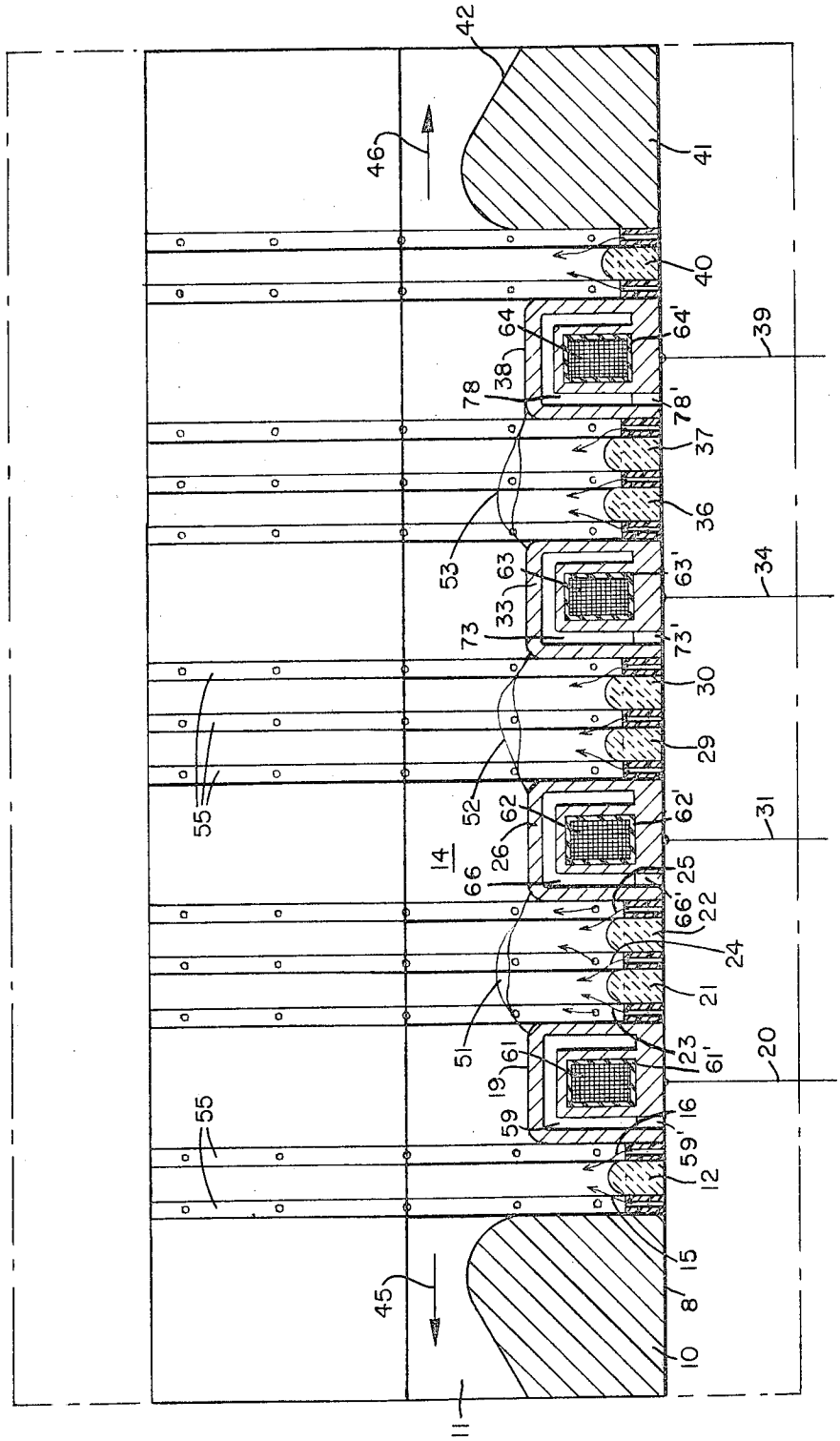
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CROSS REFERENCE ___ SEARCH ROOM

