Nov. 24, 1959 B. A. DENTON 2,914,646

ELECTRICALLY HEATED DEVICE

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Fig. 1.

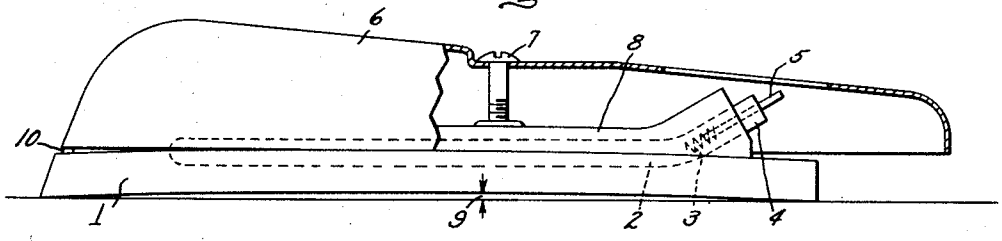


Fig. 2.

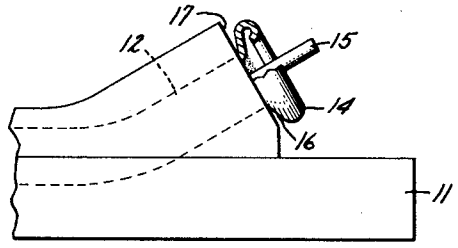
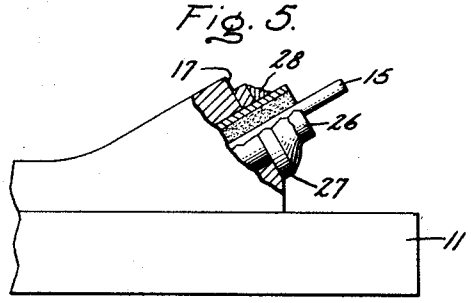


Fig. 5.



Inventor:
Bryce A. Denton,
by Laurence R. Kempton
His Attorney.

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Fig. 3.

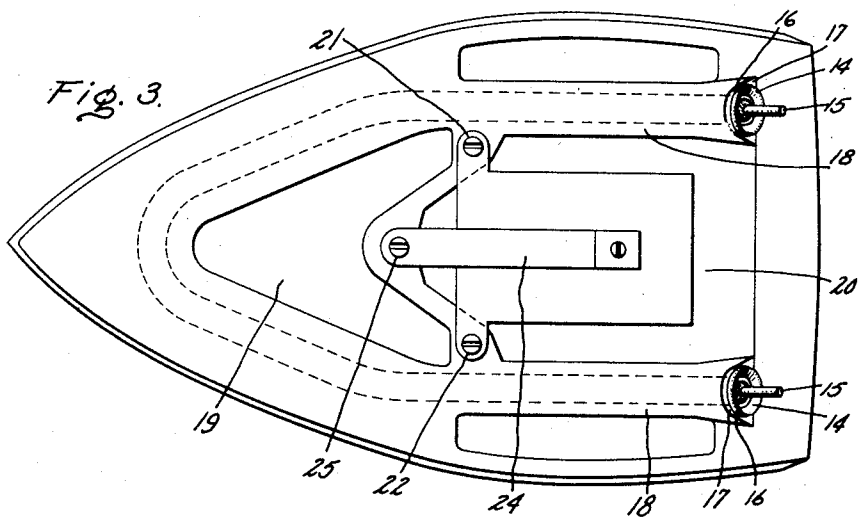
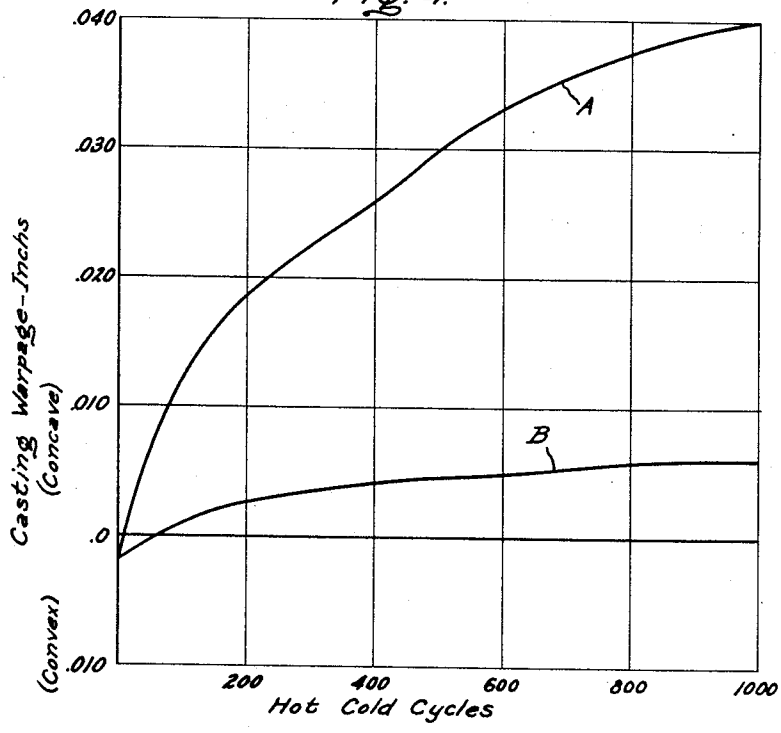


