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MULTIPLE ANNULAR ELECTRODE GAS ARC HEATER
WITH A MAGNETIC ARC SPINNER

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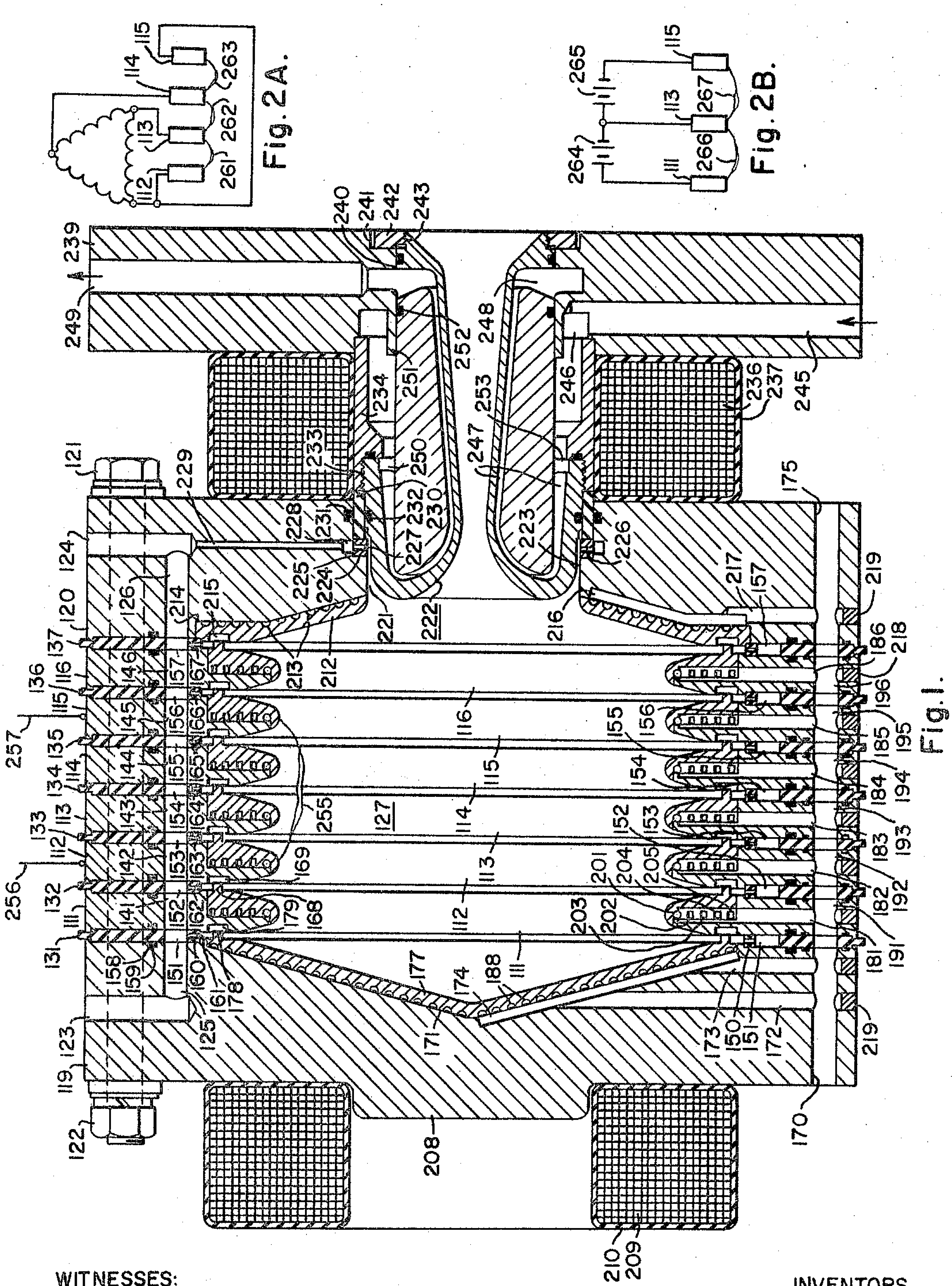

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MULTIPLE ANNULAR ELECTRODE GAS ARC HEATER WITH A MAGNETIC ARC SPINNER

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This invention relates to improvements in gas arc heaters, and more particularly to a gas arc heater utilizing all or a portion of the arc chamber wall as the electrode surfaces.