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DUAL EXHAUST THREE-PHASE ALTERNATING CURRENT ARC HEATER FOR CHEMICAL PROCESSING

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DUAL EXHAUST THREE-PHASE ALTERNATING CURRENT ARC HEATER FOR CHEMICAL PROCESSING

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ABSTRACT OF THE DISCLOSURE

An arc heater has four axially spaced annular electrodes with heat shields therebetween, and exhaust nozzles at each end with a heat shield between each nozzle and the adjacent electrode, all forming an arc chamber. The four electrodes are connected to a three phase source of alternating current to produce three arcs. Each electrode has a field coil therein to set up a magnetic field for rotating the arc(s) therefrom in an annular path. Gas is admitted to the arc chamber on both sides of all electrodes through annular paths which extend around substantially the entire periphery of the arc chamber. No portion of the gas passes through more than two arcs before being exhausted; the two exhaust vents provide for quenching a pyrolyzed process gas to a temperature at which desired recombination products are present in substantial proportion in a very short time, for example less than one microsecond.

CROSS REFERENCES TO RELATED APPLICATIONS

The use of electric arc heaters for chemical processing is described and claimed in copending patent applications assigned to the assignee of the instant invention, one of said copending applications being entitled "Arc Heater Apparatus for Chemical Processing," Ser. No. 471,914, filed July 14, 1965, by P. F. Kienast et al., now issued Pat. No. 3,445,191; another of said applications being entitled "Cross Flow Arc Heater Apparatus and Process for the Synthesis of Carbon, Acetylene, and Other Gases," Ser. No. 507,345, filed Nov. 12, 1965, by A. M. Bruning et al.; and a further one of said patent applications being entitled "Direct Conversion Chemical Processing Arc Heater," Ser. No. 527,787, filed Feb. 16, 1966, by D. A. Maniero et al., now Pat. No. 3,284,782.

FIELD OF THE INVENTION

This invention relates to improvements in arc heaters and more particularly to an improved arc heater especially suitable for chemical processing, employing a three phase source but in which gas passes through at most two arcs.

DESCRIPTION OF THE PRIOR ART

It has been known for many years that a hydrocarbon gas may be pyrolyzed by action of an electric arc and that, if the pyrolyzed gas was cooled, at certain temperatures and pressures a desired recombination product or products would be present in substantial proportion. One prior art patent exemplifying the process is Reissue No. 25,218, issued Aug. 7, 1962, to E. Schallus et al., for "Process for Carrying Out Endothermic Reactions at High Temperatures."

Generally speaking, prior art processes and apparatus do not effect cooling to the desired temperature quickly enough to avoid substantial production of carbon, and in the time interval between pyrolysis and cooling to the temperature of maximum yield of the desired product, other undesired recombination products are produced, reducing the yield of the desired product.

Some prior art apparatus also heats the feedstock gas to a temperature in excess of that required to produce complete pyrolysis.

In our invention, we provide that the gas to be pyrolyzed passes through, at most, two arcs, thereby insuring that the pyrolyzed gas will not be raised to such an extreme temperature that it will take a long time to cool it to a desired temperature at which a desired recombination product is present in substantial proportion. Furthermore, we provide exhaust nozzles at both ends of the arc chamber, so that the pyrolyzed gas can be quenched to a desired temperature in a very short time interval, if desired less than one millisecond.

SUMMARY OF THE INVENTION

In summary the present invention provides an arc heater having dual exhausts at both ends of means forming the arc chamber, thereby deriving certain advantages. One of these advantages is that a minimum residence time interval exists between the time a gas molecule is heated by the arc and pyrolyzed and the time when it is quenched to some predetermined temperature. This is a most important aspect in the production of such reactions as natural gas to acetylene, or air to nitrous oxide, because the product is unstable at high temperatures and the gas must be quenched in less than one millisecond in order to recover the product when such feedstocks as natural gas or air are pyrolyzed by the arc. The dual exhausts of our invention shortens the residence of time while permitting three-phase alternating current operation with the advantages derived from three arcs.

