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M. D. SCADRON ET AL
 PROCESS OF MANUFACTURING HEATING MEANS FOR
 DE-ICING STATIC PORTS AND THE LIKE
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3,229,358

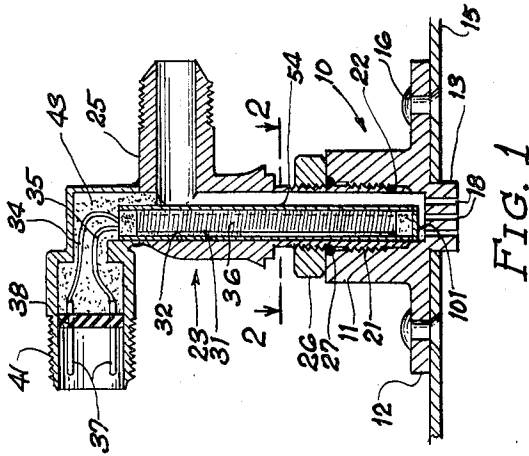


FIG. 1

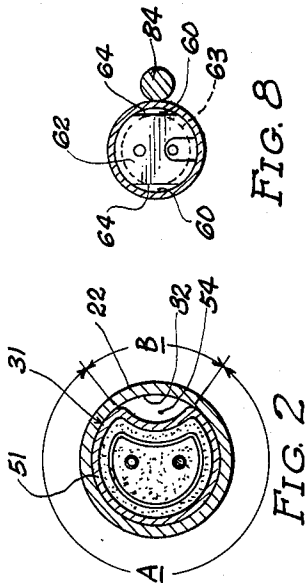


FIG. 2

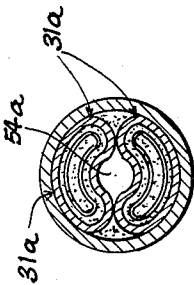


FIG. 3

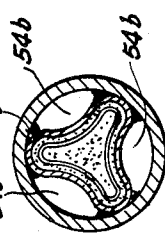


FIG. 4



FIG. 7

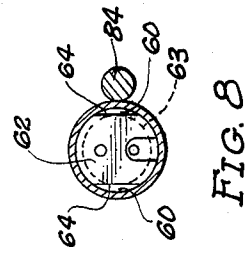


FIG. 8

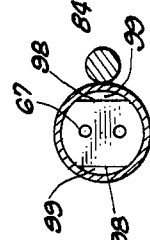


FIG. 9



FIG. 10

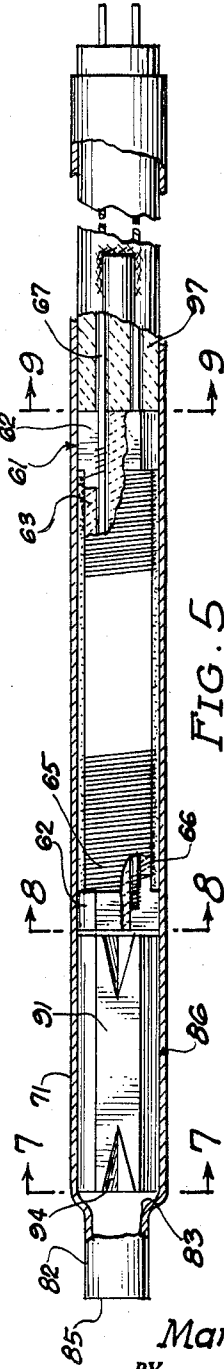


FIG. 5

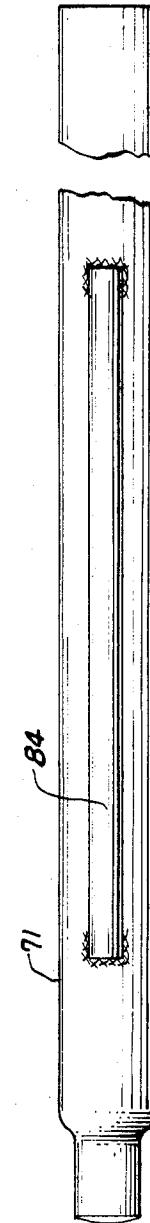


FIG. 6

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PROCESS OF MANUFACTURING HEATING MEANS FOR DE-ICING STATIC PORTS AND THE LIKE

