United States Patent [19]

Beasley et al.

[11] **3,920,963**

[45] **Nov. 18, 1975**

[54] **RESISTANCE HEATER WITH IMPROVED THERMOCOUPLE**

[75] Inventors: **Robert E. Beasley,** Homeland; **Robert W. Hannah,** Hemet, both of Calif.

[73] Assignee: **Rama Corporation,** San Jacinto, Calif.

[22] Filed: **Apr. 14, 1975**

[21] Appl. No.: **567,593**

[52] **U.S. Cl.** **219/523;** 219/494; 219/544; 338/241; 425/144

[51] **Int. Cl.**[2] **H05B 3/80;** H05B 1/02

[58] **Field of Search** 219/328, 331, 494, 523, 219/544; 338/238, 239, 240, 241, 242, 273; 425/144

[56] **References Cited**

UNITED STATES PATENTS

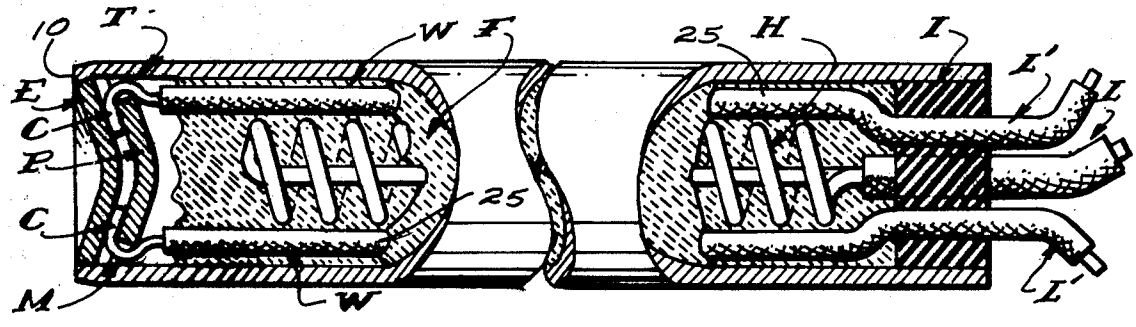
2,831,951	4/1958	Desloge	338/241
3,080,543	3/1963	Boggs	338/273
3,340,382	9/1967	Lennox	219/544
3,499,189	3/1970	Perras	425/144
3,609,809	10/1971	Slicker	425/144
3,751,014	8/1973	Waterloo	425/144 X
3,754,118	8/1973	Booker	219/523
3,890,485	6/1975	Kozbelt	219/523

Primary Examiner—Volodymyr Y. Mayewsky
Attorney, Agent, or Firm—Georges A. Maxwell

[57] **ABSTRACT**

A resistance heater structure with a tubular metal jacket, which jacket is swaged inwardly to reduced diametric extent during manufacture of the heater; a thermocouple junction comprising two axially spaced substantially radially extending conical metal parts tightly engaged within the sheath and having spaced opposing surfaces and a pair of thermocouple wires extending longitudinally in the sheath and having connector portions in pressure contact engagement with and between said surfaces at spaced locations, said conical parts and connector portions being first assembled in the sheath in contacting relationship and such that the parts are re-formed to reduce their radial extent, increase the axial extent and urge said opposing surfaces in tight engagement with said connector portions when the sheath is swaged.

8 Claims, 10 Drawing Figures



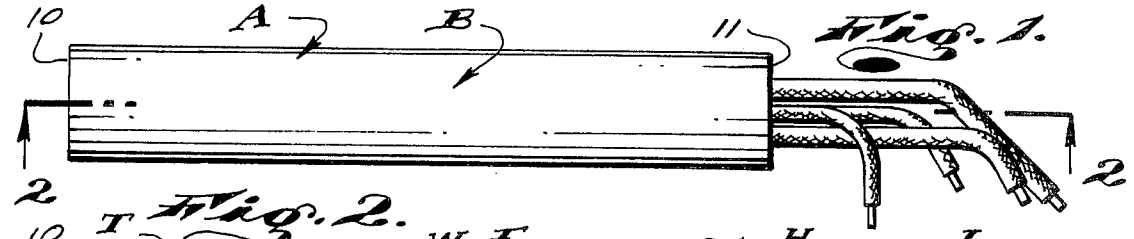


Fig. 1.

