not essential that the heating means comprise an electrical resistance element. For example, steam or hot water pipes could also be employed.

It is not essential to position the heating means exactly at the interface between the two concretes. The heating means can also be imbedded in the graphited concrete **10**. Such an arrangement is often employed when the graphited concrete is used alone, and not in combination with a lower layer of nongraphited concrete **12**, as is required in applications where high strength is needed. As an alternative to imbedding the heating means in the graphited concrete **10**, the heating means may simply be in contact with a lower surface of a slab of graphited concrete.

In forming the heating ground covering and heating means of the present invention, a layer of nongraphited concrete **12** is first poured. Of course, a suitable bed may be laid below this lower layer, and the lower layer may be reinforced with steel mesh, for example. Heating means, such as an electrical resistance element **14**, are then positioned on the concrete. Subsequently, a layer of graphited concrete is poured over the nongraphited concrete and the heating means while the nongraphited concrete is still in a green state. As before, the graphited concrete comprises Portland cement and about 35–85 percent graphite by weight. The pouring of the graphited concrete **10** onto the nongraphited concrete **12** while the latter is in a green state produces an overall sandwich of high strength, and overcomes any tendency of the two layers to separate.

The following examples are intended to illustrate the present invention, and should not be construed as limitative, the scope of the invention being determined by the appended claims.

EXAMPLE 1

A graphited concrete sandwich was prepared in accordance with the present invention by first preparing concrete from a dry mix consisting of 20 percent Portland cement, 40 percent fine sand, and 40 percent coarse gravel, by weight. The wet concrete was poured into each of two wooden forms to make slabs measuring 42 inches on each side by 2 to 2.5 inches thick. A nichrome heating element was placed on top of each slab. These two heating elements were each in the general shape of a W, and were identical in all respects. The ends of the heating elements were permitted to protrude slightly beyond the edge of the slabs in order that they could be connected to a source of electrical energy.

A graphited concrete was prepared by mixing 20 percent Portland cement, 30 percent sand, and 50 percent graphite. Sufficient water was again added to achieve the proper consistency. While the aforementioned concrete slabs were still in the green state, the graphited concrete was poured over one of the slabs and the electrical resistance elements to form a graphited upper layer about 2 inches thick. The previously mixed, nongraphited concrete was poured over the heating element on the other slab.

Both of the slabs were placed out of doors on a cold winter day. They were allowed to stand until a snow storm had occurred, and about one-half inch of snow had collected on each slab. After the snow had collected the heating elements were connected in parallel to a 110-volt source, and both elements were switched on.

After about 1 hour, a strip of snow about 5 inches wide had melted directly above the heating element (the nongraphited sample). At the same time, the graphited sample showed even melting over the entire slab, and no bare spaces had yet appeared.

Thirty minutes later the pattern of melted snow in the nongraphited slab was unchanged. The graphited slab was entirely free from snow.

After another 30 minutes had elapsed, the nongraphited sample was again observed. While some additional melting had occurred, the nongraphited sample still had unmelted snow on its surface. At this time, both heating elements were switched off.

EXAMPLE 2

About one-fourth inch of snow was collected on each of the concrete slabs employed in example 1. Both heating elements were again switched on at the same time. After 1 hour had elapsed, both slabs were observed. Again, the nongraphited slab showed melting along a thin line directly above the heating element. The graphited sample, on the other hand, was melting evenly, and no bare spots had yet been produced.

After an additional hour both samples were again observed. The nongraphited slab showed little additional melting. The graphited slab on the other hand, was completely clear of snow.

EXAMPLE 3

The following test was conducted with the slabs employed in the previous example, but during a heavy snow storm. The test was started after 5 inches of snow had accumulated on each slab. After about 5 both slabs were observed. The nongraphited slab showed melting only directly over the heating element, while the remainder of the slab had a thick layer of snow. The graphited slab in contrast, was completely clear of snow except at the outer edges.

EXAMPLE 4

A third slab of graphited concrete was prepared as in example 1 except that the upper, graphited layer contained 20 percent Portland cement, 40 percent sand, and only 40 percent graphite. Both this and the nongraphited slab were placed out of doors, and, after a snow storm, 2–3 inches of snow had accumulated. Both heating elements were switched on and the slabs were observed after 1 hour. The nongraphited slab showed melting only over the heating element, as before. The graphited slab was melting more evenly, although a small bare space had been produced in the center. Thus, the melting was not quite so even as that which had been produced by the slab having 50 percent graphite in the graphited layer.

Both slabs were again observed after another hour had elapsed. The nongraphited slab retained a U-shaped pattern of snow between the legs of the W, while the graphited slab was clear except for some snow at the outside edges.

Both slabs were again observed after an additional ½ hour had elapsed. The nongraphited slab showed no significant change, while the graphited slab showed some additional melting, although there was still a small amount of snow at the outside edges.

EXAMPLE 5

Three slabs of concrete were formed having the following compositions:

Sample No.	1	2	3
Weight percent of dry mix			
Portland cement	15	15	15
Sand	85	50	0
Graphite	0	35	85

Each slab was 4 inches square by 1 inch thick. Each slab was allowed to completely set up before any tests were run.

A laboratory hot plate was switched on at its high-temperature setting, and was allowed to remain on for a sufficient time to reach its equilibrium temperature. Each of the slabs was then placed on the hot plate, and paraffin shavings were sprinkled on the slab near the center. In each instance, the time required to produce any observable melting was measured, together with the time required to completely melt the shavings. These times were recorded, and are indicated in the table below.

Sample No.	1	2	3
Time to first melt (sec.)	170	115	80
Percent decrease as compared to nongraphited sample	—	32.3	53.0
Time for complete melting (sec.)	272	195	160
Percent decrease as compared to nongraphited sample	—	28.3	41.2

As can be seen from the above table, the graphited samples showed improvements of as much as 53 percent in melting time as compared to the ordinary, nongraphited sample.

