April 4, 1939. H. E. TRENT 2,152,934

HEAT TRANSMITTING SURFACE

Filed June 21, 1934 2 Sheets-Sheet 1

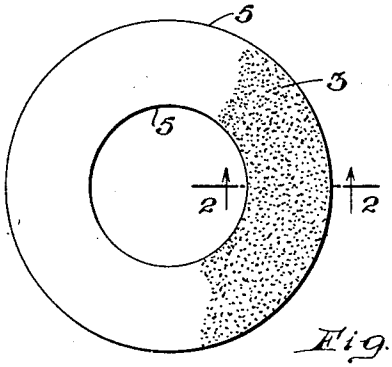

Fig. 1.

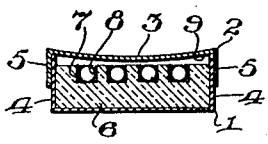

Fig. 2.

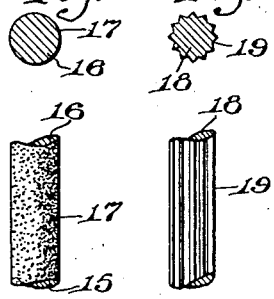

Fig. 3a Fig. 3b

Fig. 3c Fig. 3d

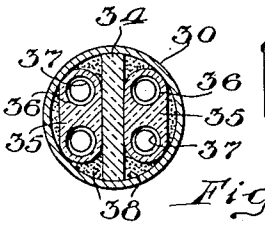

Fig. 8.

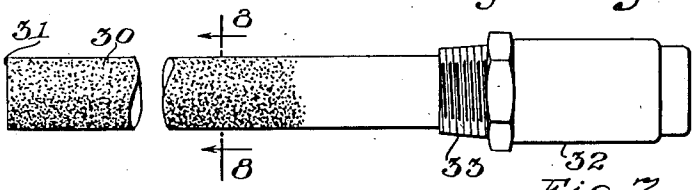

Fig. 7.

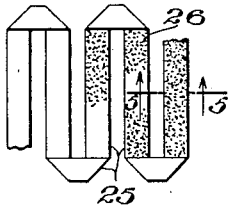

Fig. 4.

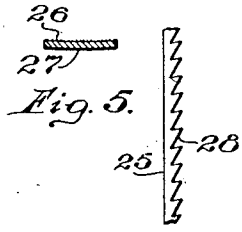

Fig. 5. Fig. 6.

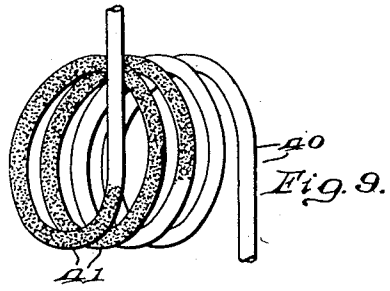

Fig. 9.

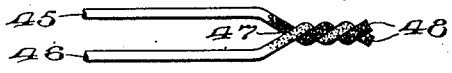

Fig. 10.

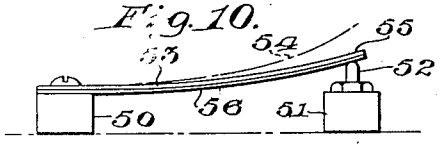

Fig. 11.

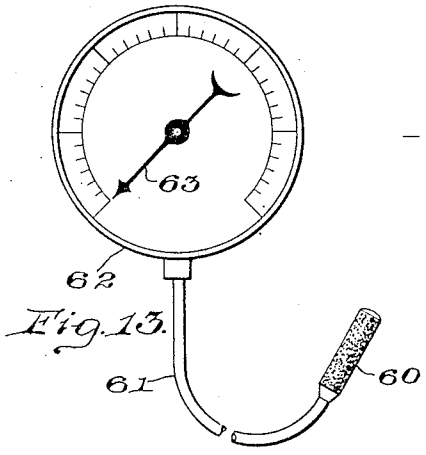

Fig. 13.

