Sept. 29, 1959 H. C. STEINER 2,906,902

TEMPERATURE RESPONSIVE ARRANGEMENT

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FIG.1.

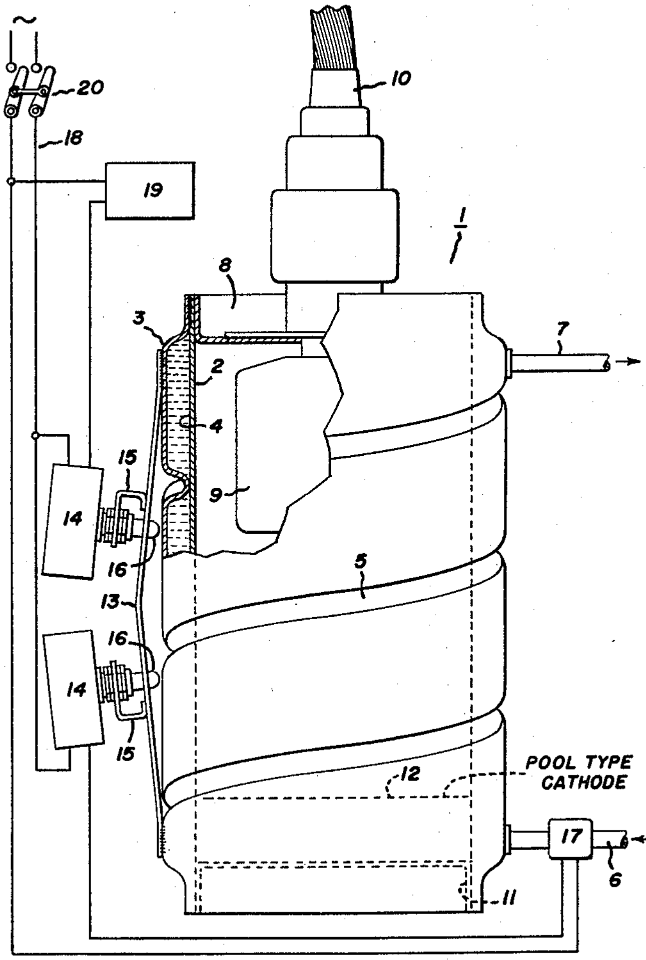


FIG.2.

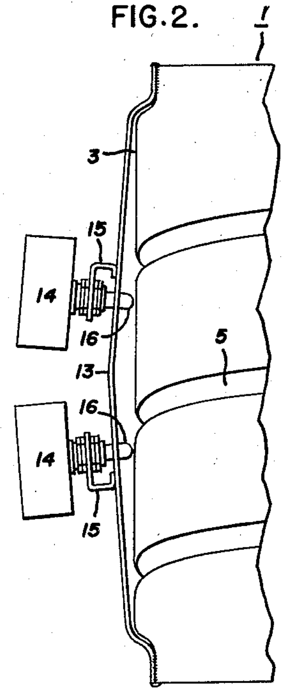
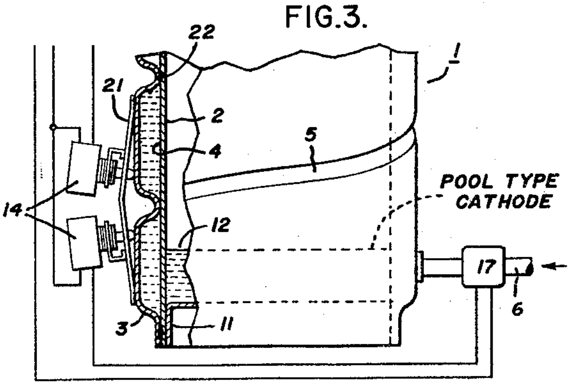


FIG.3.



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TEMPERATURE RESPONSIVE ARRANGEMENT

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9 Claims. (Cl. 313—29)

My invention relates to temperature responsive controlling means and pertains more particularly to an improved arrangement for controlling the cooling and protection against overheating of enveloped devices which are subject to heating during normal operation and which are ordinarily cooled by the passage of a coolant through a coolant chamber associated with the device.

