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R. COX ET AL

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ELECTRIC HEATER

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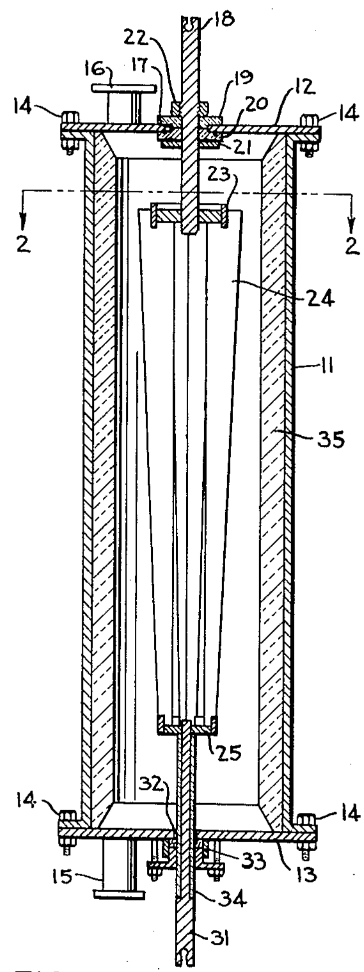

FIG. 1

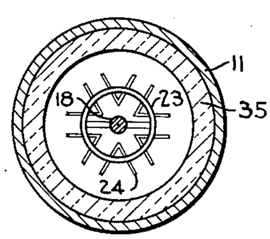

FIG. 2

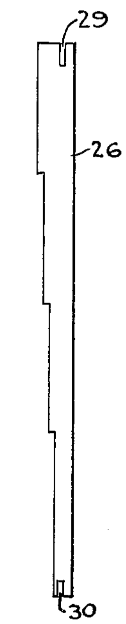

FIG. 3

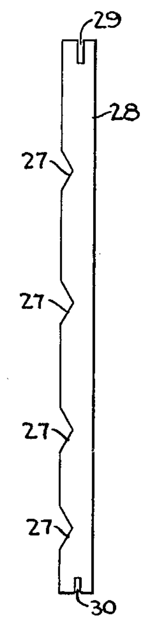

FIG. 4

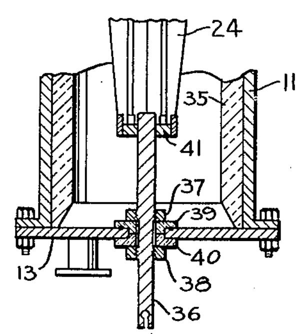

FIG. 5

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ELECTRIC HEATER

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6 Claims. (Cl. 219—39)

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This invention relates to electric heaters and pertains more particularly to a device for electrically heating a gas flowing therethrough.

Electric heaters presently used for heating a flowing gas generally employ a heating element or conductor having a constant cross-sectional area throughout its length. With the conductor arranged lengthwise in the heater in a plane parallel to a gas stream passing therethrough, it is readily apparent that difficulties in heating the gas will be encountered because of the inefficiency of the above arrangement. Thus, with a constant flow of cold gas being put through the heater when a constant voltage is applied to the conductors or heating elements, the conductors will have a much lower temperature at one end where the cold gas is entering the heater than at the other end where the conductor is in contact with the warm gas leaving the heater.

Since the material of which a conductor is made has a maximum temperature to which it can be heated without destroying or deforming the conductor, it may be seen that the temperature at the cold end of the conductor cannot rise above a certain value which is considerably lower than the temperature of the warm end. Hence, the use of conductors of constant cross-sectional area in a heater limits the amount of heat which may be developed, calculated on a given weight of the conductor. Since the temperature at the cold end is much lower than the maximum temperature which the material of the conductor can stand, neither the material nor the space occupied by the conductor is used economically.

It is therefore a primary object of the present invention to provide an electric heater employing heating elements or conductors of special shape whereby the temperature difference between any two points along the conductors is made relatively small when the stream of gas is passed through the heater in a direction parallel to the conductors.

Other objects of this invention will be understood from the following description taken with reference to the attached drawing, wherein:

Figure 1 is a longitudinal view, in cross section, of a gas heater according to the present invention.

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Figure 2 is a cross-sectional view taken along the line 2—2 of Figure 1.

Figures 3 and 4 are longitudinal views of other embodiments of conductor strips employed as heating elements in the present heater.

Figure 5 is a fragmental cross-sectional view of another embodiment of an expansion joint employed in the present heater.

The present invention is directed to an electrical gas heater employing longitudinal conductor strips, the resistance per unit of length of which decreases in the direction of the flow of gas. Thus, the heat developed per unit length is greater where the gas is cold than where the conductor is in contact with the already heated gas. Provided that the conductor is of homogeneous material, the resistance per unit of length decreases in the direction of the flow of gas if the cross-sectional area increases in the same direction. The cross-sectional area can be altered by varying the width and/or the thickness of the strip; in practice, only variation of the width is practicable. If the width increases, the heating surface is increased proportionally, whereas variation of the thickness has hardly any effect on the size of the heating surface. To facilitate the transfer of heat, the width adopted should be as great as possible, and in connection therewith the thickness should be kept as small as is consistent with the required strength and rigidity of the conductor; the most favorable thickness should preferably not be departed from. With appropriate gradation of the resistance per unit of length, the cross-sectional area and the width of the strip respectively, an almost uniform temperature can be achieved over the whole length of the conductor when put to the use for which the device is intended.

