ABSTRACT: A heating assembly of improved efficiency wherein electrically energized heating elements are disposed between the peaks of ridged heat-absorbing and re-radiating surfaces and preferably combined with a convection-reducing wire screen in immediate proximity to the peaks of the surfaces, the angularly disposed ridges and the wire screen cooperating to increase the radiant heat output by a more effective utilization of the heated air and by improved infrared radiation capability.
ELECTRICAL INFRARED RADIATION SYSTEM

BACKGROUND OF THE INVENTION

1. Field of the Invention

This invention is in the field of infrared heaters using electrically energized heating elements combined with surfaces which are efficient radiators of infrared energy and with a screen which serves to cause a back pressure to be applied to the heated air to thereby confine it more closely to the radiating zone.

2. Description of the Prior Art

Prior art systems employing electrical heating elements have been handicapped because of the relative inefficiency in terms of amount of power required to produce an adequate amount of radiant energy. Generally, such heaters have utilized highly polished reflector systems which direct the radiant energy emanating from the back of the radiating element toward the area being heated in front of the radiating element.

Frequently, these reflector systems became tarnished or covered with dust or other foreign matter which seriously affected the total radiant energy output, sometimes by as much as 50 percent or more. The polished reflector had a tendency to gradually oxidize and lose its highly polished surface because the air being heated by the electrical heating elements frequently raised the temperature of the reflector to values on the order of 400° to 500°F or more.

One of the most common types of electrical heating elements embodies a metallic sheath in which there is located a helical coil of electrical resistance wire confined within a compacted mass of magnesium or other heat-insulating material. Another type involves the use of a bare wire wound on ceramic forms. The bare wire type has even less radiant energy output per watt of input than the tubular type, due to a substantially smaller surface area.

In connection with the tubular elements, regardless of how much pressure is used in compacting the magnesium, there still exists a substantial temperature differential between the heating element embedded in the magnesium and the outer metal sheath. Normally, in most tubular elements the temperature differential between the heating-element wire and the outer sheath is on the order of 400° to 600°F. There are obvious limitations to simply increasing the total outer radiating surface area of the tubular sheath in order to gain additional output energy. Any attempt to increase the diameter of the outer sheath is met with the necessity of supplying considerably more power to the heated element, which requires that the wire temperature become so high that internal damage is likely.

Furthermore, the additional wattage required under these circumstances does not give increased efficiency, and results in a shorter life.

A substantial amount of the heat loss and the resulting temperature differential arises from the fact that room air striking the high temperature heating surface carries away a substantial amount of heat and decreases the overall efficiency of the unit.

SUMMARY OF THE INVENTION

In the heating assemblies of the present invention, electrically energized radiant-heating elements are located in the included angle between a plurality of ridged surfaces. The close proximity of the heating elements to the ridges provides efficient heating of the ridges from the hot air coming off of the heating elements and from the radiant energy given off by the heating elements. The effective radiating area is thereby increased, providing for more efficient transmission of heat by infrared radiation. In addition, the presence of the wire screen serves to confine the heated air more closely to the vicinity of the radiating surfaces at the base of the notches. The heating elements, the inclined surfaces of the ridged elements, and the screen interact in a complex manner because of the multiple reflection of the infrared energy between the ridges and the heating elements. This mutual interaction is further assisted by the heated air which is retained about the heating elements. It has been found that the circulation of the air under these circumstances creates a turbulent swirling effect in the ridged cavity areas, and this action is substantially independent of the position of the elements so that the heating elements can be disposed either vertically or horizontally in the system of the invention and improved results will still be obtained.

BRIEF DESCRIPTION OF THE DRAWINGS

FIG. 1 is a cross-sectional view of a heating assembly embodying the improvements of the present invention;

FIG. 2 is a fragmentary cross-sectional view of the end structure of the assembly shown in FIG. 1;

FIG. 3 is an end view of the assembly shown in FIG. 1; and

FIG. 4 is a cross-sectional view of a modified form of the invention.

DESCRIPTION OF THE PREFERRED EMBODIMENTS

In FIG. 1, reference numeral 10 indicates generally a heating assembly including outwardly flared perish cubic foot. As illustrated, the exhaust port 12 is a body of a heat-reflective sheet such as a piece of aluminum foil 13 lines the bottom of the well portion 12. Disposed in the well portion 12 is a body of a heat-insulating material such as a ceramic wool which has low density, high temperature stability, and a very low k factor. One of the particularly preferred types of materials finding use in the present invention is that sold by the name "Kawool." This material is preferably used at a density of about 3 to 8 pounds per cubic foot, and preferably at 4 to 6 pounds per cubic foot. A pair of support brackets 15 and 16 is secured to the housing to confine the body 14 of ceramic wool therein.