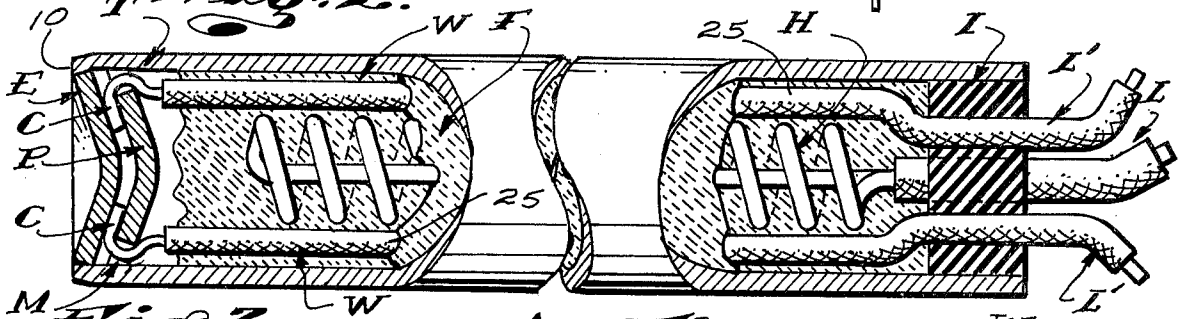


Fig. 2.

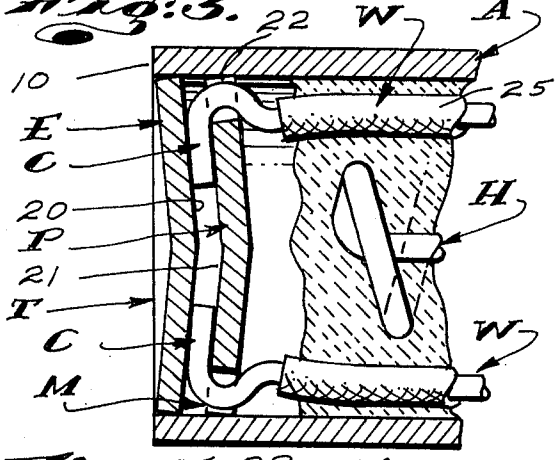


Fig. 3.

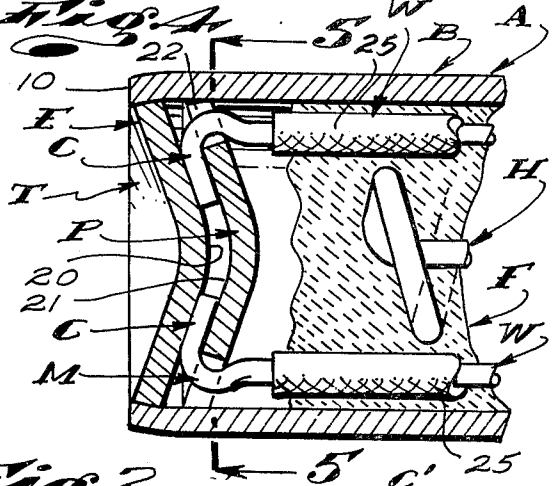


Fig. 4.

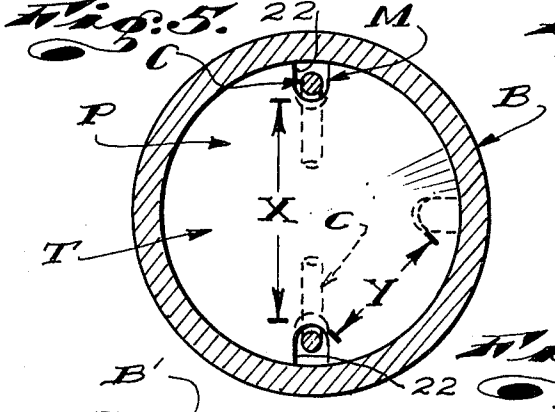


Fig. 5.

