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Northrup, Jr. et al.

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[54] **ELECTRICAL HEATING DEVICE FOR AIR DUCT**

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[51] **Int. Cl.**[2] **H05B 3/02;** H01C 1/014

[58] **Field of Search** 219/353, 355, 359, 363, 219/366–371, 374–377, 379–382, 532, 551; 338/57, 58, 278–282, 286, 290, 296, 298, 304, 305, 316–321

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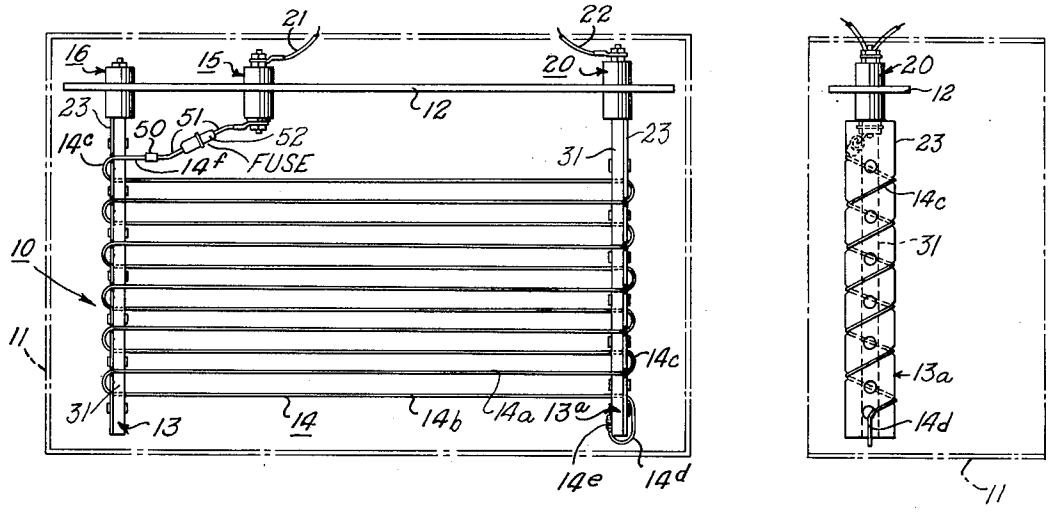
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[57] **ABSTRACT**

An electrical resistance heating device for use in an air duct connected with a blower for heating air forced across the device along the duct, comprising a mounting plate, a pair of spaced parallel support bar assemblies connected with the mounting plate the support bar assemblies each including a thin plate aligned parallel with the direction of air flow in the duct, an electrical resistance-type heating element formed of a single length of wire coiled about the support bar assemblies including staggered straight sections of substantial length extending in parallel relationship so that the major portion of the element is made up of parallel straight wire sections and semicircular connecting sections between the straight sections extending around and spaced from the outside faces of the thin plates for maximum air cooling, and insulated connectors through the mounting plate coupled with the heating element and adapted to be connected to an electrical circuit for supplying power to the device.

