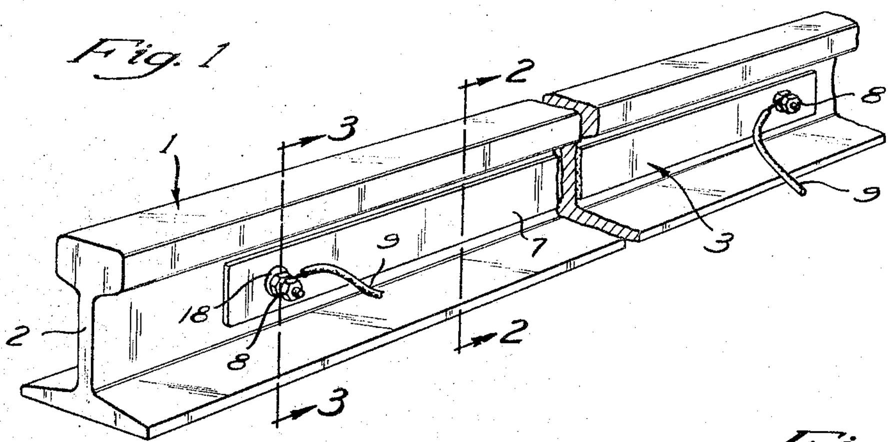
Oct. 31, 1967 G. W. DAVIS 3,349,722

ELECTRICAL RESISTANCE RAIL HEATER

Filed Nov. 27, 1964

Fig. 1



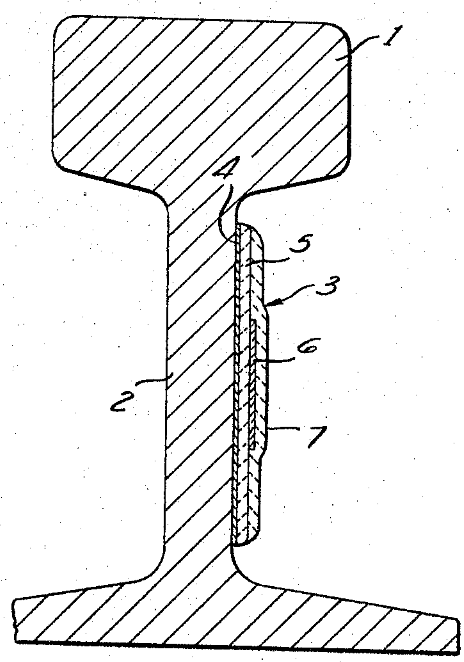
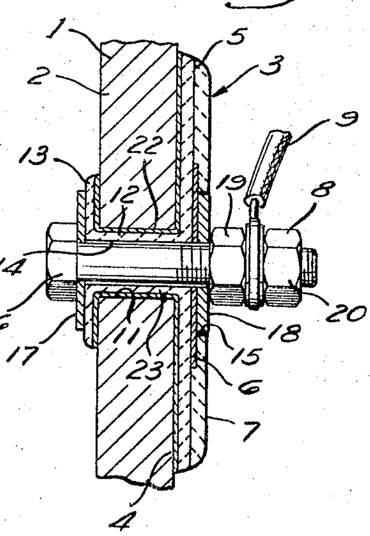