EXAMPLE 6

Three composite concrete slabs, similar to those used in example 1 (less heating elements), were prepared having various percentages of graphite in the upper layer. The base layer of each slab contained 15 percent Portland cement and 85 percent sand. After the base layers were poured, each was covered with a top layer while the base was still in the green state. The composition of the top layers is shown in the following table:

Sample NO.	1	2	3
Weight percent of dry mix			
Portland cement	15	15	15
Sand	85	35	0
Graphite	0	50	85

A cylindrical test sample was cut from each slab with a diamond drill. Each cylinder was 6 inches in diameter by about 4 inches high. The cylinders were tested for compressive strength in a Riehle compression machine according to A.S.T.M. method C39-66 for molded concrete cylinders. The data were corrected to the standard cylinder height of 12 inches. The results are shown in the following table:

Sample No.	1	2	3
Compressive strength, p.s.i.	4,000	2,300	2,300

As can be seen from the above table, all of the samples had adequately high-compressive strength for many applications. Furthermore, when the graphited concrete was prepared in a sandwich with nongraphited concrete, no reduction in strength was produced by an increase in the percentage of graphite to 85 percent of the dry mix. In all of the tests, it was noted that breakage did not occur at the interface between the graphited and nongraphited concrete, indicating that a strong bond had formed.

EXAMPLE 7

Two concrete plates were formed having the following dry mix compositions:

Sample	1	2
Weight percent of dry mix		
Portland cement	15	15
Sand	85	20
Graphite	0	65

Each sample measured 2.5 inches square by 1 inch thick, and had a groove of 0.035 by 0.035 inch deep across the center of each surface. Fine gauge thermocouples were cemented into the grooves in the surface of each sample, and the samples were placed between two similar samples of known thermal conductivity with the same type of thermocouple instrumentation. To minimize contact resistance, each surface was coated with a thin layer of silicone grease. The composite specimen was placed between the plates of an upper heater and a lower heat sink and a reproducible load was applied to the top of the complete system. A guard which could be heated was placed around the system and the whole of the interspace and surroundings were filled with a heat insulating powder. By means of suitable adjustment to the power in the various heaters and of the cold sink temperatures, a steady distribution was maintained in the system and undue radial heat loss prevented by keeping the guard at a temperature close to the average temperature of the sample. At equilibrium conditions, the temperatures at various points in the system were evaluated from the thermocouple readings, and the heat flow in The specimen derived from that flowing in each standard sample. The results are shown in the following table:

Temperature (° F.)	Thermal conductivity (B.T.U. hr.$^{-1}$ deg. F.$^{-1}$)
Sample 1	
100	1.29
300	1.15
500	1.16
100	1.14
Sample 2	
100	0.98
300	0.75
500	0.70
100	0.73

As can be seen from the above table, the graphited concrete sample showed significantly higher thermal conductivity than the nongraphited sample at each temperature.

It is also significant that the thermal conductivity of the graphited concrete sample returned to nearly its original value at 100° F. after it had been heated to 500° F. In contrast, the nongraphited sample showed significantly reduced thermal conductivity after heating to 500°. This result indicated that the nongraphited sample showed some breakdown in the area of the heating element at high temperatures. The graphited sample, on the other hand, conducted heat away from the heating element at a rate that was rapid enough to prevent such deterioration. As previously mentioned, this deterioration is attributed to dehydration of the tricalcium silicate in the concrete.

Obviously, many modifications and variations of the invention as hereinbefore set forth will occur to those skilled in the art, and it is intended to cover in the appended claims all such modifications and variations as fall within the true spirit and scope of the invention.

We claim:

1. A ground covering and heating means comprising a graphited concrete slab comprising Portland cement and about 35 to 85 percent graphite, based on the weight of the graphited concrete dry mix; and heating means for heating said slab below the upper surface thereof.

2. The ground covering as defined in claim 1 wherein said heating means comprise an electric resistance wire.

3. The ground covering and heating means as defined in claim 2 wherein said wire is imbedded in said slab.

4. The ground covering and heating means as defined in claim 2 wherein said wire is in contact with a lower surface of said slab.

5. The ground covering and heating means as defined in claim 2 wherein said concrete further comprises sand.

6. The ground covering and heating means as defined in claim 2 further including a concrete base layer below said resistance wire.

7. The ground covering and heating means as defined in claim 6 wherein said graphited concrete contains about 50-85 percent graphite.

8. A method for forming a ground covering and heating means comprising: pouring a layer of nongraphited concrete; positioning heating means on said concrete; and pouring layer of graphited concrete over said nongraphited concrete and said heating means while said nongraphited concrete is in a green state, such graphited concrete comprising cement and about 35-85 percent graphite by weight.

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UNITED STATES PATENT OFFICE
CERTIFICATE OF CORRECTION

Patent No. 3,626,149 Dated December 7, 1971

Inventor(s) Peter R. Carney and Raymond F. Stevens

It is certified that error appears in the above-identified patent and that said Letters Patent are hereby corrected as shown below:

Column 3, line 46, "one-fourth" should be "3/4".

Column 3, line 63, after "5" insert "hours".

Column 5, line 50, "The" should be "the".

Column 5, line 52, please correct the table to the following:

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100	0.98
300	0.75
500	0.70
100	0.73

Column 6, line 30, after "comprising" insert a colon.

Signed and sealed this 6th day of June 1972.

(SEAL)
Attest:

EDWARD M.FLETCHER,JR.
Attesting Officer

ROBERT GOTTSCHALK
Commissioner of Patents

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