5 Claims, 7 Drawing Figures



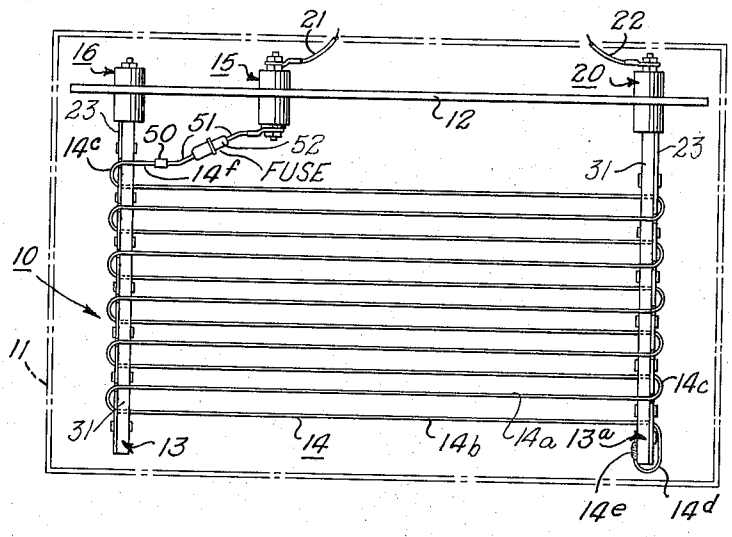


Fig. 1

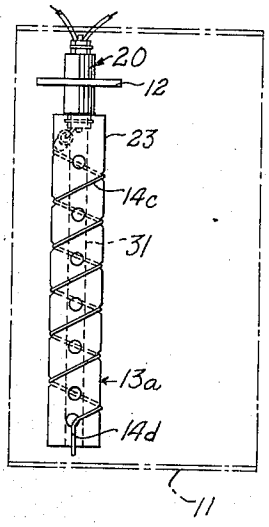


Fig. 2

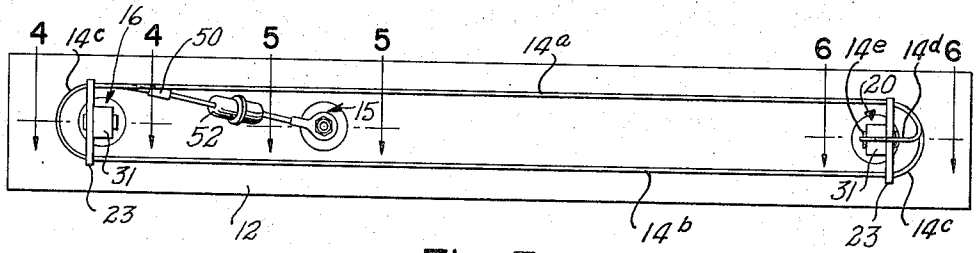


Fig. 3

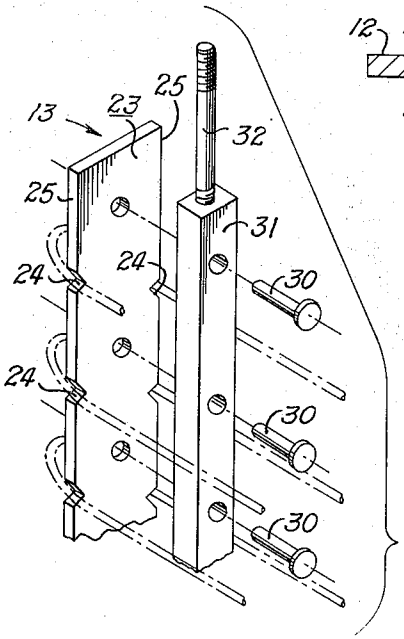


Fig. 7

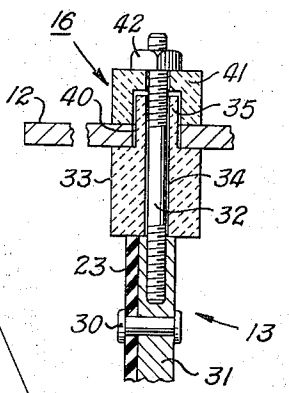


Fig. 4

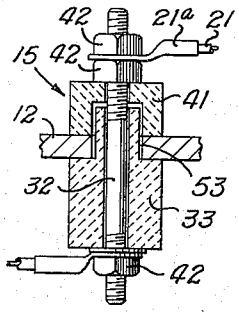


Fig. 5

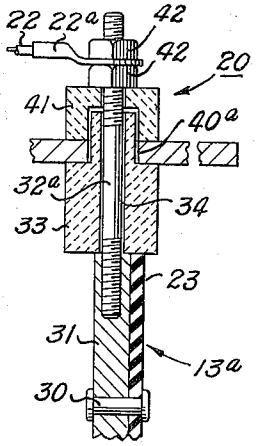


Fig. 6

ELECTRICAL HEATING DEVICE FOR AIR DUCT

This invention relates to heating devices and, more particularly, relates to an electrical resistance-type heating unit for use in an air stream.