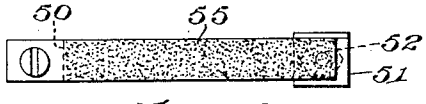

Fig. 12.

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HEAT TRANSMITTING SURFACE

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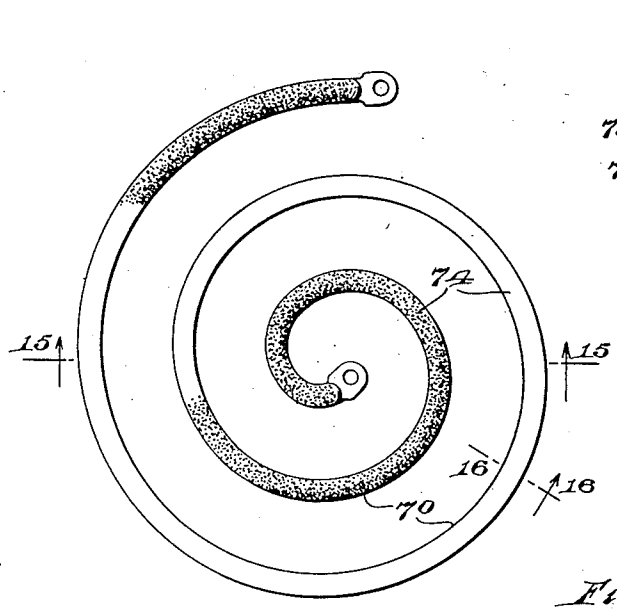

Fig. 14.

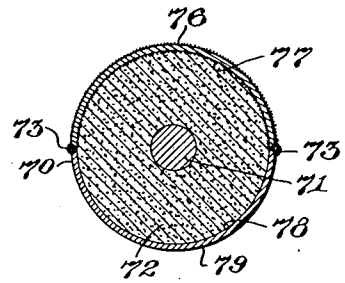

Fig. 16.

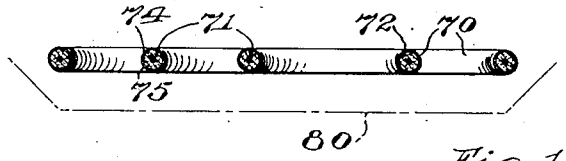

Fig. 15.

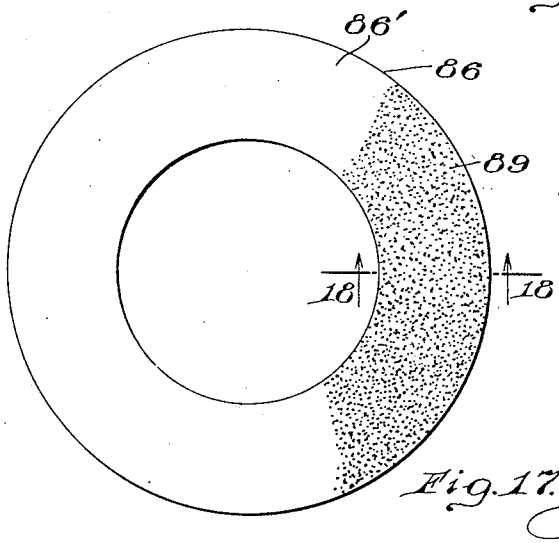

Fig. 17.

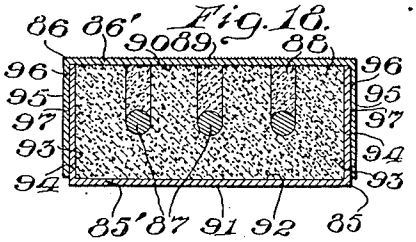

Fig. 18.

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HEAT TRANSMITTING SURFACE

Harold E. Trent, Philadelphia, Pa.

Application June 21, 1934, Serial No. 731,624

2 Claims. (Cl. 201—64)

This invention relates broadly to heat transmitting surfaces, but especially to the surfaces of articles and devices having surfaces by or through which heat is transferred, either in one direction, or in the other, or both, and commonly classed as radiation and absorption.

