

Sept. 26, 1933.

H. E. TRENT ET AL
ELECTRIC RESISTANCE UNIT

1,928,142

Filed April 11, 1930

2 Sheets-Sheet 1

Fig. 1.

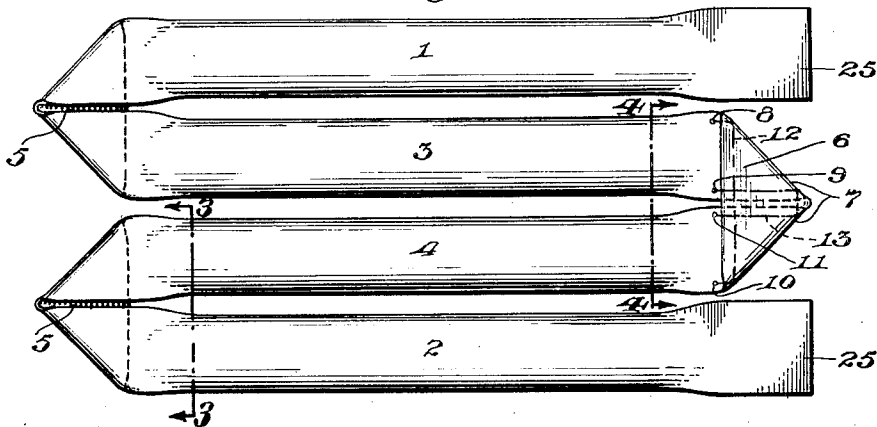


Fig. 2.

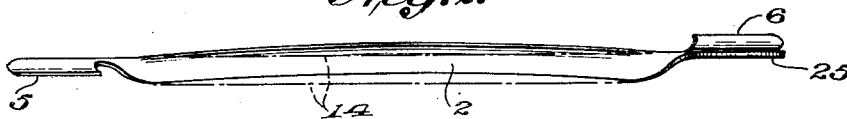


Fig. 3.

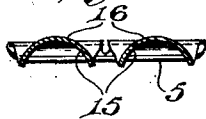


Fig. 4.



Fig. 5.



Fig. 6.

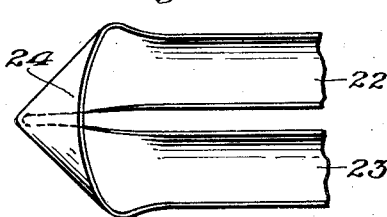


Fig. 8.



Fig. 9.

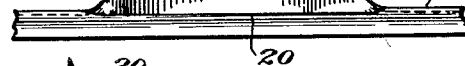
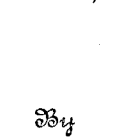


Fig. 7.



Fig. 10.