In the past, electrical resistance-type heating devices for use in air streams for heating the air have most generally included heating elements formed of electrical resistance-type wire formed into a relatively tight helix, thereby providing a substantial number of small coils disposed closely together so that the interchange of heat between nearby sections of the coils and between the coils themselves is substantial. Such an arrangement has a number of disadvantages including requiring either frequent replacement of the heating element or operation at a lower than desired current and, thus, temperature. The close proximity of the various coils and sections of the coils to each other produces damaging effects due to the exchange of heat between nearby sections of the wire heating element. Additionally, the use of rather tightly wound coils and a large number of the coils supported in close proximity to each other may effect a rather substantial pressure drop in the air flowing across the heating element along an air duct. Further, such heating elements often have insulating spacers along the coils to maintain some spaced relationship between the coils, such insulating spacers shielding small, short sections of the element wire from air flow so that excessive temperatures causing damage to the element wire may occur. Additionally, shielded areas of the coils along the supporting structure of the heating element tends to cause hot spots in the element and thereby premature failures.

In accordance with the invention there is provided an electrical resistance-type heating device for use in a forced air duct comprising a mounting plate, spaced support bar assemblies secured from the mounting plate, an electrical resistance heating element formed by a single length of wire wound about the support bar assemblies to provide a plurality of spaced straight wire sections between the bars, and insulated connectors secured through the mounting plate to opposite ends of the heating element and adapted for connection with leads in a circuit for providing power to the heating element. The heating element is particularly characterized by the straight wire sections and a minimum amount of the element wire being shielded from the air by the supporting structure of the device.

It is a particularly important object of the invention to provide a new and improved heating device.

It is another important object of the invention to provide a new and improved electrical resistance-type heating device for use in an air stream.

It is another object of the invention to provide an electrical resistance-type heating device which has improved heat transfer characteristics.

It is a further object of the invention to provide a heating device of the electrical resistance type which is capable of carrying a larger current flow than conventional coiled-type heating elements at comparable temperatures.

It is a further object of the invention to provide an electrical resistance-type heating device in which a minimum amount of the wire of the heating element is blocked off from the air flow due to the novel arrangement of the supporting structure for the heating element.

It is a still further object of the invention to provide a heating device of the character described which effects a minimum pressure drop within an air duct as the air flows along the duct past the heating device.

It is a further object of the invention to provide a heating device for air ducts which effectively produces a plane of heat across the duct.

It is a still further object of the invention to provide a heating device of the character described wherein a plurality of straight wire sections forming the heating element of the device are disposed at spaced locations which minimize the radiation and conduction between the wires, thereby providing maximum heat transfer to the air flowing over the heating element.

It is a still further object of the invention to provide a heating device of the character described which is capable of operating at lower temperatures while providing comparable air temperatures as prior art devices.

The details of the invention, together with its objects and advantages, will be more thoroughly understood and appreciated from the following detailed description of a preferred form of the invention taken in conjunction with the accompanying drawings wherein:

FIG. **1** is a top plan view of one embodiment of a heating device constructed in accordance with the invention shown supported across a forced air duct illustrated in phantom lines;

FIG. **2** is an end view, as seen from the right end of FIG. **1**, of the heating device shown in the duct in FIG. **1**;

FIG. **3** is an enlarged front view in elevation of the heating device removed from the air duct;

FIG. **4** is an enlarged fragmentary view in section along the line **4—4** of FIG. **3**;

FIG. **5** is an enlarged fragmentary view in section along the line **5—5** of FIG. **3**;

FIG. **6** is an enlarged fragmentary view in section along the line **6—6** of FIG. **3**; and

FIG. **7** is an exploded fragmentary perspective view showing a portion of the heating element support structure of the device.