In order to accomplish the results sought, the object is to so extend or roughen the surface of the article or devices, which in probably all cases is either of sheet metal or has a metal-covered coating, in such manner that the heat absorption or radiation quality of the article or device will in effect be materially increased, preferably substantially uniformly, so that the area of surface contact of such article or device with the surrounding medium (either liquid, solid or gas) is considerably increased, without affecting the inherent physical and electrical characteristics, such as the resistance and strength of roughened conductors, and the thermal lag of thermo-couples, while increasing the sensitivity and emissivity of the latter, and corresponding characteristics of the other devices below mentioned. More particularly with respect to air heaters, it has been proved that their temperature rise is more rapid, and their radiation considerably more pronounced. In the case of heater units and resistance wires in general, those with extended surfaces radiate more heat units per watt consumption, with the same overall cross section, resulting in economy of space for a given temperature.

Such articles as the invention may be applied to, fall into certain more or less well defined classes, as for instance, (*a*) extending the protective casing about various types of heat sources, such as electric resistance wires and rods, the surfaces of tubes through which heat-conducting fluids flow and in which instances such casing may be extended upon both of its inner and outer surfaces, the former to accelerate the absorption of the heat from the heat source or fluid, and the latter to accelerate the radiation of such heat; (*b*) extension of the surface of a wire, band, or rod, which comprises the heat source when serving as resistance for the passage of an electric current; (*c*) extension of the outer surface only of a casing, to accelerate the radiation of heat therefrom, when heat is conducted from an internal heat source or transmitting medium, or otherwise, directly to such casing as through the agency of intervening packing material; (*d*) extension of the outer, or even both surfaces of a bulb or other container for the expansible liquid of a thermometer, or the like; (*e*) extension of the outer, and, if desired, the inner gas- and air-engaging surfaces respectively of a refrigerator coil, in order to absorb heat more rapidly from the surrounding atmosphere, transmit it to the heat-absorbing and conducting fluid contained therein, or the extension of the internal surfaces of such tubes as those in a fire-tube boiler, which are surrounded externally by the heat-absorbing medium; (*f*) extension of the surfaces of the joined portions of a pyrometer unit, in order to make such unit more susceptible and responsive to the heat being measured; (*g*) extension of either one or more of the surfaces of a thermostat unit; and no doubt further applications in classes, which the foregoing tend to suggest to those engaged in the various branches of engineering and the sciences.

An indirect application of the invention consists in etching or otherwise roughening or extending the surface of a sufficient portion of a metal container, or a given portion of the same to varying degrees, as a means of increasing the heat transmitting surfaces. Another application of the invention which has proved of marked advantage is the provision of an aluminum casing for heater units, the surface of which casing is so treated as to make it electrically insulative and of a much higher melting point, and at the same time etched or otherwise roughened so as to increase its heat radiation characteristic. The treatment referred to is known as an anodic coating, and can be of such character as to increase the heat-absorption of such casing upon one side and its heat radiation characteristic upon the opposite side. Such a casing upon a heat unit, provided with a positively extended surface, develops a unit which possesses many of the advantages of a so-called stainless steel casing for rigidity and durability, but with increased heat absorption, transmission and emission, together with lower costs of production and higher melting point, than aluminum with ordinary commercial surface finish.

The roughening or extension of the surface of such units as those here listed may be accomplished in several ways. Sand blasting has been found most satisfactory, the coarseness of sand used determining largely the resultant degree of extension of the surface. Coarse etching and rapid electro-plating, acid erosion, or etching, have also been found advantageous in certain instances, but they are usually slower to carry out than sand blasting, though they can be employed in some places or upon some articles, for which sand blasting is not so well adapted.