Fig. 4.



Inventor:
Bryce A. Denton,
by Laurence R. Kempton
His Attorney.

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ELECTRICALLY HEATED DEVICE

Bryce A. Denton, Ontario, Calif., assignor to General Electric Company, a corporation of New York

Application April 23, 1958, Serial No. 730,372

9 Claims. (Cl. 219—25)

This invention relates to electrically heated devices such as flatirons and the like; and particularly to such devices wherein a sheathed electrical heating element is embedded in the metal forming the device.

Electrical heating elements adapted to be cast or otherwise inserted into a mass of metal forming an electrically heated device are usually of the sheathed construction. Typically, the resistance element is centrally supported within a tubular metallic sheath and insulated therefrom by a mass of highly compressed electrical insulating, thermally conductive material, such as magnesium oxide. While the outer protective sheath may be formed of aluminum, brass, or other available metals, it is more frequently steel for reasons of cost, strength, and ability to withstand the high temperatures involved. The sheathed heating element at its ends is provided with cold terminals in the form of electrically conductive pins secured internally of the sheath to the resistance element. The ends of these pins, upon being exposed, provide a means for establishing electrical connection to the resistance element. After the sheathed heating element has been manufactured and formed into the desired shape, it is positioned within a mold into which molten metal is poured or otherwise supplied to form the electrically heated device. The result is that a highly efficient, physically rugged electrically heated device is provided. For many uses, and particularly in the flatiron field, the casting metal is preferably highly conductive of heat emanated from the heating element, and additionally light weight is often a prerequisite. Thus, aluminum and aluminum alloys are preferable for the casting.

When electrically heated devices, such as flatiron soleplates, are manufactured with an aluminum casting in which is embedded a steel sheathed heating element, it has been found that the exposed ends of the sheathed heater are retracted into the casting following temperature cycling under operating conditions from cold to hot and return. This retraction of the sheathed heater within the casting is accompanied at the same time by warpage of the casting. In the flatiron field, to which this invention is particularly directed, it has been found in practice that the ends of the sheathed heater may be retracted into the casting by as much as one-quarter inch. At the same time, it has been found that the flatiron soleplate warps so that the ironing surface, instead of remaining flat, becomes concave. This warpage of the soleplate also results in an improper fit with other components of the flatiron; and in particular, unsightly gaps become apparent between the soleplate and the outer enclosing shell for the flatiron operating mechanism. In addition, warpage of the soleplate is likely to affect adversely the calibration of the automatic temperature control mechanism used in the iron or electrically heated device.

Correspondingly, one of the objects of this invention is to provide an electrically heated device with a cast-in or embedded sheathed heating element which will not be

subject to warpage after prolonged use over a wide range of temperatures.

A further object of this invention is to provide a construction for a device including a sheathed heater cast into a metallic plate which will entirely prevent retraction of the heater into the casting.

Another object of this invention is to provide an electrically heated device having a cast-in sheathed heating element with improved terminal ends for the heater.

Still another object of this invention is to provide an improved soleplate for flatirons or the like with reduced metallic content, thus resulting in a lower manufacturing cost, but without sacrifice of any operating characteristics.