Referring to the drawings, a heating device **10** embodying the invention is shown supported across a duct **11** for directing air flow past the heating device to heat air from a blower, not shown, forced through the duct to an enclosure to be heated, not shown. The heating device **10** includes a mounting plate **12**, a pair of spaced mounting bar assemblies **13** and **13***a*, and an electrical resistance heating element **14** supported on the bar assemblies. The heating element **14** is connected through insulated coupling assemblies **15** and **20** to leads **21** and **22** extending to a source of electrical current, not shown, for supplying power to the heating element at a sufficient level to increase the temperature of the heating element to heat air in the duct **11** forced across the heating device.

Each of the identical support bar assemblies **13** and **13***a* includes an elongated rectangular-shaped plate **23** formed of a heat-resistant dielectric material, such as mica. The plate **23** has a pluralilty of staggered, spaced notches **24** formed along the long opposite edges **25** of the plate. Each plate **23** is connected by longitudinally spaced brads **30** to an elongated electrical conducting bar **31** which may be formed of a metal such as steel which is nickel-plated to resist the corrosive effects of heat and moisture within the air flowing along the duct in which the heating device is supported. A rod **32**

threaded along opposite end portions is secured at one end into an end of the bar **31** in the assembly **13** in axial alignment with the bar for supporting the bar from the mounting plate **12.** A rod **32***a* is similarly secured into the bar **31** of the assembly **13***a* for conducting current to the bar and securing the bar to the plate in the mounting assembly **13***a*. Each of the plates **23** is substantially wider than the bar **31** on which the plate is mounted so that the intermediate curved portions of the heating element **14** supported by the plate do not engage the bar.

The bar assembly **13** is supported perpendicular to and along the front face of one end portion of the mounting plate **12** against a tubular ceramic insulator **33** which has a bore **34** for the rod **32** and a reduced end portion **35** disposed through a hole **40** in the plate **12.** A hollow ceramic cap **41** fits over the insulator portion **35** on the back face of the mounting plate **12.** A nut **42** is tightly threaded on the outer end portion of the rod **32** against the cap **41** pulling the ceramic insulator portions tightly together on opposite sides of the plate **12** clamping the insulator to the mounting plate and firmly holding the mounting bar assembly **13** perpendicular to and extending from the front face of the mounting plate.

The mounting bar assembly **13***a* at the other end of the heating device is supported on the mounting plate **12** in an identical manner using the same parts including the ceramic insulators **33** and **41** and a slightly longer threaded support and conductor rod **32***a*. The ceramic insulators are mounted at the hole **40***a* through the mounting plate **12** held tightly against the plate on opposite sides by a pair of nuts **22** on the outer threaded end portion of the rod **32***a*. Clamped between the nuts **42** is an end connector **22***a* on the lead **22** for connecting the lead with the rod **32***a* so that current is conducted from the lead through the rod into the bar **31.** The support bar assemblies **13** and **13***a* differ only in that the bar assembly **13** performs only a supporting function while the bar assembly **13***a* in the particular form of the device shown is also a conductor through the bar **31** to one end of the heating element **14.**

The heating element **14** comprises a continuous length of nickel-chromium (nichrome) wire especially wound in a modified form of a laterally elongated helix pattern having a plurality of parallel spaced straight upper portions **14***a* and parallel spaced straight lower portions **14***b* interconnected by intermediate integral semicircular 180° turn portions **14***c*. The lengths of the straight portions **14***a* and **14***b* and the diameters of the turn portions **14***c* are spaced and sized in accordance with the spacing and sizes of the plates **23** along with the staggered edge notches **24** on the plates. The diameter of the turn portions **14***c*, as evident by FIG. **7,** is determined by the spacing between the adjacent corresponding pairs of staggered notches **24** along the opposite edges of the plates. The modified helical shape of the heating element to fit the staggered notches on the plates provides staggered positioning of the upper and lower straight heating element portions **14***a* and **14***b* so that such straight portions are not immediately above and below each other. Thus, air flowing along the duct receives maximum heat from the heating element straight portions while transferring minimum heat between the heating element portions since any one defined column of air of less thickness than the wire spacing would only pass around a single one of the straight heating element portions. The upper and lower straight portions of the heating element lie in a pair of spaced planes which are perpendicular to the axis of the duct **11.** Planes of heat are provided with minimum heat exchange between wire sections or portions.