Fig. 2

Fig. 3



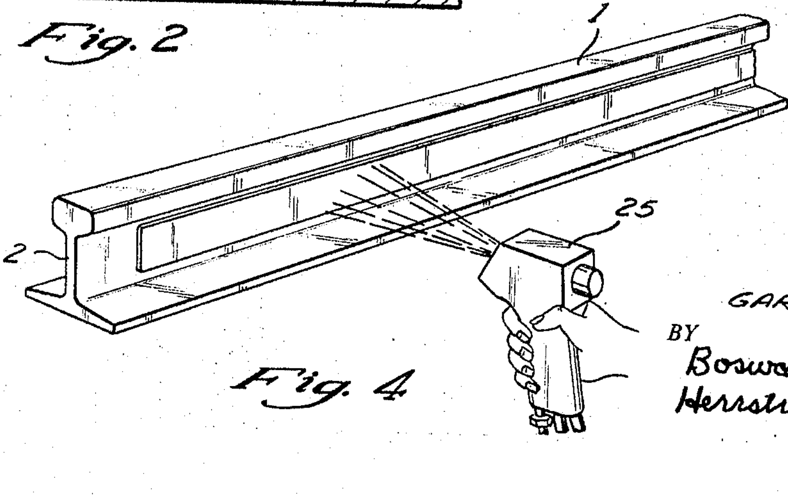


Fig. 4

INVENTOR.
GARY W. DAVIS
BY
Bosworth, Sessions
Herrstrom & Knowles
ATTORNEYS

United States Patent Office

3,349,722

Patented Oct. 31, 1967

1

3,349,722

ELECTRICAL RESISTANCE RAIL HEATER

Gary W. Davis, Mentor, Ohio, assignor to Cleveland Technical Center, Inc., Cleveland, Ohio, a corporation of Delaware

Filed Nov. 27, 1964, Ser. No. 414,206
4 Claims. (Cl. 104—279)

This invention relates to means for heating, and more particularly to electrical means for heating solid bodies by conduction.

While the invention is capable of other applications, it will be described below primarily in connection with the heating of railway rails to prevent undesirable accumulations of ice or snow, since the invention provides exceptional advantages in such use.

In modern railroad operations, it is necessary to prevent or remove substantial accumulations of ice or snow at rail switches and other locations on railroad rails in climates where such accumulations can occur. Otherwise, proper operation of the switches and such other portions of the rails could be impaired if not prevented, with consequent possibilities of damage or danger to rolling stock or personnel.

Undesirable accumulations of ice or snow heretofore have been prevented or removed by the application of heat to the rails by two general types of heating means: gas-fired or electrically energized infrared heaters designed and located to direct infrared radiation at the desired location on the rail; and mechanically attached tubular or strip type electrical heaters which transmit heat by conduction to the desired portions of the rail. Heaters of these types are quite expensive to install, to operate, and to maintain, and are characterized by other disadvantages. Thus the gas or electric infrared heaters generally are necessarily mounted a substantial distance from the area to be heated, so that their efficiency is reduced according to the inverse square law. The mechanically attached electrical heaters are usually attached to the rail at spaced intervals; as such a heater expands, it usually sags or droops away from the locations to be heated on the rail between the points of attachment. Moreover, since the electrical heating element is also necessarily located a substantial distance away from the rail in this type of heater, the efficiency of heating is not as great as is desirable.

To heat rail switches to prevent or remove accumulations of snow and ice, it has been the usual practice to mount one of the above types of heater at the stock or fixed rail; thus, a conduction type of electric heater usually has been mounted under the rail head on the gauge side, or inside, of the stock rail. While the heater so located has been advantageous for melting any snow or ice tending to accumulate on the stock rail between the stock rail and the switch point, it is poorly located to keep ice from forming on the switch point itself since the switch point is unheated when not in contact with the stock rail. Such an arrangement has also been disadvantageous in other respects, because a switch point of special shape is usually required to clear the heater and because it is difficult and costly to perform maintenance work on a heater which is so located between the switch point and stock rail.

An object of the present invention is the provision of an electrical heater, and a method of making such heater, that can overcome or avoid as many of the above disadvantages as desired. Another object is the provision of electrical heating means that is exceptionally efficient because the heating element may be mounted on, and located in extremely close proximity to the rail so that heat can be transfered by conduction from the heating element to the rail at the desired location. A further

2

object is the provision of a heater that may be easily mounted on a movable part of a rail, such as a switch point, to heat it to prevent accumulation of snow and ice. Another object is the provision of a method for readily and inexpensively forming the heater in place on the rail by spraying of constituents that will form the electrical heating element and the means insulating the element.

These and other objects of the invention will become apparent from the following description of a preferred embodiment thereof, in connection with the attached drawings, in which:

FIGURE 1 is a perspective of a portion of a railroad rail on which is mounted a heater embodying the invention;

FIGURE 2 is a section, to an enlarged scale, along line 2—2 of FIGURE 1;

FIGURE 3 is a section, also to an enlarged scale, along line 3—3 of FIGURE 1, showing one of the electrical terminals; and

FIGURE 4 is a perspective indicating a method of forming electrical heating means embodying the invention.