In U.S. Patent No. 2,822,489 of James L. Zehner and assigned to the same assignee as the present application, there is disclosed and claimed an arrangement for controlling the cooling and protection against overheating of devices subject to heating during normal operation. This arrangement includes an envelope, a bowed strip having the ends thereof secured at spaced points on the exterior of the envelope, and control means operated by movements of the bowed strip as effected by expansion and contraction of the envelope caused by heating of a device contained in the envelope. Additionally, in this patent there is shown and claimed an envelope structure including spaced inner and outer walls defining a coolant chamber. In this arrangement the heating of the inner wall results in elongation thereof which has the effect of stretching or straining the outer wall of the envelope to effect bowing movements of the bowed strip and thereby control operation of control means associated with the strip and envelope. A plurality of switches may be employed as the control means, one being utilized for controlling the coolant flow through the coolant chamber and the other as an over-temperature protective device.

I have found that greater sensitivity to temperature changes of the device in the envelope and thus more rapid response of the coolant flow control means and the over-temperature protective device can be obtained by making the outer wall of the coolant chamber more flexible than the inner wall, thus to avoid any substantial restraining effect on the thermal expansion and contraction movements of the inner wall which, in turn, are effective for determining the bowing movements of the strip. This type of structure has been found particularly advantageous where applied, for example, to ignitron or pool-type cathode electric discharge devices wherein the cylinders comprising the coolant chamber walls are generally made of stainless steel and substantial additional thermal expansion of the inner wall is required to overcome or compensate for the additional contraction of the outer cylinder thus to give the bowed reference strip sufficient movement to cause the switches to operate. When tubes of this type are started and are required to carry a full load current before the coolant flow through the jacket commences the inner wall can be restrained substantially by the outer wall and under such conditions the bowing movements of the strip might not be sufficiently rapidly responsive to the temperature change of the inner wall. This can cause operation to become somewhat marginal and it is possible for the tube to lose control before the microswitches operate to start the flow of cooling water or to open a protective control. This problem is particularly accentuated due to the fact that most users of liquid cooled tubes of the presently considered type prefer to operate with as high a water temperature or as little liquid flow as possible in order to effect a maximum saving of water.

Accordingly, a primary object of my invention is to provide with an enveloped device subject to heating and contained in an envelope including a coolant chamber, new and improved means for controlling the cooling of the device and protecting same from overheating.

Another object of my invention is to provide new and improved temperature control means adapted for conserving coolant while insuring adequate cooling and protection against overheating.

Another object of my invention is to provide new and improved means adapted for both improving cooling effects and increasing responsiveness of control means to temperature changes.

Further objects and advantages of my invention will become apparent as the following description proceeds and the features of novelty which characterize my invention will be pointed out with particularity in the claims annexed to and forming part of this specification.

In carrying out the objects of my invention I provide an envelope housing a device subject to heating. The envelope includes spaced inner and outer walls forming a chamber for having a coolant circulated therethrough. A spiral corrugation is provided in the outer wall for defining a spiral coolant path and for rendering the outer wall relatively more flexible longitudinally than the inner wall. A bowed member has its ends secured at spaced points on the envelope and straddles at least one transverse section of the spiral corrugation. Switching means are provided which are operated in response to changes of the bow in the bowed member.

For a better understanding of my invention reference may be had to the accompanying drawing in which:

Figure 1 is a side elevational view of an electric discharge device of the ignition type partially broken away to illustrate a form of my invention incorporated therein;

Figure 2 is a fragmentary side elevational view illustrating a modified form of my invention; and

Figure 3 is a fragmentary side elevational view partially broken away to illustrate still another modified form of my invention.

Referring to the drawing, I have shown in Figure 1 my invention as applied to a power conversion tube or electric discharge device of the ignitron type including an elongated cylindrical envelope 1. The envelope 1 is preferably formed of stainless steel and includes spaced inner and outer walls 2 and 3, respectively, forming a coolant chamber 4. Formed in the outer wall 3 is a spiral depression or corrugation 5, which corrugation contacts the outer surface of the inner wall 2 and defines a helical coolant path from a coolant inlet 6 to a coolant outlet 7. This construction can be obtained by fitting a preformed spirally corrugated outer cylinder over a straight-walled inner cylinder and then sealing, as by welding, the corresponding edges of the cylinders in the manner illustrated in Figure 1.