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8 Claims. (Cl. 29—155.65)

This invention relates to de-icing heating arrangements for incorporation with devices having a passage wherein the passage and the exterior of the device are subjected to temperature sufficiently low to induce freezing of moisture entrained in the air or other gas flowing through the passage and past the device. In particular it has reference to electrical heaters for incorporation with air-entry ports as used on aircraft as well as the combination of the port and heater, for example, a port to sense the static pressure of the ambient air.

The problem of icing of air-admitting adjuncts, e.g., static ports and Pitot tubes as used on aircraft, is constantly presented and much effort has been directed to its solution. In general, prior arrangements have attempted to combat icing, whether incipient or actual, by providing electrical heating means adjacent to a wall, either interior or exterior, of the port or tube. Inasmuch as the surface presented to the air stream by the device and the wattage consumed by the heater must both be a minimum compromise is unavoidable for, if an overrated heater is used, its bulk not only increases the dimensions of the device and thus its air resistance but consumption of current rises beyond what the specification allows.

The present invention relates to an arrangement of passage-forming means and heater which is characterized by minimum dimensions and therefore minimum air resistance and in which the rate of heat transfer from the heater to the remainder of the device is a maximum, thereby substantially reducing the wattage consumed. In accordance with the principles of the invention an elongated, electrical heating element of the metallic-sheathed type is provided with a peripheral portion juxtaposed to a congruent portion of the interior wall of the passage. Desirably the thus juxtaposed portions are further rendered into intimate contact by brazing. The remainder of the periphery of the heating element is conformed re-entrantly to define, with the corresponding remainder of the passage wall, the air passage through the device. Thus, not only is heat transmitted most efficiently to the body of the device to inhibit ice formation but the air passage is maintained at a temperature sufficient to prevent icing there-within.

Inasmuch as the physical dimensions of devices to which the invention heater is primarily adapted present restrictions on the size of the heating element incorporated therewith in the manner alluded to above. The invention, in another aspect, comprehends a sheathed heater element per se having the configuration stated and capable of being fabricated to small dimensions, and the method of so fabricating the same.

Other objects and advantages of the invention will become evident from the following description which, together with the accompanying drawing, discloses various forms which the invention heater may assume in practice, as well as certain steps in the method of manufacturing the same.

In this drawing:

FIG. 1 is a longitudinal cross section of a static port as used, for example, on aircraft and incorporating the novel heating element of the invention;

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FIG. 2 is a cross section taken on the line 2—2 of FIG. 1;

FIG. 3 is a cross section similar to that of FIG. 2 but of an alternative embodiment;

FIG. 4 is a cross section similar to that of FIG. 2 but of still another alternative;

FIG. 5 is a combined side elevation and section to show certain steps in the fabrication of the heater element;

FIG. 6 is an elevational view similar to the showing of FIG. 5 to illustrate other steps in the fabrication;

FIGS. 7, 8 and 9 are cross sections taken on the lines 7—7, 8—8 and 9—9 respectively of FIG. 5; and

FIG. 10 is a later step in the processing sequence to be described in connection with FIGS. 5 and 6.