In arc heaters in which a steady flow of gas is heated by an electric arc to increase the enthalpy of the gas, it is necessary in high power devices to prevent localized overheating and concomitant metal evaporation from the electrodes.

Some expedients which have proved to some degree successful have been water cooling of the electrodes, and rapid moving of the arc over the electrode surface, such as that which is achieved by means of interaction of the arc with a mangetic flux field, to prevent the metal evaporation which would occur with stationary arc contact locations.

In addition, it is usually desirable and frequently necessary to provide that all parts of the arc heater chamber which are exposed to direct radiation from the arc and the hot gases are cooled, to allow for operation for extended periods. Insulators and sealing O-rings in particular have to be optically baffled so that they do not receive direct radiation from the arc and the incandescent gases. Furthermore, the various components of an electric arc heater must be so located and electrically insulated from each other as to cause the arc to be maintained between electrodes and the gas to be effectively heated by this arc. The arc must not be allowed to transfer to undesired arc paths, and preferably the gas enters at a position, or at an angle, so that it is effectively heated and mixed to provide for uniform gas temperature.

Apparatus embodying our invention accomplishes all of these desirable and necessary objectives in apparatus suitable for direct current, or single, two or three phase alternating current operation, and particularly well suited for high temperature operation. In summary, our invention includes, but is not limited to, an arc chamber or arc heater in which the electrodes or arc contact areas are formed by all or portions of the cylindrical wall enclosing the arc area, or forming the pressure vessel. This allows the use of large arc contact areas for a given chamber size. Cold gas admitted between electrodes moves the arc toward the center of the arc chamber. The cylindrical or ring electrodes may be water cooled, and as in conventional practice, the nozzle may be water cooled, and the means for plugging up the other end of the arc chamber may be water cooled and have its own cooling manifold.

More specifically, in our invention the walls of the arc chamber may consist of a stack of several water cooled rings which also serve as electrodes. The gas to be heated enters between the rings; the rings are insulated from one another by means of insulating discs which are shielded from radiation and hot gases by means of optical baffles and the transmission of the cold air to be heated between the plates. The arc length may be varied by making connections to rings which are further apart or closer together as desired.

Accordingly, a primary object of our invention is to provide a new and improved gas arc heater offering advantages over any now known in the art.

Another object of the invention is to provide a new and improved arc heater utilizing the cylindrical walls of the arc chamber as electrodes.

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A further object of the invention is to provide a new and improved gas arc heater in which the walls of the arc chamber consist of a stack of several electrically insulated water cooled rings which also serve as electrodes.

Still a further object of the invention is to provide a new and improved gas arc heater especially suitable for heating gases to extremely high temperatures.

Still a further object is to provide arc heater apparatus for direct current, single phase alternating current or multiphase alternating current operation.

Yet another object is to provide a new and improved arc chamber having improved optical baffling of insulating and sealing parts.

These and other objects will become more clearly apparent after a study of the following specification, when taken in connection with the accompanying drawing, in which:

FIGURE 1 shows a cross section through an arc heater constructed according to our invention; and

FIGS. 2A and 2B show the arc heater apparatus connected respectively to a three phase alternating current source to produce three arcs, and connected to a direct current source to produce a plurality of direct current arcs.

Referring now to the drawing of FIG. 1, it is seen that the walls of the arc chamber consist of a stack of several water cooled rings some of which also serve as electrodes. The gas to be heated enters between these rings. The rings are insulated from one another by means of insulating discs which are shielded from radiation and hot gases by means of optical baffles and the transmission of the cold gas to be heated between the rings.