The envelope is closed at its upper end by a header assembly including an anode seal, generally designated by the numeral 8. The header assembly 8 supports a generally cylindrical positive electrode or anode 9 centrally within the upper end of the envelope. As is well understood, the seal construction supports the anode in insulated relation with respect to the envelope and provides an externally accessible anode terminal designated by the numeral 10. The anode, in accordance with common practice in electric discharge devices of this type, can be formed of graphite.

The opposite end of the cylindrical envelope is closed by a cup-shaped header 11 which is welded to the lower end of the inner cylinder 2 to form a hermetic seal. The negative electrode or cathode of the device is contained in the envelope and is provided by a pool of conducting liquid, indicated by the numeral 12, which to advantage may be mercury. In the operation of power conversion tubes or devices of this character some of the cathode 8 is vaporized initially, for example, by a starter electrode (not shown) and, thus, an arc discharge is established between the surface of the cathode and the anode. This operation results in the generation of substantial heat which requires cooling of the device to enable satisfactory long life and safe operation. Additionally, as will be readily appreciated by those skilled in the art, considerable difficulty is experienced in providing discharge devices of this character which are relatively free from arc back resulting from high vapor pressure in the envelope. One method of minimizing arc back in this type of device is by cooling the envelope during operation of the device to condense the vapor therein on the inner wall of the envelope, thus to cause it to flow back to the pool. For this purpose the chamber 4 is provided for enabling coolant circulation therethrough from the inlet 6 to the outlet 7.

In cooling the particular type of device illustrated, it is economically desirable to employ as little coolant as possible and as low-temperature coolant as is available. When such low-temperature coolant is employed, means are required to avoid over-cooling or operation of the device below a predetermined temperature range which would result in undesirably low vapor pressure in the tube and thereby adversely affect the operation of the device. Additionally, when employing a low-temperature coolant it is desirable to provide means for minimizing condensation or "sweating" on the exterior of the tube. In the above-mentioned U.S. Patent No. 2,822,489 of J. L. Zehner there is disclosed and claimed temperature control means including a bowed strip or member having its ends secured at spaced points on the outer wall of the envelope and switching means operated by changes in the bow of the bowed member as effected by relative thermally-caused elongation or expansion and contraction of the envelope and bowed member for controlling the coolant flow through the coolant chamber and the current flow through the device. In this arrangement the change of the bow in the bowed member is effectively employed to operate switching means which are adapted for controlling the coolant circulation and for avoiding overheating of the device in the event that the cooling means is not effectual in maintaining the temperature of the device below a predetermined maximum above the desired operating range.

I have found, however, that at low-coolant temperatures such, for example, as 10 degrees centigrade, but within the range normally encountered in operation of the device, the stainless steel cylinders comprising the coolant jacket and walls of the envelope contract sufficiently to cause the switch operating bowed member or strip to bow out substantially beyond the normal position. Consequently, if the tube is subsequently started and required to carry a full-load current with the bowed member in this substantially bowed position and with no water flowing through the coolant chamber it would be necessary for the inner cylinder to be heated to a higher temperature than normal to overcome the contraction of the outer cylinder and thus give the reference strip or bowed member sufficient bow reducing movement to cause the switches to be operated. That is, after substantial contraction of the inner and outer cylinders due to a low-coolant temperature condition, the outer cylinder will ordinarily have a substantial restraining effect on the elongation of the inner cylinder and, thus, prevent the inner cylinder from causing rapidly responsive bowing movements of the bowed strip. Under these conditions operation can become somewhat marginal and because the switches cannot operate rapidly in response to temperature changes of the inner wall of the envelope it is possible for the mercury vapor in the device to exceed the desired pressure, whereby control of the tube can be lost before the control switches can be operated to start the flow of cooling water to effect condensation of the vapor and thus control the vapor pressure or to open protective controls. This problem is generally accentuated because most users of the disclosed type of device prefer to operate with as high a water temperature as possible in order to save the maximum amount of water. Thus their switches will be set for operation or admission of coolant into the chamber at relatively high temperatures which will require greater thermal expansion of the envelope to effect operation. That is, the inner wall will have to be heated to a greater extent to effect the amount of thermal expansion that will be required to both elongate and overcome the restraining effect of the outer wall, thus to operate the coolant-control switch and enable coolant flow through the chamber.

