Nov. 14, 1961 D. W. PORTER 3,009,045

HEATING ELEMENT

Filed Sept. 12, 1960

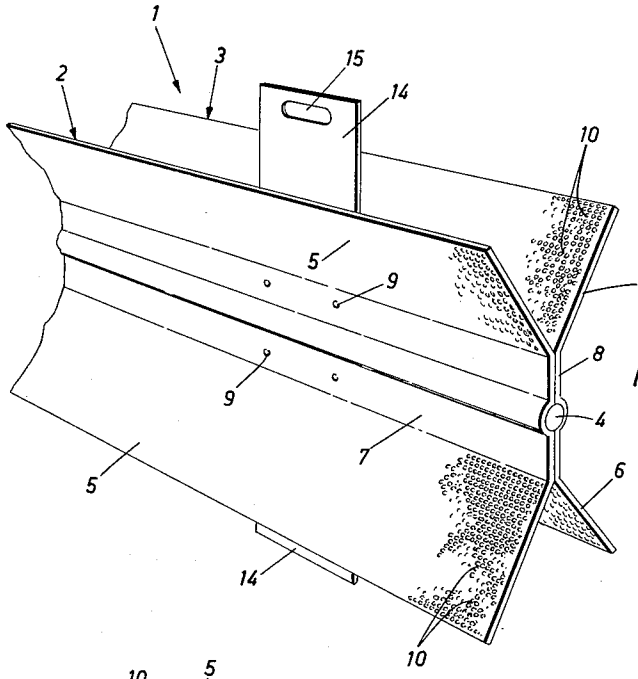


FIG. 1

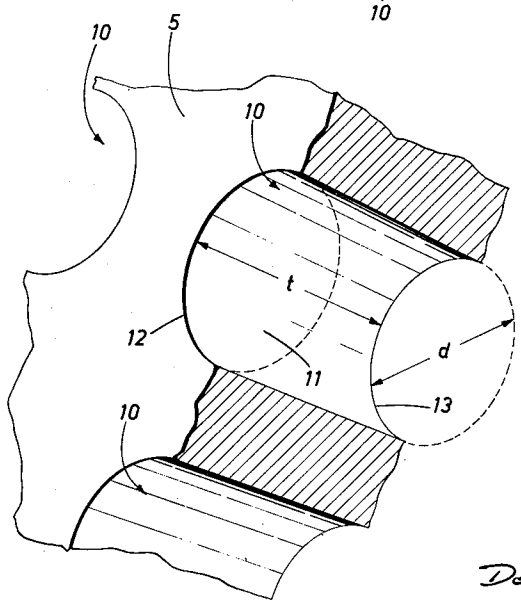


FIG. 2

Donald William Porter

Inventor

by: D. F. Sim

Attorney

United States Patent Office 3,009,045 Patented Nov. 14, 1961

3,009,045

HEATING ELEMENT

Donald William Porter, Kitchener, Ontario, Canada, assignor to Dominion Electrohome Industries Limited, Kitchener, Ontario, Canada

Filed Sept. 12, 1960, Ser. No. 55,517
14 Claims. (Cl. 219—19)

This invention relates to the art of heating and heat transfer. More particularly, this invention relates to a heating element designed to transmit the maximum amount of heat from the element to a fluid, in particular, air, in which the element is immersed.

It is well known that heat may be transferred from one body to another in any or all of the following modes: conduction, convection and radiation. The transport of heat energy between neighbouring volumes of a material substance by virtue of a temperature difference between the neighbouring volumes is known as heat conduction. The transfer of heat energy from a body by a fluid which absorbs heat at one place and moves to another place, where it rejects some of the heat energy to a cooler portion of the fluid, is known as heat transfer by convection. On the other hand, heated liquids or solids emit thermal radiation as a result of their temperature. This thermal radiation is electromagnetic in nature, and, on striking another solid or liquid, reverts to heat energy. In this manner heat energy is radiated from one body to another.

