Aug. 22, 1939. E. L. WIEGAND 2,170,174

ELECTRIC RESISTANCE HEATING ELEMENT

Filed Aug. 26, 1935 3 Sheets-Sheet 1

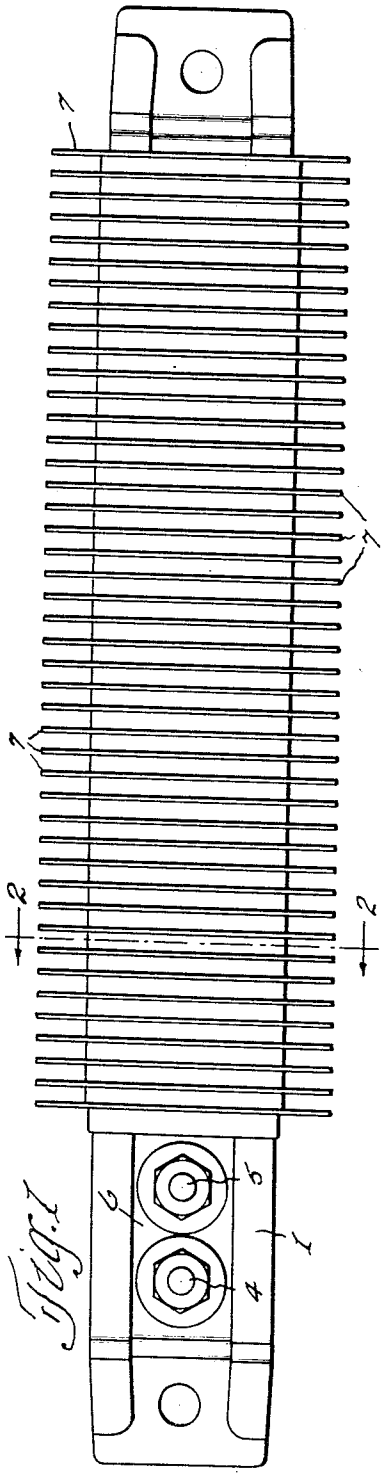


Fig. 1

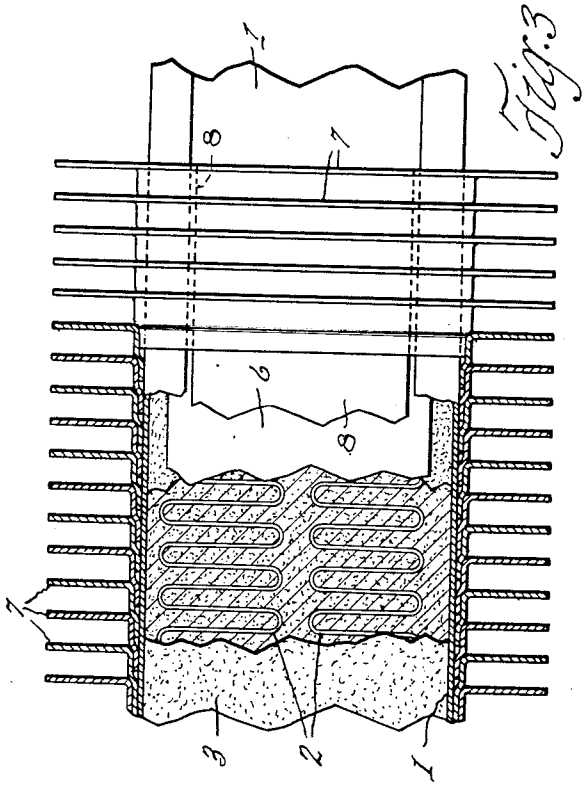


Fig. 3

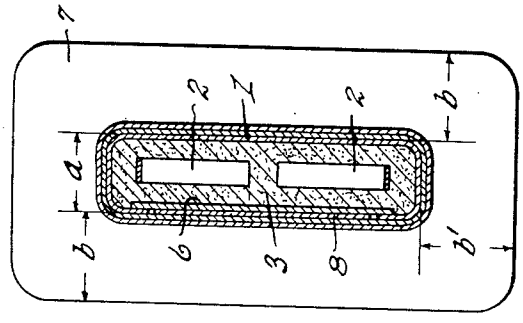


Fig. 2

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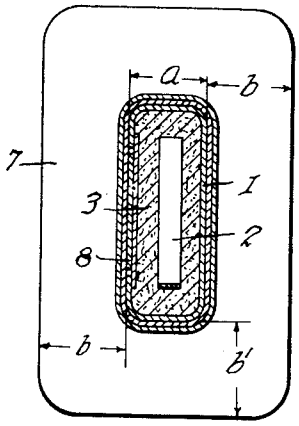