Regarded broadly the invention, in one aspect, comprehends an electrical heater element for insertion in a fluid passage to heat both the wall defining the passage and the fluid passing therethrough. Where herein we employ the term "fluid" we intended to encompass fluent substances generally. In accordance with the principles of this phase of the invention the heater element comprises an initially cylindrical sheath enclosing an electrical conductor of relatively high resistance which, when connected in a supply circuit of selected voltage, undergoes a substantial rise in temperature, e.g., Nichrome wire. The conductor, preferably wound into helical form or a mandrel of insulating material, is housed in the sheath, from which it is electrically isolated by a refractory material such as densely compacted magnesium oxide powder. Following such assembly the sheath and its contents are deformed by an appropriate instrumentality to provide an exterior longitudinal channel. The diameter of the sheath is chosen to be a fairly snug fit in the passage and, therefore, when the completed heater is inserted therein the channel will, with the interior wall surface of the passage, define a smaller passage for flow of fluid. The relative transverse dimensions of the inserted heater and the original passage as well as the longitudinal channel in the heater are so chosen as to provide a usable fluid passage as required. Desirably the heater is rendered into intimate contact with the interior wall surface of the initial passage by brazing or similar medium in order to improve heat transfer to the several parts of the device subject to deposition of moisture and consequent icing. By reason of the deformation performed on the heater element a substantial area thereof constitutes a part of the wall of the ultimate fluid passage. Accordingly such passage is heated directly by radiation as well as by conduction through the metal constituting the device.

In other aspects the invention comprehends features of construction of the heater itself and the process of manufacturing the same.

By way of example the invention heater will be described in connection with a static port as used on an airplane, viz. to sense static air pressure in flight. Thus, adverting to FIG. 1 there is shown a mounting 10 including a first boss 11, a flange 12 and a second boss 13. The mounting is secured at a selected location on the skin 15 of the aircraft by rivets 16 or equivalent means. The boss 13 has one or more passages 18 for admission of air and, since, such passages 18 are normal to the principal direction of the air stream, the pressure sensed by the device is static head as contrasted with the velocity head of an associated Pitot tube.

The boss 11 is internally threaded at 21 to receive one correspondingly threaded end 22 of a fitting 23, in this case an elbow. At this point it is to be noted that the form of the body with which the heater is incorporated is variable, the desideratum being a metallic or other heat-conducting body through which a fluid passage is provided. To obtain the desired orientation of the other end

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25 of the fitting a locknut 26 is provided and the same also confines a gasket 27 to seal against possible leakage past the nut 26. The end 25 of the fitting is threaded for connection thereto of a conduit (not shown) leading to the indicating instrument, as will be understood.

A heating element 31, to be considered in more detail subsequently, is received in a bore or initial passage 32 of the fitting 23 and extends over substantially the full length thereof. The leads 34 and 35 of the resistance winding 36 are carried to terminal posts 37 supported on an insulating disc 38 secured in a connector sleeve 41. A complementary sleeve (not shown) is engaged with the sleeve 41 to connect the heater in the supply and/or control circuit. Suitable insulation 43 surrounds the leads 34 and 35.

Inasmuch as the heating element 31 serves to heat both the exterior and interior of the port the same is, in accordance with the principles of the invention, given a form now to be detailed. As shown best in the example of FIG. 2 the same comprises a tubular metallic sheath 51 which, regarded in its transverse aspect, comprises a portion A extending over approximately 270° of arc and a portion B extending over approximately 90° of arc. For convenience of description and claiming the cross section of the heating element may be described as "substantially concavo-convex." The initial diameter of the sheath (prior to deformation by swaging and indentation in a manner to be detailed) is so chosen that when operated upon it may yield a diameter such as to provide a snug fit in the passage into which it is introduced, e.g., the bore 32 of the fitting 23 of the example. After being located in its desired longitudinal position the portion A is desirably brazed or otherwise rendered into intimate contact with the adjoining surface. Such operation may be accomplished by allowing some clearance between the passage and the portion A and inserting a thin strip of silver solder therein. Heat is then applied to the exterior of the assembly.

It will be noted that the portion B will, together with the adjacent passage surface 32, will define a conduit 54 substantially of elliptical transverse aspect through which the air may pass from the openings 18 into the leg 25 of the fitting 23. By reason of the intimacy of contact between the portion A of the heater and the adjoining wall surface the body of the device will be heated by conduction and that the wall surfaces of the conduit 54 will be heated by conduction and radiation.

