June 28, 1960 J. L. COLTEN ET AL 2,943,289

HEATING STRUCTURE

Filed June 12, 1959 2 Sheets-Sheet 1

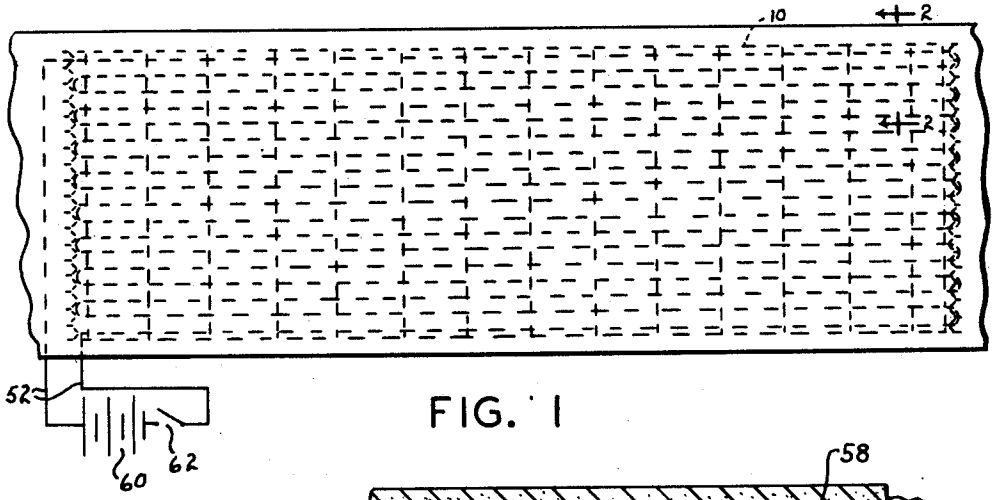


FIG. 1

FIG. 2

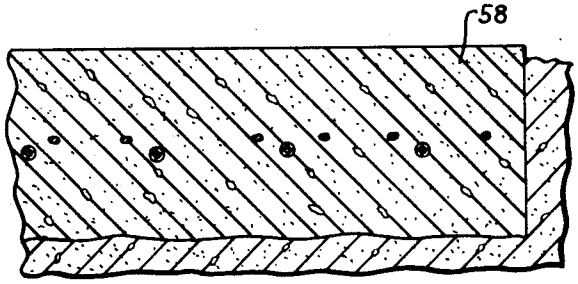




FIG. 4

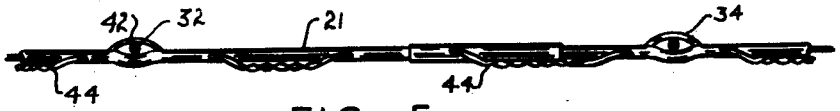


FIG. 5

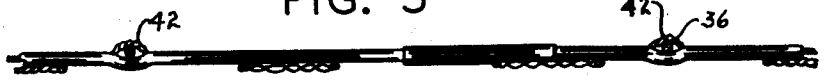


FIG. 6

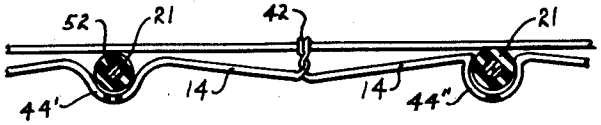


FIG. 7

INVENTOR.
JERROLD L. COLTEN
LEE M. WATSON
BY M. A. Hobbs
ATTORNEY

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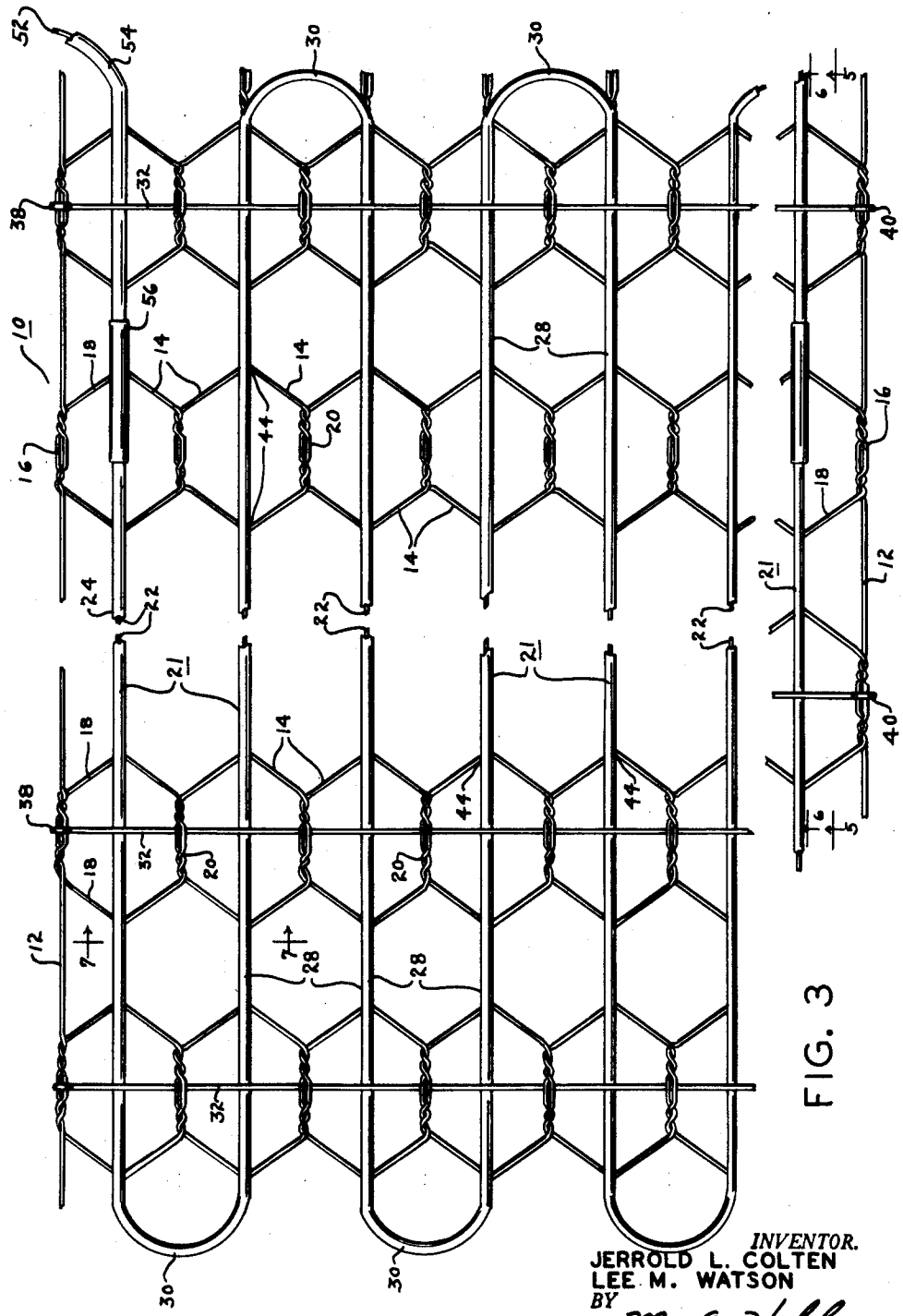


FIG. 3

INVENTOR.
JERROLD L. COLTEN
LEE M. WATSON
BY
M. A. Hobbs
ATTORNEY

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HEATING STRUCTURE

Jerrold L. Colten, South Bend, Ind., and Lee M. Watson, Three Oaks, Mich., assignors to Welcraft Products Co., Inc., New Carlisle, Ind., a corporation of Indiana

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14 Claims. (Cl. 338—208)

The present invention relates to a heating unit and more particularly to an electrical heating structure adapted to be embedded in the ground, driveways, runways, sidewalks, ramps, steps, roads, floors and the like.

The primary object of the present invention is to provide a heating structure which will effectively and economically maintain the temperature of driveways, sidewalks, ramps and the like at a level sufficient to melt ice and snow, and which can be easily and economically manufactured on a mass production basis using materials and equipment readily available on the market.

It is a further object of the invention to provide a heating structure of the aforesaid type having a series of electrical heating element sections mounted on a wire mesh carrier, which can be fabricated with a minimum number of operations and which when completed is sturdy, durable, and convenient to handle, store and install.

A further object of the invention is to provide an electrical heating unit which is adapted to be embedded in concrete or other material forming driveways, sidewalks, roads and the like, and which has an electrical resistance wire supported on and carried by a porous, flexible metal structure giving substantial protection to the wire while it is being embedded in the concrete and facilitating effective and uniform distribution of heat from the wire throughout the surface of the driveways and sidewalks overlying the unit.