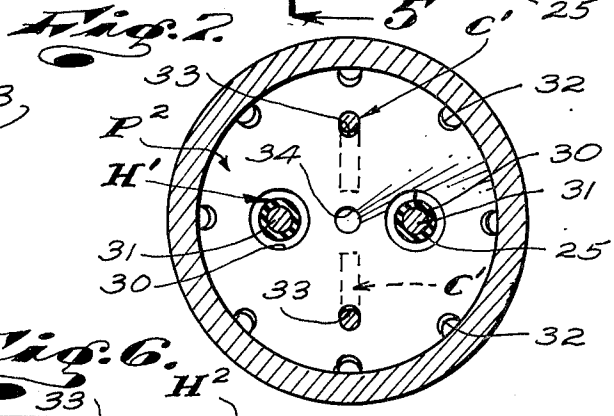


Fig. 7.

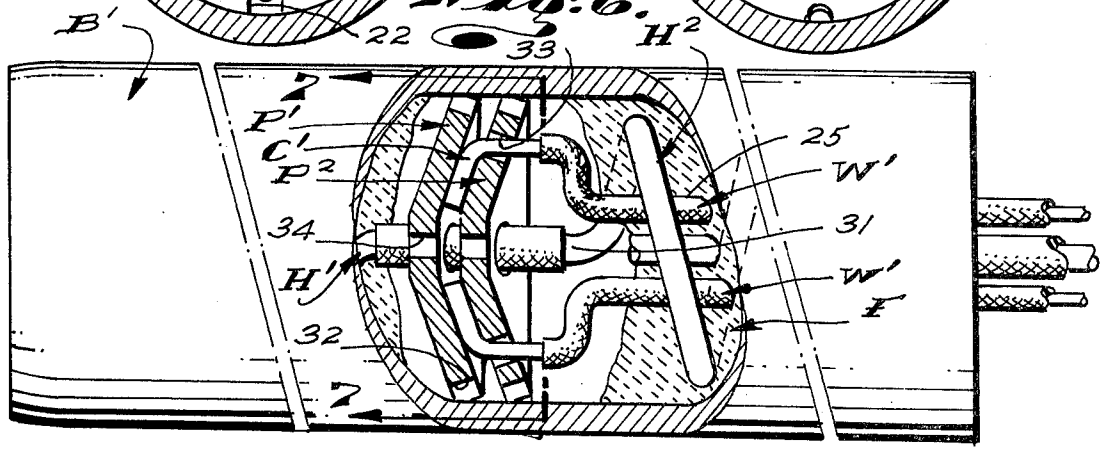


Fig. 6.