Six water cooled rings are shown designated **111** to **116** inclusive, but it should be understood that any convenient number of rings may be employed. The rings have a plurality of bores therethrough at spaced intervals around the periphery thereof so that the rings may be clamped between the two end plates of the chamber, these end plates being generally designated **119** and **120**. The end plates **119** and **120** also have aligned bores therein for the passage of the bolts, one of these bolts being shown at **121** having a nut **122** on the end thereof. Between each pair of adjacent rings there is a washer composed of electrically insulating material, and similar washers insulate ring **111** from the end cover plate **119**, and insulate ring **116** from the end cover plate **120**, these washers of insulating material being designated **131** to **137** inclusive. It is seen that both of the end cover plates **119** and **120** have a cold gas inlet, these being designated **123** and **124**, communicating with transverse bores **125** and **126**. When the end plates and rings are assembled to form the wall of the chamber, the transverse bores **125** and **126** are aligned with transverse bores of substantially equal diameter in each of the ring members, the bores in the ring members being designated **141** to **146** respectively.

Each of the aforementioned insulating washers or discs **131** to **137** is seen to have an inner diameter such that the inner edge of the washer stops at substantially the outer edges of passageways **125** and **126** and bores **141–146** so that annular passageways **151, 152, 153, 154, 155, 156** and **157** are formed, all communicating with the bores **125** and **126** by way of the bores **141–146** in the rings **111** to **116**, and forming annular air headers which extend all the way or substantially all of the way around the periphery of the chamber. Disposed between the annular passageways **151–157** and the interior of the arc chamber are a plurality of annular gaskets **161–167** respectively, composed of insulating material, each gasket having a plurality of small radially extending bores therein at spaced intervals around the periphery thereof so that air is admitted to the chamber at a number of spaced points between each pair of adjacent rings. Two of the radial passageways in gasket **161** are shown and identified at **150** and **160**; each of the other gaskets **162–167** has similarly placed radial bores, as shown.

It is seen that each of the rings **111–116** has an annular tongue extending around the entire periphery thereof, and that this tongue extends into an adjacent groove which extends around the entire periphery of the next adjacent ring, but without touching the adjacent ring, and maintaining the electrical insulation between adjacent rings. The tongue of ring **111** is designated **168** and the groove in ring **112** is designated **169**. The tongue **168** provides an optical baffle so that direct radiation from the arc **255** or from incandescent gases in chamber **127** does not reach the insulating washer **162**. Radiation reaching the washer might destroy the physical and electrical properties thereof. Each and every one of the plates **111** to **116** inclusive has this annular tongue on one side thereof and an annular groove on the other side thereof as shown, for protecting all of the washers **161–167**.

As aforementioned, the inside edges of insulating washers **131** to **137** terminate in a circle coexistent with the edges of bores **125**, **126**, and **141** to **146**, to form the aforementioned plurality of annular spaces or annular passageways around the entire perimeter of the arc chamber. As aforementioned, inside of these annular passageways are annular insulating ring members **161–167** each having a plurality of spaced radial passageways communicating between the adjacent annular space and the interior of the arc chamber **127**. Each of the annular spaces forms in effect a manifold for admitting air at a number of spaced positions around the entire periphery of the chamber.

It is understood that a second air header or air inlet similar to **123–124**, not shown for convenience of illustration, may be provided at a convenient position around the periphery of the arc chamber, the second air header also communicating with the manifolds **151** to **157** inclusive.

The rear cover plate generally designated **119** has an annular groove **158** therein in which is disposed an O-ring **159** for forming an air tight seal between the adjacent wall of the cover plate and the insulating washer **131**. Each of the rings **111** to **116** inclusive is seen to have two oppositely disposed annular grooves therein on the two sides thereof in which are disposed O-rings for providing seals between the rings and the insulating washers. In addition, the cover plate **120** at the other end of the chamber has an annular groove therein containing an O-ring for providing an effective seal.

It is further seen that the end cover plate **119** is tapered or conical shaped on the inside thereof, forming a substantially conical wall portion **171**, against which is securely mounted a conical shaped wall lining or portion to form the inner wall of the chamber, this conical shaped wall lining being composed of a material which is highly heat conductive, such as copper, and having a plurality of concentric circular passageways **188** of progressively increasing diameter on the backside thereof for the flow of cooling fluid, such as water, to cool this portion of the wall of the chamber. It is further seen that the back cover plate **119** has a cutaway portion or slot **174** therein and has two passageways **172** and **173** communicating with this slot, the passageways **172** and **173** communicating with a water inlet **170**, the slot **174** forming in effect a manifold for admitting cooling fluid to the plurality of circular passageways **188**. At the minimum, another slot such as **174** and another set of passages such as **172**, **173** and **170** are provided to serve as outlets for the water entering through **170**, these not being shown for convenience of illustration. As will be seen hereinafter, the arc heater chamber may include two or more water inlets which are spaced from each other at a predetermined angular distance around the periphery of the chamber, and may include two or more water outlets at convenient places around the periphery of the chamber, these not being shown for convenience of illustration.

