Sept. 19, 1961 E. C. FEHNER 3,001,054

HEATING PANEL HAVING A PLURALITY OF CURRENT PATHS

Filed Aug. 1, 1958

Fig. 1.

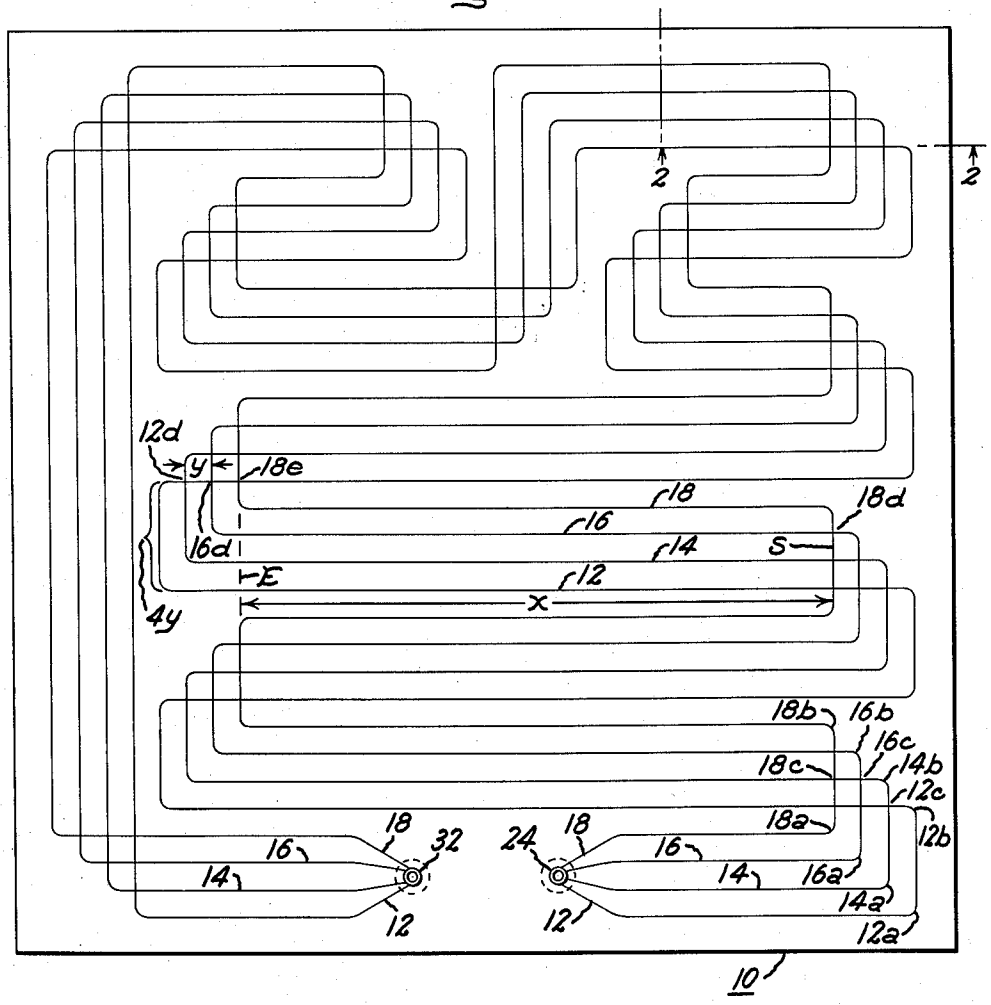
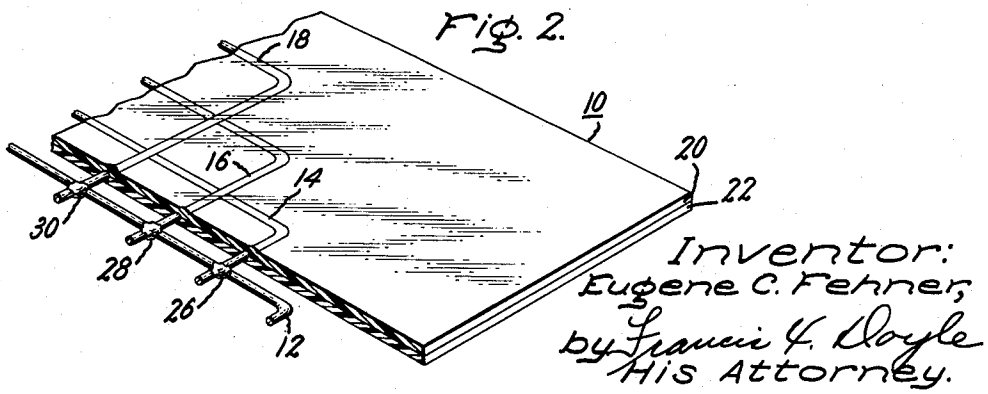