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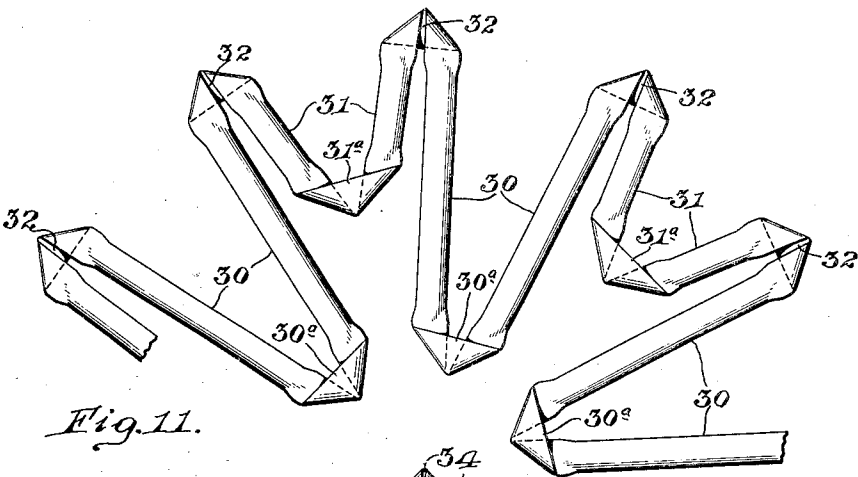
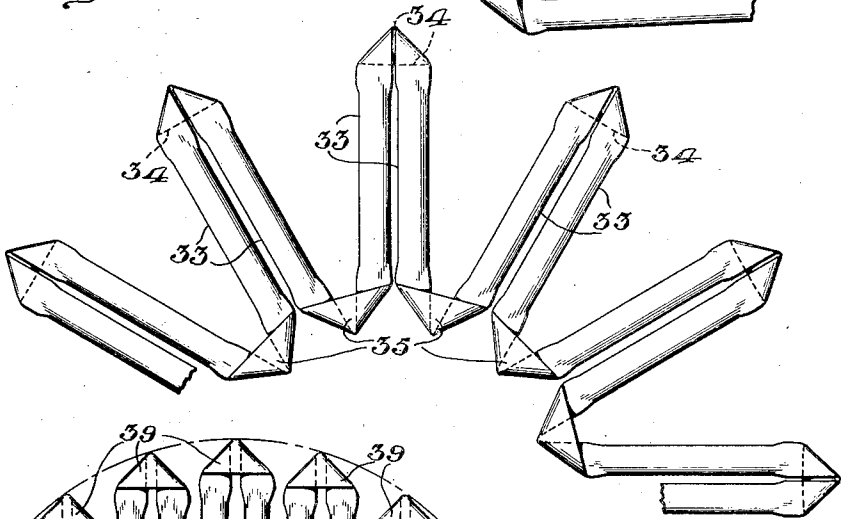
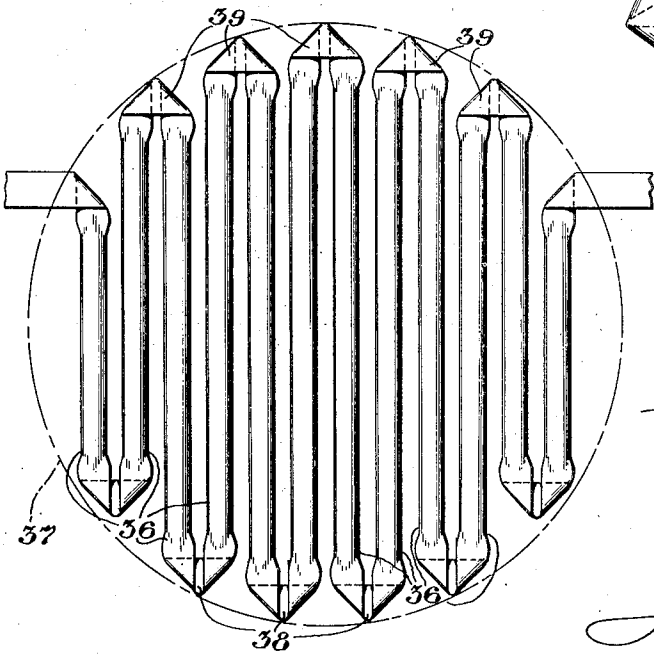
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2 Sheets-Sheet 2



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1,928,142

ELECTRIC RESISTANCE UNIT

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Application April 11, 1930. Serial No. 443,528