When a fluid such as air is in contact with a body whose temperature is higher than that of the main body of the fluid, heat will be transferred from the body to the fluid by a combination of conduction and convection. Where the fluid is a gas, for example, air, the amount of heat transferred by radiation will be negligible. Neglecting heat transfer by radiation, the following equation may be written.

$$\frac{dQ}{dt}=hA\Delta\theta \qquad (1)$$

Where

$$\frac{dQ}{dt}$$

is the rate of heat transfer by convection and conduction, A is the surface area of the body in contact with the gas, $\Delta\theta$ is the temperature difference between the surface of the body and the main body of the gas, and h is termed the convection coefficient.

The mechanism of heat transfer in this case can be seen when it is considered that while the gas in contact with the surface of the body may be in motion, there is a relatively thin film of stagnant gas next to the surface. If the motion of the gas is turbulent, the thickness of the film is less than if the motion of the gas is laminar. Heat is transferred from the body to the gas by combined conduction through the film and convection in the gas. The convection coefficient h in Equation 1 includes the effect of both conduction and convection and may be determined experimentally.

It will be seen from a consideration of Equation 1 that the rate of heat transfer in this case is directly proportional to the surface area of the body in contact with the gas. Bearing this in mind, it will be understood why devices such as air-cooled internal combustion engines are provided with fins of large surface area, usually cast integral with the cylinder walls of the engines.

It will be appreciated, however, that there is a limit on the amount of heat transfer area which can be made available by the addition of fins. This limit may be dictated by the economics of either manufacture or use, space requirements, or weight or all of these. Moreover,

it is quite apparent that sufficient space must be left between adjacent fins to permit adequate air circulation therethrough.

It is a primary object of my invention to provide a heat conducting fin which is designed to transfer larger amounts of heat from a heat source than has hitherto been possible.

It is another primary object of my invention to provide such a heat conducting fin as aforementioned, and yet to provide, in combination with a heat source, a heat conducting fin which actually employs a smaller amount of material than has hitherto been possible.

A further object of my invention is to provide such a heat conducting fin as aforementioned and which is relatively light in weight.

Yet another object of my invention is to provide such a heat conducting fin as aforementioned and which permits transfer of greater amounts of heat from a heat source, while occupying lesser space than has hitherto been possible.

Still another object of my invention is to provide a heating element which may be manufactured without difficulty and at a low cost.

In brief, apparatus embodying my invention comprises a heat source and a heat conducting fin associated with the heat source in heat transfer relationship. The fin has a plurality of openings extending therethrough. The openings are defined by side walls having a greater surface area than the total cross-sectional areas of the openings at the open ends thereof. In an embodiment of my invention which is preferred because of its ease of manufacture, the openings are circular, the depth of the openings being greater than one-half the diameter thereof.

Other objects and advantages of my invention will become apparent from the following detailed description taken in conjunction with the drawings, in which:

FIGURE 1 is a perspective view of a portion of a baseboard heating element embodying my invention, and

FIGURE 2 is an enlarged view of a portion of one of the fins of the baseboard heating element shown in FIGURE 1.

It will be appreciated that while my invention is illustrated and hereinafter described in connection with a baseboard heating element, my invention is applicable to any apparatus comprising a heat source and a heat conducting fin associated with the heat source in heat transfer relationship. The terminology "heat source" is to be interpreted as any device or apparatus capable of and used for, whether purposely or incidentally, the production of heat. For example, my invention is particularly applicable with air cooled internal combustion engines such as stationary engines, automobile and aeroplane engines and motorcycle engines, to name only a few.