In order to maintain accurately a constant temperature over the whole length of the strip-shaped conductor, it is necessary to use shapes with slightly curved outlines, for example, such as given by hyperbolas. These lines can be determined by calculation. As they differ only slightly from straight lines, strips in the form of elongated trapezoids can be used in most cases.

An electrical gas heater of the present design is of importance where the maximum permissible temperature for the material of which the conductor is made is appreciably lower at the point of heaviest load (i. e., at the upper end of a suspended strip-conductor) than elsewhere in the conductor. By employing a heater of the present design where the cold gas contacts the warmest part of the conductor and the warm gas contacts the coldest part of the conductor, an advantage is realized by the increased transfer of heat to the cold gas which permits the use of a heater having conductors which are shorter in length and hence lighter in weight.

As shown in Figures 1 and 2, a preferred embodiment of the present heater may comprise a longitudinal housing or tube 11 closed at either end by plates or covers 12 and 13, which may be secured to the housing 11 in any suitable manner as by bolts 14. Both covers 11 and 12 are provided with suitable port means, such as flanged nipples 15 and 16, to which may be connected the intake and discharge flow lines (not shown) serving as a gas conduit.

One cover 12 (preferably the top cover when the axis of housing 11 is positioned vertically) is provided with a central opening 17 in which a bar member 18 is fixedly held in a fluidtight manner, said bar member serving as an electrical conductor. One end of the bar member 18 extends into the housing 11 through a pair of flanged insulation rings 19 and 20 of porcelain, rubber, etc., which serve as electrical insulation between the bar 18 and the cover 12. A holding ring 21 and a holding nut 22 may be secured to the bar member 18, as by welding or screw threads, and serve to position the bar 18 with regard to the cover 12.

Affixed to the end of the bar member 18 within the housing 11 is a support ring or spider 23 from which depend a plurality of metallic fin elements or strip conductors 24. The conductors 24 are preferably secured to the spider 23 by welding. The spider 23, together with a second spider 25 welded to the lower ends of the conductors 24, serves as means for maintaining the conductors in preferably equidistant spaced relationship to each other. If desired, additional spiders or spacing elements may be secured to the conductors at other points between the ends thereof.

The conductors 24 are preferably made of any suitable thin-gauge metal, the long sides of said conductors being tapered as shown in Figure 1. The narrowing of strips 26 can also be carried out in steps as shown in Figure 3 instead of being gradually tapered. Increased resistance per unit length can also be obtained by notches or perforations 27 of increased depth in a strip 28, as shown in Figure 4. The strip conductors 24 and 28 may also be provided with slots 29 and 30 which are adapted to receive the support spiders 23 and 25, respectively.

The most satisfactory method of suspending the strip-conductors is with the broad end uppermost; the greatest mechanical load is then borne by the strongest parts. In this case the gas to be heated must be passed along the conductors from bottom to top. Should the strength of construction permit, the strips may, however, also be suspended from their thin ends, and the gas passed from top to bottom.

The strips 24 which are to be fitted into a tube 11 can be distributed in various ways over the available space. A preferable form of construction is that whereby a number of strips are bent to a V-shape, i. e. bent in such a way that a cross-section at right angles to the axis of the tube shows a V-shape, as shown in Figure 2. The apexes of the V's should preferably point towards the axis of the tube. To ensure as far as possible an even distribution of heat, the bent strips 24 should be spaced in such a manner that roughly the same amount of gas flows along the outer sides of the conductors as along the inner sides.

The spider 25, which is fixedly secured to the lower end of the conductor-strips 24, is also preferably secured to a bar member 31 which extends through a central opening 32 in the bottom cover plate 13 of the housing 11. A suitable stuffing box 33 surrounds the bar member 31 to provide a fluidtight seal which allows the bar 31 to slide in or out due to expansion or contraction of the strip-conductors 24 as they are heated and cooled. Since the member 31 serves as an electrical contact bar or terminal for supplying current to the conductors 24, it is electrically insulated from the cover plate 13 in any suitable manner, as by a surrounding tube of insulation 34 which may be carried in a recessed portion of the bar member, as shown in Figure 1. If desired, the entire housing 11 may be insulated to prevent excessive heat losses, as by installing suitable insulating material 35 around the inside or outside of the housing 11.

While in the embodiment illustrated in Figure 1 the lower bar member 31 is slidably mounted in the lower plate 13, it is realized that various design changes may be made in the present heater to allow for the expansion of the strip-conductors 24, without departing from the scope of the invention. Thus, instead of the bar member 31 being fixedly secured to the spider 25 and mounted for sliding movement through the lower cover plate 13, a bar member 36 (Fig. 5) may be fixedly secured to the lower plate 13 by holding nuts 37 and 38 and by insulation rings 39 and 40 while a spider 41 is mounted for sliding electrical contact along the portion of the bar 36 which extends into the housing 11. Hence, as the strip-conductors 24 expand and contract the spider 41 slides along the bar member 36 which is mounted in a fluidtight manner in plate 13.