Still another object is to provide a porous flexible unitary structure which can readily be placed or embedded in the ground or in concrete or asphalt in a single simple operation without any special skill or know-how and without any special tools, equipment or fixtures.

Another object of the invention is to provide a reinforcing structure having an electrical heating wire distributed substantially throughout, which permits the wire to be quickly laid and held in place during construction of driveways, walks and the like, eliminating the tedious and time consuming operation normally interrupting the construction work of laying and securing the individual strands or sections of wire in place.

Additional objects and advantages will become apparent from the following description and accompanying drawings, wherein:

Figure 1 is a plan view of a strip of pavement or a section of a driveway illustrating our heating structure schematically in broken lines;

Figure 2 is a fragmentary transverse sectional view taken on line 2—2 of Figure 1 showing our heating structure embedded in a section of pavement such as a driveway;

Figure 3 is an enlarged fragmentary plan view of our new heating structure with portions broken away to better show the construction thereof;

Figure 4 is a fragmentary side elevational view of the heating structure shown in Figure 3;

Figure 5 is a vertical cross sectional view of the heating structure taken on line 5—5 of Figure 3;

Figure 6 is a vertical cross sectional view of the heating structure taken on line 6—6 of Figure 3; and

Figure 7 is an enlarged fragmentary cross sectional view of the heating structure taken on line 7—7 of Figure 3.

Referring more specifically to the drawings, numeral 10 designates a wire mesh or screening carrier consisting of longitudinal marginal wires 12 and intermediate wires 14, each marginal wire being connected with an adjacent intermediate wire 14 at spaced intervals, as at portions 16 at which said wires are interlocked by twisting. The portions of the intermediate wire between the twisted portions 16 are offset laterally at 18. The offset portions 18 are in turn twisted or intertwined with portions of adjacent intermediate wires 14 at 20. The arrangement is such that a regular substantially hexagonal pattern is formed in the screen with adjacent intermediate wire portions 14 interconnected at twisted portions 20 thereof regularly and uniformly throughout the area of the screen. The twisted portions 16 and 20 provide regularly spaced and arranged portions of reinforced character for increased strength. The wire may be of any suitable gauge, preferably galvanized and preferably sufficiently thin to be inherently flexible so that the screen can be rolled lengthwise into a coil if desired. The screen will normally be used in widths of twelve inches to twenty-four inches, and formed in convenient lengths, such as lengths of five feet, ten feet, twelve feet, twenty feet, or any other length which will enable a user to complete a drive or heated area of any desired length by using a combination of units of different standard lengths.

An insulated electric resistance or heating element 21 is carried by the screening. The heating element consists of resistance wire 22 encased within an insulating waterproof sheath 24 of flexible materials, such as a thermoplastic material. One thermoplastic material particularly well suited for the insulation 24 is a vinyl resin of thin wall construction which accommodates bending of the wire 22, is waterproof, and constitutes a good electrical insulation. It will be understood, however, that any type of insulation coating, such as rubber, synthetic rubber, fabric coated or impregnated with waterproofing material, or the like, may be utilized.

The insulated heating wire 21 is arranged in a plurality of straight sections 28 spaced apart substantially uniformly and interconnected at curved portions 30 adjacent opposite edges of the screen carrier. Each longitudinal section 28 is secured to the carrier at a plurality of spaced points along its length. The pattern in which the heating wire is arranged, and the points at which it is secured to the screen, may vary somewhat from that shown as long as the spacing of the heating wire sections imparts the desired heating characteristics to the unit and as long as a secure anchorage of the heating wire to the screen is obtained.

The manner in which the heating element is secured to the wire mesh carrier is of primary importance in the present invention and consists of a plurality of spaced wire shafts 32 extending laterally across carrier 10 and interlocking the heating element and carrier by alternately passing over a section of the element and thence under a twisted portion 20 as seen at numerals 34 and 36, respectively. The two ends 38 and 40 of the shaft are looped around or otherwise locked to marginal wires 12 at twisted portions 16 in order to secure the shafts firmly in place and to prevent displacement while the heating structure is being handled. The spacing of the shafts is preferably uniform throughout most of the length of the structure; however, it is usually desirable to space the shafts somewhat closer together near the ends of the structure to give additional support at the places in the structure where

displacement of the heating element from the carrier is most likely to occur. The wire shafts are relatively stiff but are sufficiently flexible that they may dip slightly in passing over the heating element sections and under twisted portions **20**.