In the illustrated embodiment, the rail **1** has on its web **2** a heater **3** comprising a layer **4** of metal fuse-bonded to the web surface, a superimposed layer **5** of electrical insulating material that is fuse-bonded to the layer **4**, a strip layer **6** fuse-bonded to layer **5** and formed of suitable resistance metal sized to provide desired electrical resistance so it can act as a heater element, and a superimposed layer **7** of electrical insulating material that is fuse-bonded to the heating element strip layer **6** and the insulating layer **5** to enclose the heating element. Suitable terminals **8** are located near the ends of the heater. Power supply leads **9** connected to terminals **8** supply electrical energy to the heating element.

Each of these terminals **8**, as shown in FIGURE 3, is mounted in an opening **11** that extends through the web **2** of the rail. Suitable electrical insulating material **12** is located in the portion of opening **11** through web **2**, and extends radially at **13** from the opening on the side of the web **2** opposite the side on which heater **3** is mounted. An insulated opening **14** extends through insulation **12** and **13**, layers **4**, **5** and **6**, terminating in a radially enlarged recess **15** that extends through outermost layer **7** and exposes a substantial area of the metal of heating element **6** around the end of opening **14**. A bolt **16** extends through the opening **14**, through a metal washer **17** that bears against insulation **13**, through washer **18** that is located in recess **15** and bears against the bared portion of heating element **6** associated with opening **14**, and is clamped in place by locknut **19** threaded on the bolt. Another nut **20** clamps the end of the connected lead **9** between the nuts **19** and **20**. The terminal **8** thus makes electrical contact with the heating element **6**, but is insulated from the rail **1**.

When an electrical current of suitable voltage and amperage is passed through the heating element **6**, heat is generated for heating the rail as desired.

Layers **4**, **5**, **6** and **7** in the illustrated embodiment are produced by plasma spraying of the materials of which the layers are formed. Known plasma spraying equipment, such as the "Plasma-gun," model PG-100, of Avco Corporation, may be used. In this device, particles that carry electrical charges across a space or gap, are produced by passing an inert gas, such as argon, through an electrical discharge between two electrodes. The gas atoms and molecules are bombarded with electrons in the discharge and become so active that internal bonds of the atoms fail, so that collisions between atoms and molecules cause the freeing of electrons, which mix with positively charged ions and neutral atoms to produce ionization. As the numbers of collisions increase, the temperature of the ionized mixture increases and radiant energy emanates. The resulting highly disturbed state of matter has been named "plasma" and exists at temperatures which may be as high as 10,000° F. or higher. In the plasma gun, powdered materials are introduced which are softened or liquified by the plasma and ejected by the gun in a closely controlled spray of plasma and material to be sprayed. The gun can be manipulated to spray desired areas.

FIGURE 4 of the drawings shows the formation of one of the layers of the illustrated layers by spraying of layer material by a hand-held plasma gun **25**. It is apparent that known automatic equipment could be used in which a relative movement between the rail and the gun is automatically effected and controlled.

The first layer **4** which is formed of metal firmly bonded by fusing to the rail **1** and to the second layer **5**, makes possible considerably better adhesion of the second layer **5** than would be possible in the absence of the first layer by compensating for differences in the thermal expansions of the heating element layer **6**, the second layer **5**, and the rail **1**. For this purpose, it is preferable that the metal of first layer **4** be such that its coefficient of thermal expansion lies substantially midway between the coefficient of thermal expansion of the metal of rail **1** on one hand, and the coefficient of thermal expansion of the material of insulating layer **5** on the other hand.

The second layer **5** acts as an electrical insulator to insulate the heating element **6** from contact with the rail **1**. Preferably it is formed of electrical insulating ceramic material, and is sprayed and fuse-bonded under such conditions, that a dense highly adherent layer of ceramic material is formed that is essentially free of cavities or voids capable of containing moisture or other contaminants that could cause electrical current to leak or short circuit to the rail.