Briefly stated, in accordance with one aspect of this invention, a metallic sheathed heating element is embedded, for example by casting into a mass of metal to define, typically, a flatiron soleplate. The casting metal is selected for its heat conductivity and light weight, aluminum and aluminum alloys being most frequently used for this purpose. Such metals as aluminum have relatively large coefficients of thermal expansion. On the other hand, the heater sheath is preferably of steel to combine high strength with low cost. Low carbon steels of this type typically have a relatively low coefficient of thermal expansion. Although the expansion characteristics of the metal casting compared to the metallic sheath of the heater tends to cause retraction of the heater into the casting after temperature cycling, this is prevented by positively anchoring the sheath ends to the casting. This construction also prevents warpage of the casting which would otherwise occur when there is a larger cross-sectional area of cast metal on one side of the heating element as compared to the cross-sectional area on the opposite side thereof.

While the specification concludes with claims particularly pointing out and distinctly claiming the subject matter which I regard as my invention, it is believed the invention will be better understood from the following description taken in connection with the accompanying drawings in which:

Fig. 1 is a side elevation, partially in section, illustrating a prior art form of a portion of an electrically heated flatiron;

Fig. 2 is a partial side elevation, partially in section, illustrating the present invention;

Fig. 3 is a top plan view of a flatiron soleplate embodying the present invention;

Fig. 4 are performance curves illustrative of the difference between the construction of Fig. 1 and the construction in accordance with the present invention; and

Fig. 5 is a side elevation, partially in section, similar to Fig. 2, but illustrating a modified form of the present invention.

Referring to the drawings, in Fig. 1 I have shown a portion of an electrically heated flatiron in accordance with the prior art. Typically, this flatiron includes a soleplate 1 in which is embedded, as by casting, a sheathed heating element 2. Typically, heating element 2 includes an electrical resistance wire 3 centrally supported within an outer protective metallic sheath 4. In a manner well known in the art, resistance wire 3 is maintained in spaced relation from sheath 4 and is electrically insulated therefrom by a mass of material such as magnesium oxide. Each end of the heating element is provided with a terminal pin 5, commonly referred to as a "cold" terminal to establish electrical connection to the resistance wire 3. The resistance wire 3 is suitably anchored to an end of terminal pin 5 within the sheath 4. Following manufacture, a portion of sheath 4 is stripped, to expose an end of the terminal 5 so that electrical connections can

be made safely without danger of short circuit to the metallic sheath. Typically, the flatiron includes also an outer enclosing shell **6**, adapted to conceal and protect the automatic operating mechanism within the iron. The shell is, of course, secured to soleplate **1** by means such as a threaded fastening device **7**.

Soleplate **1** of the electrically heated device is usually cast from aluminum or an aluminum alloy which combines the advantages of heat conductivity and light weight, as well as relatively low cost. In practice, the sheathed heating element **2** is held in position within a mold into which the casting metal is poured, thereby providing an electrically heated device of the desired shape. In order to conserve casting metal and to provide a device which more uniformly distributes the heat over the bottom surface of soleplate **1**, it is common practice to locate the heating element in a raised rib **8** in the casting. Thus, there is a substantially greater cross-sectional area of metal below heating element **2** than above.

On the other hand, the electrical heating element preferably is manufactured utilizing steel for sheath **4**. Steel has a substantially higher melting point than the aluminum used for the casting, and therefore there is no risk of destruction of the sheath during the casting operation. Furthermore, steel is capable of withstanding the high temperatures which may occur during normal operation of the electrically heated device. Also, steel combines the further advantages of high strength and relatively low cost, as compared to brass, bronze, aluminum, or the like. Typically, a low carbon steel has been used successfully for sheath **4**.