My improved arrangement includes the spirally corrugated outer wall 3 and the corrugation 5 therein has the desired effect of rendering the outer wall 3 relatively more flexible or weak longitudinally than the inner wall. As a result, the outer wall 3, because it serves in much the same sense as an accordion pleat, has only a minimal restraining effect on the thermal expansion of the inner wall. Thus, the bow in the switch-operating bowed member can be changed by the inner wall in more rapid response to temperature changes in the envelope.

In the form of my arrangement illustrated in Figure 1 the control means includes a bowed strip or member 13 having its ends secured, as by spot welding, at longitudinally spaced points on the outer wall 3 of the envelope. In this arrangement the ends of the bowed member are secured to the outer wall near the ends thereof and the bowed member extends across or straddles all of the transverse sections of the spiral corrugation 5 and the bow of the bowed member changes in accordance with relative longitudinal expansion and contraction of the inner wall 3 and the bowed member. That is, with longitudinal expansion of the inner wall 2 the bow of the bowed member is diminished for operating control means, while contraction of the inner wall is effective in returning the bowed member to its original bowed state. The corrugation in the outer wall 3 renders the latter longitudinally more flexible in much the same manner as an accordion pleat or bellows structure and, thus, the outer wall 3 has no substantial restraining effect on the elongation and contraction of the inner wall or, in other words, the outer wall 3 follows the expansion and contraction movements of the inner wall more readily than would a straight sided outer wall. Accordingly, the bowing movements of the member 13 are more directly responsive to the thermal expansion and contraction of the inner wall and thus control or switching means operated by the bowing movements of the member 13 are more rapidly responsive to temperature changes in the envelope.

The above-mentioned switching means adapted for being operated by the bowing movements of the member 13 can comprise a plurality of microswitches 14 suitably mounted by brackets 15 on the bowed member 13. The bowed member 13 can be apertured for extension therethrough of operating plungers 16 of the switches, thus to enable the operating plungers to cooperate with the outer wall of the envelope. In this arrangement diminution of the bow of the bowed member, as effected by the expansion of the inner wall of the envelope, will move the plungers toward the envelope for engagement therewith to operate the switches; and longitudinal contraction of the inner wall will return the bowed member to its original bowed state for moving the plungers out of engagement with the wall, again to operate the switches.

In the arrangement illustrated in Figure 1 one switch is adapted for engaging the envelope and being thereby operated at a predetermined degree of change in the bow of the bowed member and the other switch is adapted for operating at a predetermined different degree of change in the bow of the bowed member. Thus, one of the switches **14** is adaptable for controlling, for example, an electrically actuated valve control means **17**, thus to control the coolant flow into the coolant chamber through the inlet **6**. The valve control means **17** may be of any well known and commonly employed type and its operation in response to actuation of one of the microswitches can be effective for conserving coolant and avoiding overcooling of the device, whenever the cooling effect is no longer required. The other switch is adaptable for avoiding overheating of the device by operating a control circuit **18**. The circuit **18** can control the operation of a device **19** for operating the latter if for any reason the cooling means is ineffectual in maintaining the temperature of the device below a predetermined maximum of a predetermined desired operating range. Alternatively, the device **19** can be a circuit breaker control to operate a circuit breaker for controlling current flow through the ignitron, or it can operate a bell alarm, a warning light or any other type of signal device for indicating overtemperature. If an automatic circuit breaker is not employed the signal will enable an operator to open manually a master switch **20** provided between the just-described circuitry and a power source therefor.

Thus, if the tube is operated in a circuit and upon starting is required to carry a full-load current and has previously been cooled to a point where the walls of the envelope have contracted substantially, the valve **17** will be closed and no water flow through the cooling chamber will be taking place. Under these conditions it is possible for the vapor in the tube to become so dense as to result in arc back and thus loss of control of the tube before the coolant commences to flow unless the microswitch controlling coolant flow is caused to operate substantially rapidly in response to the temperature increase which causes the too-high density mercury vapor. In my arrangement the inner wall will elongate substantially rapidly in response to the temperature increase and will be substantially unrestrained by the corrugated relatively longitudinally flexible outer wall, with the desired effect that the bow in the bowed member **13** will change more quickly and the microswitch controlling the coolant flow will be caused to operate and thus admit cooling liquid into the chamber for reducing the temperature in the device and thus controlling the vapor condensation and pressure in the device. If for some reason the coolant is not effective for maintaining the device within the desired temperature range, the other microswitch, which can be adjusted for operating at a predetermined higher temperature, will be caused to trip or be operated for opening the current circuit through the device or operating other protective controls or an alarm.