The carrier is preformed for receiving shafts **32** by bending outwardly or arching as seen at numeral **42**, all of the twisted portions **20** in a particular transverse row across the carrier, the transverse rows of preformed arches being spaced from one another along the carrier, usually every three to five transverse rows apart. As seen in Figure 3, the transverse rows of preformed twisted portions near the left hand end are spaced only one row apart whereas, for the purpose of illustration, the rows in the intermediate portion of the structure are spaced four rows apart. When the heating element and shafts are in interlocking relationship the sections of the heating element are bent slightly downwardly, as seen in Figures 4, 5 and 6, i.e. dipping slightly below the upper plane of the carrier into or adjacent the V or trough-shaped connection **44** in and between connecting wires **14**. The dipping of the sections into the hexagonally shaped spaces prevents both lateral and longitudinal slippage of the heating element sections. While the sections of heating element are shown overlying the twisted portions **20** in the intermediate transverse rows between shafts **32** they may be offset slightly to the side one way or another without interfering with the effective locking of the strands in the hexagonally shaped spaces.

To facilitate the formation of a sturdy connection between the heating element sections **28** and the carrier, and to prevent lateral shifting of the sections on the carrier, intermediate wires **14** are preferably pre-bent to form in effect a trough-shaped structure for receiving and retaining the wire sections. Wires **14** may be bent to hold the wire sections **28** only loosely, as shown at numeral **44'** in Figure 7 or bent to grip or clamp the wire sections, as illustrated at numeral **44''**, to retain the sections in place on the carrier without shafts **32**. The trough-like structures for securing the heating element wire in place are in rows and can be used with carriers having longitudinal and transversely arranged wires. The troughs may be in either of these two sets of wires.

In fabricating the present heating structure, a section of the wire mesh carrier **10** is unrolled from a coil of the mesh, which has been preformed to provide arches **42** in twisted portions **20** of pre-selected transverse rows, and cut to the desired length, for example ten, fifteen or twenty-five feet. The heating element is then cut to length and laid back and forth in sections as shown in the drawing in a predetermined pattern, generally in equal spaced parallel relationship. While the sections of the heating element are held in place on the carrier, a jig of suitable construction presses the strands downwardly at the place where the shaft **32** is to be inserted under arches **42** of a transverse row of twisted portions **20**, and the shaft of the correct length is inserted lengthwise from one side of the carrier. The shaft is then secured in place by bending the ends of the shaft around marginal wire **12** with a suitable tool either manually or power operated. The jig is moved successively along the carrier from one shaft inserting operation to the next until the shafts have been inserted at all the pre-selected positions. While in the operation described the jig is moved, in some operations the jig may be held stationary and the carrier moved relative to the jig.

The opposite ends of the heating wire are connected to cold lead wires **52**, each preferably being of flexible character, though not necessarily so, and provided with an insulating sheath **54** which may be of thermoplastic material such as a vinyl resin, or of any other suitable type. The terminal portions of the wires **22** and **52** are connected by a suitable insulated electrical connector **56**. The electrical leads **52** may be connected to any suitable source of power **60** to complete a circuit under the control of a switch **62**.

In the use of the unit, as in a driveway, concrete **58** is first poured in the usual forms (not shown) to a depth of at least several inches and preferably to a depth of one and one-half inches to two inches less than the desired depth or thickness of the pavement or slab, and is leveled throughout in the conventional manner. Our unit of the desired length is then laid upon the concrete. In the case of a driveway, the units are positioned in the concrete at the part or parts where snow removal is desired, and are laid the length of the driveway with the lead wires **52** of each unit projecting laterally to the exterior of the form. In long driveways a number of units may be required, the units being laid end to end in alignment throughout. The strip units are laid substantially flat so as to be substantially parallel with the plane of the finished surface of the pavement. Thereupon additional concrete is poured into the form to cover the strip units and to complete the slab or pavement.

The lead wires **52** of adjacent strip units or sections are then connected to a source of power **60** in a circuit under control of switch **62**. If desired, adjacent strip units or sections may constitute independent circuits or they may be connected in series or in parallel relation.