Fig. 4

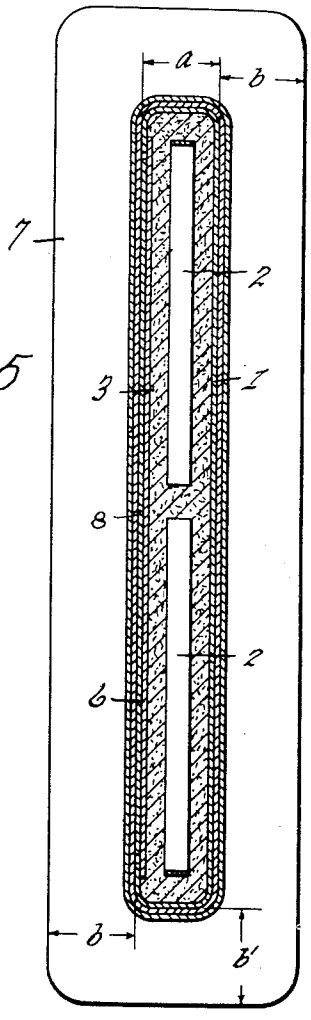


Fig. 5

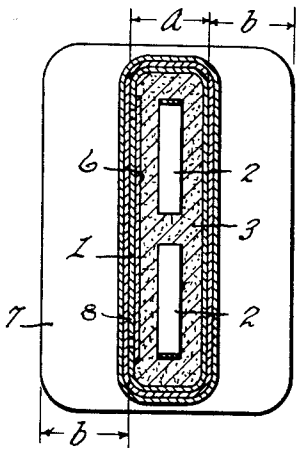


Fig. 6

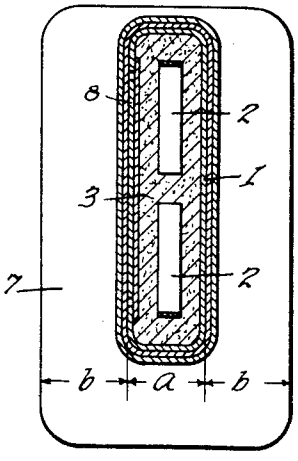


Fig. 7

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ELECTRIC RESISTANCE HEATING ELEMENT

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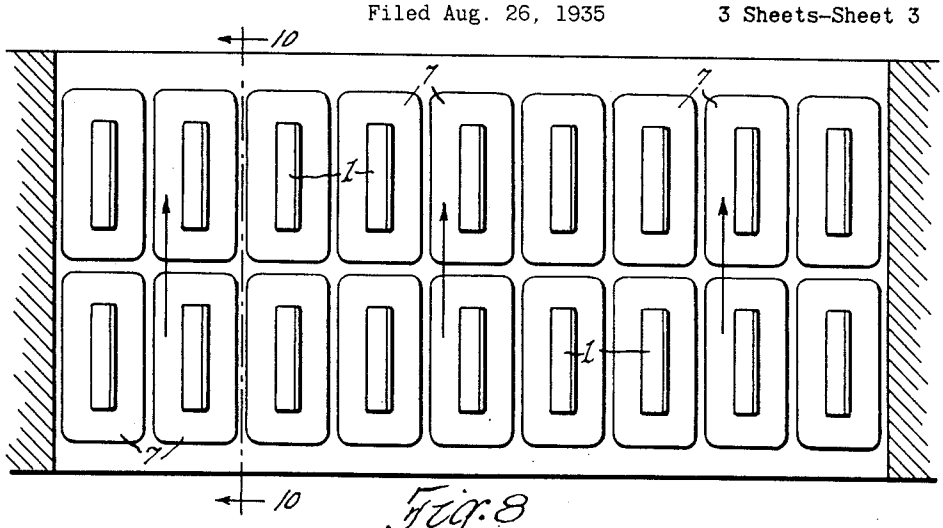