The difficulty which has been encountered with flatirons constructed in accordance with Fig. 1 and as described above is that the exposed ends **4** of the sheath of the heating element are retracted into, or partially retracted into, casting **1** following a number of temperature cycles from room temperature to operating temperatures. For example, after 200 cycles from room temperature to 550° F. and back to room temperature, substantial retraction of sheath **4** into the casting has been observed. This retraction of the heating element is accompanied at the same time by warpage of the casting as shown in Fig. 1. Typically, and with constructions as described above, the ironing surface of the soleplate becomes concave, with contact of the soleplate on the ironing surface only at the toe and at the heel. The central portion of the soleplate is bowed upwardly, resulting in a space as at **9**, indicating the concavity which results. At the same time, this warpage tends to result in unsightly gaps such as **10**, which may occur between shell **6** and the upper surface of the soleplate. Serious warpage of a soleplate as described above after prolonged temperature cycling renders the iron useless. To avoid this difficulty, it has been common practice in the past to increase the mass of metal in the casting, the increased metal providing additional strength capable of resisting the warpage tendency. However, the increased mass of metal not only increases the weight of the iron unnecessarily, but also tends to increase the time for the soleplate to reach equilibrium temperatures after the thermostat setting has been changed.

While I do not wish this invention to be limited by a theory explaining heating element retraction and soleplate warpage, it is believed that these effects can be explained by the differences in thermal expansion rates of the metal forming casting **1** as compared to the metal of heating element sheath **4**. In the typical example given, casting **1** is of aluminum having a thermal coefficient of expansion of 24×10^{-6} per degree centigrade. On the other hand, low carbon steel used for the sheath of the heating element has a corresponding coefficient of thermal expansion of 12×10^{-6} per degree centigrade. Upon application of power to the heating element, the aluminum casting **1** expands much more rapidly than steel sheath **4**, so that sheath **4** is in effect freed from the aluminum casting, and relative motion can occur. However, as the aluminum of the casting cools, at some point the sheath of the heating element is gripped tightly, whereupon further contraction of the aluminum tends to shorten or compress longitudinally the steel sheath. While this ratcheting effect is relatively minute on a given temperature cycle from room temperature to maximum temperature and return, the combined effect from a number of cycles produces substantial retraction of the sheathed heating element into the casting.

Furthermore, as noted above, the heating element is so positioned within the casting that the cross-sectional area of metal above the center line of the heating element is substantially less than the cross-sectional area below the heating element. Upon the differential expansion and contraction between the casting metal and the sheath of the heating element as described above, the forces tending to contract the sheath of the heating element are such as to stretch the aluminum of the casting. If the upper portion of the casting has less cross-sectional area and therefore is weaker, as is usually the case, it tends to stretch to a greater degree than the portion of the casting below the heating element. Therefore, these forces tend to cause the casting to warp, resulting in the bow observed from toe to heel as illustrated by Fig. 1.

In accordance with the present invention, heating element sheath retraction and soleplate warpage are prevented by utilizing the construction as illustrated in Figs. 2 and 3. Again, the soleplate **11**, typical of an electrically heated device for which this invention is adapted, is cast of a lightweight metal such as aluminum. A heating element **12**, similar to the element described in connection with Fig. 1, is again cast in position within soleplate **11**, with a portion of sheath **14** of the heating element projecting outside of the casting at both ends of the heating element. Similarly, cold terminals **15** for the heating element provide means for establishing electrical connections. However, in accordance with this invention, sheath **14** is upset and flared outwardly as clearly shown in Figs. 2 and 3 to provide a shoulder as at **16** adapted to bear against an end surface **17** of the casting adjacent the ends of the sheathed heater. With this construction, it is obviously impossible for the sheath of the heating element to be retracted within the casting. Furthermore, with the construction as illustrated by Figs. 2 and 3, it has been found in practice that warpage of soleplate **11** is greatly reduced or eliminated entirely, even though the total mass of metal in the soleplate casting is also reduced. For example, as shown in Fig. 3, the heating element may be confined within relatively small ribs **18**, and the thickness of the metal forming the soleplate casting may be reduced on both sides of these ribs. Additionally, a substantial cavity such as at **19** may be provided in the soleplate, for example to define a steam generating cavity when the electrically heated device is used in a steam iron. Thus, with this reduction in the volume of cast metal, both the weight and the cost of the iron can be reduced; and at the same time, the casting exhibits a more rapid heat response during operation.

