

Nov. 12, 1968

MASAO ANDO

3,410,977

METHOD OF AND APPARATUS FOR HEATING THE SURFACE
PART OF VARIOUS CONSTRUCTION MATERIALS
Filed March 28, 1966

FIG. 1

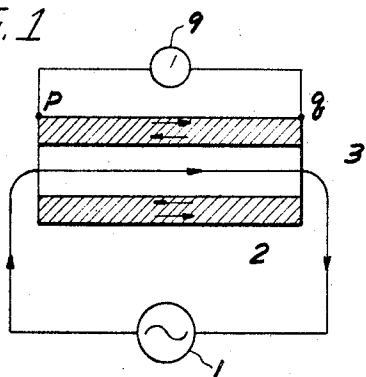


FIG. 2

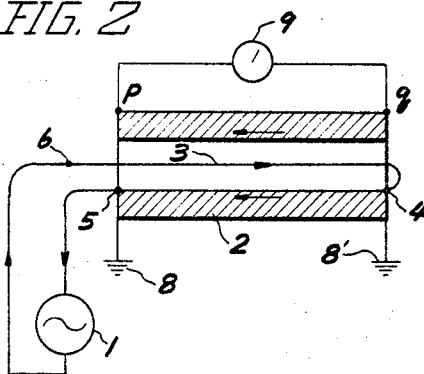


FIG. 3

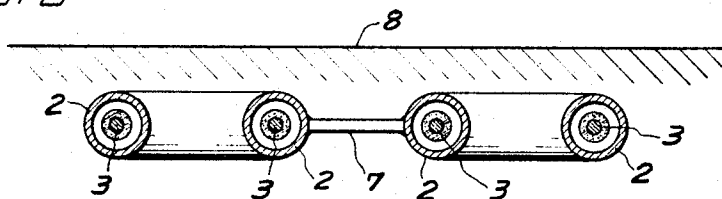
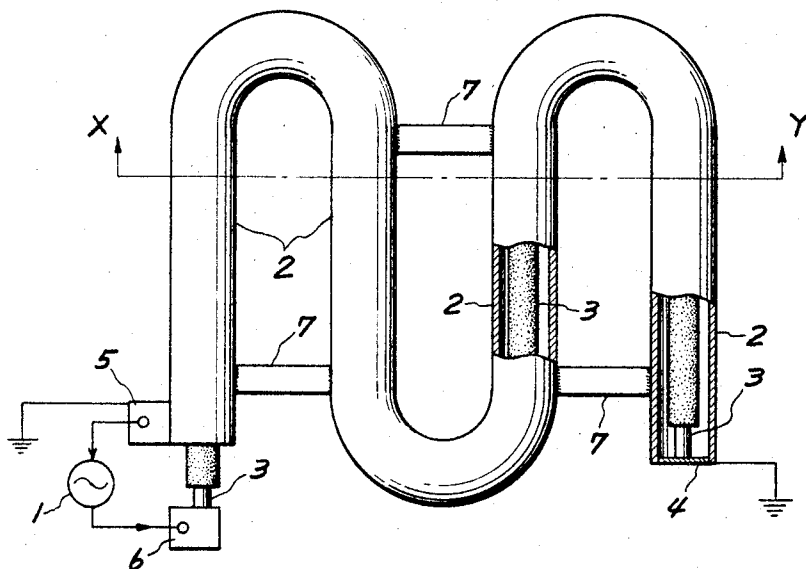


FIG. 4



1

2

3,410,977 METHOD OF AND APPARATUS FOR HEATING THE SURFACE PART OF VARIOUS CONSTRUCTION MATERIALS

Masao Ando, 72 Higashi-tamagawa-cho,
Setagaya-ku, Tokyo, Japan
Filed Mar. 28, 1966, Ser. No. 538,040
3 Claims. (Cl. 219—10.49)

ABSTRACT OF THE DISCLOSURE

Method of and apparatus for heating the surface of a road, floor and the like by using a heat-generating pipe buried in the construction material, consisting of an outside pipe made of a highly magnetic metal and an insulated wire disposed in the inside of said outside pipe, one end of said insulated wire being connected to one terminal of an alternating current source and the other end connected to a terminal fixed on one end of said outside pipe, the other end of the outside pipe being directly connected to the other terminal of the alternating current source. When an alternating current flows through the outside pipe, it passes only the inner surface of said pipe by the skin effect of the alternating current so as to generate heat on the inner surface of said pipe without current appearing on the outer surface of said pipe.