Extending substantially across the full width of the housing is a ridged metal plate 16. The included angle between the peaks of the ridges in the plate 16 is preferably in the range from 30° to 90° for best results. While the ridges in FIG. 1 are shown as having a triangular cross-section, for some applications it may be more desirable to use a ridged structure with flattened peaks or even with a pyramidal configuration.

Disposed between the peaks of the ridges and the plate 16 are a plurality of electrical heating elements generally indicated at numeral 17 of the drawings. These elements may be of the hairpin type or they may be individual elongated heating elements. In the form of the invention shown in FIG. 1, the heating elements 17 include an outer metal sheath 18 filled with a compacted mass of magnesium 19 in which there is embodied a helical electrical resistance wire 20. As illustrated, the heating elements 17 are disposed near the base of and in close proximity to the walls of the ridges in the plate 16.

Disposed in close proximity to the peaks of the ridges of the plate 16 is a metal screen 21 which serves to provide a significant back pressure on the hot air which is heated by the heating elements 17 and radiates infrared back toward the heating elements. The screen 21 has marginal end portions 22 and 23 which are covered by a mat 24 composed of a ceramic wool material of the type used in the body 14, but preferably of a higher density, say about 8 pounds per cubic foot. As illustrated, the ends of the mat 24 may be folded over about the marginal edges of the plate 16 and over the top of the marginal flange portions 22 and 23. Additional bats of ceramic wool insulation 25 and 26 may be interposed between the marginal flange portions 22 and 23 and the edges of the plate 16. The lateral edges of the plate 16 and the screen 21 are thus freely floating in the ceramic insulation, so that they can better absorb stress due to expansion and contraction. A pair of pressure plates 27 and 28 are provided as suitable fastening means 29 and 30 to apply confining pressure to the ridges of the screen and the plate.

The screen 21 may be made of any suitable metal and preferably has openings in the range from about 4 to 100 per square inch in order to provide the back pressure effect on the gases being heated by the heating element 17. For best results, the screen 21 should be spaced no more than about one-half
inch from the tops of the ridges in the plate 16, with one-quarter to one-half inch being preferable. The ridged surfaces are preferably constructed of a metal which will both absorb and reemit infrared radiation very efficiently. It is desirable that the ridges absorb as much radiant energy from the radiant elements as possible and pick up as much heat from the heated gases as possible in order to attain a peak efficient radiant temperature. When the peak efficiency is obtained when the metal surfaces oxidize and turn very dark, preferably black, over a period of time during normal operation so that they act as very efficient radiant energy emission sources. For this purpose, it is preferable to use stainless-steel-type metals which become darkened at the elevated temperatures at which the heater operates. Such stainless steels are usually ferrous-base metals containing nickel, chromium or both. The ferritic-type stainless steels are particularly effective in providing the desired darkening reaction upon oxidation. The maximum darkening effect seems to occur in about 12 to 24 hours of continuous use.

The structure of the end of the heating unit is best illustrated in FIGS. 2 and 3 of the drawings. As illustrated, there is provided an L-shaped support plate 31 which is welded or otherwise attached to the plate 16. A block 32 of ceramic wool abuts up against the body 14 of ceramic wool, and a portion of the mat 24 of ceramic wool extends between the inner face of the block 32 and the depending leg of the support bracket 31. As best seen in Fig. 3, the block 32 is provided with oversilled apertures 33 through which the heating element 17 extends. This type of structure is designed to prevent excessive endwise motion. When the ridges 16 are heated, normal expansion takes place, and the ceramic fiber insulation is compressed to accommodate the thermal expansion.

The form of the invention illustrated in FIG. 4 of the drawings illustrates a dual arrangement in which two 240-volt element arrays can be used in conjunction with a 480-volt supply. The assembly there shown includes a housing 41 having outwardly inclined baffle walls 42 and 43 and a well 44. Disposed within the well 44 is a divider 45 secured to the base of the well 44 by means of suitable fastening means 46 and 47. The divider 45 separates the assembly into two heating units identical in configuration. The left-hand unit includes a body 48 of relatively low density ceramic wool and a mat 49 of relatively higher density ceramic wool material. A ridged plate 50 has a marginal flange portion 81 in opposed-spaced relation to a corresponding marginal flange portion 52 of a metal screen 53. The mat 49 is folded over the top of the marginal flange portion 52, and a pad 54 of suitable insulation is interposed between the two marginal flange portions. A pressure plate 55 fastened to the baffle wall 42 by means of suitable fastening elements 56 presses the ceramic wool against the marginal flange portions.

A plurality of tubular heating elements 57 is received within the notches provided by the ridge surfaces, as in the previous embodiment.

Similarly on the right side of the assembly, there is provided a body 61 of ceramic wool, and a mat 62 also composed of heat-insulating material. The ridged plate 63 rests on the mat 62 and has a marginal flange portion 64 facing a corresponding marginal flange portion 65 of a screen 66 disposed over the ridged plate 63. A pad 67 of insulation is received between the two opposed marginal flange portions. A pressure plate 68 secured to the baffle wall by means of fastening means 69 serves to apply compressive force against the ceramic wool in which the marginal flange portions 64 and 65 are embedded.