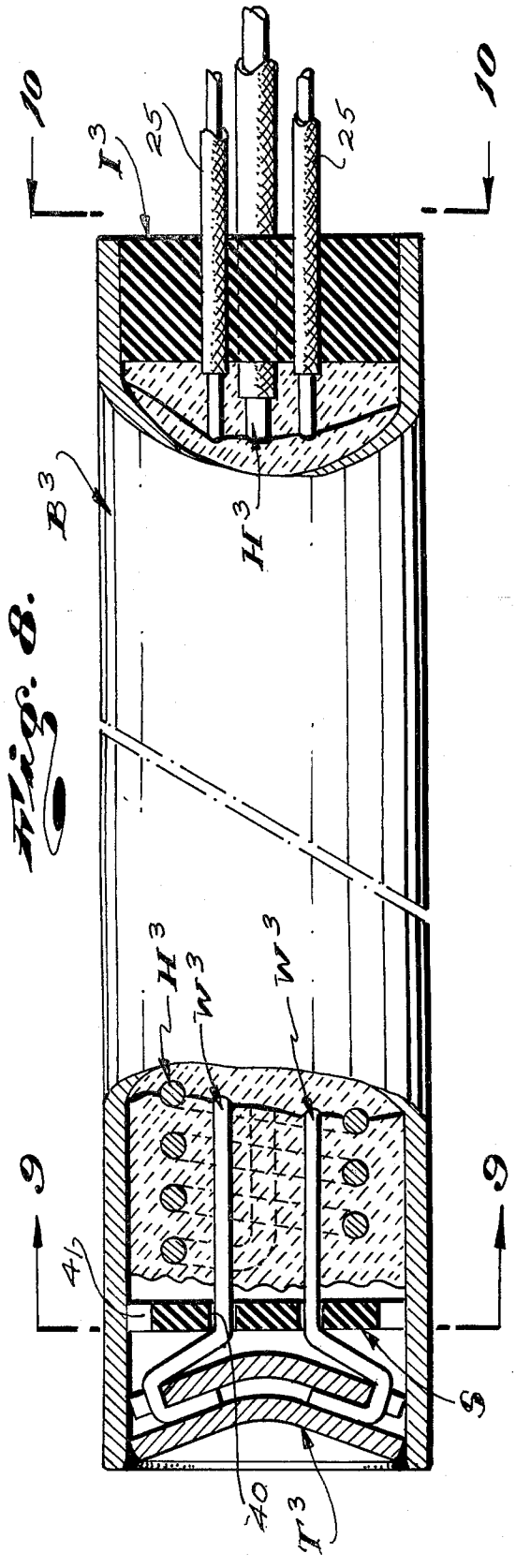


Fig. 8.

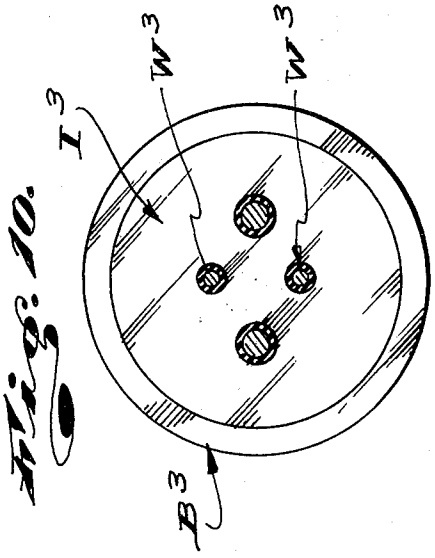


Fig. 10.

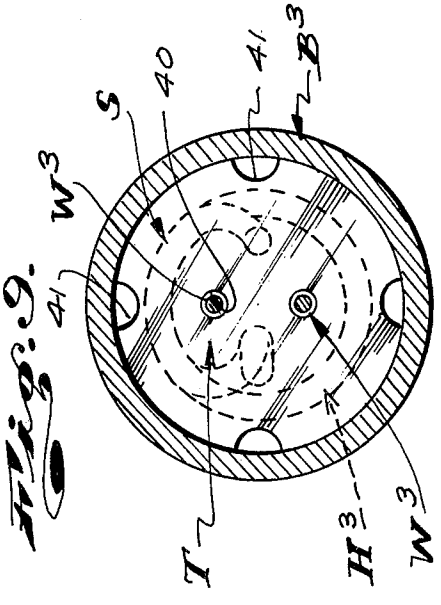


Fig. 9.

RESISTANCE HEATER WITH IMPROVED THERMOCOUPLE

This invention has to do with cartridge-type electric resistance heaters and is more particularly concerned with a cartridge heater structure embodying a novel, improved thermocouple means.

Cartridge-type heaters which include elongate tubular, outer metallic sheaths; central, longitudinally extending electrical resistance heating elements within the sheaths, power leads extending freely from the elements and an end of the sheaths; and, fillers of dielectric material in the sheaths and about the elements to orient and support the elements in proper relationship within the sheaths are old and well known to all those familiar with the art to which the instant invention relates.

Further, it is well known and common practice in the art to provide heaters of the character referred to above with means to effect control of the heat generated by the heaters, which means commonly include and/or utilize a thermocoupler, fixed to the heater sheaths and having lead wires which extend to suitable power control means, such as on and off switching means in the power supply for the heaters and with which the power leads are connected.

While in some instances, thermocouples are related to the exteriors of the heater sheaths, it is common and desired practice to relate them to the insides of the sheath structures where they are suitably supported and protected. The exterior mounting of thermocouples to heaters is considered to be make-shift and is, as a general rule, only practiced when it is desired to relate thermocouples to already constructed heater units.

In accordance with the teaching of the prior art, where the thermocouples are related to the interiors of the sheaths of cartridge heaters, it has been considered necessary or most desirable and it has become substantially common practice to fix the junctions of the thermocouples to the inside surfaces of the sheath structures as by welding or brazing and to thereby prevent the junctions from becoming displaced from the sheaths and rendered ineffective by the interjacent disposition of the insulating filler material therebetween.

Due to the rather small size and the oftentimes delicate nature of the thermocouple junctions, a notable number of special junction structures have been proposed and put to use and a notable number of special mounting means which enable the junctions to be fixed to the sheaths, as by welding or brazing, without burning or otherwise damaging the junctions, have been proposed and put into practice.