6 Claims. (Cl. 201—74)

- The object of the invention is to provide improvements in electrical resistance units adapted for use within, or in association with, apparatus characterized by relatively high temperatures, and the method of making such units, though the same method may be employed to produce units used merely for the resistance which they offer to the passage of an electric current, without involving an appreciable rise in temperature.
- Another object is to provide a commercial resistance unit of standard or uniform electric resistance characteristics, at a cost below that which has heretofore been possible for a product of similar grade, the improved method being adapted to produce a unit of great length from an original bar, ribbon, rod, or strip (hereinafter broadly referred to as a ribbon), from which smaller units of any desired ohmic resistance can be cut at will.
- A further object is to provide an improved resistance unit comprising a series of spaced parallel, or angularly disposed, sections, each of which is substantially rectilinear, but in cross section is preferably curved or corrugated for a purpose hereinafter described, and longitudinally is preferably originally curved slightly to a predetermined degree, in order that when heated to its normal "working" temperature, or the temperature at which it is designed to be employed, in a given piece of apparatus, it will automatically tend to straighten out as its temperature rises until it lies either in a given plane, or acquires a substantially flat shape.
- Still other objects are to provide a resistance grid or unit in which the flow or passage of an electric current is in general in alignment with the grain of the metal; to provide such a unit in which the resistance offered between any two pairs of longitudinally equi-distant points is equal, and in which the resistance between two points directly opposite each other upon adjacent edge portions of two different sections is equal to that between two points directly abreast said first points but located upon the opposite edge portions of the same two sections; to provide portions at least of such a resistance unit with longitudinal, transverse or diagonal corrugations, to predetermine to a large degree the direction and relative effectiveness of the heat emanating therefrom, and to prevent entirely, or to predetermine the degree of flexing or warping of the unit with increases in temperature; to provide a resistance unit formed of spaced parallel, or angularly disposed, sections in which those portions of said unit connecting such sections offer uniform electrical resistance throughout their entire transverse extent, since they are of constant cross section and molecular density at all points, thereby causing all points of the unit to heat uniformly and maintain the same temperature at a given time; to provide a method for forming resistance units of any desired overall length or breadth from an original ribbon, or the like, of any given width and thickness; to provide a resistance unit in which the so-called crossovers from section to section are relatively smooth and rounded, thereby insuring a better automatic position adjustment of the various portions of the unit in its refractory supports; to provide such a unit with apertures with the portions of metal removed therefrom of such shape as to preserve the original resistance of the unit and at the same time permit the passage of air or gas currents when such is desired in certain types of apparatus such as heating devices for various purposes; and to provide further details of construction which are hereinafter described and broadly claimed.
- With these and other objects in mind, the present invention comprises further details of construction and operation which are fully brought out in the following description when read in conjunction with the accompanying drawings, in which Fig. 1 is a plan view of a resistance unit comprising one embodiment of the invention; Fig. 2 is an end elevation of the same; Figs. 3 and 4 are sections respectively on the lines 3—3 and 4—4 of Fig. 1; Fig. 5 illustrates a modified cross section of the resistance unit sections; Fig. 6 is a top plan and Fig. 7 is an edge elevation of a fragmentary portion of a modified form of crossover bend between adjacent unit sections; Fig. 8 is a top plan and Fig. 9 is an edge elevation of a fragmentary portion of a modified form of resistance unit section, provided with one or more apertures and air or gas directing flanges; Fig. 10 is a section on the line 10—10 of Fig. 8; and Figs. 11, 12 and 13 show modifications or variations in the arrangement of the grid sections to conform to all requirements of various types of apparatus.
- Referring to Figs. 1 to 4, one embodiment of the invention is illustrated as comprising essentially a ribbon of any suitable resistance metal or alloy, formed into one of the many shapes of grids which the said invention anticipates, and when reference is made to a ribbon this term is to be understood as including all possible cross sections of material adapted for the instant purpose, whether of equal thickness from side to side,

or bar, rod, tube, or in fact any other practicable shape.

The original ribbon is shown as comprising rectilinear terminal sections 1 and 2, between which may be formed as many intermediate sections 3 and 4 as are necessary to provide the desired resistance of a given unit. These several sections are integral continuations one of another, and sections 1 and 3 and sections 4 and 2 are connected by so-called crossover sections 5, which may underlie the plane of said first four sections as shown, or overlie said plane as may be desired, while the central sections 3 and 4 are connected by a crossover section 6, which may also either overlie or underlie the plane of said first sections, each crossover being formed by a double right angle bend of the original ribbon by manual or automatic means of any suitable type. These under- and over-lying crossover sections are of any desired number, being determined by the number of terminal and intermediate sections, and it will be noted that they preferably do not touch the sections which they serve to connect at any point, being spaced therefrom as shown in Figs. 3 and 4. As a result of this structural relation, when the sections 1, 2, 3 and 4 are parallel, the geometrical shape of the crossover is that of a right-angle triangle having equal "legs" 7 representing the lines of connection between each such crossover and its adjacent sections. This results in the insurance of equal resistance between any two points 8 and 9 abreast of each other on one section and two other points 10 and 11 which are abreast upon another section, the direct paths of an electric current between corresponding points being indicated by the dotted lines 12 and 13. This principle is equally true in the case of the underlying sections 5.