The opposite marginal flange portion 71 of the screen 53 and the corresponding marginal flange portion 72 of the screen 66 are also embedded in a mat 73 of ceramic wool, as are opposed marginal flange portions 74 and 75 of the ridged plates 50 and 63, respectively. A fastening means such as a stud 76 extends through the divider 45 and applies a compressive force to the marginal flange portions in place while accommodating some lateral movement due to thermal expansion. With this type of arrangement, it will be noted that both of the ridged plates 50 and 63 as well as both of the screens 53 and 66 are unconfined laterally except for being embedded in a mass of ceramic wool, so that they are free to move without creating excessive thermal stresses in the surrounding structure.

With the type of assembly shown in the drawings, heating elements designed to operate at 240 volts with a resultant temperature of about 1,500°F. have been observed to achieve temperatures as high as 1,700°F., and in some cases even as high as 1,900°F., for the same power input that provides only a 1,500°F. temperature when used with a conventional reflector system.

The very effective insulation used at the rear of the ridged surfaces reduces the heat loss to the rear such that the housing temperatures at the rear of the assembly are substantially lower than even on air-cooled reflector systems. As a specific example, the reflector and housing temperature of a conventional type of infrared radiating element has been measured at 375°F., whereas a housing temperature of 200°F. was achieved with the assembly of the present invention utilizing the same heating element at precisely the same power input.

Numerous tests have indicated that the electric infrared heaters of the present invention have a substantially higher output than the best gas-fired types of equivalent sizes. In one test with two heating elements rated at 1,800 watts each, more than 40 percent greater output was obtained over the best commercial type of natural-gas-fired infrared radiant heaters with an input of 25,000 B.t.u. With heating elements rated at 3,000 watts each, utilizing two elements in a hairpin configuration in a unit 3 feet long, almost three times as much output was obtained as in conventional gas-fired heaters of 30,000 B.t.u. input rating.

The heaters of the present invention were used to dry slow-drying enamel paints which had been applied to a ¼-inch sheet steel. It was found that the paint could be dried to the touch within 15 to 20 minutes by the use of these heaters. In another test, a thin-gauge sheet metal painted with a gloss white baking enamel could be raised in temperature from the ambient temperature of 190°F. in 1 minute, and to 290°F. in 2 minutes. These temperatures were measured at the rear of the metal after the infrared radiation had penetrated the paint. An acrylic lacquer was dried on an automobile and was ready for smoothing within 1 hour. Normal ambient air-drying in hot, dry weather, requires 16 hours.

In another test, a plastic material that required 20 minutes to 2 hours of heat-up time in a hot air tunnel at 400°F. could be heated to the point where the plastic material was soft and could be vacuum formed in a matter of seconds. Even transparent material such as a ¼-inch sheet of "Plexiglas" could be softened sufficiently for vacuum forming in approximately 5 minutes, as contrasted to the normal time of more than 2 hours in a 400°F. hot air kiln.

In another test, a heating assembly in accordance with the present invention using a single element in the ridges was compared to the results obtained using a single heating element of precisely the same size in conjunction with a reflector. It was found that the assembly of the present invention provided the same radiation output at 130 volts as obtained from the same unit operating at 240 volts in a reflector system.

A double heating system of the type shown in FIG. 4 of the drawings having four long tubular rods 56 inches long and placed in a housing 2 feet wide and 53 inches long was used to dry freshly pressed ceramic tile containing approximately 7 ½ percent moisture. It was found that the tile could be sufficiently dried in 1 ½ minutes so that a glaze could be sprayed onto the tile. The normal time cycle to accomplish the same results was 6 days of drying in a heated, controlled-humidity room.

It will be evident that various modifications can be made to the described embodiments without departing from the scope of the present invention.

I claim as my invention:
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1. A heating assembly comprising a housing, a pair of unconnected ridged plates supported in said housing, said plates being composed of a metal which absorbs infrared radiation efficiently and which becomes an efficient infrared radiator at the operating temperature of the assembly, an electrical heating element disposed below the peaks of the ridges in said plates, a wire screen in closely spaced relation to the peaks of said ridges, and thermal-insulating means spacing said plates from the rear of said housing.

2. The heating assembly of claim 1 in which said ridges are formed on a plate extending across said housing, and the assembly includes a mat of ceramic wool spacing said plate from the rear of said housing.

3. The assembly of claim 1 in which the included angle in the ridges is in the range from 50° to 90°.

4. The heating assembly of claim 1 in which said plates are laterally supported within said housing on a mat of ceramic wool.

5. The heating assembly of claim 1 in which said ridged plates are composed of stainless steel.

6. The assembly of claim 1 in which said screen has from four to 100 openings per square inch and is positioned within about one-half inch of the peaks of said ridges.