The combination of the wire mesh carrier **10** and the multiple sections **28** of insulated heating element **21** will not sink in the fresh or fluid concrete of its own weight, and will not readily become displaced when the layer of concrete is poured thereon. Thus the strip units remain in the desired plane at a selected spacing below the top surface of the pavement **58** and substantially uniformly spaced therefrom throughout its length.

The wires or heating elements **21** are maintained evenly or substantially uniformly spaced, or spaced in any other pattern having substantially uniform heating effect upon the pavement **58** in which they are embedded. The anchoring of the heating element to the wire screening places the insulation sheath **24** of the heating elements in contact with the wire screen carrier at twisted or reinforcing portions **20** so as to transfer heat to the wires making up the screen. These screen wires, being formed of metal, constitute good conductors of heat and serve to distribute evenly the heat generated by the heating element **21** throughout all portions of the carrier **10** and substantially uniformly throughout the area of the pavement **58** in which the wire screen is embedded.

The strip unit is preferably placed with the heating element **21** positioned below the carrier. In this manner the wire screen **10** serves to protect the heater wire **21** from injury incident to manipulation of the concrete as the top layer of the concrete is leveled by tools in forming the pavement **58**. Thus the wire screen protects the heating element **21** from damage and at the same time serves to retain the heating element in proper position in the fluid concrete. In addition to protection of the heating wire, the wire carrier **10** serves to reinforce the concrete and to minimize cracking of the concrete. Avoidance of cracking of the concrete also tends to protect the heating element **21** embedded therein against breakage.

Although the present description has been directed primarily to a heating structure for installation in driveways, sidewalks, ramps, floors and the like, the structure can be effectively used without modification to warm or heat lawns and garden areas, hot beds and other farm applications, and walks and driveways constructed of loose material such as gravel, crushed stone and the like. In installing the present heating structure for these uses it is placed at a depth of between two and six inches, i.e. a sufficient depth below the surface to hold the structure in place and to protect it from surface travel. The term "pavement" will be used in the claims to refer to and include all the uses and purposes of the present heating structure mentioned herein.

While only one embodiment of the invention has been illustrated and described in detail herein, it is under-

stood that changes in the construction may be made without departing from the scope of the invention.

We claim:

1. A combination heating and reinforcing structure, comprising a carrier having marginal wires and flexible longitudinally and diagonally arranged wires forming laterally and longitudinally arranged hexagonal spaces throughout the carrier, the longitudinally arranged wires having arched portions arranged in spaced transverse rows across said carrier, the arches of each transverse row extending in the same direction, an insulated wire heating element arranged in longitudinal sections extending substantially the full length of the carrier and being disposed between the longitudinal wires having said arches and on the side of said carrier on which said arches extend, said longitudinal sections being connected alternately at their ends, shafts at the transverse rows of said arches extending under the arches and over the sections of heating element wire between said arches depressing said element wire into the respective hexagonal spaces and being secured at their ends to the marginal wires, and flexible insulated electrical leads connected to the ends of said heating element wire and projecting beyond the edge of said carrier.

2. A combination heating and reinforcing structure, comprising a carrier having marginal wires and flexible longitudinally and diagonally arranged wires forming laterally and longitudinally arranged hexagonal spaces throughout the carrier, the longitudinally arranged wires having arched portions arranged in spaced transverse rows across said carrier, the arches of each transverse row extending in the same direction, a heating element wire arranged in longitudinal sections extending substantially the full length of the carrier and being disposed between the longitudinal wires having said arches and on the side of said carrier on which said arches extend, said longitudinal sections being connected alternately at their ends, shafts at the transverse rows of said arches extending under the arches and over the sections of heating element wire between said arches depressing said element wire into the respective hexagonal spaces and being secured at their ends to the marginal wires, and electrical leads connected to the ends of said heating element.

3. An electric heating structure, comprising a carrier having marginal wires and longitudinally and diagonally arranged wires forming laterally and longitudinally arranged hexagonal spaces throughout the carrier, the longitudinally arranged wires having arched portions arranged in spaced transverse rows across said carrier, the arches of each transverse row extending in the same direction, an insulated wire heating element arranged in longitudinal sections extending substantially the full length of the carrier and being disposed between the longitudinal wires having said arches and on the side of said carrier on which said arches extend, said longitudinal sections being connected alternately at their ends, and shafts at the transverse rows of said arches extending under the arches and over the sections of heating element wire between said arches and being secured at their ends to the marginal wires.

