United States Patent

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[72] Inventor **Louis David Minsk**
Hanover, N.H.

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[54] ELECTRICALLY CONDUCTIVE ASPHALTIC CONCRETE

5 Claims, No Drawings

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Primary Examiner—J. V. Truhe
Assistant Examiner—Hugh D. Jaeger
Attorneys—Harry M. Saragovintz, Edward J. Kelly, Herbert Berl and Lawrence E. Labadini

ABSTRACT: The passage of an electric current through an electrically conductive asphaltic concrete surface generates sufficient heat within the surface to prevent the accumulation of snow and ice thereon. The asphaltic concrete is made electrically conductive by incorporating graphite particles within the concrete mix.

ELECTRICALLY CONDUCTIVE ASPHALTIC CONCRETE

The invention described herein if patented, may be manufactured and used by or for the Government for governmental purposes, without the payment to me of any royalty thereon.

This invention relates to the generation of heat electrically in an asphaltic concrete pavement or other surface. More particularly, this invention relates to the prevention of the accumulation of ice and snow on pavement by use of an asphaltic concrete made electrically conductive by the addition of graphite particles thereto and by the passage of an electrical current through such asphaltic concrete to generate sufficient heat to melt the ice or snow.

BACKGROUND OF THE INVENTION

Present practical methods of control of snow and ice accumulation on paved surfaces can be classified as chemical, mechanical and thermal. Melting of frozen precipitation by heat can be accomplished by direct application of thermal energy from an exposed flame or an electrically energized radiant source, by pipes carrying hot liquid or by electrical resistance cables buried in the upper portion of the pavement. The application of heat from above the surface by radiant energy requires the melting of the entire ice or snow mass to effect removal, a method that consumes large quantities of energy. The buried electrical cable method is preferable since it enables the heat to be applied more efficiently to the snow or ice than the other methods. However, there are drawbacks to the use of buried heating cables. Either the spacing between the cables must be very small or the temperature of the cables must be very high to obtain adequate heat input to melt snow or ice in the areas between them. Furthermore, cables must be buried relatively deep in the pavement to obtain the optimum distribution of heat for a given electrical input and cable size. This requires a major construction job for placement of the cables as well as the undesirable task of breaking the pavement surface in old construction. The use of imbedded pipes carrying hot fluid is subject to the same disadvantages as set forth for buried electrical cables. Additionally, if repair work on the pipes or cables is required, then the pavement must be torn up which is both costly and disruptive of normal operations on the paved surface.

SUMMARY OF THE INVENTION

I have discovered a novel method and novel materials which make it possible to generate heat uniformly and efficiently at the ice-pavement interface to effect separation of ice with a minimum energy or to effect melting of snow or ice. The heat is generated by passage of an electrical current through an asphaltic concrete pavement layer having a resistivity within the range from about 1 to about 5 ohm-inch. Asphaltic concrete paving material having the desired resistivity characteristics is prepared by incorporating within conventional asphaltic concrete mixes a quantity of graphite particles. Electricity is carried to the conductive asphaltic concrete pavement layer by conductor busses or cables spaced widely apart (3 to 15 feet or more, depending on the voltage gradient selected). Such electrically conductive paving material can be easily applied as a thin continuous overlay to existing pavements avoiding the type of major construction involved in burying cables or pipes in existing pavements. Repair work is easily accomplished by patching with a mix of the same electrically conductive material. In addition, since there would be significantly fewer electric cables or pipes used there would be a concomitant reduction in the likelihood of damage to such cables.

Accordingly, it is among the objects of the present invention to provide a method and means for efficiently generating heat at the surface of an asphaltic concrete pavement to prevent accumulation of snow or ice thereon. Other objects will become apparent in the following detailed description of the present invention.

DESCRIPTION OF THE PREFERRED EMBODIMENTS

The electrically conductive asphaltic concrete composition having a resistivity within the range from about 1 to about 5 ohm-inch is composed of a conventional asphaltic concrete composition to which has been added and thoroughly blended a quantity of high purity graphite particles. Asphaltic concrete, also known as bituminous concrete is a widely available article of commerce which varies somewhat in the percentage of its components. Such concrete consists, in the main, of a sand, crushed stone or gravel aggregate combined with an asphalt cement binder. The properties of the resulting concrete surface will depend on the relative proportions of sand and crushed stone or gravel as well as the size of the stone and gravel. The asphalt cement acts as a binder for the aggregate and generally comprises from 5 to 15 percent or more by weight of the composition. High purity graphite is graphite containing 90 percent or more pure carbon and 10 percent or less of ash or volatiles. Graphite particles suitable for use in the present invention range in size from particles no larger than those which can completely pass through a No. 4 Sieve and no smaller than particles which can pass through a No. 200 Sieve, said Sieve numbers being in the U.S. Standard Sieve Series. The following two Examples illustrate the preparation of typical asphaltic concrete compositions according to the present invention.

EXAMPLE I

An asphaltic concrete mixture containing 276 lbs. 9/16-inch crushed stone, 550 lbs. ⅜-inch crushed stone, 642 lbs. of sand and 166 lbs. of asphaltic cement (100—120 penetration) was prepared according to techniques known in the art. 366 lbs. of a high purity graphite (98 percent carbon, 2 percent ash and volatiles) particles, which will pass 100 percent of the particles through a No. 4 Sieve and 0 percent through a No. 20 Sieve was added to a pug mill after the aggregares had been batched and thoroughly blended in the hot asphaltic concrete mixture while the mix is maintained at a temperature of 350° F.