Fig. 8

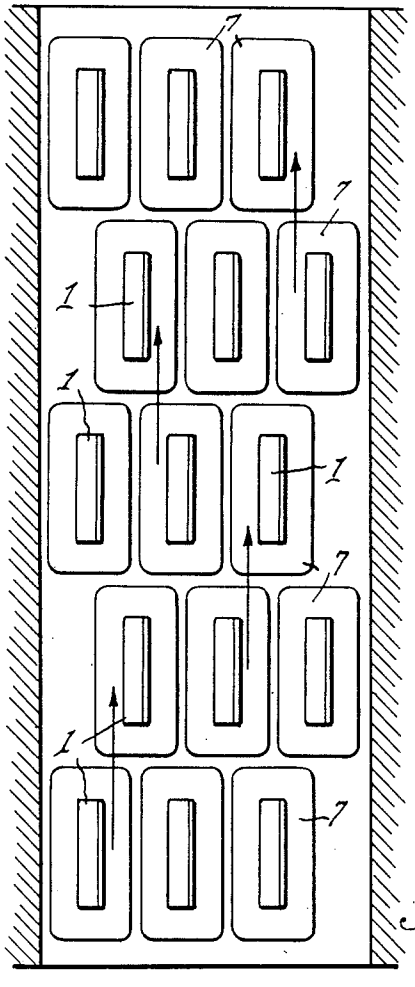


Fig. 9

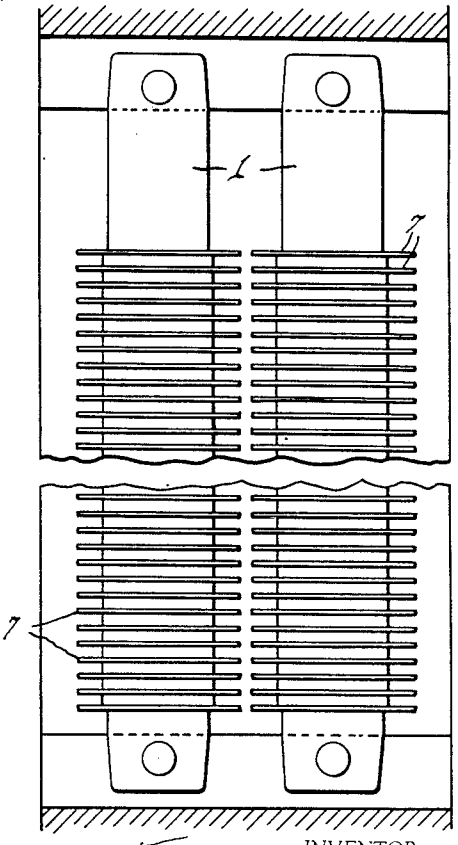


Fig. 10

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Patented Aug. 22, 1939

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UNITED STATES PATENT OFFICE

2,170,174

ELECTRIC RESISTANCE HEATING ELEMENT

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Application August 26, 1935, Serial No. 37,986

4 Claims. (Cl. 219—38)

This invention relates to electric resistance heating units and apparatus embodying the same, and one of the objects of the invention is to provide improvements of a simple and practical nature whereby the energy produced in a heating element of the strip type can be emitted or diffused more quickly and easily than with previous devices, thereby causing the heating element proper to operate at a lower temperature than otherwise with a given energy input thus increasing the life of the heating element and contributing to a more efficient conversion of electrical energy into heat.

Another object of the invention is to provide a heating element having fins thereon which are so shaped and proportioned with respect to the body of the heating element as to exhibit a high degree of heat conduction and heat dissipation.