Fig. 2.



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United States Patent Office 3,001,054
Patented Sept. 19, 1961

3,001,054
HEATING PANEL HAVING A PLURALITY OF CURRENT PATHS

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Filed Aug. 1, 1958, Ser. No. 752,608
1 Claim. (Cl. 219—19)

This invention relates to a heating panel and, more particularly to a heating panel having a plurality of current paths to improve the reliability of the heating element.

In present day heating panels when the resistance wire forming the heating element of such panels becomes broken, the heating panel is generally rendered inoperative. Where a number of resistance wires are provided in a heating element, the breakage of a single wire, while not making the panel inoperative, will result in a lack of uniform heating.

In present day heating panels which are being utilized in defense efforts, the reliability of such heating panels is extremely important. For example, the heating panels which are utilized in many of our present day missiles, to maintain the missile in constant operative readiness, must, of necessity, be provided with a very high degree of reliability. It is well known that present day missiles and other similar weapons are of such extreme complexity and delicacy in their circuitry and other elements, that many of these weapons are required to be maintained at a substantially constant temperature to allow the operation of the weapons when desired. When these weapons are maintained in a constant state of readiness, it is clearly very necessary that the heating elements, relied upon to maintain the necessary temperature of the weapon, be sufficiently reliable to maintain the desired temperature and to be free of failures.

Many present day heating panels utilizing a number of resistance wires to make up the heating element have not proved sufficiently reliable, since the breakage of a single wire within the heating element generally renders a large portion of the panel inoperative.

It has been found that by providing a number of shorts across the wires of a multi-wire heating element, at points of equal potential, that most of the wire forming the heating element can be kept in operation. This is true, since a break occurring between the various shorts provided, will only drop out the portion of the wire which is found between the shorts and the wire will be placed in circuit again at the shorting point. However, the addition of shorting wires or bars causes an increase in weight and the cost of heating panels. In many applications, such as missiles, where the heating panel is retained within or on the missile throughout the flight of the missile, the increase in weight of the heating element can lead to many problems, such as interfering with the flight stability of the missile. The necessity of preventing any unnecessary increase in cost is obvious.

It is, therefore, an object of this invention to improve the reliability of heating panels without the addition of shorting wires or shorting bars.

It is a further object of this invention to improve the reliability of heating panels by the provision of shorts at points of equal potential throughout the panel, without increasing the weight or cost of the heating panel.

In carrying out this invention in one form, the wires forming the heating element are arranged in a series of short runs, the wires in each run being crossed-over each other at the start of a new run. At the cross-over point each wire contacts each other wire, thereby providing shorts at such points so that if one wire within a run should become broken between the cross-over points, the

remaining wires will carry the current between such points and redistribute the current to the other wires at the cross-over point. In this manner only a small area of the panel is affected by a break in the resistance wire.