Each of the annular ring members **111** to **116** inclusive is seen to have a passageway extending radially thereof for communicating with a transverse bore through the ring, these bores being in alignment with each other while the rings are arranged in a stack and in alignment with the aforementioned bore or passageway **170** in end plate **119**, and also in alignment with a bore or passageway **175** in the downstream cover plate **120**. These radial passageways are designated **181** to **186** respectively, and the transverse bores through the plates are designated **191** to **196** respectively. It is seen that the aforementioned washers **131** to **137** inclusive also have bores therethrough in alignment with the aforementioned bores **191** to **196** inclusive in the rings to provide a complete and free passageway between inlet **170** and inlet **175**. The conical shaped chamber lining composed of copper or other highly heat conductive material **177** has an annular lip or tongue **178** passing into but not touching the adjacent annular groove **179** in ring **111**, to provide the aforementioned optical baffling for the aforementioned annular ring of insulating material **161** having the aforementioned plurality of spaced radially extending passageways including **150** and **160** for admitting air or other gas to the arc chamber **127**. As aforementioned, the conical chamber end lining portion **177** is seen to have circular or semi-circular passageways **188** concentric with the apex of the cone and communicating between the water header **174** and an outlet water header disposed at another position and not shown for convenience of illustration. If desired, two inlet water headers may be provided, and two outlet water headers may be provided.

The aforementioned radially extending passageways **181** to **186** inclusive in the rings **111** to **116** inclusive extend through the outer ring portion which may be composed of stainless steel or some other strong nonmagnetic material, and extend into and communicate with a plurality of concentric circular or annular passageways extending around the entire periphery of the inner portion of the ring which is composed of copper or other suitable highly heat conductive material. Water going into inlets **170** and **175** flows through the radial extending passageways, for example, passageway **181** into the five internal circular passageways in ring **111**, these five passageways being designated **201** to **205**. At some other convenient position around the perimeter of the ring, a radially extending passageway conducts water from the aforementioned circular passageways to an outlet water passageway which may correspond to the passageway **170–175**. The circular passageways in ring **111** have been selected merely for illustration. It will be understood, and it is seen, that each of the rings **112** to **116** inclusive also has five annular passageways communicating with a radial passageway which communicates with the water inlets **170** and **175**.

The aforementioned end plate **119** has a raised circular portion **208** for supporting and maintaining in position a field coil **209** mounted in an insulating housing **210**. It will be understood that the end plate **119** is composed of nonmagnetic material. Leads, not shown for convenience of illustration, are connected to the field coil **209** for setting up a magnetic field of the desired magnitude and direction, for purposes to become hereinafter more clearly apparent.

At the nozzle end of the chamber, the right-hand end as seen in the figure, the end plate **120** has a lining portion **212** with a plurality of annular passageways **213**, the liner portion **212** being composed of copper or other highly heat conductive material and being seated in the cut-away portion **214** in end plate **120**. The liner portion **212** has an annular groove **215** therein adjacent the aforementioned annular tongue in ring **116**, for providing optical baffling of the gasket 167 of insulating material in axial alignment with the aforementioned insulating washer 137. A water header 216 communicating with all of the annular passageways 213 also communicates by way of a passageway 217 with the aforementioned water input 175. The radially extending passageways 172, 173, 181 to 186, and 217 can conveniently be formed by boring radially into the ring or end cover plate as the case may be and then plugging up the portion of the bore which passes through the outer wall portion, some of these plugs being shown at 218 and 219.