It has been recognized that in practice, a thermocouple junction could be established by a portion of a heater sheath occurring between the points of joinder between the ends of a pair of thermocouple wires or leads fixed to the sheath. While the above has been recognized, it has not been effectively and satisfactorily put into practice due to the fact that the wires are, in most instances, necessarily so small or fine that they cannot be satisfactorily fixed to the sheaths, in predetermined spaced relationship and/or without being burned or otherwise damaged. The above has resulted in the provision of special thermocouple junctions at the ends of a pair of wires which junctions are such that they can only be related to a single spot or point on the wall of the sheath and are therefore responsive to the temperature of the sheath at that single spot or point.

In the ordinary cartridge-type heater of the character here referred to, the front end of the tubular sheath, remote from that end from which the power leads and thermocouple leads extend, is closed and sealed by a thin, flat, radially extending metal disc or front end wall which is press-fitted and/or welded in place and the other or rear end of the sheath is closed by an apertured rear end plug, through which the several leads extend. The sheath is originally oversized in diametric extent and is, during manufacture of the heater, swaged radially inwardly to compact the filler within the heater into tight, fixed, orienting and supporting engagement about the heater element and thermocouple leads or wires. Upon swaging of the sheaths, the noted front end wall and rear end plug are partially collapsed or reformed and compacted.

It is an object and feature of my invention to provide a heater construction of the general character referred to above, including novel thermocouple means wherein the front end wall of the sheat cooperates to establish the thermocouple junction and wherein the thermocouple wires are effectively mechanically connected with the junction structure without welding, brazing or the performance of other work upon them which is likely to damage them.

It is another object and feature of my invention to provide a structure of the general character referred to above wherein the thermocouple junction is established by the front end wall of the sheath and a junction plate or disc rearward of said end wall and between which the ends of the thermocouple wires extend and are clampingly engaged when the sheath is swaged during manufacture of the heater.

Yet another object and feature of the present invention is to provide a structure of the character referred to wherein the end wall of the sheath and the junction disc are preformed whereby they re-form in a predetermined manner when the sheath is swaged during manufacture of the heater and in such a manner that they move and/or are urged into clamping engagement with the thermocouple wires related thereto.

It is yet a further object and feature of my invention to provide a thermocouple junction structure of the general character referred to above wherein the junction plate is provided with orienting means to accurately establish the effective points of contact between the junction and the thermocouple wires.

An object and feature of my invention is to provide a thermocoupling junction of the character referred to wherein the end wall and junction disc or plate are longitudinally and radially outwardly divergent, nested together, conical parts of obtuse angle with spaced opposing surfaces between which ends of the thermocouple wires are initially engaged in bearing contact and which are such that when reformed radially inwardly, upon swaging of the sheath, their angle becomes more acute, the space between their opposing surfaces is diminished and said ends of the wires are clamped tight therebetween.

The foregoing and other objects and features of my invention will be apparent and fully understood from the following detailed description of typical preferred forms and applications of my invention, throughout which description reference is made to the accompanying drawings, in which:

FIG. 1 is a side elevational view of a heater embodying my invention;

FIG. 2 is an enlarged detailed sectional view taken as indicated by line 2—2 on FIG. 1;

FIG. 3 is an enlarged detailed sectional view of a portion of the structure shown on FIG. 2 showing parts in one position;

FIG. 4 is a sectional view taken as indicated by line 4—4 on FIG. 3;

FIG. 5 is a view similar to FIG. 3 showing the parts in another position;

FIG. 6 is a longitudinal sectional view of another form of my invention;

FIG. 7 is a view taken as indicated by line 7—7 on FIG. 6;

FIG. 8 is a view similar to FIG. 2 showing another form of our invention;

FIG. 9 is a view taken as indicated by line 9—9 on FIG. 8; and

FIG. 10 is a view taken as indicated by line 10—10 on FIG. 8.

The instant invention is primarily concerned with my new thermocouple junction structure, which junction structure can be related to or with a multiplicity of different forms of cartridge type heaters. That is, the junction that I provide can be advantageously related to or incorporated in substantially any cartridge type heater having a tubular metal sheath which is swaged radially inwardly during the course of its manufacture and is not ordinarily affected by the nature and/or form of the resistance element, the rear end plug structure, the insulating filler and other such structural details of or in the heater with which it is related.