This invention relates to a method of and apparatus for heating the surface of road or wall electrically.

Recently various electrical heating methods have been attempted to heat the surface of road and floor in order to prevent them from being frozen, also to thaw snow or to heat a building.

Among them, there is known a method in which cables having insulation of butyl rubber and sheath of polyvinyl chloride (hereinafter it will be referred to as BN cable) or mineral insulated cables having a sheath of metal (hereinafter it will be referred to as MI cable) are buried under the road surfaces or in the inside of walls and electricity is passed therethrough to generate heat.

Though the method relied on the BN cables is relatively inexpensive compared with those relied on the MI cable, the BN cables are liable to be broken. Though the MI cables possess greater mechanical strength, the connection method thereof is rather complicated. Because of the fabrication problem, the metal sheath of the MI cable is made of the same material with core material and for this purpose copper is mostly used which makes the MI cables relatively expensive. Furthermore the copper does not adapt itself well to the construction material of road and floor, such as concrete, asphalt and the like. Hence it is liable to be damaged when it is used under the road where there is traffic of heavy vehicles.

An object of the present invention is to provide a method for heating the surface of road, floor or wall electrically which has overcome the above-mentioned drawback inevitable in the conventional methods.

Another object of the present invention is to provide an apparatus which can heat the surface of road, floor or wall electrically with economical advantage.

Such objects and other advantage can be attained by the method and the apparatus of the present invention.

The apparatus of the present invention consists of an outside pipe of highly magnetic metal which is buried in the to-be-heated construction material and a perfectly insulated wire disposed in the inside of the said outside pipe. One end of said insulated wire is connected to one terminal of an alternating current source and the other end is connected to a terminal fixed on one end of the said out-

side pipe, the other end of the said outside pipe being directly connected to the other terminal of the said alternating current source so as to generate heat only on the inner surface of the said outside pipe when an alternating current is passed through the wiring system. The method of the present invention consists in generating heat on the inner surface of an outside pipe made of a highly magnetic metal and buried in the inside of a construction material by passing the alternating current only on the inner surface of the said outside pipe by using an insulated wire which is disposed in the inside of the said outside pipe. One end of said insulated wire is connected to an alternating current source and the other end is connected to the other end of the said outside pipe, and the other end of the said outside pipe is directly connected to the other terminal of the same alternating current source.

A preferred embodiment of the invention has been chosen for purposes of illustration and description and is shown in the accompanying drawings, forming a part of the specification, together with the contrast drawing using conventional apparatus wherein FIGURE 1 shows schematically the distribution of current and voltage in the inside of steel pipe when alternating current is passed through the wire placed in the inside of the said steel pipe, FIGURE 2 shows schematically the distribution of current and voltage in the apparatus of the present invention, FIGURE 3 shows the apparatus of the present invention when it is buried under the surface of a road, corresponding to the view of the cross section taken along the line X-Y of the FIGURE 4, and FIGURE 4 shows one embodiment of the method of burying the apparatus of the present invention.

In the contrast drawing, FIGURE 1, 1 is an alternating current source, 2 is a steel pipe (e.g. $\frac{3}{4}$ ") having a thickness of about 3 mm. and 3 is an insulated wire having a cross sectional area of about 22 mm.² which is passed through the steel pipe 2 as shown in this figure.

When an alternating voltage of commercial frequency is impressed from the source 1, a current flows in the wire 3. For illustration purposes this current is i . Since 2 is a highly magnetic steel pipe, a current i' which is approximately equal to i flows through the pipe 2 in the direction shown in the FIGURE 1. In other words, i' is an eddy current and also a skin current. It is well known that the depth of the skin d (cm.) can be expressed by an equation:

$$d = 5030 \sqrt{\rho / \mu f} \quad (1)$$

wherein ρ is a specific resistance (Ω cm.) and μ is a permeability (σ) and f is a frequency of the source. (c./sec.)