The circular passageway 221 through the end plate 120 has disposed therein an aforementioned nozzle generally designated 222, and which may be composed of nonmagnetic material. It has proven desirable in practice to electrically insulate the nozzle of an arc heater from the tank or chamber structure, and to this end a space 223 is provided around the inner portion of the nozzle between the outer wall of the nozzle and the wall of the opening 221. There is an annular groove 224 in the adjacent wall portion 221 having disposed therein an annular washer 225, which may be composed of insulating material, having at spaced intervals around the periphery thereof radially extending passageways, two of these being shown at 226 and 227. These radial passageways including 226 and 227 communicate with an annular air header 228, which is connected by way of passageway 229 to the aforementioned air inlet 124. Air under considerable pressure coming out of the spaced passageways 226 and 227 in addition to keeping hot gases from coming in contact with the insulating parts 225 and 230, will follow the contour of the nozzle and help reduce convected heat to the nozzle, and reduce the possibility of the arc striking to the nozzle.

An annular ring 230 composed of electrically insulating material spaces the outer wall of the nozzle from the adjacent wall of the end plate 120. Two O-rings are provided for insuring a close sealing engagement of the insulating ring 230 with both the end plate 120 and the nozzle 222, these O-rings being designated 231 and 232 located in their respective annular grooves. The nozzle 222 is seen to have a threaded rim portion at 233, the threads engaging adjacent threads in a cylindrical support member 234; mounted adjacent the ring member 234 around the outside thereof is an additional field coil 236 in housing 237 composed of insulating material. Leads, not shown for convenience of illustration, are connected to the field coil 236 for bringing an energizing potential thereto to set up a magnetic field in conjunction with the field of coil 209, inside the arc chamber. Coils 209 and 236 may be energized by a direct current. It is understood that the end plate 120 is composed of nonmagnetic material. The nozzle structure includes a flange portion 239 with a central aperture 240 therein and a cut-away portion adjacent the central bore 240 forming the groove 241, in which is disposed a substantial ring composed of metal and having threads on the inner surface thereof, the threads on the inner surface of ring 242 engaging adjacent threads in the metallic portion of the nozzle at 243. The flange portion 239 has an inlet passage 245 for cooling fluid communicating with an annular water header 246. From thence the water flows through a channel 247 closely adjacent the inner wall of the nozzle and communicating with an outlet water header 248. Outlet water header 248 communicates with an outlet water passage 249. If desired, the nozzle may be a two-piece construction; peripherally spaced studs 250 and 253 separate one portion of the nozzle from the adjacent wall portion which is exposed to the gas, to form the passageway 247, and the outer end of the nozzle is supported in spaced position by an annular lip portion of the flange 239, this lip portion being designated 251. An O-ring seal is provided at 252. Ring member 234 completes the spacing.

Nozzle and nozzle flange assembly are held in place

by means of bolts and proper spacers to end plate 120, these not being shown for convenience of illustration.

As previously stated, the arc or arcs are located between the rings which form the walls of the chamber. An arc is shown at 255 taking place between rings 112 and 115, which have connected thereto electrical connections 256 and 257 respectively. It will be understood that the rings 112 and 115 are selected for illustration purposes only. The arc may be shortened by bringing electrical potential to rings which are closer together, or the arc may be lengthened by applying the electrical potential to rings which are spaced farther from each other.

The embodiment of the invention shown provides apparatus well suited to accomplish the aforementioned objectives of the invention. The apparatus combines the functions of the electrodes and the heat shield or walls of the gas heating chamber, thereby eliminating the electrodes, since the chamber walls would preferably be water cooled in a conventional arc heater. The apparatus is readily adaptable to single phase, two phase or three phase alternating current, or to direct current, by making electrical connections to two or more of the chamber rings. As previously stated, the arc length may be varied by making connections to rings which are farther apart or closer together, as desired. It is also possible to maintain a number of arcs in parallel by making multiple connections to the rings. It has been found that the arc heater of our invention may be designed much smaller than a comparable heater utilizing conventional electrodes.

FIG. 2A shows the apparatus of FIG. 1 connected to a three phase source. For example, a delta connected transformer secondary connected as shown produces three arc paths 261, 262, and 263 inside the chamber.

FIG. 2B shows the apparatus of FIG. 1 connected to a direct current source symbolized by batteries 264 and 265 to produce two arcs 266 and 267.