Obviously, too, the same effect can be obtained in certain instances by impressing the roughening characteristics into a particular surface by means of a die or by rolls, and when such a method is employed a definite leaning or slanting of the surface irregularities can be provided, if desired, so that a resulting acceleration or retardation in the movement of fluids across such surface can be pre-arranged and predetermined, depending upon the direction of slant and the depth and cross section of the individual irregularities or excrescences. Such an extension or roughening of the heat-radiating surface of an article, combined with a certain degree of concavity of such surface, results in a still further increase in the efficiency of the article as a means for transferring heat to or from fluids in its vicinity.

With these objects thus broadly stated, the invention consists in further details of construction, which are fully brought out in the following description, in conjunction with the accompanying drawings, in which

Fig. 1 is a plan view of a ring heated unit showing one application of the invention;

Fig. 2 is a section on the line 2—2 of Fig. 1;

Figs. 3*a* and 3*b* show cross sectional views, and Figs. 3*c* and 3*d* show corresponding elevational views of two forms of roughened wires or rods;

Fig. 4 is a plan view of a zigzag type of ribbon or band heater unit shown in U. S. Patent No. 1,928,142;

Fig. 5 is a section on the line 5—5 of Fig. 4;

Fig. 6 is an exaggerated side elevation of a heater element, having at least one roughened surface, the teeth or serrations of which are greatly enlarged, and which may be directed in an upward direction, for purposes hereinafter set forth;

Fig. 7 is an elevational view of a heater unit which can be used for immersion in liquids, or merely extend into the interiors of heating chambers, or the like; Fig. 8 is a section on the line 8—8 of Fig. 7; Fig. 9 represents a portion of a refrigerator cooling coil; Fig. 10 represents the connected portions of the two metallic elements comprising the thermo-couple employed in pyrometers of various types; Fig. 11 is a side elevation representing any well-known type of thermostat; Fig. 12 is a side elevation of the same; Fig. 13 represents any of the various well-known types of thermometers, having bulbs provided with roughened outer surfaces; Fig. 14 is a plan view of a spiral form of tubular heating unit; Fig. 15 is a vertical diametrical section of the same on the line 15—15 of Fig. 14; and indicating by dot-and-dash lines the relative position of an optional reflecting plate if present; Fig. 16 is an enlarged transverse section on the line 16—16 of Fig. 14; Fig. 17 is a top plan view of a ring type heating unit of another form; and Fig. 18 is a transverse section on the line 18—18 of Fig. 17.

Referring to Figs. 1 and 2 of the drawings, a ring type electric heating unit is shown as comprising an annular casing, which in turn comprises a base 1 and a cover 2, each of said base and cover being of substantially U-shape cross section, and the latter preferably having a concave outer surface 3, while the casing sections are secured together by inter-engagement of their overlapping telescopic side walls 4 and 5, respectively. Within the base section 1 is positioned a vitreous element 6 of porcelain or the like, and usually comprising a series of grooves 7, extending inwardly from its usually upper face. Within these several grooves electric resistance coils 8 are positioned, and secured in any suitable manner, as for instance, by means of a suitable cement, sand, or equivalent means, or the resistance coils may be otherwise supported by cement, mica, or other heat resisting dielectric. In this application of the invention, if the inner surface 9 of the upper wall of the cover section 2 is suitably extended by roughening, as hereinbefore referred to, said upper wall will receive and absorb heat from the electric resistance coils 8, much more readily than if such surface were smooth, as has heretofore been the practice. Furthermore, if the outer concave surface 3 of said cover wall is similarly extended by roughening, it will radiate heat therefrom much more readily than if smooth, while by slightly concaving such last-named surface the heat radiated therefrom is in effect more concentrated in its effect with respect to any object adjacent thereto and designed to receive heat therefrom. To further elaborate the principles involved, if the opposite plate of the unit be polished upon either or both the inside and outside, the effect will be that the heat which would ordinarily pass through the plate, is to a certain extent retarded and the other surface radiates the heat so diverted.