In accordance with the above, and so as not to unduly burden this disclosure with detailed description of structure which does not materially affect and/or is not materially affected by the invention, I will restrict the disclosure to the thermocouple junction means to the extent which is practical.

Referring to FIGS. 1 through 5 of the drawings, I have shown an elongate cartridge heater A with my thermocouple means or structure T related thereto.

The heater A includes an elongate, tubular metal outer sheath B with open front and rear ends 10 and 11, a substantially radially extending, metal front end wall E engaged in and closing the front end of the sheath, an apertured cylindrical plug I, established of compactible dielectric material engaged in and closing the rear end of the sheath, an elongate heater element H, shown in the form of an elongate coil of resistance wire arranged centrally and extending longitudinally in the sheath in spaced relationship from the sheath B, wall E and plug I; power leads L connected with the element H and extending axially rearwardly therefrom, through power lead receiving apertures in the plug I and thence rearwardly from the heater and a filler F of compacted granular dielectric material in the sheath, in and about the coiled element H and supporting said element in fixed predetermined position within the sheath and between the opposite ends thereof.

In establishing the heater A, the sheath, end wall and plug are greater in diametric extent than the finished product. The several parts are assembled, with the filler deposited therein in non-compacted form.

Subsequent to assembly, the cartridge is swaged radially inwardly, progressively from one end thereof to the other, with resulting tight compaction of the filler F within the construction.

The foregoing structure is illustrative of the rather simple, basic or standard structure to be found in most cartridge type heaters and of that type of heater with which my new thermocouple means T is intended to be most effectively related.

The thermocouple means T that I provide, as shown in FIGS. 2 through 5 of the drawings includes a junction plate P similar to the end wall E arranged within the sheath adjacent the rear surface of the end wall E and a pair of elongate thermocouple wires W arranged within the sheath B and filler F to extend longitudinally thereof in spaced relationship with the element H and the sheath B. Wires W have front contact portions C turned to extend between the end wall E and plate P in pressure contacting engagement therebetween and having rear lead portions L′ extending through lead apertures in the plug I and thence rearwardly from the heater.

The power leads L and lead portions L′ are adapted to connected with an appropriate power supply and control means for the supply (not shown) in accordance with common and accepted practice. Since the power supply and the control means thereof, which means is responsive to the thermocouple means T, can vary widely in practice and does not affect the essence of this invention, further detailed illustration and description thereof would serve no purpose and will be dispensed with.

Considering the thermocouple means T in particular and as shown in FIGS. 2 through 5, the front wall E, which is a part of that means, and the plate P are conical formed sheet metal elements or parts with radially outwardly and axially forwardly extending, axially spaced, opposing rear and front surfaces 20 and 21, respectively. The plate P distinguishes from the wall E in that it includes passage means M to accommodate and permit engagement of the forward connecting portions C of the wires W, which extend radially between the wall and plate and thence rearwardly from the plate. The means M can be in the form of a pair of circumferentially spaced apertures in the plate, through which the connecting leads C can be engated or can, as shown, be a pair of circumferentially spaced axially and radially outwardly opening notches 22 in the periphery of the plate.

In practice, the end wall E and the plate P are initially conically formed at an obtuse angle of, for example, 15° and such that when compressed radially inwardly by those forces applied to the structure when it is swaged, cause re-forming of the wall and plate, substantially uniformly, into conical forms of more acute angles, for example, to angles of 20°.

It will be apparent that the initial angle of the conical wall E and plate P is subject to considerably variation without departing from the spirit of this invention and is established or determined to a large extent by such factors as the thickness, diameter and hardness of the wall and plate, as well as the extent to which they are to be reduced in diametric extent when worked upon.

In practice, the wall E can be initially press-fitted into tight sealing engagement in the sheath or can, if desired, be pressed or slidably engaged therein and suitably fixed therein as by induction welding, brazing or the like. The plate P is preferably snugly engaged in and with the sheath in light pressed engagement therewith, but can, if desired, be tacked or fixed therein as by induction welding.