Another object of the invention is to provide a heating element and fin construction therefor in which the diffusion of energy is accomplished as largely as possible from a practical standpoint by an electrical potential drop and with a minimum thermal gradient.

A further object of the invention is to provide a heating unit which will convert the maximum amount of energy in a minimum cubical space and within a minimum projected area of the device with respect to its operating face.

Another object of the invention is to provide a heating unit of the character described which will materially advance that phase of the heating art which has to do with the transmission of energy by a fluid convecting medium, such as molten solids, liquids or gases.

A more specific object of the invention is to provide a heating unit of the character described which will limit and balance the maximum temperature gradient between the heat source and the convecting medium to the end that the limit of capacity may be increased with a given heat source temperature or the heat source temperature may be kept at a minimum at a given capacity thus avoiding the limitation of the electrical heating art as imposed by the internal temperature on the one hand and by permissible external temperature on the other hand.

A further object of the invention is to provide a heating unit of the character described which makes use of these principles for the purpose of obtaining maximum economy in respect to the materials required for transmitting energy from the resistor to the convecting medium, as well as in the cubical space, surface area or both.

My heating unit is particularly adaptable and useful in heating gases and fluids, by convection where a forced draft is employed to move the convecting medium. My improved heating unit also enables me to deliver a maximum amount of heat, that is, wattage or B. t. u.'s in a given space or area, and at the same time enables me to materially reduce the weight and area of metal required for a given capacity heating unit.

I have found that a rather critical relation exists between the size of the heating element proper and the radiating fins in order to obtain the maximum diffusion of heat with a minimum difference in temperature gradient at different points on the fin. In other words, there exists a rather critical relation between the size, shape and spacing of the fins and the size and shape of the heating element proper in order to obtain an efficacious diffusion of heat by convection. With most metals economically usable in heating elements of the character described, it is not economical or efficient to raise the fin temperature more than say 280°–300° F. above room temperature for the purpose of heating by convection, for the reason that when the temperature of the fin greatly exceeds this point, too large a proportion of heat is transmitted by radiation instead of by convection which is undesirable in a convection heater. It is therefore desirable to maintain the temperature of the fin such that the maximum amount of heat is diffused by convection, as the amount of heat which a moving stream of fluid or gas will absorb under convection conditions is limited.

My heating unit is especially useful and desirable for occasional or auxiliary heating where a forced draft is employed to diffuse the convection medium and I have provided a unit which employs a plurality of so-called strip heaters having fins thereon, there being a definite relation between the shape and size of the fins and the shape and size of the strip heaters proper. The shape and contour of the strip heater proper is also of importance in a unit of this character and I preferably make use of a plurality of thin narrow heating elements which may be disposed in a group in such position that the convecting medium is caused to pass over the thin or flat side of the strip which enables me to position a plurality of heaters one behind the other or in staggered relation in very close proximity to each other without unduly obstructing the flow of the convecting medium through the unit.

According to my invention, the heating element, whatever may be its detailed construction, is surrounded by a plurality of metal fins spaced

apart and projecting laterally and affording an extended area for the diffusion of heat generated inside the element. When the insulation is surrounded by a metallic sheath, these fins preferably have metal-to-metal contact with the sheath and each fin preferably has integral therewith a laterally extending portion disposed at one edge thereof which at least engages and preferably interlocks with a similar portion on an adjacent fin so as to intercept all heat passing outwardly from the resistor and so as to secure the whole fin structure in place. Preferably the fins are transverse to the major axis of the element although I do not limit myself to such a construction. Owing to the relatively large diffusion surface provided by the fins combined with the close and firm contact of the metallic parts with each other, the heat generated in the resistor is dissipated so rapidly and easily that the resistor is maintained at a comparatively low temperature for a given energy input, thus reducing the danger of the heater burning out and greatly improving the efficiency of the unit due to the lack of need for any overpotential or excessive temperature gradient in order to produce the required dissipation of heat. Likewise the large dissipating surface enables a transfer of heat from the metal to the surrounding fluid with a smaller temperature-difference than otherwise which is important in case of air-heating as tending to avoid the production of any unpleasant odor, and is also important in connection with the heating of other fluids in that the tendency to decomposition of the fluid is reduced.