Another important advantage of our invention is that the dual exhausts will enable three-phase alternating current to be utilized for large scale operation. This is important to such reactions as the conversion of natural gas to acetylene, which may require as much as 150 megawatts of power per plant, since the economics of three-phase alternating current are most favorable considering both installed equipment costs and operating efficiency.

A further advantage of the dual exhaust arc heater of our invention is that it reduces the problem of carbon deposition within the arc heater since there is less surface area and fewer arc gaps where carbon can deposit.

Still a further advantage offered by our arc heater is that arc heater operation is more efficient, since some of the hot gas in prior art three phase arc heaters has to travel through three arcing regions, a feature which we have avoided in our invention, and further because no highly radiating high-temperature gas core exists or is required to the extent that it would be in the standard three-phase arc heaters designed according to the prior art.

Furthermore, since very high enthalpies of 10,000 to 20,000 B.t.u. will not be required for optimum acetylene production, and in fact high enthalpy levels of this order must be avoided since they produce excessive carbon, the short arc gap operation of a few inches per arc provided by our apparatus is very desirable. Gas introduced into our arc heater flows through either one or two arcs prior to being exhausted.

BRIEF DESCRIPTION OF THE DRAWING

The single figure of the drawing illustrates a dual exhaust arc heater according to our invention, a portion of the drawing being in section in which the electrodes, nozzles, and heat shields are shown schematically.

DESCRIPTION OF THE PREFERRED EMBODIMENT

In the drawing between boundary lines 7 and 8, reading from left to right there is a nozzle generally designated

10 having an exhaust vent 11, a heat shield 12 which it is understood has electrical insulating means electrically insulating it from the nozzle, and which electrical insulation or heat shield includes means for admitting a gas into the arc chamber generally designated 14, on both sides of the heat shield 12. The heat shield member 12 and the means for bringing gas into the arc chamber 14 in paths indicated by the arrows 15 and 16 may be similar to that described in one of the aforementioned copending patent applications or in an application for "Gas Arc Heater," Ser. No. 349,893, filed Mar. 6, 1964, now issued Patent No. 3,309,550, by C. B. Wolf et al., and assigned to the assignee of the instant invention. On the other side of the heat shield member 12 is a first electrode generally designated 19 having means connected thereto symbolized by lead 20 for connecting the electrode to one terminal of a three-phase source of alternating current potential. The electrode 19 has coil 61 in insulating housing 61' mounted therein; the electrode fluid cooled over the portion of the surface thereof which is exposed to direct radiation from any arc in the chamber 14, as is the portion of the surface of nozzle member 10 which is exposed to direct radiation or exposed to very hot gases, by means not shown for convenience of illustration. Generally speaking the cooling means for the electrode 19 includes a passageway 59 therein near the arc-exposed surface for circulating a cooling fluid, the passageway 59 connecting with fluid inlet 59', there being a similar fluid outlet not shown in the plane selected for illustration, which in turn have fluid inlet and fluid outlet header means connected thereto and extending to the outside of the arc heater, and if desired being in the area between boundary line 8 and the adjacent parallel dashed line representing the outside diameter of the pressure vessel or arc heater. Generally speaking the cooling arrangement may be similar to that shown and described in the aforementioned copending application Ser. No. 527,789. On the right hand side of the aforementioned electrode 19 there is an additional portion of a heat shield comprising two heat shield rings designated 21 and 22. Ring 21 is electrically insulated from electrode 19 and is also electrically insulated from ring 22. On the other side of ring 22 there is also electrical insulation which insulates ring 22 from a second electrode 26 which has field coil 62 therein, the coil 62 having insulating housing 62' therearound. The rings 21 and 22 and the electrical insulating means disposed between the two rings and between the rings and the adjacent electrodes provide for the admission of process gas through three paths indicated by the arrows 23, 24 and 25. On the other side of the aforementioned electrode 26, which is fluid cooled by passageway 66 therein having inlet 66', is another section of the heat shield including ring members 29 and 30, and electrode 26 has lead 31 for connecting it to one terminal of a three-phase alternating current source. On the right hand side of the aforementioned ring member 30 of the heat shield is a third electrode 33 having a lead 34 for connecting it to one terminal of a three-phase source of alternating current. Electrode 33 is fluid cooled by passageway 73 therein having inlet 73', and the electrode 33 has field coil 63 therein, the coil 63 having insulating housing 63' therearound. On the right hand side of the aforementioned electrode 33 are additional heat shield rings 36 and 37, and on the right hand side of ring 37 there is a fourth electrode 38 having a lead 39 thereto for connecting the electrode 38 to one terminal of an alternating current three-phase source. Electrode 38 has fluid passageway 78 therein with inlet 78', and the electrode 38 has field coil 64 therein mounted within insulating housing 64'. If desired electrodes 19 and 38 may be connected to the same terminal of the three-phase source with the resulting production of three arcs 51, 52 and 53 between the electrodes as shown. Any suitable preferably direct current source, not shown, is provided, connected to the magnetic field coils for energizing the same, the coils producing magnetic fields which cause arcs 51, 52 and 53 to rotate in annular paths. The field coils may be similar