The heating element **6** is a strip of metal formed of suitable metallic material that is sprayed and fuse-bonded under such conditions as to form a strip of metal that is highly adherent to layer **5**, that is dense and essentially free of cavities or voids and that has the desired electrical resistance characteristics for the desired heating effect.

The last layer **7** acts to protect and insulate the heating element **6**. It is preferable that this layer be formed in place of electrical insulating ceramic material that is fuse-bonded under such conditions that it firmly adheres to the layers **5** and **6** and is so dense that it is essentially free of cavities or voids that could contain moisture or other contaminants that could cause current leakage or short circuiting.

In an actual example of a heater embodying the invention, the portion of the surface of a web **2** of the rail **1** on which the heater was to be affixed was thoroughly cleaned down to the bare metal by grit blasting by means of abrasive grits, such as angular steel particles or aluminum oxide particles, although it could have been cleaned by grinding or other suitable operations. The cleaned surface was about 3" wide, and slightly more than four feet long.

The first layer **4** was then formed in place on and fuse-bonded to the cleaned surface. This layer was a layer of nickel-chrome metal alloy approximately 0.001" to 0.002" thick, 3" wide and four feet long. It was made by plasma spraying of coarse powder of an alloy of 80% nickel and 20% chromium, the powder having a bulk density of approximately 7.5 grams per cubic centimeter, being sprayed by use of argon as the inert gas, an arc current of 500 amperes and an arc voltage of 33 volts, to form a layer of the desired size that firmly adhered to the rail.

By use of identical plasma gun apparatus, the next layer **5** of aluminum oxide was formed in place on and fuse-bonded to the first layer of nickel chrome metal. In forming the sprayed layer, fine aluminum oxide particles having a bulk density of approximately 3.3 grams per cubic centimeter were plasma sprayed in an inert gas of argon at an arc current of 700 amperes and an arc voltage of 30 volts, to form a layer approximately .05" thick and extending the full width and length of the first layer **4** and firmly adhering to it.

The third layer **6**, constituting the resistance heating element, was then plasma sprayed on the second layer **5**. This third layer was a layer of nickel-chrome alloy approximately .009" thick and 1¼" wide, located centrally of the width of the second layer **5**, and extended for substantially the full length of that layer, but preferably was slightly short of each end of the second layer. Layer **6** was formed by plasma spraying the same kind of nickel-chrome powder, under the same conditions, as described above for the first layer **4** to form a layer of the desired size that firmly adhered to layer **5**.

The last layer **7** was aluminum oxide and was formed of the same material as the first layer under the same plasma spraying conditions. This third layer was approximately 0.030" to 0.035" thick and 3" wide, and completely enclosed the heating element layer **6** except for the bare portions at the ends contacted by the terminals; it firmly adhered to layer **6** and adjacent portions of layer **5** not covered by layer **6**.

In the illustrated embodiment the insulation **12** in the opening **11** and insulation **13** adjacent the opening was formed by plasma spraying a first layer **22** of nickel-chromium alloy, like that of layer **4**, on the inner walls of the opening **11** and around such opening for a substantial distance on the surface of the web opposite the surface carrying the heater. A second layer **23** of insulating aluminum oxide is similarly sprayed onto this first layer **22** within the opening **11** and on the rear side of the web **2**.

The recess **15** through the outermost layer **7** may be machined after formation of the outermost protective layer **7**, but preferably is formed by shielding the portion of the heating element layer **6** to be bare while the outermost layer **7** is being sprayed, so a circular recess **15** of the desired size, in which the metal of layer **6** is exposed, results when the shield is removed. The bolt **16**, washers **17** and **18**, nuts **19** and **20** and conductor **9** for each terminal **8** can then be installed, to provide the desired electrical contact with the heating element **6** and the desired electrical insulation from rail **1**.

When the above described heater was operated at an average electrical power consumption of about 175 watts per foot of length it developed a temperature of about 165° F. in the head of the rail **1**. A power consumption of 300 watts per foot is required in a widely used conventional electrical rail heater to produce the same head temperature. It is apparent that very substantial power savings may be provided by heaters embodying the invention.