In the formation of an electric resistance grid of this type, the relatively rigid connected portions, comprising and adjacent to said crossover sections, are mounted in or upon any suitable supports preferably of refractory material, and, due to the rounded edge and smooth surface portions of these parts, they offer no appreciable resistance to the free movement of the grid with respect to said supports during changes in temperature, while between the crossover sections, the intermediate as well as the terminal sections are preferably transversely curved or corrugated, as indicated in Figs. 3 and 4, or as in Fig. 5, and longitudinally are also curved slightly, as shown in Fig. 2. This latter initial curvature is in order that when heated the grid sections will be found to have flattened out substantially along the dot-and-dash lines 14, and the combined curvatures result in limiting or predetermining the extent of deformation due to high temperatures and other physical stresses which may be imposed upon them.

With regard to the transverse curvature referred to, the grid is designed to be mounted preferably with the concave surfaces 15 directed towards the interior of a furnace or other locality, towards which the maximum heat is to be concentrated, and with the convex surfaces 16 more closely adjacent to supporting surfaces such as the walls of a furnace or the like. In certain cases the angular shape 17 of Fig. 5 may be employed, but when the exterior angle 18 of such structure is positioned close to or in contact with the usual heat-insulating or refractory surface, the heat from this central angular portion is not dispelled as rapidly from the opposite edge portions, with the result that the temperature of the grid section is

not uniform throughout, but varies sharply in contradistinction to the characteristics of sections curved as represented by Figs. 3 and 4.

It will also be noted that corrugation of the grid sections between the crossovers results in withdrawing their adjacent edges farther apart than otherwise, thereby preventing any likelihood of intermediate portions of such sections coming into contact with each other and becoming welded together, with a resulting shortening of the effective grid length, lowering of its resistance, and greater heating throughout its active portion, as more current is thereby permitted to pass. This corrugation also assists in accelerating the emanation of heat from the grid, as less heat is confined behind the several grid sections in what might otherwise be pockets or relatively dead air spaces, if said sections were flat or reversely curved, that is, with their concave surfaces directed towards the inclosing walls of a furnace, or similar surface.

On the other hand, when it is desired to provide a grid structure for air or gas heaters, or the like, by which for instance the air of a room or large chamber is to be heated by circulation, as contrasted with radiation and conduction which are primarily depended upon within furnaces, each grid section 19 as shown in Figs. 8 to 10 may be cut as at 20 to form one or more elongated perforations, through which air or gas may pass quite freely from the concave to the convex side of the section, as indicated by the arrows in Fig. 10, or vice versa. In order that perforation of the section shall not result in decreasing the metallic path of the current, with consequent increase in resistance and temperature, the material removed from such perforation is retained and merely deflected at any desired angle to form a flange 21, which serves both to stiffen the section and to impart still further heat to air or gas passing thereby. Obviously, such gas flow may be in the reverse direction if desired, but the functions of the aperture and flange are the same as before, and, while perforating said sections is not necessary when the grids are used in a furnace, this same perforation of the grid sections may also be used in such installations if desired.

In either form of grid, whether its sections are perforated or not, the crossovers instead of being flattened as hereinbefore described may, especially when heavier metal is used, be rounded or bowed, as shown in Figs. 6 and 7, thus preventing fracture. Here the sections 22 and 23 are respectively corrugated and at their ends merge into an outwardly bowed crossover section 24, in shape resembling somewhat a semi-cone. This shape of crossover is of particular value in air or gas heaters having perforated sections, as the air or gas can better circulate between the crossover and adjacent portions of the connected sections, than when flattened as previously described. Finally, it should be stated that electric conductors may be connected to such grids as here described by any suitable means, and for this purpose the ends 25 of the terminal sections 1 and 2 are indicated as being left in a flattened condition and may additionally be provided with apertures, binding posts, or special shapes, to facilitate the connection of leads thereto, according to the preference of the user.