I have shown my improvements as applied to a sheathed strip heater of the type shown in my Patents Nos. 1,614,330, issued January 11, 1927 and No. 1,614,938, issued January 18, 1927, although my invention is not limited to this particular form of heating element. However, I prefer to employ an electrical resistor which is closely embedded in a refractory insulating material having good heat conductivity and the whole being covered by a metal sheath or casing of an appropriate contour, although my invention is not limited to any particular form of sheath or to any particular insulating material.

In the drawings accompanying and forming a part of this specification, Fig. 1 is a top plan view of an electric heating element embodying my invention; Fig. 2 is a vertical sectional view on the line 2—2 of Fig. 1; Fig. 3 is a fragmentary view partly in section and partly in elevation of the heating element shown in Fig. 1; Fig. 4 is a vertical sectional view similar to Fig. 2 showing a fin of the same width as that shown in Fig. 1 but of less length; Fig. 5 is a vertical sectional view of a modified form of my invention in which the width of the sheath is greatly increased, the fin having the same width adjacent the longer side of the sheath as that form of the invention shown in Figs. 2 and 4; Fig. 6 is a vertical sectional view similar to Fig. 4 in which a fin is employed of considerably less length than that shown in Fig. 4, the width and thickness of the sheath being the same as that shown in Fig. 4; Fig. 7 is a view similar to Fig. 6 and identical therewith except that the fin is not centrally positioned with respect to a different size fin; Fig. 8 is a somewhat diagrammatic horizontal sectional view showing a plurality of my improved heating elements arranged in an opening in a wall structure; Fig. 9 is a view similar to Fig. 8 showing a slightly different arrangement of the heating elements in which the several heating elements are disposed in staggered relation; and Fig. 10 is a vertical sectional view on the line 10—10 of Fig. 8.

Referring now to the drawings, my heating element preferably consists of an elongated sheet metal sheath 1 which may be formed of iron, steel, copper, brass or any other suitable material and which is relatively thin with respect to its length and in which is arranged a resistance wire or ribbon 2 which is preferably embedded in a mass of granular refractory insulating heat conducting material 3 which is tightly compacted about the resistor. The resistor may be in the form of a ribbon or a helically wound coil and preferably has a pair of terminals 4 and 5 disposed at one end of the sheath as shown most clearly in Fig. 1, although variations in the particular form of the resistor and the arrangement of the terminals may readily be made without departing from the spirit of my invention. The top of the metal sheath is preferably closed by means of a cover 6 which is held in place by the bent-over side edges of the lower half of the sheath. Surrounding the metal sheath and arranged in spaced relation thereon are a plurality of metal fins 7 shown in detail in Fig. 2. Each fin is preferably shaped to provide a radially disposed plate portion and a laterally extending somewhat flattened tubular flanged portion which has extended metal contact with the shell or sheath and with a similarly shaped portion of an adjacent fin. The flanged portion of each fin is shouldered and overlaps a similar flanged portion of an adjacent fin, as shown most clearly in Fig. 3. Each fin engages and preferably interlocks with an adjacent fin so as to intercept all heat passing outwardly from the resistor and so as to secure the whole fin structure in place. Disposed over the cover plate 6 and in contact therewith is a metal filler strip 8 which is of the same thickness as the inturned flanges of the metal sheath 1. This filler strip is of such width as to substantially fill the space between the edges of the inturned flanges of the sheath and serves to provide a smooth outer surface on the flange side of the sheath so that the flanged portions of the fins will have a firm metal-to-metal contact with the sheath and with the filler strip, as shown most clearly in Figs. 2-7 inclusive. The fins are preferably arranged transverse to the major axis of the element. The end fins are preferably rigidly secured to the sheath by being welded thereto. The thickness of the sheath is designated by the character *a*. Each fin is of such size and so proportioned with respect to the sheath that the distance from the surface of the longer side of the sheath to the adjacent outer edge of the fin, which is designated *b*, is the same as the distance from the opposite side of the sheath to the opposite edge of the fin. The distance *b* is preferably the same as the distance *a*. The distance from the surface of the shorter side or narrow edge of the sheath to the outer edges of the fin is designated by the reference character *b'*. The maximum dimension of *b* should be such that with the average air velocity usually obtained in a blast heater the temperature of the fin immediately adjacent the sheath, which we will call T, never exceeds twice the temperature at the outer edges of the fin, which we will call T', or in other words T' should never be less than