Illustrated in Figure 2 is a modified form of my invention wherein the envelope **1** may be the same as that illustrated in Figure 1 but which has the ends of the bowed member **13** secured to the ends of the envelope at which the inner and outer walls **3** and **4** joined. In the embodiment of Figure 1 some stretching or elongation of the outer wall **3** by the inner wall **2** will be required to change the bow in the bowed member even though it will not be so great as to have a substantial restraining effect. In Figure 2 the strip **13** is secured to the very ends of the envelope and thus is more directly responsive to the longitudinal elongation and contraction of the inner wall of the envelope. This arrangement minimizes still further any restraining effect of the outer wall and affords a still greater degree of switch-operating sensitivity.

In Figure 3 is illustrated another embodiment of my invention and in which the envelope **1** can be the same as that illustrated in Figures 1 and 2. In this embodiment, however, a bowed member **21** is provided which has its ends secured, as by spot welding, to the outer wall **3** of the envelope on opposite sides of only a single transverse section of the spiral corrugation **5**. At the next transverse section of the spiral corrugation the outer wall is secured to the inner wall, as by spot welding, at **22**. Thus, the bow in the bowed member **20** will depend upon the elongation and contraction of the inner wall **2** of the envelope in the region from the lower end of the envelope to the section at which the outer wall is secured to the inner wall at **22**. This enables the microswitches **14** to be operated more directly in response to temperature changes in a particular region of the device, such as in the region immediately above the cathode **12**. In this arrangement the lowermost section of the corrugation **5** or the single section over which the bowed member **21** extends serves to render the lower end of the outer wall more flexible longitudinally than the corresponding section of the inner wall or, in other words, adapts this section of the outer wall for minimizing any restraining effect thereof on the inner wall, which enables more rapid response in the operation of the switches **14** according to the temperature in the corresponding lower region of the device.

Thus, it will be seen that I have provided an improved arrangement for operating controlling means in more direct response to the internal temperature of the device. Additionally, it will be seen that the spiral corrugation **5**, in addition to rendering the outer wall more flexible than the inner wall, serves to define a helical coolant path between the coolant inlet and outlet and the contact of the corrugation with the inner wall improves heat dissipation from the inner wall through conduction to the outer wall and radiation therefrom. Still further, I have provided an improved arrangement for operating controlling means in more direct response to particular portions of the device such, for example, as the region immediately above the cathode.

It is to be understood from the foregoing that while I have utilized a spiral corrugation to render the outer wall more flexible, other means may be employed for rendering the outer wall more flexible or weaker than the inner wall such, for example, as annular depressions other than in a spiral form or weakening of the outer wall by various other means.

It will be understood further from the foregoing that while I have shown my invention applied to an electric discharge device of the ignitron type, it is equally applicable for controlling the cooling and over-temperature protection of any enveloped device which is subject to heating and which includes a coolant chamber having spaced inner and outer walls.

It will be still further understood from the foregoing that my invention is not limited to the use of electrical switches as the controlling means, nor must the controlling means be carried by the bowed member. For example, mechanical controlling means including operating arms actuatable by the bowed member can be effectively employable in my invention.

While I have shown and described specific embodiments of my invention I do not desire my invention to be limited to the particular forms shown and described, and I intend by the appended claims to cover all modifications within the spirit and scope of my invention.

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

1. An envelope adapted for housing a device subject to heating, said envelope including spaced inner and outer walls defining a coolant chamber, a bowed element having the ends thereof secured at spaced points on the exterior of said envelope, controlling means operated by movements of said bowed element as effected by expansion and contraction of said envelope, and said outer wall

being more flexible than said inner wall between the ends of said bowed element, whereby any restraining effect of said outer wall on the expansion and contraction of said inner wall is minimized and the bowing movements of said strip are thereby rendered more directly responsive to the expansion and contraction of said inner wall.

2. An envelope adapted for housing a device subject to heating, said envelope including spaced inner and outer walls joined at the ends thereof and defining a coolant chamber, a bowed strip having the ends thereof secured to the ends of said envelope at which said inner and outer walls are joined, switching means operated by movements of said bowed strip as effected by expansion and contraction of said envelope, and said outer wall being longitudinally more flexible than said inner wall between the ends of said strip.