Referring to Fig. 3, there are here shown two forms of electric resistance wires or rods for heater units greatly enlarged. The first form of wire 15, having a circular cross section as shown at 16, has its outer surface 17 roughened or extended in any suitable manner, as hereinbefore suggested, in order to more readily radiate the heat generated by reason of the resistance offered by said wire to an electric current passing therethrough. The other enlarged elevation of an improved resistance wire, together with a cross section of the same, comprises a wire or rod 18, having its surface 19 knurled, serrated, finely corrugated, grooved, or roughened in regular shape (as compared with the irregularly roughened surface 17 of the wire 15), or otherwise extended, as by means of the forming die or rolls (neither being shown), through and by means of which the wire, or rod, is formed. In each of these wire or rod formations, it is intended that the surface of the same shall be substantially extended through roughening in various ways, without altering the physical characteristics of the wire, including the resistance offered by an electric current, its temper, ductility, tensile strength, etc.

Referring to Figs. 4, 5 and 6, there is shown another prime electric heating unit in the form of a zigzag ribbon 25 known to the electrical industry as folded and the same being in the form of suitable resistive metal or metallic alloy. Either or both of the opposite surfaces 26 and 27 of this ribbon may be extended, or as in Fig. 5 only the upper surface 26, which is slightly concaved, is roughened, for the purpose of increasing the emissivity of heat from that surface, in a manner similar to that of the concave surface 3 of Fig. 2. However, in this particular type of heater unit, especially when in upright position, as shown in Figs. 4 and 6, the roughening serrations may be directed either upwardly or downwardly, and for illustrative purpose have been shown in Fig. 6 as being diected upwardly, in order to thereby accelerate the flow of a fluid past such surface, instead of tending to retard the flow of such fluid, as when the serrations are directed downwardly,

it being understood that the file-teeth shown in Fig. 6 are very greatly magnified in shape, in order to illustrate this particular function, whereas in practice they are much more finely formed.

Referring to Figs. 7 and 8, a heating unit is here shown of a type which is intended to extend into and to heat a chamber containing air or other gases, or into a pot, cauldron, or other container, for liquids of various sorts. This unit primarily comprises a casing 30 of tubular or other suitable shape, closed at one end 31 and having its opposite end firmly secured within and supported by a terminal head 32, which is usually provided with screw threads or other means 33, for operatively supporting said unit with respect to the particular chamber or container which it is employed to heat, either alone or in conjunction with other such units. In the type here shown for illustrative purposes, the interior of the casing is bisected by a partition 34, upon the opposite sides of which are beads or other suitable elements 35 of vitreous and electrically insulating characteristics, and through which extend channels 36 for receiving and operatively positioning either straight or coiled electric resistance wires 37, the space between said beads or the like and the surrounding casing being preferably filled by relatively compactly placed heat conductive material, designed to aid in permitting heat from the resistance wire to pass to the inner surface of said casing. The outer surface of said casing is extended by roughening in any suitable manner, as hereinbefore described, with the result that the heat of the unit as a whole increases and is radiated much more rapidly than with a plain external surface, and consequently with a lower wattage consumption creates a higher effective temperature for any fluid which may surround or be adjacent to said unit.

Referring to Fig. 9 a coiled tube 40 is shown, to represent the heat-absorbing cooling coils within a refrigerator system, the external surface 41, of any part or all of each of the convolutions of said coil being extended in any suitable manner, in order to extend the corresponding surface of such tube and proportionately increase the heat-absorbing characteristics of the coil as a unit, without varying the effective cross section of the coil convolutions.

Referring to Fig. 10, there is here shown one end portion of a thermo-couple comprising elements 45 and 46 of two different kinds of metal or metallic alloys twisted together at 47, and the surfaces 48 of the twisted portions of said elements being roughened in any suitable manner as by sand blasting, etching, or the like, to similarly increase the area of that portion of the surface of the couple, which is normally designed to enter and be subject to the heat within a furnace, oven, or other heated chamber, in order by any well-known further apparatus to indicate exteriorly of such chamber the heat of its interior.