The pair of thermocouple wires W and their lead ends or portions L′ can be provided with a high temperature insulation jacket **25** and the connector portions or connectors C thereof are established by simply stripping the jackets **25** from the front ends of the wires. The connector portions C are engaged through their related notches **22** and are turned radially inwardly to extend between the wall E and plate P, as illustrated.

In initial assembling of the structure, the connector portions C engaged in positive, uniform bearing contact with and between the opposing surfaces **20** and **21** of the wall and plate and in such a manner that when the said wall and plate are re-formed, upon radial inward swaging of the structure, they are tightly and positively clamped in contact with and between the plate and wall.

Functionally, the desired and necessary tight clamping engagement of the connector portions C between the wall E and the plate P is attained or achieved by the reduction of space between the parallel, angularly disposed opposing conical surface **20** and **21** when the angle of those surfaces is increased, upon swagging of the construction and reduction of the diametric extent of the cones or wall and plate. The noted reduction of space between the surface **20** and **21** can be likened to the reduction in distance between opposite sides of a parallelogram when it is flattened, that is, when its two diagonally opposite corners of obtuse angles are made more obtuse and the other acute angle corners are made more acute.

It will be apparent that if the connector portions C are in bearing contact with the opposing surfaces of the wall and plate before the angle of those surfaces is increased, upon increasing the angle of those surfaces and reduction of the space therebetween, the pressure of contact between the connector portions and the noted surfaces is necessarily materially increased.

In furtherance of my invention, the apexes of the conical end wall and plate are disposed rearwardly and in opposition to the direction in which the longitudinal progressive swagging of the structure is performed, which is from the rear to the front end of the sheath.

As a result of the above, as swaging of the structure is performed, and the filler F is compacted within the sheath, the filler is progressively displaced axially forwardly in the sheath, toward the plate P and in such a manner that it urges and holds the plate P toward the wall E and in tight engagement with the contact portions C prior and preparatory to actual re-forming of said plate and wall.

The above is quite significant and important since it assures proper and desirable positioning of the related parts preparatory to re-forming them and eliminates the likelihood that the parts will become displaced upon swaging of the sheath and before the wall and plate are re-formed.

In operation, the wall E and the plate P establish the thermocouple junction and the thermocouple reads the average of gradient between the last or outermost points of contact between the plate P and the connector portions C.

In practice, the notches **22** and therefore the outermost points of contact between the plate P and the connector portions C, can, as shown, be on diametrically opposite sides of the plate P, thereby affording a maximum gradient area or distance, as indicated by the arrow X in FIG. **4** of the drawings.

Alternatively, as shown in dotted lines in FIG. **4** of the drawings, and as might be desired in large diameter heaters, the notches **22** might be spaced less than 180°, for example, they might be spaced 90° apart. In such a case the effective gradient arm or distance of the junction is reduced, as indicated by the arrow Y.

In another form of my invention, and as shown in FIGS. **6** and **7** of the drawings, the thermocouple junction is established between the ends of the heater, intermediate a pair of longitudinally spaced, adjacent heater elements H′ and H^2.

In such a case, two conical plates P′ and P^2 are provided. The plate P′ is the equivalent of the wall E and the plate P^2 is the equivalent of the plate P in the first form of the invention. The plates P′ and P^2 differ from the wall E and plate P in that they are provided with pairs of registery apertures **30** to accommodate and through which insulated conductors **31** extend to connect the elements H′ and H^2 together and they are provided with registery pairs of circumferentially spaced notches **32** about their outer peripheries to allow for the passage or migration of filler F′ through the plates when the filler is being deposited in the construction.

In all other respects, the plates P′ and P^2 are basically the same as and the wall E and plate P in the first form of the invention.

The connector portions C′ of the wires W^2 are the same as the portions C of wires W and can be related to the plates P′ and P^2 at selected notches **32** in the plate P^2 or can, as illustrated, be engaged through special connector openings **33** positioned in the plate P^2 in predetermined spacial relationship whereby a desired gradient is provided across the plates by the junction structure.

Further, so as to assure proper filling of the structure with filler F′, the centers of the plates are provided with registery filler conducting openings **34.**

In this second form of the invention, the plates P′ and P^2 are initially snugly engaged in the sheath, with the connector portions C′ of wires W′ snugly engaged therebetween. Upon subsequent swagging of the sheath and resulting compressing and re-forming of the conical plates, the connector portions C′ are tightly clamped between the plates and tight, pressure heat conducting contact between the plates and the sheath is established.