3. An envelope adapted for housing a device subject to heating, said envelope including spaced inner and outer walls defining a coolant chamber, a bowed strip having the ends thereof secured at longitudinally spaced points on said envelope, switching means operated by movements of said bowed strip as effected by expansion and contraction of said envelope, and at least one transverse depression in the outer wall of said envelope between the ends of said strip rendering said outer wall more flexible longitudinally than said inner wall, whereby the bowing movements of said strip are rendered more directly responsive to the longitudinal expansion and contraction of said inner wall.

4. An envelope adapted for housing a device subject to heating, said envelope including spaced inner and outer walls defining a coolant chamber, a bowed strip having the ends thereof secured at longitudinally spaced points on said envelope, switching means operated by movements of said bowed strip as effected by expansion and contraction of said envelope, and a transversely extending corrugation in the outer wall of said envelope between the ends of said strip, said corrugation engaging but being unsecured to said inner wall for defining a predetermined coolant path through said chamber and rendering said outer wall longitudinally more flexible relative to said inner wall, whereby the bowing movements of said strip are rendered more directly responsive to the longitudinal expansion and contraction of said inner wall.

5. An envelope adapted for housing a device subject to heating, said envelope including spaced metal inner and outer walls defining a coolant chamber, a spiral corrugation in the outer wall of said envelope defining a spiral coolant path in said chamber and rendering said outer wall more flexible longitudinally than said inner wall, a bowed strip extending across at least one transversely extending section of said spiral corrugation and having the ends thereof secured at longitudinally spaced points on said outer wall, and switching means operated by bowing movements of said strip effected by expansion and contraction of said envelope.

6. An electric discharge device comprising a plurality of electrode elements adapted for cooperating and generating substantial heat during normal operation of said device, an envelope containing said elements and including spaced inner and outer walls defining a coolant chamber, the outer wall of said envelope being more flexible longitudinally than the inner wall, a bowed element having the ends thereof secured at spaced points on said envelope, and controlling means operative in accordance with the amount of bow in said bowed member as determined by the longitudinal expansion and contraction of said inner wall.

7. An electric discharge device comprising a plurality of electrode elements adapted for cooperating and generating substantial heat during normal operation of said device, an envelope containing said electrode elements and including spaced metal inner and outer walls defining a coolant chamber, a transversely extending depression in said outer wall whereby said outer wall is rendered more flexible longitudinally than said inner wall, a bowed strip having the ends thereof secured to said envelope on opposite sides of said depression and adapted to operate control means through bowing movements effected by longitudinal expansion and contraction of said inner wall.

8. An electric discharge device comprising an envelope, a pool-type electrode contained in said envelope, said electrode being adapted for having a portion thereof vaporized during operation of said device, said envelope including spaced metal inner and outer walls defining a chamber for having a coolant circulated therethrough, a spiral corrugation in said outer wall engaging said inner wall for defining a spiral coolant path in said chamber, increasing heat transfer between said walls and rendering said outer wall more flexible than said inner wall, a bowed member having the ends thereof secured to said envelope at longitudinally spaced points on opposite sides of at least one transverse section of said spiral corrugation which is unsecured to said inner wall, and control means operated by bowing movements of said bowed member as effected by longitudinal expansion and contraction of said inner wall.

9. An electric discharge device comprising an envelope, a pool-type electrode contained in said envelope, said electrode being adapted for having a portion thereof vaporized during operation of said device, said envelope including spaced metal inner and outer walls defining a chamber for having a coolant circulated therethrough, a spiral corrugation in said outer wall engaging said inner wall for defining a spiral coolant path in said chamber, increasing heat transferred between said walls and rendering said outer wall more flexible than said inner wall, said corrugation having a transverse section being secured to the inner wall at a point vertically spaced from said pool-type electrode, another transverse section interposed between said first-mentioned section and said pool-type electrode, said other transverse section being located adjacent the surface of said pool-type electrode and being unsecured to said inner wall, and a bowed strip having the ends thereof secured to said outer wall on opposite sides of said other transverse section of said corrugation and adapted to operate control means through bowing movements effected by longitudinal expansion and contraction of said outer wall as effected by thermally-caused longitudinal expansion and contraction of said inner wall.

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