In operation, the intake and outlet nipples 15 and 16 are connected into a pipe line carrying gas to be heated and the contact bars 18 and 31 are connected to a suitable power source (not shown) whereby electric current may be applied to the strip-conductors 24. Gas entering the inlet port 15 flows past the hottest and smallest portions of the strip-conductors 24 first and continues upward in the housing 11 past the wider and cooler portions of the conductors and thence out the discharge port 16. The conductors 24 in the form of strips are particularly suitable for heating purposes owing to their broad surface and relatively small cross-sectional area. When strip conductors 24 of a suitable taper are employed, a substantially uniform temperature may be achieved over the whole length of the conductors.

The present gas heater has been found to be especially effective when used to pre-heat a mixture of nitrogen and hydrogen before the mixture is brought into contact with a catalyst during the synthesis of ammonia. While the heat of the reaction is generally used to pre-heat the gases, it is necessary to use an auxiliary heater during the start-up period.

By way of example, a few figures are given below relating to the dimensions of a device according to the invention used in an ammonia-synthesis column wherein a quantity of nitrogen-hydrogen mixture in the proportion of 3:1 is brought by the heating device to a temperature suitable for the reduction of a fresh oven charge:

Length of heating device	3.20 m.
Quantity of gas to be heated	1100 m.³/hour
Pressure of the gas	50 atm.
Diameter of heater	90 mm.
Number of strip-conductors (material: V2A steel; trapezoid-shaped; arranged as in Figure 2; space between strips and wall of tube equal in size to space in the centre between the strips; the strips bent at an angle of 60°)	6
Width of strips, upper end	about 67 mm.
Width of strips, lower end	about 42 mm.
Thickness of strips	0.22 mm.
Initial temperature of synthesis-gas	20° C.
Final temperature of synthesis-gas	500° C.
Average temperature of conductors	780° C.
Energy	200 kVA.
Voltage (A. C.)	100 v.
Current	2000 a.

By the arrangement described above, the temperature differential between the ends of the conductor strips is reduced by approximately a factor of ten as compared with uniform width strips.

The invention claimed is:

1. An electrically operated gas heater comprising a closed housing having a chamber formed therein, inlet and outlet port means at opposite ends of said housing for flowing a gas through said chamber, a plurality of metal conductors carried within said chamber, said conductors extending over a major portion of the distance between the inlet and outlet port means, the resistance per unit length of said conductors decreasing and the cross-sectional area thereof increasing in the direction of the flow of gas through said chamber, and means extending through the wall of said housing for supplying an electric current to said conductors.

2. A device for electrically heating a flowing gas, said device comprising a closed housing having a chamber formed therein, inlet port means provided near the bottom of said housing, outlet port means near the top of said housing, a plurality of metal conductors suspended vertically within said housing, the cross-sectional area of said conductors taken in a horizontal plane increasing from the bottom to the top of said conductors, and means extending through the wall of said housing for supplying an electric current to said conductors.

3. A device for electrically heating a flowing gas, said device comprising a closed housing having a chamber formed therein, inlet port means provided near the bottom of said housing, outlet port means near the top of said housing, a plurality of metal conductors suspended vertically within said housing, said conductors comprising strips of sheet metal in the form of elongated

trapezoids, the width of said conductors decreasing from the top to the bottom thereof, and means extending through the wall of said housing for supplying an electric current to said conductors.

4. A device for electrically heating a flowing gas, said device comprising a closed housing having a chamber formed therein, inlet port means provided near the bottom of said housing, outlet port means near the top of said housing, a plurality of metal conductors suspended vertically within said housing, said conductors comprising strips of sheet metal in the form of elongated trapezoids, the width of said conductors decreasing from the top to the bottom thereof, support members within said housing securing said conductors to the top and bottom of said housing, and electrical contact bar means extending through the wall of said housing and in contact with said support means for supplying an electric current to said conductors.

5. A device for electrically heating a flowing gas, said device comprising a closed housing having a chamber formed therein, inlet port means provided near the bottom of said housing, outlet port means near the top of said housing, a plurality of metal conductors suspended vertically within said housing, said conductors comprising strips of sheet metal in the form of elongated trapezoids, the width of said conductors decreasing from the top to the bottom thereof, and electrical contact bar means extending through the wall of said housing and in contact with said support means for supplying an electric current to said conductors, one of said support members being mounted on one of said bar means in movable relationship with one end of said housing.

6. A device for electrically heating a flowing gas, said device comprising a closed housing having a chamber formed therein, inlet port means provided near the bottom of said housing, outlet port means near the top of said housing, a plurality of metal conductors suspended vertically within said housing, said conductors comprising strips of sheet metal in the form of elongated trapezoids, the width of said conductors decreasing from the top to the bottom thereof, said conductors being bent along their vertical center lines to form V-shaped troughs having apexes pointing toward the center of said housing, and means extending through the wall of said housing for supplying an electric current to said conductors.

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