Referring to Figs. 11 and 12, there is shown in diagrammatic arrangement the essential elements going to make up a thermostat switch, and comprising any suitable pair of supports 50 and 51, the latter operatively positioning a contact element 52, while the former securely supports one end of a two-ply metallic element 53, which has the characteristic of bending away from contact with the element 52, as suggested by the dot-and-dash line 54, under the influence of and in accordance with the changes in temperature of said element, and thereby indicating corresponding changes in the temperature of the adjacent atmosphere, or other body of fluid. Either one or both of the opposite surfaces 55 and 56 of this element may be extended as hereinbefore described, in order to more rapidly adsorb or radiate heat as the case may be, and thereby become correspondingly more sensitive in its flexing or rectification under the influence of rapid changes in temperature, to alternately open and close an electric circuit in which such switch may be operatively connected.

Referring finally to Fig 13, there is here shown any well-known type of temperature affected bulb 60 of glass, metal, or other suitable resistance, and containing mercury, alcohol, or other suitable liquid, having the desired high co-efficient of expansion, which by reason of its extending through the tube 61 into the gauge casing 62, actuates the indicator hand 63, or as in the case of an ordinary thermometer is visible through the usual glass stem thereof, in order to be more sensitive and thereby respond more accurately and rapidly to changes in the temperature adjacent to said bulb. Thus, when the temperature adjacent to said bulb rises, the heat is absorbed by the bulb and transmitted to the heat expansible fluid contained therein, while upon a decrease in temperature adjacent to said bulb, the extended surface of the same tends to more rapidly radiate the heat previously absorbed, so that the liquid therein will contract more rapidly, and accordingly after the position of the upper level of such liquid in the case of an ordinary thermometer, or the positioning of the indicating hand 63 in the representative form of gauge shown in Fig. 13.

Referring to Figs. 14, 15 and 16, there is shown a heating unit comprising a tube 70, within which is positioned any desired form of electric resistance wire 71, rod, coil, or the like, the same being operatively spaced centrally within and away from the inner surface of said tube by interposed granular, electrically resistant, heat conductive material 72. Referring more particularly to Fig. 16, the tube 70 may be either drawn and therefore of seamless, or of seamed construction, as suggested by the slight enlargements along the lines of weld 73. In the case of tubing without seams, in accordance with the present invention, the normal upper portion 74 of the outer surface of the same is etched, sand-blasted, or otherwise extended, as hereinbefore described, while the normal lower surface 75 of the same is polished. In the case of seamed tubing, before assembling both the outer and inner surfaces 76 and 77 of the normal upper half are extended, while both the inner and outer surfaces 78 and 79 of the normal lower half are polished. With such a construction and treatment of the upper and lower sections of the surfaces of an unseamed tube, it has been found that the upper portion of the tube radiates heat much more rapidly than the lower portion, and that the degree of radiation of the lower portion is very substantially lessened by polishing, than if left in its original condition both unpolished and unextended. Moreover if the upper and lower portions of the inner surface of a seamed tube are also treated as above mentioned, it has been found that a still greater advantage is obtained, as the extended upper portion 77 of said inner surface absorbs the heat more readily than if unextended, while the extended portion 76 of the outer surface radiates

such heat to the same degree. By contrast, polishing the lower portion 78 of the inner surface of the tube greatly lessens the absorption of the heat thereby, while the polished lower portion 79 of the outer surface correspondingly lessens the radiation of the heat actually absorbed by said lower portion, as hereinbefore mentioned. These comparisons were first proved, not in a horizontal unit such as that illustrated, but by vertically arranged units in which the natural radiation of heat and the rise of heated air adjacent to such unit did not enter into the results. In all such tests the radiation differential was so marked between extended and polished surfaces, that it was easily realized that the same relationship would be equally advantageous with units in and for all sorts in various position, so that while the presence of an auxiliary radiating element, such as the reflector indicated by the dot-and-dash lines 80, could do no harm if present, and migh conceivably be of some relatively small value, such an element is no longer essential and its use therefore lies more in catching drippings and its ability to assist in shielding the heating unit from extraneous drafts of air, which would otherwise tend to deflect the normally rising air currents, or even blow them laterally away from the medium designed to be heated by said unit.