The end of the heating element at the outer end of the support bar assembly **13***a* is sharply bent at **14***d* outwardly around the end edge of the plate **23** of the assembly **13***a* and welded at **14***e* along the outer end portion of the bar **31** for making electrical contact with the outer end of the bar. The other end **14***f* of the heating element along an inward portion of the other support bar assembly **13** near the mounting plate **12** is secured by a lead coupling **50** with a short fused lead section **51** including a suitable replaceable cased fuse **52.** The other end of the lead section **51** is connected on an inward threaded end portion of a rod **32** in the connector **15** by a nut **42.** The rod is supported, as best seen in FIG. **5,** through a ceramic insulator assembly including one of the tubular ceramic insulators **33** and a ceramic insulator cap **41** which are clamped on opposite sides of the mounting plate **12** through a hole **52** in the plate. A connector **21***a* is held on the outer threaded end portion of the rod **32** between a pair of the nuts **42** connecting the lead **21** to the conductor rod. Thus, the inward end of the heating element **14** is connected through the fused lead **51** and the mounting plate to the lead **21,** and the outer end of the heating element is connected at **14***e* through the bar **31** of the mounting assembly **13***a* to the lead **22.** Connection of the leads **21** and **22** to a source of electrical energy supplies the heating device with current for heating the wire element **14.**

When the heating device is energized through the leads **21** and **22,** air is forced along the length of the duct **11** perpendicular to the plane of the heating device. The air flows across the straight segments **14***a* and **14***b* and the turn segments **14***c* of the heating element. The heat transfer characteristics of the heating element is substantially better than prior art devices because of the maximum exposure of the various segments of the heating element **14** to the air flow and their particular arrangement in the air stream.

One or more of the heating devices **10** may be placed in the duct **11** for heating air forced along the duct. The mounting plate **12** is secured by any suitable form of bracket not shown, within the duct, preferably oriented such that the planes of the straight heating elements **14***a* and **14***b* are perpendicular to the longitudinal axis of the duct so that the air flows along lines perpendicular to such planes. The leads **21** and **22** are connected with a suitable power source, such as an available supply of 220-volt, 60-cycle current. The circuit through which the current flows includes the rod **32***a* and the conductor bar **31** of the support bar assembly **13***a*, the heating element **14** the outer end of which connects at **14***e* with the outer end of the bar **31,** and the fused lead section **51** connecting through the rod **32** in the connector **15** to the lead **21.** As air flows along the duct past the heating element, the air is heated by the straight element sections **14***a* and **14***b* and the turn sections **14***c*. The current flowing through the resistance-type heating element **14** increases the temperature of the wire comprising the element for heating the air passing over the element. The thin, flat shape of the mica plates **23** provides minimum interference with the air flow, and the very small lengths of the heating ele-