The term "insulating" if employed without a modifier herein and in the claims means electrically insulating.

Whereas we have shown and described our invention with respect to an embodiment thereof which gives satisfactory results, it should be understood that changes may be made and equivalents substituted without departing from the spirit and scope of the invention.

We claim as our invention:

1. Arc heater apparatus comprising, in combination, means forming an arc chamber, the chamber forming means including at least a first wall portion and a second wall portion both composed of conductive material and electrically insulated from each other, the first and second wall portions having substantially the same inner dimensions and forming first and second electrodes, nozzle means disposed in one end of the chamber, means closing the other end of the chamber, means for admitting gas to be heated into the chamber through the space between electrodes, means for applying an electrical potential across the two wall portions to form an arc inside the chamber between the two electrodes, and means for setting up a magnetic field in the chamber in predetermined direction with respect to the arc.

2. Arc heater apparatus comprising, in combination, means forming an arc chamber having a side wall composed of conductive material, means electrically insulating one portion of the side wall of the arc chamber from another portion of the side wall of the arc chamber, the portion and the other portion of the side wall being of similar shape and similar dimensions, said insulating means being disposed between the one portion and the other portion and being of predetermined dimensions whereby an annular space exists between the two portions and adjacent the chamber, means for bringing electrical potential to said one portion and said other portion and causing an electric arc to take place between the side wall portions inside the chamber, nozzle means for the chamber, and means for admitting gas to be heated into the

chamber through the space between said one portion and said other portion.

3. Apparatus according to claim 2 including in addition means for cooling the wall portions of the chamber.

4. Apparatus according to claim 2 including in addition means for setting up a magnetic field in the chamber in predetermined position with respect to the arc.

5. Arc heater apparatus comprising, in combination, chamber forming means including at least first and second annular wall portions of similar dimensions composed at least partially of conductive material, means disposed between the first and second wall portions and electrically insulating the wall portions from each other, means for conducting a gas to be heated to the interior of the chamber including annular means disposed between the first and second annular wall portions, means for applying an electrical potential to the first and second annular wall portions to cause an arc inside the chamber between the first and second wall portions, means for setting up a magnetic field of predetermined strength and direction with respect to the arc inside the chamber, means for sealing one end of the chamber, and nozzle means disposed in the other end of the chamber for exhausting gas from the chamber after being heated by the arc.

6. Apparatus according to claim 5 wherein the first and second wall portions are additionally characterized as each having an inner portion composed of a highly heat conductive material and having at least one annular passageway therein, and including in addition means for conducting a cooling fluid to the passageway and conducting the fluid from the passageway.

7. Arc heater apparatus comprising, in combination, means forming an arc chamber, the chamber forming means including first and second end plates, at least two annular rings composed of conductive material disposed between the first and second end plates and electrically insulated from the first and second end plates and from each other, the annular rings having an inner portion composed of a highly heat conductive material, the inner portion having at least one annular passageway therein, each ring having fluid inlet and fluid outlet conduits communicating with the annular passageway for bringing a cooling fluid to the annular passageway and conducting fluid therefrom, first means adjacent the first end plate for producing a magnetic field when energized, second means adjacent the second end plate for producing a magnetic field when energized, the first and second magnetic field producing means being energized in a manner to produce a magnetic field of predetermined direction and intensity in the chamber, the first end plate having a plurality of concentric substantially circular passageways therein near the inner surface thereof, means for bringing a cooling fluid to the passageways of the first end plate and conducting fluid therefrom, the second end plate having a plurality of substantially annular concentric passageways therein near the inner surface thereof, means for bringing a cooling fluid to the passageways of the second end plate and conducting fluid therefrom, means for admitting gas to be heated to the chamber, means for applying an electrical potential between the two rings to cause an arc therebetween inside the chamber, the nozzle means adapted to be cooled by a cooling fluid disposed in the second end plate, gases admitted to the chamber after being heated by the arc therein being exhausted through the nozzle means.