4. A heating structure, comprising a carrier having marginal wires and longitudinally and diagonally arranged wires forming laterally and longitudinally arranged hexagonal spaces throughout the carrier, the longitudinally arranged wires having arched portions arranged in spaced transverse rows across said carrier, the arches of each transverse row extending in the same direction, an insulated wire heating element arranged in longitudinal sections extending substantially the full length of the carrier and being disposed between the longitudinal wires having said arches and on the side of said carrier on which said arches extend, and shafts at the transverse rows of said arches extending under the arches and over the sections of heating element wire between said arches.

5. A heating structure, comprising a carrier of longitudinally and diagonally arranged wires, the longitudinally arranged wires having arches arranged in spaced transverse rows across said carrier, the arches of each transverse row extending in the same direction, an insulated wire heating element arranged in longitudinal sections and being disposed between the longitudinal wires having said arches and on the side of said carrier on which said arches extend, and shafts at the transverse rows of said arches extending under the arches and over the sections of heating element wire between said arches.

6. A heating structure, comprising a carrier having marginal wires and longitudinally and transversely arranged wires, the longitudinally arranged wires having arched portions arranged in spaced transverse rows across said carrier, the arches of each transverse row extending in the same direction, an insulated wire heating element arranged in longitudinal sections and being disposed between the longitudinal wires having said arches and on the side of said carrier on which said arches extend, and shafts at the transverse rows of said arches extending under the arches and over the sections of heating element wire between said arches and being secured at their ends to the marginal wires.

7. A heating structure, comprising a carrier of longitudinally and transversely arranged wires, the longitudinally arranged wires having arched portions arranged in spaced transverse rows across said carrier, the arches of each transverse row extending in the same direction, an insulated wire heating element arranged in longitudinal sections and being disposed between the longitudinal wires having said arches and on the side of said carrier on which said arches extend, and shafts at the transverse rows of said arches extending under the arches and over the sections of heating element wire between said arches.

8. A heating structure, comprising a carrier of longitudinally and transversely arranged wires and marginal wires connected to said transversely arranged wires, a heating element wire arranged in longitudinal sections being disposed between the longitudinal wires, and shafts at spaced intervals along said carrier extending transversely thereacross alternately under said longitudinal wires and over said heating element sections and being secured at their ends to said marginal wires.

9. A heating structure, comprising a carrier of longitudinally and transversely arranged wires, a heating element wire arranged in longitudinal sections being disposed between the longitudinal wires, and shafts at spaced intervals along said carrier extending transversely thereacross alternately under said longitudinal wires and over said heating element sections.

10. A heating structure, comprising a carrier of longitudinally and diagonally arranged wires, the longitudinally arranged wires having arches arranged in spaced transverse rows across said carrier, the arches of each transverse row extending in the same direction, said diagonal wires having troughs extending in the direction opposite said arches, an insulated wire heating element arranged in longitudinal sections and being disposed in said troughs, and shafts extending under the arches and over the sections of heating element wire between said arches.

11. A heating structure, comprising a carrier having marginal wires and longitudinally and transversely arranged wires, the longitudinally arranged wires having arches arranged in spaced transverse rows across said carrier, the arches of each transverse row extending in the same direction, said transverse wires having troughs extending in the direction opposite said arches, and an insulated wire heating element arranged in longitudinal sections and being disposed in said troughs, and shafts extending under the arches and over the sections of heating element wire between said arches and being secured at their ends to the marginal wires.

12. A heating structure, comprising a carrier of longitudinally and diagonally arranged wires, said diagonal

wires being bent between said longitudinal wires to form troughs, and an insulated wire heating element arranged in longitudinal sections and being disposed in said troughs between the longitudinal wires, the portions of said diagonal wires forming said troughs engaging said element sections.

13. A heating structure, comprising a carrier having marginal wires and longitudinally and transversely arranged wires, said transverse wires having troughs extending inwardly in the same direction, and an insulated wire heating element arranged in longitudinal sections disposed in said troughs, the portion of said transverse wires forming said troughs gripping said element sections.

14. A heating structure, comprising a carrier having

longitudinal and transverse sets of wires, the wires of one set having troughs extending inwardly in the same direction, and an insulated wire heating element arranged in a series of sections disposed in said troughs, the portion of said wires forming said troughs gripping said element sections.

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