ment wire along the edges of the mica plate at the notches **24** provide a very minimum amount of the wire element which is even partially shielded from the air flow. This tends to minimize wire failure which frequently occurs at hot spots which are not adequately cooled or have poor heat transfer characteristics along prior art heating elements. The use of the single strand straight and semicircular turn sections of the wire heating element as distinguished from the prior art spring like coils provides maximum heat transfer between the air and the wire heating element with minimum heat transfer between sections of the wire as occurs in adjacent, tightly wound coils of prior art elements. The alternate spacing of the straight sections of the heating element between the two planes along which the element sections **14***a* and **14***b* are aligned minimizes the flow of air from one heating element section to an adjacent heating element section reducing the movement of heat between the heating element sections and increasing the heat transfer into the flowing air. The cumulative effect of employing the straight, single-strand wire heating element, the minimum amount of the heating element wire shielded from air flow, and the positioning of the wire strands provides air heat corresponding to prior art devices at lower wire temperatures which increases element life. Due to better heat transfer characteristics, the heating element may carry more current than prior art devices, if desired, without damage to the wire. Additionally, the configuration of the heating element results in a lower air pressure drop across the device than occurs with the tightly wound coils of the prior art units. Planes of heat are produced by the arrangement of the straight wire sections of the heating element. The wire spacing and alternate positioning of the sections of the heating element results in less heat transfer both by radiation and by conduction between the sections.

Another particularly desirable feature of the heating element configuration of the invention is that it lends itself to rapid assembly techniques with minimum hand work required, as distinguished from prior art devices which necessitate major hand assembly operations in placing the tightly wound coils and supporting insulators on the frames used for such devices. Various techniques are available with the present invention to automate the winding of the heating element wire to the desired configuration. For illustrating the highly efficient heat transfer characteristics of the heating device it has been found that at zero air flow rate the temperature of the element may go as high as 1800° F. while at normal air flow the heating element temperature never exceeds 1000° F.

What is claimed is:

1. An electrical resistance-type heating device comprising: a mounting plate; spaced support bar assemblies secured at opposite ends of said mounting plate, each of said support bar assemblies having a conductor bar formed of an electrical current conducting material and a substantially flat, thin heating element mounting plate formed of a heat-resistant dielectric material secured to said conducting bar for supporting a heating element, the planar surfaces of said dielectric mounting plate being aligned in a direction parallel with the line of air flow past said heating device for providing minimum air resistance to air flow along said dielectric plate; a heating element formed of a straight electrical resistance type conductor shaped in a modified helix pattern having a plurality of straight sections interconnected at opposite ends of said heating element by curved turn sections whereby said straight sections are aligned in two spaced parallel planes, said straight sections in one of said planes being misaligned from said straight sections in the other of said planes, said heating element being mounted on said dielectric plates of said mounting bar assemblies, said straight sections of said heating element in one of said planes extending between corresponding edges of said dielectric plates while said straight sections in the other of said planes extending between the opposite corresponding edges of said dielectric mounting plates, said turn sections of said heating element encompassing the outside plane surfaces of said dielectric plates in spaced relation thereto whereby said mounting bar assemblies lie within said heating element at opposite ends thereof; and conductor means connected through said mounting plate to opposite ends of said heating element for supplying electric current to said heating element.

2. A heating device in accordance with claim **1** wherein each of said mounting bar assemblies is supported on an insulator from said mounting plate.

3. A heating device in accordance with claim **2** wherein at least one of said conductor bars is electrically connected with one end of said heating element whereby said conductor bar comprises a part of the conductor means for supplying electric current to said heating element.

4. A heating device in accordance with claim **3** wherein the conductor means for supplying electric current to the other end of said heating element includes a fused lead assembly coupled by insulating means through said mounting plate.

5. An electrical resistance heating device for heating a column of air in a duct comprising: support means comprising spaced support bar assemblies including heat-resistant dielectric thin planar mounting panels aligned parallel to the direction of air flow past said device; and a heating element supported on said panels comprising a single strand of straight electrical resistance wire wound about said panels in a modified helix shape having straight sections arranged in two substantially parallel spaced planes extending between corresponding edges of said panels, said straight sections being parallel with each other and the straight sections in one plane being staggered relative to the straight sections of the other plane whereby a defined column of air passes across only one of said straight wire sections, and said single strand of wire includes semicircular sections connecting adjacent straight sections of said wire between opposite edges of each of said panels, said semicircular sections being disposed along outside faces of said panels and spaced outwardly from said panel faces for maximum air flow over said sections.

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