Referring to Figs. 17 and 18, the same principle as just described is shown as bein applied to the upper and lower sections of a ring type heater unit casing. The lower unit 85 telescopes into the upper unit 86 (or vice versa), while within such casing is operatively positioned any desired form of resistance wire 87, rod, helix, or the like, the same being spaced away from the surrounding wall of said casing by means of heat conductive, electrically insulative material 88, in the usual manner. As in the case of the tube above described, either or both of the outer and inner surfaces of each of the casing sections may be extended or polished in accordance with the principle here involved, or portions of such surfaces may be so treated while the remaining portions thereof are left untreated. In the particular construction shown in Figs. 17 and 18, the uppermost outer and inner surfaces 89 and 90, respectively, of the top wall 86' of the normal upper section 86 are sand-blasted, etched, or otherwise extended, while the lowermost outer and inner surfaces 91 and 92, respectively, of the bottom wall 85' of the normal lower section 85 are polished. In addition, the intervening side walls of the two sections which overlap each other may be left untreated, or otherwise treated as may be preferred, depending largely upon the difficulty and expense involved. For instance, if not impracticable from a commercial standpoint, the inner surfaces 93 of the side walls 94 of the lower section 85 may be extended so as to absorb heat as rapidly as possible, while the outer surfaces 95 of the adjacent side walls 96 of the upper section 86 may also be extended, so as to radiate such heat most rapidly, the intervening adjacent surfaces 97 of the two pairs of telescoping side walls being left untreated or otherwise as desired, so as to insure the best possible contact between said walls for the transmission of heat therebetween, instead of the heat transmission being retarded by the interposition of a dead air space therebetween. It is also to be understood that the uppermost wall 86' of the upper section of this type of unit may be concaved, as shown in Fig. 2, instead of being planar as shown in Fig. 17, thereby producing a radiation and concentration of heat unattainable by any other known construction.

In the appended claims, it is to be understood that extension of the surface of an article by roughening does not mean the corrugation or otherwise irregularizing of the surface, when the immediate surface of such individual corrugations or the like remain relatively smooth, though the invention does contemplate the roughening of corrugated or in fact any other type or shape of surface, when the extension is the result of the roughening and not of the corrugation or irregularizing alone, except as shown in Fig. 3.

Among the uses to which the extension of surfaces, as herein described, is particularly adapted, is that of increasing the surface area and therefore the capacity of the plate or plates, foil, paper, or other elements, of an electric condenser, without increasing the overall area of such plate or plates, or of the condenser as a whole. It is therefore intended that the invention shall be considered as covering this adaptation and use of the principles involved, although the absorption or emission of heat (or "cold") is not involved.

Having thus described my invention what I claim as new and desire to secure by Letters Patent is:

1. The combination of a primary electric resistance heat-radiating metallic unit having an outer surface extended, as by etching, sandblasting or coarse plating, without materially affecting the cross sectional area, a second unit comprising a sheet metal casing having a surface directed towards said primary unit and similarly extended, so as to increase the heat absorption of said second unit from said primary unit, and said second unit also having a surface directed away from said primary unit and similarly extended, so as to increase the heat absorption of said second unit from said primary unit, and said second unit also having a surface directed away from said primary unit and similarly extended, so as to increase the heat radiation of said second unit away from said primary unit, and refractory insulating material substantially filling the space between said primary unit and said second unit.

2. A heating unit, comprising a sheet metal casing having a normally upper wall and a normally lower wall, both the outer and inner surfaces of said upper wall being positively extended, as by etching, sandblasting or coarse plating, without a corresponding material increase in the cross sectional area of said wall, and both the inner and outer surfaces of said lower wall being relatively polished, and electric resistance wire also having a similarly extending surface within said casing, and refractory material supporting and substantially filling the space between said wire and said upper wall.

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