to those described in aforementioned copending application Ser. No. 527,789. To the right of electrode 38 is another portion of a heat shield which may comprise a single ring 40 with means on both sides thereof for admitting gas into chamber 14; ring 40 has adjacent thereto but electrically insulated therefrom on the other side an additional nozzle member 41 having an additional exhaust vent 42, nozzle member 41 being fluid cooled by means not shown for convenience of illustration.

Summarizing, all heat shield rings are electrically insulated from each other and from adjacent nozzle members and/or adjacent electrodes.

In accordance with the condition of operation of the arc heater, gas leaving the arc heater through the exhaust vents 11 and 42 in paths indicated by the two arrows 45 and 46 may be substantially completely pyrolyzed process gas or may be gas which has been quenched to a certain temperature in a certain time interval, the time interval for example it takes gas passing through the arc 51 to pass through the exhaust vent 11, or the time interval which takes gas passing through arc 53 to pass through the exhaust vent 42. As a result the gas obtained from the arc heater may actually contain some of the desired recombination product. The invention includes and contemplates the use of additional quenching means, when needed, to obtain complete quenching in a short interval of time, for example less than one millisecond, the additional apparatus not being shown for convenience of illustration. Examples will be found in the prior patented art and in the literature of the art. Clamping means, not shown for convenience of illustration, is provided for clamping nozzle 10 to nozzle 41 and clamping all of the members therebetween firmly in position. The clamping means may include bolts extending the entire length of the apparatus and having nuts which are tightened to provide the clamping.

It is seen that gas enters the arc chamber 14 through 13 different points or paths indicated by the 13 arrows some of which have been identified as arrows 15, 16, 23, 24 and 25. Gas also enters the arc chamber by the three paths indicated by the arrows underneath the arc 52; gas also enters the arc chamber by three paths indicated by the arrows under arc 53, and gas also enters the arc chamber by paths indicated by the two arrows on the two sides of the heat shield 40, making a total of 13 different paths. It will be understood that the paths indicated by the arrows are actually paths which are substantially annular or which extend substantially 360° around the entire arc chamber, these paths being provided if desired by a plurality of peripherally spaced bores communicating with suitably located annular gas headers in the rings of the heat shield, or in the electrodes, or in the nozzle members, in accordance with the teachings of one or more of the aforementioned copending patent applications. It will be understood that the gas headers, not shown for convenience of illustration, have gas inlets, not shown.