FIGS. 3 and 4 are cross sections similar to that of FIG. 2 to illustrate alternative embodiments. In these cases the air passage or passages are indicated at 54a and 54b, and the heater or heaters at 31a and 31b. In either case heat is supplied to the air passage or passages and to the sheath. In the embodiment of FIG. 4 heat transfer may be implemented by soldering or brazing as indicated.

A preferred construction of heater comprises a spool 61 of ceramic material (FIG. 5) of beryllia, alumina or the like having flanges 62 flanking a cylindrical winding portion 63 of smaller diameter than the flanges. The flanges are relieved for a portion of their periphery by flats 64—64 to define, with the sheath blank 71 suitable spaces 60—60 for a purpose to appear.

The resistance wire 65, e.g., Nichrome, is helically wound on the portion 63 either in juxtaposed coils or in a helical groove provided therein, and the ends are connected by welding or otherwise to terminal leads 66 and 67 passing through bores through the spool 61. The leads 66 and 67 are left sufficiently long to permit further processing now to be described.

A hollow cylindrical sheath blank 71 of any suitable metal, e.g., No. 347 stainless steel, and of a length somewhat longer than that of the spool 61 is provided. Its original diameter is slightly in excess of the finished diameter to permit swaging to an arcuate final diameter. One end 82 of the blank is reduced in diameter to provide a shoulder 83. A rod 84 of hard material and of prede-

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termined diameter and of a length more than spanning the overall length of the spool 61 is tack-brazed at its ends to the periphery of the blank 71. For example, for a blank 71 of $\frac{3}{8}$ " diameter the rod will be $\frac{1}{8}$ " diameter, and for a spool of length 2" the rod will be 3" long, thereby to extend beyond the spool approximately $\frac{1}{2}$ " at each end.

A pellet 86 of friable refractory material is deposited in the tube 71 from the right hand end. This pellet is a cylinder which is longitudinally truncated over its length to provide diametrically opposite flats 91—91, in turn defining with the tube 71 a pair of spaces 92—92. Adjacent its ends the pellet is notched on both sides as indicated at 94—94. While notching at one end only is sufficient for the intended temporary use, both ends are desirably made the same to eliminate concern by the operator as to which end of the pellet is to be inserted first.

Following insertion of the pellet 86, the heater core assembly comprising the spool, its winding and leads are assembled with another pellet 97 bored to receive the terminal leads 67 therethrough and these parts are inserted in the blank 71 to abut the pellet 91. Since the position of the leads 67 is desirably definitely angularly related to the portion B of the heater the same are orientated as shown with respect to the rod 84 which may then be removed. Although some endwise clearances between the components are shown on the drawing for clarity of comprehension no clearance need actually exist. The pellet 97 is provided with two diametrically opposite flats 98—98 (FIG. 9) similarly to the pellet 86 to provide a pair of spaces 99—99.

Now the left end of the sheath blank 71 is taped closed and, with the tube held vertically a suitable pulverulent refractory, e.g., powdered magnesium oxide is poured into the upper end. Meanwhile the tube is vibrated in any suitable joggling device to insure that all voids are filled. The spaces 99—99, 60—60 and 92—92 allow the powder to pass through to the left hand end and to fill all other voids. Vibration is continued until the powder is well-compacted. Passage of the powder into the spaces 92—92 is facilitated by the notches 94—94 acting as funnels. The right hand end (presently the uppermost end) is then taped shut and the assembly (FIG. 5) is then turned end for end. The tape is removed from the left end (presently the uppermost end) and that end welded or otherwise closed. A metallic plug or disc may be used as part of this plugging operation. The assembly is turned end for end and vibrated once more as further assurance that the powder is a well-compacted mass. It will be understood that such mass remains until the heater assembly 31 is cut from the processing assembly, and that the powder surrounding the winding 65 serves to insulate and to provide additional stability for such winding throughout the life of the heater.

The assembly of FIG. 5 is now swaged to its final diameter, in the example, $\frac{3}{8}$ ", and then annealed.