In addition, in Fig. 3 I have shown a cavity area **20** adapted to receive a thermostatically operated switch assembly. The details of this switch assembly have not been shown, since such devices are well known and recognized in the art. Suffice it to note for the present that the switch assembly includes a frame secured at **21** and **22** to the soleplate casting. This switch assembly may be actuated to control application of power to the electrical heating element by a bimetallic strip **24** secured to the soleplate, for example at a point **25**. For temperature response reasons, the frame of the switch is mounted independently of the thermostatic or bimetallic element. Thus, if soleplate warpage occurs, it is likely that calibration of the switch assembly with respect to the bimetallic element will be upset, and the iron will not longer operate in the temperature range as selected by the opera-

tor. However, in accordance with the present invention, soleplate warpage is substantially eliminated, and therefore thermostat calibration remains substantially unchanged throughout the life of the flatiron.

An additional advantage of the construction illustrated by Figs. 2 and 3 is that constant clearance is provided between terminal pins **15** and casting surfaces **17**. Previously, excessive retraction of the heating element presented a risk of short circuit between the casting and conductor connected to terminal pins **15**.

To demonstrate more clearly the advantages of the present invention a quantity of flatiron soleplates were manufactured utilizing an aluminum casting for the soleplate in which is embedded a sheathed type electrical heating element, having a sheath of low carbon steel. One group of soleplates was prepared for operation by stripping of the metallic sheath as illustrated in Fig. 1, thus providing exposed terminals for electrical connection to the resistance wire forming the heating element. The other group of identical soleplate castings was prepared by upsetting the exposed sheath of the heating element at each end as illustrated by Fig. 2, thus again exposing terminals for electrical connections. However, in this case, the upset sheath of the Calrod heating element bears against end surfaces of the casting as illustrated clearly in Fig. 2. Thereafter, these groups of flatiron soleplates were electrically connected to a source of power and the soleplates were alternately heated and cooled from room temperature to approximately 500° F. with return to room temperature. The cycle frequency included two hours at the high temperature, followed by cooling to room temperature for two hours. The averaged results for this simulated life test have been plotted in Fig. 4. Curve A illustrates the warpage which resulted with the construction illustrated by Fig. 1; while curve B indicates the warpage observed with the construction in accordance with Figs. 2 and 3, utilizing the upset sheath at each terminal of the heating element. It may be noted that in both cases the flatiron soleplate initially was convex, in that a central point of the soleplate projected approximately two mils below the toe and heel. Those soleplate castings without the upset heating element sheath exhibited substantial warpage, and after a thousand cycles, the same central point in the soleplate was concave .040" as compared to the toe and heel of the iron. At the same time, however, those castings constructed with an upset sheath at the terminal ends exhibited only slight warpage in the concave direction, and in an amount insufficient to interfere with normal usage of the flatiron soleplate.

While the construction of Fig. 2, utilizing the technique of upsetting the sheath of the heating element at the terminal ends, is the preferred embodiment of this invention, there are obviously other methods of firmly anchoring the ends of the sheath of the heating element with respect to the casting. For example, in Fig. 5 the sheath **26** of the heating element is anchored with respect to end surfaces **17** of casting **11** by welding or brazing a washer **27** to the sheath as illustrated. This washer bears against surface **17** on one of its surfaces, and the washer is prevented from movement with respect to sheath **26** of the heating element by the welding or brazing metal **28**.

From the above, it can be seen that a number of advantages result from the rigid securement of the heating element sheath to the casting at the terminal ends. In the first place, retraction of the sheath of the heating element within the casting is prevented, and thus certain electrical hazards are obviated. Previously, heating element retraction has been accompanied by a reduction in length of the sheath, which in turn causes the insulating material within the sheath to become less compacted. As a result, overheating of the heating element is likely to occur. Prevention of sheath retraction in accordance with the teachings of this invention avoids this risk. More importantly, warpage of the soleplate casting can be prevented, even though a casting is formed with less metal than heretofore utilized. The reduction in the volume of metal in the soleplate casting reduces not only the cost, but also the weight of the completed product; and the reduced mass of metal results in a product which heats faster and is more readily controlled as to temperature. Finally, the elimination of soleplate warpage provides a product having a longer useful life, and difficulties such as misfit of components and parts after prolonged temperature cycling are avoided.

The specific method of forming terminals on a sheathed tubular heating element and the terminal itself formed by such method has not been described in detail in this application and is not claimed herein, this subject matter being disclosed and claimed in the copending application Serial Number 830,082, filed July 28, 1959, in the name of Herman Felts and assigned to the General Electric Company, assignee of the present invention.