Heaters embodying the invention thus may be easily formed on railway rails. They may be made to provide a rail temperature in a wide range of temperatures by proper selection of spray constituents and proportions. They may be applied to fixed or movable rails. They can be made to have long life of trouble-free operation.

In the illustrated embodiment, the insulation for the terminal bolts **16** can be provided by conventional insulating bushings and washers rather than by the sprayed layers disclosed, if desired. It is apparent also that the sprayed layers of the illustrated embodiment may be formed of materials other than those indicated, to provide similar results.

Heating means embodied in the invention may be formed by the indicated or equivalent spray technique on bodies to be heated other than rails, which bodies may be formed of metals or other suitable materials known to the art on which substances suitable for forming the heaters of the invention may be spray-applied to form adherent coatings.

Those skilled in the art will appreciate that other changes and modifications can be made in the invention without departing from the spirit and scope thereof. The essential features of the invention are defined in the appended claims.

What is claimed is:

1. In combination, a railway rail that is to be heated, and a heater on said rail comprising a first layer of solidified metal formed in place on the web of said rail by application of heat-softened metal that becomes fuse bonded to said rail on solidification, a layer of solidified ceramic material formed in place on said first layer of metal by application of heat-softened ceramic material that becomes fuse bonded to said first layer of metal on solidification to form a dense highly adherent layer of solidified ceramic material that is essentially free of cavities or voids capable of containing moisture or other contaminants that could cause electrical current to leak or short circuit to the rail, said first layer of metal having a coefficient of thermal expansion between the coefficients of thermal expansion of the metal of said rail and of said ceramic material of said layer such that the bonds between said web of said rail and said first metal layer and between said first metal layer and said layer of ceramic insulating material are unimpaired by thermal expansions throughout the range of temperatures of the heater; a second layer of solidified metal of electrical resistance properties formed in place on said layer of ceramic material by application of heat-softened metal that becomes fuse bonded to said layer of ceramic material upon solidification to form a dense highly adherent layer of solidified resistance metal that is essentially free of cavities or voids and that has electrical resistance characteristics that will provide the desired heating effects, and connector means in electrical contact with said second metal layer but electrically insulated from said first metal layer and said rail, said connector means including an opening through the web of said rail, in which connector means said first layer of metal extends over the inner wall of said opening and on the surface of the web of the rail opposite the surface on which said heater is applied, and in which connector means said layer of solidified ceramic material extends over said first layer of metal in said opening and on said opposite surface of said web, to define an insulated opening through said web of said rail and an insulated portion on the rear side of said web of said rail, and which connector means includes conductive means passing through said insulated opening and electrically contacting said second layer of solidified electrical resistance metal and having a portion extending from said heater and rail to which electrical connections can be made.

2. The combination of claim 1 comprising a covering layer of solidified ceramic material formed in place on said second layer of metal and on said first layer of ceramic material by application of heat-softened ceramic material that becomes fuse bonded to said first mentioned layer of ceramic material and said second layer of metal on solidification to form a dense highly adherent protective layer of solidified ceramic material that is essentially free of cavities or voids capable of containing mositure or other contaminants that could cause electrical current to leak or short circuit.

3. The combination of claim 1 in which the metal of said first metal layer has a coefficient of thermal expansion substantially midway between the coefficients of thermal expansion of said rail and of said layer of ceramic insulating material.

4. The combination of claim 1 in which the metal of said second metal layer has substantially the same coefficient of thermal expansion as the metal of said first metal layer.

References Cited

UNITED STATES PATENTS

2,068,639	1/1937	Alsaker et al.	238—14.12
2,088,949	8/1937	Fekete	174—105
2,405,192	8/1946	Davis	338—22 X
2,500,299	3/1950	Broome	246—428 X
2,859,321	11/1958	Garaway	219—543 X
2,910,567	10/1959	Holstein	246—428 X
2,939,807	6/1960	Needham	117—212
2,962,393	11/1960	Ruchelshaus	117—212
3,007,026	10/1961	Woodling	219—543 X
3,113,253	12/1963	Ishikawa et al.	317—258
3,197,335	7/1965	Leszywski	338—308 X

RICHARD M. WOOD, *Primary Examiner.*

V. Y. MAYEWSKY, *Assistant Examiner.*