$$\frac{T}{2}$$

The maximum for the distance b is also such that T should not greatly exceed 2T'. The distances b and b' are preferably, though not necessarily, the same but the ratio between the distance b and the thickness of the sheath remains constant.

While I do not limit myself to the exact proportions herein mentioned, I have found that the best results are obtained if these proportions and relationships are substantially adhered to. It is also desirable that the fins have a close and somewhat extended metal-to-metal contact with the sheath, substantially as shown in the drawings, although I do not intend to limit my invention to these exact proportions.

In Fig. 4 I have disclosed a slightly modified form of heating element which is identical wtih that shown in Fig. 2 except that the sheath and fin are both shorter. In other respects, this form of the invention is the same as that illustrated in Figs. 1, 2 and 3.

In Fig. 5 there is disclosed another modified form of my invention in which the heating element proper is considerably greater in width but of the same thickness. The width of the fin adjacent the longer side of the sheath is the same as the heating element shown in Figs. 1–4 inclusive. In other respects this form of the invention is identical with that shown in Fig. 4.

In Fig. 6 there is disclosed another modified form of my invention which is identical with that shown in Fig. 4 except that the length of the fin is materially shortened, the width being the same.

In Fig. 7 there is disclosed another modification of my invention which is identical with that shown in Fig. 6 except that the fin is shorter at one end than at the other.

In connection with the forms of the invention enclosed in Figs. 4–7 inclusive, it should be noted that the width of the fin adjacent the longer side of the sheath is the same in all instances.

If the width of the fin is materially increased, it will not materially affect the amount of heat diffused but will not be economical and will result in a waste of material as well as space. For practical purposes in blast heater operation, I propose to regulate the width of the fin such that the temperature on the outer side edges thereof shall not greatly exceed 150° F. above room temperature and the temperature on the inner edge thereof immediately adjacent the sheath shall not greatly exceed 300° F. above room temperature. In other words, I propose to maintain a maximum fin temperature below an elevation above room temperature where a critical increase in heat dissipation by radiation occurs.

In Fig. 8 I have disclosed a plurality of rows of heating elements arranged within an opening in a wall structure one behind the other and over which air is blown by a fan (not shown). Due to the relative sizes of the fins with respect to the metal sheath or shell and also due to the fact that the sheaths are relatively thin with respect to their width, it will be seen that I am able to arrange a plurality of heating elements one behind the other without unduly obstructing the flow of air or other convecting medium through or over the heating elements. In Fig. 8 the arrows indicate the direction of flow of air or other convecting medium which is lengthwise of the fins and across the longer side of the sheaths.

In Fig. 9 I have disclosed a plurality of my improved heating elements arranged within an opening in a wall structure in staggered relation. It will be seen from this figure that there are several courses of heating elements and that the air or other convecting medium which follows the direction of the arrows in that figure may pass over the maximum amount of heat diffusing surface. The particular shape of the heating elements and the relative size and shape of the fins cooperative to provide transverse ducts which extend parallel to the length of the fins and across the longer sides of the metal sheaths. Such construction and arrangement as I have described enables me to convert the maximum amount of energy within a minimum cubical space and with a minimum temperature gradient between the heat source and the convecting medium which enables me to diffuse a maximum amount of heat with a minimum resistor temperature. I am also able to materially reduce the weight and area of metal required for a given capacity heating unit. The construction and arrangement illustrated in Fig. 7 are particularly adapted for use where a forced draft is employed to diffuse a convecting medium. By such an arrangement I am able to reduce the weight of metal to 1½ pounds per kilowatt or even lower. The construction shown in Fig. 7 is especially adapted for use in a unit heater where a plurality of rows of heaters are provided, one behind the other, which permits a maximum number of such heaters to be used in a given area with maximum heat release from the total unit.