The scope of this invention is set forth in the appended claim, however its objects and advantages, in a preferred embodiment thereof, will be better understood from the following description taken in connection with the accompanying drawing in which:

FIGURE 1 is a plan view of a heating panel constructed in accordance with a preferred embodiment of this invention;

FIGURE 2 is a perspective view taken on the line 2—2 of FIGURE 1, showing a detail of the preferred embodiment of this invention.

Referring now to the drawings, in which like numerals are used to indicate like parts throughout, and especially with reference to FIGURE 1, there is shown a heating panel, generally designated as **10**, made in accordance with a preferred embodiment of this invention. As shown, the heating panel **10** comprises a series of resistive wires **12**, **14**, **16** and **18** imbedded within a laminated plastic. The formation of the panel, as shown in FIGURE 2 comprises two layers of plastic, such as **20**, **22**, and may be of any desired plastic, such as for example polymerized methyl methacrylate. Of course, it should be understood that this invention also applies equally to heating blankets or laminates which may be formed of fabric or fabric in combination with various coatings, such as silicone rubber, rather than plastic as herein described. FIGURE 2 shows the heating panel in which the two layers of plastic material are separate, however, it will be understood that when the plastic material is laminated the plastic material may flow together to form a unitary, homogeneous panel.

Referring again to FIGURE 1 the heating wires **12**, **14**, **16** and **18** are shown as attached to a terminal **24**, which is adapted to be connected to a source of electric current (not shown). The resistance wires leave the terminal **24** and form a series of runs, generally parallel, throughout the panel. A first run is shown, comprised of wires **12**, **14**, **16** and **18**, generally parallel to the bottom of the heating panel **10**. At the point indicated as **12*a*** heating wire **12** turns at right angles, continues for a short distance parallel to the side of panel **10**, and thence turns again at a right angle at point **12*b***, and begins a second run across the panel, parallel to the bottom edge of panel **10**. Each of wires **14**, **16** and **18** turn in a similar manner at points **14*a***, **16*a*** and **18*a*** respectively, and run for a short distance parallel to the side of panel **10**, and then at points **14*b***, **16*b*** and **18*b*** turn again at right angles and run parallel to the bottom of panel **10**. It will be noted that after resistance wire **12** turns at point **12*b*** and begins to run parallel to the bottom of panel **10**, that it cuts across each of wires **14**, **16** and **18** between points **14*a*—14*b***, **16*a*—16*b***, and **18*a*—18*b***. Wire **14** crosses wire **12** beyond point **12*b*** as does wire **16** and wire **18**. It will be noted that wire **14** crosses lines **16** and **18** in a manner similar to wire **12**, line **16** crosses lines **12** and **14** in a manner similar to **14** crossing wire **12**, and crosses wire **18** in a manner similar to **12**, while wire **18** crosses all three wires **12**, **14** and **16** in a manner similar to the way in which wire **14** crosses wire **12**. Thus it is seen that each of wires **12**, **14**, **16**, and **18** cross-over each of the other three wires making up the resistance element of the panel **10**.

The four wires continue throughout the entire panel to make a relatively short run as is shown, turn at right angles for a short distance, then turn at right angles again for another run. At each turn in the series of wires each wire crosses over the other three wires thereby providing a short circuit at these cross-over points. At

each of these shorted cross-over points, being selected as points of substantially equal potential, the current flowing through each of the wires continues to flow in the same manner through the wires of the next run. However should one of the wires be broken, for example, should wire **14** become broken between terminal **24** and point **14***a*, it is obvious that the current flowing from terminal **24** would be carried by wires **12**, **16**, and **18**. At the cross-over point, namely where wire **14** crosses wire **12** at point **12***c*, where wire **14** crosses wire **16** at point **16***c*, and where wire **14** crosses wire **18** at point **18***c*, the current which is being carried by wires **12**, **16** and **18** will be redistributed between wires **12**, **14**, **16** and **18** so that from the cross-over point along the second run each of the wires will be carrying the desired current. For the short run between terminal **24** and the cross-over point each of wires **12**, **16** and **18** will be carrying an excess of current which can be considered as aiding in providing the extra heat required in that portion of the panel to make up for the heat loss due to the breakage of wire **14**. Since the distance is short compared to the total length of wire in the heating panel, the excess current will not be sufficient to create a hot spot. Throughout the remainder of the panel, wire **14** will carry the desired current and will provide the desired heat, as will each of the other three wires.