8. Arc heating apparatus comprising, in combination, means forming an arc chamber, a first field coil disposed on the outside of the chamber forming means in predetermined position thereon, the chamber forming means including a first end plate composed of nonmagnetic material, a second end plate composed of nonmagnetic material having a substantially central aperture therein, nozzle means composed of nonmagnetic material mounted in the aperture and electrically insulated from the second end plate, a second field coil mounted on the second plate and encircling the nozzle means, the first and second field coils being adapted to be energized to set up a magnetic field in the chamber, a plurality of annular rings, the rings being similar to each other and stacked in axial alignment between the first and second end plates, a plurality of insulating washers disposed between the plurality of rings respectively, an additional insulating washer insulating the ring adjacent the first end plate therefrom and a further insulating washer insulating the ring adjacent the second end plate therefrom, and means connected to a selected plurality of the rings for bringing energizing potentials thereto and forming at least one arc between the selected plurality of rings inside the chamber, gas to be heated being admitted to the chamber through spaces between rings, the arc between the selected rings heating the gas in the chamber whereafter the gas is exhausted through the nozzle means.

9. Arc heater apparatus comprising, in combination, a plurality of spaced similar rings composed of conductive material, a plurality of annular washers composed of electrically insulating material disposed between the plurality of rings respectively, each of the rings having an inner portion composed of a highly heat conductive material, each of the rings having at least one circular passageway in said inner portion, each of the rings having inlet conduit and outlet conduit means communicating with the circular passageway, the rings and washers being disposed in the form of a stack of axially aligned rings, first and second end cover plates mounted on the ends of the stack, means clamping the first and second end cover plates together and holding the rings and washers in position therebetween, fluid inlet means communicating with the inlet conduits of all of the rings for bringing a cooling fluid thereto, fluid outlet means communicating with the outlet conduits of all of the rings for conducting fluid therefrom, gas inlet means communicating with the spaces between all of the rings, gas to be heated being admitted to the chamber formed by the rings and the first and second end cover plates by passing between the rings, nozzle means disposed in the second end cover plate, means for applying an energizing potential to at least two selected rings to produce an electric arc in the chamber between the selected rings, and means for setting up a magnetic field in the chamber, the gas in the chamber after being heated by the electric arc being exhausted through the nozzle means.

10. Arc heater apparatus comprising, in combination, a plurality of similar annular rings composed of conductive material and disposed in axial alignment in a stack, a plurality of annular insulating gaskets disposed between the rings and insulating and spacing each ring from the rings on each side thereof, a first end cover plate composed of a nonmagnetic material disposed adjacent the ring at one end of the stack, an additional gasket insulating the first end cover plate from said adjacent ring, a second end cover plate located adjacent the ring at the other end of the stack, the second end cover plate having an annular aperture therethrough, nozzle means disposed in the annular aperture, a further gasket insulating the second end cover plate from the adjacent ring, each of the rings having a plurality of concentric circular passageways therein of progressively increasing diameter, each of the rings having conduit means therein connecting with the plurality of circular passageways for bringing a cooling fluid to the passageways and conducting fluid therefrom, means for admitting gas to be heated to the chamber through the spaces between rings, means for applying an energizing potential to a selected two of the rings to form an electric arc therebetween inside the chamber, and means for setting up a magnetic field of predetermined strength and direction inside the chamber, the arc heating the gases admitted to the chamber whereafter the gases are exhausted through the nozzle means.

11. Arc heater apparatus according to claim 10 wherein the insulating gaskets are additionally characterized as being of greater inner diameter than the inner diameter of the rings whereby an annular space exists between each pair of rings, each of the rings having a transverse bore therethrough communicating with the annular spaces, means forming gas input header means communicating with the transverse bores and the annular spaces, a plurality of annular ring members composed of insulating material disposed partially in the annular spaces respectively, the thickness of the annular ring members being such as to allow substantially unimpeded flow of gas in the annular spaces, each of the annular ring members having a plurality of radially extending passageways therethrough at spaced intervals around the periphery thereof for the flow of gas into the chamber.