Accordingly in order to make $i \approx i'$, it is necessary that the thickness of the steel pipe, t cm. must satisfy the following relation.

$$t > 2d \quad (2)$$

In the circuit shown in FIGURE 1, a voltage e appears on a voltmeter 9 inserted between terminals p and q and its value is approximately half the voltage of the source 1. When short circuit or earthing occurs, between p and q the current i varies. Accordingly this connection has a serious drawback in that a human being or animal passing this part may sustain injury.

In contrast to the connection of FIGURE 1, the apparatus of the present invention has a connection of FIGURE 2. Namely the insulated wire 3 from a source 1 is passed through the inside of a steel pipe and connected to a terminal 4 conductively fixed on one end of the pipe. The other end of the source 1 is connected to the terminal 5 fixed on the other end of the steel pipe. By such an arrangement, the current i flowing through the steel pipe exists only on the inner surface of the wall by the skin effect and does not appear on the outside of the pipe. For

3

example, even if the terminals p and q fixed on the outside of the pipe are connected to a voltmeter 9, the reading of voltage is zero and as indicated by 8 and 8' even when earthings are effected, there is no flowing of earth current.

The method for surface heating of the present invention can be reduced to practice by using the steel pipe schematically shown in FIGURE 2 as heating elements. FIGURES 3 and 4 shows the arrangement of such a heating element buried under the surface of the ground. In these drawings 1 is an electric source, 2 is a steel pipe, 3 is insulated wire, 4, 5 and 6 are terminals and 8 is the earth. An alternating current from a source 1 flows to a terminal 6, through an insulated wire 3 disposed in the inside of a steel pipe 2 and reaches a terminal 4, from there it passes only the surface part of the inside wall of the steel pipe, from the terminal 5 it leaves the steel pipe and returns to the source 1. Accordingly even when such steel pipes are buried in concrete asphalt, conductive earth, or the like, and even when short circuit is made by a steel plate 7 or the like, the current i is constant and no earth current or short circuit current flows so long as the insulation of the wire 3 from the terminal 6 to the terminal 4 is perfect. This means that there is no voltage appearing on that part and it is not harmful to a human being, animal or the like.

Since the heating element is of steel, it adapts itself well to concrete, asphalt or the like road, floor or wall.

Further it can be reinforced simply by structures such as steel plates 7 and hence it can be of strong construction. There are further advantages that the temperature distribution on the surface of road, floor or wall or the like can be made uniform by using relatively broad steel plates 7 and since the construction material is of steel, it is less expensive and more economical than copper used mostly in MI cables.

What is claimed is:

1. A method for heating the surface of construction material electrically which comprises generating heat on the inner surface of an outside pipe made of a highly magnetic metal and buried in the inside of a construction material by passing the alternating current only on the inner surface of the said outside pipe by using a perfectly insulated wire which is disposed in the inside of the said outside pipe, one end of said insulated wire being con-

4

nected to the one terminal of an alternating current source and the other end connected to the one end of the said outside pipe, the other end of the said outside pipe being directly connected to the other terminal of the same alternating current source.

2. An apparatus for heating the surface of construction material electrically which comprises an outside pipe of highly magnetic metal adapted to be buried in the construction material and a perfectly insulated wire disposed in the inside of the said outside pipe, one end of said insulated wire being connected to one terminal of an alternating current source and the other end connected to a terminal conductively fixed on the one end of the said outside pipe, the other end of the said outside pipe being directly connected to the other terminal of the said alternating current source, so as to generate heat only on the inner surface of the said outside pipe when an alternating current is passed through the wiring system.

3. An apparatus for heating the surface of construction material electrically which comprises an outside pipe of highly magnetic metal adapted to be buried in the construction material and a perfectly insulated wire disposed in the inside of the said outside pipe, one end of said insulated wire being connected to one terminal of an alternating current source and the other end connected to a terminal fixed on one end of the said outside pipe, the other end of the said outside pipe being directly connected to the other terminal of the said alternating current source, so as to generate heat only on the inner surface of the said outside pipe when an alternating current is passed through the wiring system, the outside surface of said pipe being inter-connected at places by steel plates.

References Cited

UNITED STATES PATENTS

2,543,882	3/1951	Tice	219—10.49
2,635,168	4/1953	Lerza et al.	219—10.49
3,219,800	11/1965	Alexander	219—446

RICHARD M. WOOD, *Primary Examiner*.

L. H. BENDER, *Assistant Examiner*.