Referring now to the drawings for a more detailed description of one embodiment of my invention, I have shown a baseboard heating element 1 which comprises heat conducting fins 2 and 3 and a heat source in the form of a Calrod element 4. Heat conducting fins 2 and 3 have pairs of outwardly extending arms 5 and 6 respectively. Outwardly extending arms 5 and 6 are joined by center arms 7 and 8 respectively. Fins 2 and 3 may be made of any suitable heat conducting material, preferably a metal, and preferably aluminum. Aluminum has the advantages of high heat conductivity and low weight. While weight may be a factor in situ, in some instances, and dictate the use of a metal having low weight, weight is always a factor in connection with the handling and transportation of an article, both from the physical and the cost points of view. Aluminum also has the advantage of having a relatively bright finish. This eliminates most of the tendency of the fin to transfer heat by radiation to surrounding objects, and, hence, enhances the amount of

heat which is transferred to the air surrounding the heating element by conduction and convection. It will be appreciated that baseboard heating elements should be designed to radiate a minimum amount of heat, because it is desired to heat only the air surrounding the element, and radiated heat will not affect the air, but will heat other objects and surfaces which it strikes. It also will be understood, however, that it would not depart from my invention to increase the amount of heat radiated from a heating element embodying my invention by making the surface of the heating element dark. This may well be done, for example, with air cooled, automotive, internal combustion engines where the primary purpose of cooling is not to heat the surrounding air, but to remove large amounts of heat from the engine as quickly as possible.

Fins **2** and **3** may be stamped from sheets of aluminum in the form illustrated. The fins are secured together by any suitable means such as rivets **9**, with center arms **7** and **8** back to back, and with outwardly extending arms **5** of fin **2** extending away from outwardly extending arms **6** of fin **3** When the fins are so assembled, heating element **1** has an X-shaped cross-section through which air must travel.

As shown in the figures, Calrod element **4** is positioned between and supported by center arms **7** and **8**, and is in heat transfer relationship therewith. Calrod element **4** is heated by an electrical current, and the heat is transferred to fins **2** and **3** by conduction.

The outwardly extending arms **5** and **6** of fins **2** and **3** respectively are provided with a plurality of closely spaced, side enclosed, circular openings **10**. These openings are of such dimensions that the surface area of the side walls **11** defining the openings and side enclosing the same is greater than the total cross-sectional areas of the openings at the open ends **12** and **13** thereof. In other words, by virtue of such openings, the total cross-sectional area of a fin in contact with air is substantially greater than if the fin were not provided with such openings. Referring to Equation 1, it will be seen that the rate of heat transfer of a fin provided with openings **10** will be much greater than a similar fin not provided with openings, because the rate of heat transfer is directly proportional to the surface area in contact with the air. It will be appreciated that not only does a heating element embodying my invention have enhanced heat transfer properties because of increased surface area, but also because air or other fluid may pass through the element readily, certainly much more readily than if no side enclosed openings **10** were provided.

It will be appreciated that openings **10** need not necessarily be side enclosed. The openings need only satisfy the aforementioned condition that their provision results in a fin having more surface area in contact with air, and hence more heat transfer surface area, than the same fin not provided with the openings.

It will be understood that while I have shown openings **10** as being circular in shape, openings of any shape may be employed as long as, (*a*) the openings pass through the fins, and (*b*) the side walls defining an opening have a greater surface area than the total cross-sectional areas of the opening at both open ends thereof. It also will be understood that openings **10** may be provided in center arms **7** and **8**.

Circular openings **10** are preferred because they can be readily drilled or punched. In the case of circular openings, the aforementioned condition (*b*) is satisfied if the depth of the openings, i.e. the thickness of the fin, is greater than one-half the diameter of the openings. This relationship may be derived as follows:

The area of a circle is

$$\frac{\pi d^2}{4}$$

where d is the diameter of the circle.

Each cylindrical disc punched out has two circular heat transmitting surfaces with a total area of

$$\frac{2\pi d^2}{4}=\frac{\pi d^2}{2}$$

The surface area of the side walls defining an opening is $\pi d \times t$, where t is the depth of the opening, i.e. the thickness of a fin.