The rod 84 is re-affixed in its original position and assembly is passed through suitable swaging dies whereby the rod 84 is forced into the sheath blank 71 (FIG. 10) to form the indented peripheral re-entrant portion B. During this step the desired finished diameter, namely 0.343", is also imparted to the sheath.

As a result of the swaging steps it will be comprehended that the spool 61 will be crushed and the winding thereon deformed congruently to the indentation, that the matrix of refractory powder will be compressed thereby to improve the integration thereof with the heater assembly 31, and that the pellets 91 and 97 will be crushed. However, since these latter constitute no part of the final assembly their fate is immaterial.

The sheath blank 71 is now severed adjacent both ends of the spool 61, care being taken not to disturb the leads 67—67. The scrap, including the rod 84, is discarded, it being recalled that this rod was secured only at its

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ends. The outer end of the heater 31 (FIG. 1) is closed by a brazed-on closure plate 101 of proper outline and the heater is now ready for incorporation with the fitting 23, in the manner previously described.

By reason of the process steps described in connection with FIGS. 5 and 6 it will have become evident that, by employing a rod 84 somewhat longer than the eventual sheath 51 and extending the same beyond the ends thereof of the entire useful length of the sheath is provided with the channel 54; and that the ample support given to the spool 61 by the tightly juxtaposed pellets 91 and 97 allows the flanges 62—62 of the spool to be crushed during swaging without the hazard of pieces being bodily broken off the same. Stated otherwise these flanges, even though fractured, remain virtually intact, the pieces thereof being tightly bound by the sheath constricted therearound.

In the case of the alternative embodiment of FIG. 3 it will now become apparent that each of the heaters 31a is fabricated in a manner similar to that described in connection with FIG. 5 and, in the case of that form of the invention heater shown in FIG. 4 the rod 84 will be in multiple, spaced apart about the periphery of the sheath blank 71.

While we have shown particular embodiments of our invention, it will be understood, of course, that we do not wish to be limited thereto since many modifications may be made and we, therefore, contemplate by the appended claims to cover any such modifications as fall within the true spirit and scope of our invention.

We claim:

1. The method of fabricating an electrical heater of the type comprising a metallic sheath enclosing a conductive element of high electrical resistance and in which the element is spaced from, and supported relative to the sheath by a matrix of electrically-insulating material, which comprises: providing a sheath of tubular form, assembling the element on a support of friable, electrically-insulating material, said support being a slip fit in the sheath, inserting the support with the thereon-supported element in the sheath, inserting a friable plug in at least one end of the sheath abutting one end of the support, temporarily attaching an incompressible rod-like indenting member to the sheath wall, said member being at least coextensive longitudinally with said support, forcing the member into the sheath wall to deform the sheath and crush the support and removing said member.

2. The method in accordance with claim 1 characterized by the additional step of trimming the deformed sheath adjacent the said one end of the support.

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3. The method in accordance with claim 1 wherein the member is forced into the sheath by swaging.

4. The method in accordance with claim 1 further characterized in that said indenting member is of uniform cross section.

5. The method of fabricating an electrical heater of the type comprising a metallic sheath enclosing a conductive element of high electrical resistance and in which the element is spaced from, and supported relative to the sheath by a matrix of electrically-insulating material, which comprises: providing a sheath of tubular form, assembling the element on a support of friable, electrically-insulating material, inserting the support with the thereon-supported element in the sheath, inserting a friable plug in the sheath at each end of the support, temporarily attaching an incompressible rod-like indenting member to the sheath wall, said member being at least coextensive longitudinally with said support, forcing the member into the sheath wall to deform the sheath and crush the support and removing said member.

6. The method in accordance with claim 5 characterized by the additional step of trimming the deformed sheath adjacent the ends of the crushed support.

7. The method in accordance with claim 5 wherein the member is forced into the sheath by swaging.

8. The method in accordance with claim 5 further characterized in that said indenting member is of uniform cross section.

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