It is further to be understood that all of the heat shield rings are insulated from each other, from the adjoining or adjacent electrodes, and from the nozzle members by annular rings composed of electrical insulating material, some of these rings being previously mentioned, these rings being shown in the top portion of the drawing and designated 55. The rings are preferably composed of a heat resistant material such for example as Teflon. Additionally the heat shield members, the nozzles and the electrodes may include tongue and groove configurations which optically baffle the inner surfaces of the insulation members 55 so that they are not exposed to direct radiation from any of the arcs within the arc chamber. These tongues and grooves may be similar to those shown and described in a copending patent application by G. A. Kemeny et al. for "Arc Heater Apparatus," Ser. No. 428,599, filed Jan. 13, 1965, now Pat. No. 3,379,908.

It is to be understood that the aforegoing written description and the drawing are illustrative only and are not to be interpreted in a limiting sense.

We claim as our invention:

1. An arc heater for chemical processing comprising means forming a generally cylindrical arc chamber having an exhaust vent at each end thereof, the arc chamber forming means including four axially spaced coaxially aligned electrodes having similar dimensions and three spacing heat shield means having similar dimensions separating the four electrodes, the four electrodes being adapted to be connected to a three phase source of alternating current potential to produce three arcs in the arc chamber, the diameter of the arc chamber being large compared to the width of the electrodes, and the spacing between electrodes being at least substantially as great as the width of the electrodes, each of the spacing heat shield means including means forming a plurality of axially spaced and peripherally spaced radially extending passageways for bringing gas into the arc chamber in the spaces between electrodes at radial positions greater in distance from the axis than the radial positions of the arcing surfaces of the adjacent electrodes, the peripherally and axially spaced passageways between any two adjacent electrodes insuring that a sufficient volume of gas may be brought in to be heated by the arc between said adjacent electrodes without substantial blowing of the arc toward the axial center of the arc heater thereby avoiding the formation of a highly radiating high temperature gas core in the arc chamber with a resulting loss of heating efficiency and a reduction in the amount of the desired recombination product.

2. An arc heater according to claim 1 wherein each of the electrodes is additionally characterized as having an annular passageway therein extending around the entire periphery of the electrode for the flow of cooling fluid, and each electrode has a field coil mounted in an opening therein for setting up a magnetic field which exerts a force or forces on the arc or arcs which cause the arcs to rotate substantially continuously around the electrodes and between adjacent electrodes without moving the arcs toward the axial center of the arc chamber.

3. An arc heater according to claim 1 additionally characterized as having means located between each exhaust vent and the nearest adjacent electrodes for introducing a quenching fluid into the arc chamber through paths wherein the quenching fluid does not pass through an arc.

4. Arc heater apparatus including a plurality of coaxially aligned axially spaced electrodes adapted to be connected to a source or sources of potential to produce and sustain arcs therebetween, heat shield means interposed between and spacing each adjacent pair of electrodes, the heat shield means being electrically insulated from the electrodes on both sides thereof and including passageway forming means for bringing a process gas into the arc heater through a path wherein the process gas passes through an arc path, the arc pyrolizing the process gas, the electrodes and heat shield means at least partially enclosing and forming a generally cylindrical arc chamber, first nozzle means for exhausting heated gas from one end of the chamber, second nozzle means for exhausting heated gas from the other end of the chamber, first and second means forming first and second quenching zones having predetermined similar positions with respect to the first and second nozzle means respectively, the first and second quenching zone forming means being substantially equally spaced from the nearest respective electrode of the plurality of electrodes, the first and second quenching zone forming means including passageway forming means for bringing in a quenching fluid and mixing said quenching fluid with heated gas as the heated gas moves in a direction from the electrodes toward a nozzle means whereby the dwell time of any portion of the process gas heated and pyrolized in the arc heater and the time to quench are maintained substantially uniform, the rate of admission of the quenching fluid being chosen in accordance with the flow rate of the process gas and the temperature to which it is heated when pyrolized in the arc chamber whereby a substantial portion of the total gas output of the arc heater has been cooled in a time not exceeding a predetermined time to a temperature within a range of temperatures within which the desired recombination product is present in substantial proportion.