EXAMPLE II

In this example, 450 lbs. of high purity graphite particles (95 percent pure carbon), particle size being such as to completely pass through a No. 65 Sieve and only 41.2 percent to pass through a No. 200 Sieve, preheated to a temperature above 140° F. were added to an asphaltic concrete hot mix in a pug mill. The concrete mix consisted of 180 lbs. of ½inch crushed gravel, 630 lbs. of a ⅜-inch crushed gravel, 540 lbs. sand and 200 lbs of asphalt cement (85—100 penetration). The graphite was thoroughly blended in the hot mix and the temperature of the completed mix as discharged from the mill was within the range of 275° F. to 325° F.

Pavement or other asphaltic concrete surfaces are constructed in a manner well known in the art which consists generally of spreading the hot mix uniformly over a suitable base followed by compacting. The thickness of surfaces formed with the asphaltic concrete compositions of this invention may be varied within wide limits. Because of cost considerations, however, we prefer not to exceed 2 inches in thickness and for durability, we prefer not to have a surface less than one-half inch in thickness. If the surface is expected to be subjected to heavy wear, it is desirable to cover the electrically conductive surface with a nonconductive wear course of from one-half inch to 1-½inches in thickness. Such a wear course would also serve as a protective surface coating to prevent large increases in current flow caused by metal conductors falling across or penetrating the conductive asphaltic material. It is, of course, desirable to have the conductive asphaltic concrete surface as uniform in thickness as possible so as to avoid hot or cold spots in the pavement.

As the conductive concrete composition is spread over the surface to be covered, copper conductor cables are placed

within this layer of material. The cables are spaced at regular intervals and connected to a suitable voltage source so that the desired electrical potential may be maintained between the copper conductors.

In operation, the power dissipation required to prevent the accumulation of ice and snow should fall within the range of 10 to 40 watts per square foot.

Power is consumed when current flows through a purely resistive load under an applied potential according to the relation (Equation 1)

$$P=EI=\frac{E^2}{R}$$

where

P = power dissipated (w)
E = applied potential difference (v)
I = current (amp)
R = resistance (ohm)

Material exhibit a resistance directly proportional to the length of the conducting path and inversely proportional to the cross-sectional area of the conducting element, A_c, or (Equation 2)

$$R=p\frac{1}{A_c}=\frac{pl}{tw}$$

where

R = resistance (ohm)
p = proportionality constant, resistivity (ohm-in.)
l = conducting path length (ft.)
t = thickness of conducting sheet (in.)
w = width of conducting sheet (ft.)

Substituting eq. 2 to eq. 1 gives

$$P=E^2\frac{tw}{pl}$$

Power dissipation per unit surface area, A_s, is

$$P/A_s=\frac{E^2}{wl}\frac{tw}{pl}=\left(\frac{E}{1}\right)^2\left(\frac{t}{p}\right)$$

For safety reasons, it is preferred that the potential drop between electrodes not exceed 30 volts. While we have found an approximate 5 foot spacing between electrodes to be preferable, since this establishes a potential gradient of 6 volts per foot, other spacings (3—15 feet) are possible provided the 30 volt potential between electrodes not be exceeded.

EXAMPLE III

Six 6''×6'' holes or panels were cut in an existing asphalt parking lot and backfilled with sand and a standard asphaltic concrete hot mix to give two holes each having an unfilled depth of one-half inch, 1 inch and 1-½inches. The conductive asphaltic concrete composition of Example I was poured into each of the holes up to grade and compacted. Prior to completion, copper conductors were placed in the conductive concrete material and spaced 5 feet apart. Conductors were connected to center tap transformers which, in turn, were connected to auto transformers for voltage control. 60 cycle AC current was used to supply the transformers. In Table I, the thickness of the electrically conductive concrete material and the gauge of the copper conductors used are identified for each hole or panel. Table II demonstrates the effectiveness of panels prepared according to my invention in clearing snow and ice from the paved surface over a period of time during which the surfaces were covered with fresh snow of varying depths. The poor results for panel No. 2 are traceable to the fact that the power dissipation of this panel range between 3 and 7 watts per square foot, below the desired range of 10 to 40 watts per square foot.

TABLE I

Panel No.	Thickness, in.	Gage of copper conductor
1	½	#10
2	½	#6
3	1	#6
4	1	#2
5	1½	#6
6	1½	#2

TABLE II

Date	New snow, in.	Wind speed, m.p.h.	Air temp., °F.	Percent clear of panel					
				1	2	3	4	5	6
12/20/65	⅞	Calm	7	100	0	100	80	90	100
1/13/67	2	do	27	100	95	100	100	100	100
2/2/67	3-4	do	34	100	slush	100	100	100	100
2/21/67	5	do	23-28	100	50	100	100	100	100
3/6/67	2	do	29	100	0	100	100	100	100
3/16/67	4	5	26	100	Oice	100	100	100	100

I claim:

1. A method for generating heat within an asphaltic concrete pavement to prevent the accumulation of frozen precipitation thereon, which comprises passing an electrical current through conductors to an electrically conductive layer of asphaltic concrete within said pavement to complete an electrical circuit, said electric conductive asphaltic concrete having a resistivity of about 1 to about 5 ohm-inch whereby sufficient heat is generated to melt the frozen precipitation overlaying said electrically conductive layer.

2. A method according to claim 1 wherein the current is passed through the electrical conductive asphaltic concrete by spaced-apart electrodes imbedded within the concrete.

3. A method according to claim 2 wherein the potential difference between the electrodes does not exceed 30 volts.

4. A method according to claim 3 wherein the power dissipated within said electrical conductive layer of asphaltic concrete ranges from 10 to 40 watts per square foot.

5. A method according to claim 4 wherein said electrically conductive asphaltic concrete consists of asphaltic concrete mixes having dispersed therein high purity graphite particles, said graphite particles constituting from 20 percent to 30 percent by weight of the mixture based on the total weight of the concrete aggregates.