In the first form of the invention, the end wall part of the junction establishes exterior surface of the heater directly effected by the temperature of the medium in which the heater is engaged. In the second form of the invention, the thermocouple junction established by plates P′ and P^2, while within the sheath B′, is in direct, uniform and positive heat conducting contact with the sheath about its perimeter and while slower to respond to temperature changes, in a heated medium than the first form of the invention, is adequately responsive for a great number of situations.

In practice, to facilitate assembling of the means T, the connector portions P or P′ of the wires W or W′ can be secured to their related plates P or P^2 by a suitable cement, by solder or by welding, as desired or as circumstances require, before the plates and the wires are engaged and initially positioned in the sheath. Further, if desired, the wall E, plate P and connector portions C of the wires W or the plates P′ and P^2 and connector portions C′, can be suitably secured together as subassemblies, prior to their engagement in and with their

related sheaths, without departing from the spirit of my invention.

In FIGS. **8, 9** and **10** of the drawings, I have shown another and preferred embodiment of the invention. This last form of the invention is similar to the first form of the invention and distinguishes therefrom in the following specific details; first, the wires W^3 are arranged to extend longitudinally through the center of the heater coil H^3; second, the jacket 25^3 about the wires W^3 terminates immediately inward of the plug I^3; and finally, the forward end portions of the wires W^3 extend through opening **40** in a disc-like insulating spacer S arranged in the body B^3 between heat coil H^3 and the plate P^3 of the means T^3. The spacer S serves to orient the wires W^3 relative to the heater coil and serves to prevent possible contact between the connector portions C^3 of the wires and the heater coil. The spacer S can also be made to serve as a heat barrier between the heater coil and the junction structure of the means T^3 whereby the junction is not subjected to direct heat from the coil.

The spacer **40** is shown provided with notches **41** about its perimeter to conduct filler F^3 to and about the junction structure of the means T^3.

Having described typical preferred forms and applications of my invention, we do not wish to be limited to the specific details herein set forth, but wish to reserve to myself any modifications and/or variations that might appear to those skilled in the art to which my invention pertains and which falls within the scope of the following claims:

Having described my invention, I claim:

1. A thermocouple junction in a cartridge heater structure having an elongate tubular outer metal sheath having open ends, means sealing the ends of the sheath, a filler of dielectric insulating material in the sheath and a resistance heating element supported in and clear of the sheath by said filler and having contact leads extending through and from one end of the sheath, said filler being compacted tight in the sheath and about said heating element by radially inward swaging of the sheath during manufacture of the heater, said junction comprising a pair of substantially radially extending conical disc in tight peripheral bearing contact with the sheath, in electric isolation from the heating element and in partial nested axial spaced relationship with each other, a pair of thermocouple wires entering the sheath at said one end and extending axially in the sheath in electric isolation from the heating element and each having a connector portion extending substantially radially and in tight pressure contact between the discs, the connector portions last contacting and extending from the disc at predetermined spaced points on said discs, said conical discs being of obtuse angle and in pressure contact with the connector portions and the sheath before the sheath is swaged and being re-formed to a less obtuse angle and into increased pressure and heat conducting contact therewith when the sheath is swaged and said discs are re-formed radially inwardly.

2. A structure as set forth in claim **1** wherein one of said discs establishes an end wall and closes one end of the sheath.

3. A structure as set forth in claim **1** wherein one disc includes means defining openings through which the connector portions of the wires extend axially from between said discs.

4. A structure as set forth in claim **1** wherein one of said discs establishes an end wall and closes one end of the sheath and said other disc includes means defining openings through which the connector portions of said wire extend axially from between said discs and within the sheath toward the other end thereof.

5. A structure as set forth in claim **3** wherein said discs have edge portions fixed to the interior of the sheath.

6. A structure as set forth in claim **1** wherein said discs have edge portions fixed to the interior of the sheath.

7. A structure as set forth in claim **1** wherein the element includes axially spaced heating element sections with a pair of axially extending connectors therebetween and said discs are arranged in the sheath between the sections and include apertures through which said connectors extend in electric isolation therefrom.

8. A structure as set forth in claim **6** wherein the discs define openings to accommodate and through which said filler extends.

* * * * *