5. Arc heater apparatus including a plurality of coaxially aligned axially spaced electrodes adapted to be connected to a source or sources of potential to produce and sustain arcs therebetween, the electrodes having substantially cylindrical inner surfaces of a first predetermined diameter, the cylindrical inner surfaces being also coaxially aligned, heat shield means interposed between and spacing each adjacent pair of electrodes, the heat shield means being electrically insulated from the electrode on both sides thereof and including passageway forming means for bringing a process gas into the arc heater through a path wherein the process gas passes through an arc path and is pyrolized by the arc, the electrodes and heat shield means at least partially enclosing and forming a generally cylindrical arc chamber, first nozzle means for exhausting heated gas from one end of the arc chamber, second nozzle means for exhausting heated gas from the other end of the arc chamber, first and second means forming first and second quenching zones having predetermined similar positions with respect to the first and second nozzle means respectively, the first and second quenching zone forming means being substantially equally spaced from the nearest respective electrode of the plurality of electrodes, the heat shield means having a second predetermined inside diameter substantially greater than the inside diameter of the inner surfaces of the electrodes whereby process gas is admitted at a position radially substantially more distant from the axis than the positions of the cylindrical surfaces of the electrodes, the rate of process gas admission being preselected and the radial distance between the position where the process gas is admitted and the position of the arc between electrodes being preselected whereby the arc is not elongated by the gas and the gas does not cause the arc to become unstable, thereby insuring that all portions of the admitted process gas are heated to and pyrolized at substantially the same temperature, the rate at which quenching fluid is admitted being selected in accordance with the process gas flow rate and said last named temperature whereby at least the major portion of the total gas output of the arc heater is cooled within a time not exceeding a predetermined time to a temperature within a range of temperatures within which the desired recombination product is present in substantial proportion.

6. Arc heater apparatus according to claim 5 wherein the inside diameter of the cylindrical surfaces of the electrodes is at least several times as great as the radial distance between an electrode inner surface and the position of process gas admission, thereby assisting in preventing the formation within the arc chamber of a highly radiating high temperature gas core.

7. Arc heater apparatus according to claim 5 wherein the first and second quenching zone forming means are additionally characterized as each including passageway forming means for bringing in a quenching fluid and mixing said quenching fluid with heated gas as the heated gas moves in a direction from the electrodes toward a nozzle means whereby the dwell time of any portion of the process gas heated and pyrolized in the arc heater and the time to quench are maintained substantially uniform thereby further increasing the portion of the total gas output of the arc heater which is cooled to a temperature within a range of temperatures at which the desired recombination product is present in substantial proportion.

8. Arc heater apparatus according to claim 5 in which each of the electrodes is additionally characterized as having an annular magnetic field coil therein for setting up a field which exerts a force or forces on the arc or arcs from the electrode which causes an arc to move substantially continuously in an annular path around the arcing surface of the electrode and in an annular path between adjacent electrodes, the movement of the arc assisting in preventing the arc from pitting, scarring, and deforming the surface of the electrode in a manner which would tend to cause the length of the arc to vary over its annular path and thereby vary the heat imparted to any portion of the gas.

9. Arc heater apparatus according to claim 8 in which each electrode is additionally characterized as having a passageway for the flow of cooling fluid therein near the arcing surface with a fluid inlet and a fluid outlet communicating with said passageway, the fluid conducting heat

flux from the arcing surface and further assisting in preventing the arc from pitting, scarring, and deforming the surface of the electrode.

References Cited

UNITED STATES PATENTS

2,041,663	5/1936	Marx	315—111
3,139,509	6/1964	Browning	219—75
3,309,550	3/1967	Wolf et al.	315—111 X
3,400,070	9/1968	Naff	313—231 X
3,406,306	10/1968	Maniero et al.	315—111 X

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