In considering the scope of this invention, it should be clearly understood that the substantially rectilinear sections 1, 2, 3 and 4 need not be parallel, but may extend at various angles with

respect to one another (as in Fig. 11), or certain of such sections may be angularly related and the others parallel (as in Fig. 12). For instance, one of these many arrangements is embodied in a grid of the improved type for such use as upon the circular flat bottom or top of a cylindrical furnace having a vertical axis, or in circular hot plates, in each of which cases either single resistance sections, or pairs of such sections, will radiate from the center towards the circumference.

In Fig. 11, pairs of radiating slightly divergent sections 30 are connected at their adjacent outer ends by inwardly converging pairs of shorter sections 31, the sections of each longer pair being connected together by crossovers 30^a, while the sections of each shorter pair are connected by crossovers 31^a, and the adjacent sections of each neighboring pair of longer and shorter sections are connected together by crossovers 32, it being understood that each of these crossovers (as with 5 and 6) is widely spaced away from the adjacent portions of the sections which they connect. Fig. 12 by comparison shows pairs of substantially parallel resistance sections 33, the outer ends of the sections of each pair being connected together by crossovers 34, while the adjacent inner ends of sections in neighboring pairs are connected together by crossovers 35, these crossovers 34 and 35 also being relatively widely separated from the adjacent portions of the sections which they join.

In providing a grid of relatively flat circular disc-like shape (as in Fig. 13), it is also possible to run several elongated sections 36 substantially parallel, zig-zagging them as geometrical cords across the area of the disc indicated by the circular dot-and-dash line 37, in which case the crossovers 38 and 39 are also spaced from the sections which they connect, as hereinbefore described. However, each of these variations shown in Figs. 11, 12 and 13 just as fully embodies the substance of the present invention as does that form which is illustrated in Figs. 1 to 10, inclusive, and all such are as clearly covered by the appended claims.

In considering the scope of this invention, it should also be understood that, while the preferred embodiments involve the maintenance of an electric separation of the adjacent surfaces of each main, and neighboring crossover sections, these sections may be pressed directly together or indirectly connected electrically, and if united may be secured together by spot or other form of welding, riveting, or otherwise, as may be desired.

The resultant grid furthermore will fulfill the requirements of many uses, if the planes of the main sections are spaced apart or are angularly disposed, if a given surface of the ribbon faces in different directions, and if said main sections extend in widely different, or even in opposite, directions from a connecting crossover section.

Having thus described our invention, what we claim and desire to protect by Letters Patent of the United States is:—

1. A resistance unit, comprising spaced ribbon-like sections lying in substantially the same plane, and a crossover section connecting oppositely directed edge portions of said first sections, said crossover section extending across and free from contact with the surfaces, except at said oppositely directed edge portions of said first sections.

2. A resistance unit, comprising spaced ribbon-like sections, and a crossover section connecting said first sections, said last section being triangular in shape and free from contact with said first sections except at their angular end portions.

3. A resistance unit, comprising spaced ribbon-like sections having diagonal ends, and transversely arcuate throughout their width, and crossover sections connecting said diagonal end portions, free from contact with and extending across the adjacent portions of said first sections.

4. A resistance unit, comprising substantially parallel spaced ribbon-like sections having diagonal ends and transversely arcuate throughout their width, and crossover sections connecting said diagonal end portions, free from contact with and extending across the adjacent portions of said first sections, and said unit being longitudinally curved to such a degree as to permit it to assume a substantially flat shape when heated.

5. A resistance unit, comprising a transversely curved ribbon-like section provided with an aperture spanning the apex of curve of said section, the material from said aperture being left connected to said section along a lateral portion of the aperture's periphery, and extending substantially radially away from the plane of said section to provide for relatively free passage of air currents through and transversely of the plane of said section.

6. A resistance unit comprising spaced ribbon-like sections lying in substantially the same plane and a ribbon-like crossover section integrally connecting and extending across but free from contact with the faces of said first sections.

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