In order to provide more cylindrical surface area than circular disc surface area,

$$\pi d \times t > \frac{\pi d^2}{2}$$

or

$$t > \frac{d}{2} \qquad (2)$$

Heating element **1** is provided with members **14** having apertures **15** therein. Members **14** are spaced along the length of heating element **1** and are secured thereto by rivets **9**. Heating element **1** may be supported in a suitable casing (not shown) by means of screws passed through apertures **15** and into a part of the casing. The casing should be designed to promote a smooth air flow around and through the perforated heating element as well as to prevent hot air from losing heat to the casing. The casing also should present a pleasing appearance since it will be positioned along the baseboard of a room to be heated and will be visible.

It will be immediately apparent from a consideration of the foregoing disclosure that I have provided a heating element having decided advantages over prior art type heating elements. Comparing a baseboard heating element of the type described with a similar element of the same size, shape and material but not having openings **10**, a heating element embodying my invention transfers a greater amount of heat by virtue of its increased surface area and "open" structure, the latter of which promotes good circulation. At the same time, it does so using less material, and hence it weighs less. Comparing on the basis of equal amounts of heat transfer under identical conditions, a heating element embodying my invention occupies less space than a similar element not provided with openings.

It will be understood that embodiments of my invention may be used in both gaseous and liquid atmospheres. A heating element embodying my invention might be employed, for example, as an immersion heater in a liquid.

While preferred embodiments of my invention have been disclosed in detail, it will be apparent that numerous modifications may be made without departing from the spirit and scope of my invention as defined in the appended claims.

What I claim as my invention is:

1. In combination with a heat source, a heat conducting fin associated with said heat source in heat transfer relationship, said fin having a plurality of openings extending therethrough, said openings being defined by side walls having a greater surface area than the total cross-sectional areas of said openings at all open ends thereof.

2. In combination with a heat source, a heat conducting fin associated with said heat source in heat transfer relationship, said fin having a plurality of circular openings extending therethrough, the depth of said openings being greater than one-half the diameter of said openings.

3. The invention according to claim 1 wherein said heat conducting fin is made of metal.

4. The invention according to claim 3 wherein the metal is aluminum.

5. The invention according to claim 1 wherein said heat source is a Calrod element.

6. In combination with a heat source, a plurality of heat conducting fins associated with said heat source in heat transfer relationship, each of said fins having a

plurality of openings extending therethrough, said openings being defined by side walls having a greater surface area than the total cross-sectional areas of said openings at all open ends thereof.

7. A baseboard heating element comprising a pair of heat conducting fins, each of said fins having a pair of outwardly extending arms joined by a center arm, said fins being secured together with said center arms back to back and with the outwardly extending arms of each fin extending away from the outwardly extending arms of the other fin, and a heat source positioned between said center arms in heat transfer relationship therewith, said pair of fins having a plurality of openings extending therethrough, said openings being defined by side walls having a greater surface area than the total cross-sectional areas of said openings at all open ends thereof.

8. A baseboard heating element according to claim 7 wherein said heat source is a Calrod element.

9. A baseboard heating element according to claim 7 wherein said openings are provided only in said outwardly extending arms of said pair of fins.

10. A baseboard heating element according to claim 7 wherein said openings are circular, the depth of said openings being greater than one-half the diameter of said openings.

11. A baseboard heating element comprising a pair of

metal, heat conducting fins, each of said fins having a pair of outwardly extending arms joined by a center arm, said fins being secured together with said center arms back to back and with the outwardly extending arms of each fin extending away from the outwardly extending arms of the other fin, a Calrod heating element positioned between said center arms in heat transfer relationship therewith, said pair of fins having a plurality of side enclosed circular openings extending therethrough, the depth of said openings being greater than one-half the diameter of said openings.

12. A baseboard heating element according to claim 11 wherein said metal is aluminum.

13. A baseboard heating element according to claim 12 wherein said circular openings are provided only in said outwardly extending arms of said pair of fins.

14. A baseboard heating element according to claim 7 wherein said openings are side enclosed by said side walls.

References Cited in the file of this patent

UNITED STATES PATENTS

2,482,951	Vonk	Sept. 27, 1949
2,590,336	Mast	Mar. 25, 1952
2,646,972	Schmid	July 28, 1953
2,690,060	Legatski	Sept. 28, 1954