By the above construction and arrangement and with the relationship between the sheath and the fins as herein described, it is possible to convert and transfer as much as 25 kilowatts electrical energy per cubic foot of space occupied by the heating element without exceeding permissible limitations as to resistor and sheath temperature and air temperature and velocity, and without exceeding permissible overall apparatus temperature; and this is without exceeding two rows or layers of heating elements in any one direction. With such a construction I am able to diffuse as much as 10 kilowatts per square foot of projected area of the heat emitting face of the heating apparatus with only one row of heating elements.

It will now be clear that I have provided an electrical heating unit which will accomplish the objects of the invention as hereinbefore stated. It will of course be understood that the embodiments of the invention herein disclosed are merely illustrative and are not to be considered in a limiting sense as various changes may be made in the details of construction as well as in the arrangement of parts without departing from the spirit of my invention as my invention is limited only in accordance with the scope of the appended claims.

This application is a continuation in part of my application Serial No. 586,380, filed January 13, 1932, for Electric resistance heating elements.

Having thus described my invention, what I claim is:

1. An electric heating unit of the class described, comprising a metal trough rectangular in cross section, the open side of which is provided with narrow inwardly projecting flanges, a metal plate fitting under said flanges cooperating with said trough to form the inside wall of a housing, a metal filler strip positioned on the outside surface of said plate having the same

thickness as said flanges and a width to thereby fill the space between the edges of said flanges, whereby to form a smooth outer surface on the flange side of said housing, a multiplicity of spaced fins having at their centers flanged openings through which said housing extends, said fin flanges closely embracing the outside walls of said housing and said strip, a resistor having suitable outlet connections positioned in said housing and equispaced from the inside walls thereof by means of a suitable insulating material.

2. Heating means, for heating apparatus wherein a fluid is moved relative to said heating means, comprising: heat-producing means, having transversely extending heat-transfer surfaces, of a width not materially exceeding a predetermined transverse dimension of said heat-producing means, providing opposite surfaces of said heat-producing means relatively free of projecting parts, whereby a plurality of said heating means may be positioned to form part of the heating apparatus with respect to the line of fluid flow of the heating apparatus, and in a manner so that said opposite surfaces form the leading and trailing edges of said heating means and said heat-transfer surfaces are generally in the line of flow of the fluid, the leading edge of one heating means being capable of being positioned closely adjacent the trailing edge of another heating means.

3. Heating means, for heating apparatus wherein a fluid is moved relative to said heating means, comprising: heat-producing means, of non-circular cross-section, having heat-transfer fins extending from certain opposite surfaces, said fins being of a width substantially equal to the transverse length of said opposite surfaces, providing other opposite surfaces of said heat-producing means which are relatively free of projecting parts, whereby a plurality of said heating means may be positioned with respect to the line of fluid flow of the heating apparatus, and in a manner so that said opposite surfaces form the leading and trailing edges of said heating means and said heat-transfer fins are generally in the line of flow of the fluid, the leading edge of one heating means being capable of being positioned closely adjacent the trailing edge of another heating means.

4. Heating means, for heating apparatus wherein a fluid is moved relative to said heating means, comprising: heat-producing means; heat-conductive means, held in heat conducting relation with respect to the outer surface of said heat-producing means, and comprising a sheath-like covering about said heat-producing means, having transversely extending fin means, said fin means being of a width substantially equal to a transverse dimension of said heat-producing means, so that opposed surfaces of said sheath-like covering are substantially free of parts projecting materially beyond said opposed surfaces, whereby a plurality of said heating means may be positioned with respect to the line of fluid flow of the heating apparatus, and in a manner so that said opposed surfaces form the leading and trailing edge of said heating means, with said fin means generally in the path of the flow of fluid; the leading edge of one heating means being capable of being positioned closely adjacent to the trailing edge of another heating means.

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