The cross-over points throughout the panel are selected as points of substantially equal potential. That is, the voltage present in each wire at the cross-over point is substantially the same as the voltage in every other wire at that point. This provides balanced current flow in the circuit elements. Consider for example, the center portion of panel **10**, where there is shown the beginning of a run, at line S, and the end of a run, at dotted line E. The distance between line S and line E will be X, and the distance between two cross-over points on a single wire will be Y, as shown. Therefore, it can be seen that wire **12**, from line S to the cross-over point **12***d* of wires **12** and **14**, will have a length equal to $X+8Y$. Wire **14**, from line S to the same cross-over point, will have a length equal to $X+5Y$, while wire **16**, from line S to cross-over point **16***d*, will have a length of $X+3Y$ and line **18**, from the cross-over point **18***d* on line S to the cross-over point **18***e* on line E, will have a length of $X+2Y$. From the above, it will be obvious that if the cross-over segments Y are small in relation to the run length X, that the cross-over points will occur at points of substantially equal potential. While the best ratio between length X to cross-over segment Y will vary according to the wire used, and other circuit considerations, it has been found that a ratio of X to Y greater than 20 provides satisfactory circuit balance. Of course, other circuit configurations could be used, which would provide greater equality of the lengths of the wires between the cross-over points.

In FIGURE 2, there is shown the cross-over points between wires **12**, **14**, **16** and **18** as it occurs at the top right section of the heating panel **10**. It will be understood that where the wires cross-over each other the wires may be soldered to one another to provide a desired electrical connection or, in instances where the wire is sandwiched between a laminated plastic panel, as is shown in FIGURE 2, the wires may be merely laid one across the other and the heat and pressure obtained during the lamination of the panel will firmly force the wires into

good electrical contact with each other. This contact will be maintained inasmuch as the plastic material will flow completely around the wires, firmly holding them in place. However, where this invention is being used in a heated blanket, which is formed of fabric, then it is desirable that the cross-over points be soldered to provide the desired electrical connection. FIGURE 2 shows both manners of connecting the wires, wire **12** being shown as soldered to wires **14**, **16** and **18** at points **26**, **28** and **30** outside of the portion of the heating panel shown in FIGURE 2. Within the heating panel of FIGURE 2, wire **14** is shown as running beneath wires **16** and **18**, the wires being firmly held in electrical contact with each other due to the laminated plastic sandwich forming the panel **10**.

Of course, it will be understood that a second terminal **32** is provided to which there is attached the wires **12**, **14**, **16** and **18** at the opposite ends of the totality of runs for providing the second terminal of the source of electrical current to which the heating element is to be connected to provide the desired heating to panel **10**.

While there has been shown and described a preferred embodiment of this invention, it is obvious that various changes or substitutions may be made by those skilled in the art. For example, it is obvious that the runs may be varied, it is not necessary that they be run parallel to the sides of the panel **10**, nor is it necessary that the cross-over point be at areas in which the wires are turned at right angles to each other. Various other changes will occur to those skilled in the art. Thus the embodiment shown and described is considered as descriptive only, the scope of the invention being set forth in the appended claim.

What is claimed as new, and which is desired to be secured by Letters Patent of the United States is:

A heating panel comprising a number of resistance wires disposed to form a heating element, said resistance wires being formed into a series of runs, said wires crossing at the end of each run at crossover segments whereby each of said wires crosses each of the other wires of said run, each of said wires being in electrical contact with every other wire at said crossover segments, the length of each run being substantially larger than the length of the crossover segment, the ratio of the run to the segment being greater than 20.

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