12. Arc heater apparatus comprising, in combination, chamber forming means including a plurality of annular rings composed of conductive material and a plurality of insulating gaskets, the rings and gaskets being formed in a stack, there being a gasket disposed between each pair of adjacent rings and insulating each ring from the adjacent rings on both sides thereof, first and second end plate means disposed at the ends of the stack, means securing the first and second end plate means and the rings and gaskets in position to form an arc chamber, one of the end plate means having an aperture therein, nozzle means mounted in said aperture, the first and second end plate means and all of the annular rings having passageways therein for the passage of a cooling fluid, a plurality of annular rings members composed of insulating material disposed between each gasket and the chamber with an annular space between the ring member and the gasket, the annular rings and at least one of the end plate means having apertures therein for admitting gas to the annular spaces between gaskets and ring members, each of the annular ring members having a plurality of radially extending apertures therein at spaced intervals around the periphery thereof whereby gas from the annular spaces is admitted to the chamber at a plurality of spaced points between each pair of rings, each of the rings having an annular tongue on one side thereof and an annular groove on the other side thereof, the tongue of one ring extending into the groove of the adjacent ring while the rings are mounted in the stack without touching the adjacent ring and providing optical baffling for the ring members of insulating material which provide for the admission of gas to the chamber, means for setting up a magnetic field in the chamber, and means for applying an energizing potential to at least a selected two of the rings to cause an electric arc therebetween inside the chamber, gas admitted to the chamber after being heated by the arc being exhausted from the nozzle means.

13. Apparatus according to claim 10, wherein the first and second end cover plates are additionally characterized as having a plurality of annular passageways therein near the inside surface thereof, each of the end cover plates having water header means communicating with all of the annular passageways therein for bringing a cooling fluid to the annular passageways, and other water header means for conducting fluid therefrom.

14. Arc heater apparatus comprising, in combination, chamber forming means, said chamber forming means including a wall portion consisting of a plurality of alternate rings and washers, the rings being composed of conductive material and the washers being composed of electrically insulating material, means connected to at least a selected two of the rings for bringing an energizing potential thereto and producing at least one arc inside

the chamber, means for admitting gas to be heated to the chamber through at least one of the spaces between adjacent rings, nozzle means operatively connected to the chamber for exhausting heated gas therefrom, and means disposed in predetermined position with respect to the chamber for setting up a magnetic field therein.

15. Apparatus according to claim 1 wherein the means for admitting gas to be heated to the chamber includes means between the wall portions for conducting gas to be heated into the chamber at a plurality of spaced points around the peripheries of the wall portions.

16. Apparatus according to claim 14 wherein the rings are additionally characterized as each having at least one annular passageway therein near the inner surface thereof, means for bringing a cooling fluid to the annular passageways of all of the rings, and means for conducting fluid from the annular passageways of all of the rings.

17. Apparatus according to claim 2 wherein the two wall portions are additionally characterized as including annular passageways therein near the inside wall of the chamber, and including in addition means for conducting a cooling fluid to the annular passageways, and means for conducting the fluid from the annular passageways.

18. Apparatus according to claim 9 wherein each of the rings is additionally characterized as having an annular tongue extending therearound at a predetermined position thereon and each of the rings is additionally characterized as having an annular groove therein at a predetermined position thereon opposite to the annular tongue, the tongue of one ring extending into the groove of the adjacent ring without making electrical contact therewith while the rings are mounted in the stack, the tongues providing optical baffling for the insulating material disposed between the rings.

19. Arc heater apparatus comprising, in combination, chamber forming means including a wall portion, the wall portion including at least two sections of substantially the same inner diameter electrically insulated from each other, means for bringing an electrical potential to said two sections to produce an electric arc therebetween inside the chamber, means for admitting gas to be heated to the chamber between the two sections, nozzle means for exhausing heated gas from the chamber, and means for setting up a magnetic field in the chamber.

20. Apparatus according to claim 19 additionally characterized as including at least four wall sections electrically insulated from each other, and means for applying a three phase alternating current potential to the four wall sections to produce an arc having three arc paths inside the chamber.

21. Apparatus according to claim 19 additionally characterized as including at least first, second and third wall sections electrically insulated from each other, means for applying a potential between the first and second wall sections to produce a first arc in the chamber between the first and second wall sections, and means for applying an additional potential between the second and third wall sections to produce a second arc in the chamber between the second and third wall sections.

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