While the present invention has been described by reference to particular embodiments thereof, it is to be understood that numerous modifications may be made by those skilled in the art without actually departing from the invention. It is, therefore, the aim of the appended claims to cover all such equivalent variations as come within the true spirit and scope of the foregoing disclosure.

What I claim as new and desire to secure by Letters Patent of the United States is:

1. In a flatiron, a cast metal soleplate having a relatively large coefficient of thermal expansion, a sheathed tubular heater embedded by casting into said soleplate with end portions of said sheath projecting from the soleplate metal, said sheath being of a metallic material having a substantially smaller coefficient of thermal expansion than said soleplate metal, and means defining a rigid connection securing said heater sheath end portions to said soleplate, thereby to prevent retraction of said heating element sheath into said soleplate upon differential expansion of said soleplate with respect to said sheath.

2. In a flatiron, a cast soleplate predominantly of aluminum, a sheathed tubular heater embedded by casting into said soleplate with end portions of said sheath projecting from the casting, said sheath being of a steel having a substantially smaller coefficient of thermal expansion than said soleplate metal, and means integral with the end portions of said heating element sheath to prevent retraction of said sheath into said casting as a result of differential expansion of said sheath with respect to said casting during operation of said flatiron over the operating temperature range.

3. In a flatiron, a cast metal soleplate having a relatively large coefficient of thermal expansion, a sheathed tubular heater embedded in said soleplate during casting with end portions of said sheath projecting from said casting, said sheath being of a metallic material having a substantially smaller coefficient of thermal expansion than said soleplate metal, the cross-sectional area of said soleplate casting above said heater being substantially less than the cross-sectional area below said heater, and means integral with said heater sheath end portions in substantially non-movable engagement with said casting, thereby to prevent retraction of said heating element sheath within said casting upon operation of said flatiron over operating temperature ranges.

4. In an electrically heated flatiron, a lightweight soleplate formed from a metal having a substantial coefficient of thermal expansion, a sheathed tubular heater embedded in said soleplate with end portions of said sheath projecting from said soleplate, said sheath being of a material having a substantially smaller coefficient of thermal expansion than said soleplate, the cross-sectional area of metal in said soleplate above said heater being substantially less than the cross-sectional area below, and means rigidly secured to said heater sheath end portions

in substantially non-movable engagement with said soleplate, thereby to prevent retraction of said sheath into said soleplate as a result of the differential expansion between said sheath and said soleplate upon changes of temperature during operation.

5. In an electrically heated flatiron, a cast aluminum soleplate, a steel sheathed tubular heater embedded in said soleplate during casting with end portions of said sheath projecting from the casting, said sheath having a substantially smaller coefficient of thermal expansion than said soleplate metal, the cross-sectional area of said cast metal above said heater being substantially less than the cross-sectional area below said heater and means defining outwardly flared flanges on the end portions of said heating element sheath to prevent positively retraction of said sheath into said casting.

6. In an electrically heated flatiron, a cast aluminum soleplate, a steel sheathed tubular heater embedded in said soleplate during casting with end portions of said sheath projecting from the casting, said sheath having a substantially smaller coefficient of thermal expansion than said soleplate metal, the cross-sectional area of said cast metal above said heater being substantially less than the cross-sectional area below said heater, and a washer rigidly secured to each end portion of said sheath to define a flange in engagement with said soleplate to prevent positively retraction of said sheath into said soleplate.

7. An electrically heated device comprising an electrical heating element of the type including a protective metallic sheath; an object to be heated in which said heating element is embedded by casting with terminal end portions of said heating element projecting outside of said object; said object being of a lightweight material of high thermal conductivity and characterized by a relatively large coefficient of thermal expansion compared to the coefficient of thermal expansion of said metallic sheath, and means preventing relative movement of said heating element terminal end portions with respect to said object upon differential expansion of said object with respect to said heating element.

8. The combination of claim 7 in which said object is of metal predominantly aluminum.

9. The combination of claim 7 in which said object is a metal or metallic alloy predominantly of aluminum and the sheath of said heating element is a low carbon steel.

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