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[11] 3,832,519
[45] Aug. 27, 1974

# [54] ARC HEATER WITH INTEGRAL FLUID AND ELECTRICAL DUCTING AND QUICK DISCONNECT FACILITY

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[73] Assignee: **Westinghouse Electric Corporation**, Pittsburgh, Pa.

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[21] Appl. No.: **279,895**

[52] **U.S. Cl.** .............. **219/121 P**, 219/383, 313/231
[51] **Int. Cl.** .............................................. **B23k 9/00**
[58] **Field of Search** ............ 219/121 P, 74, 75, 383; 313/231; 85/32 W

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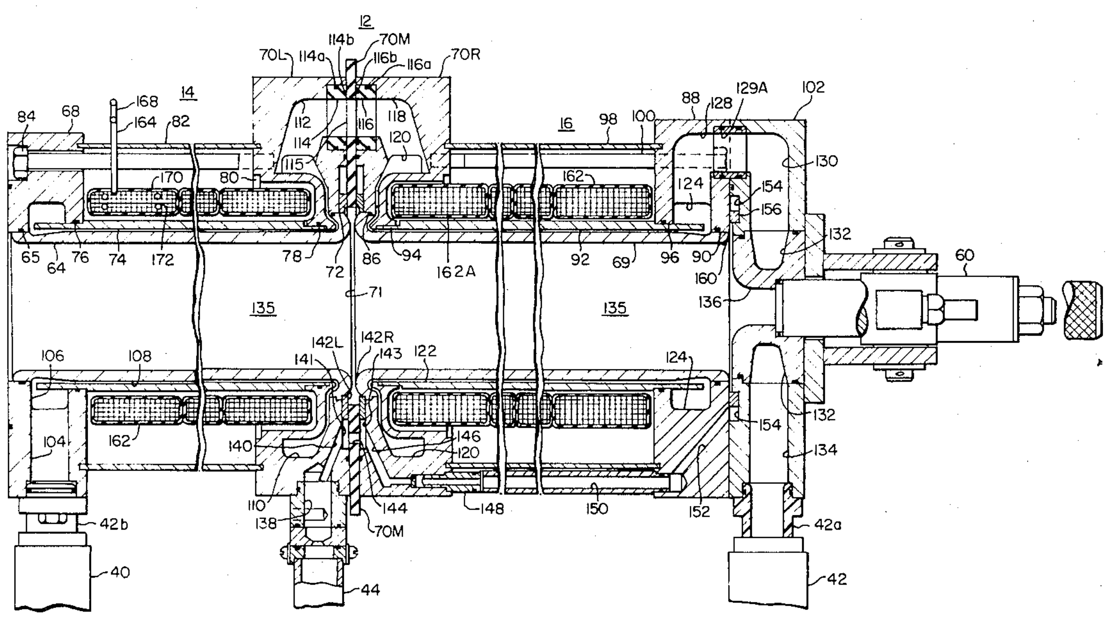
*Attorney, Agent, or Firm*—M. J. Moran

## [57] ABSTRACT

An arc heater having simplified construction allowing the use of electrodes of varying length and field coils of varying number and employing a field coil cooling fluid manifold which is adapted to provide cooling fluid and electrical power to discrete field coil assemblies. The apparatus includes an internal process gas metering orifice between electrode assemblies to allow the flow of process gas from a downstream gas entry port to an upstream gas admission ring and thence to the arc chamber in addition to a central gas admission ring disposed longitudinally between electrodes. The upstream ducting channel for the previously described process gas system includes a metering valve therein for volume control. The arc heater apparatus also includes fluid tight sealing means in a unitary electrode cooling channel. This sealing means is disposed parallel to the gap between the separable electrodes of the arc heater apparatus. When the arc heater is in an operable disposition the sealing means utilize the cooling fluid pressure to enhance sealing. The sealing means also has a special insulating configuration to increase the electrical insulation between electrodes in the electrode cooling path of differing electrical potential.

**4 Claims, 7 Drawing Figures**



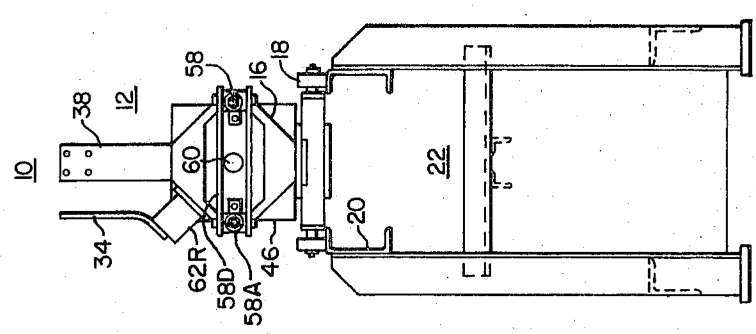
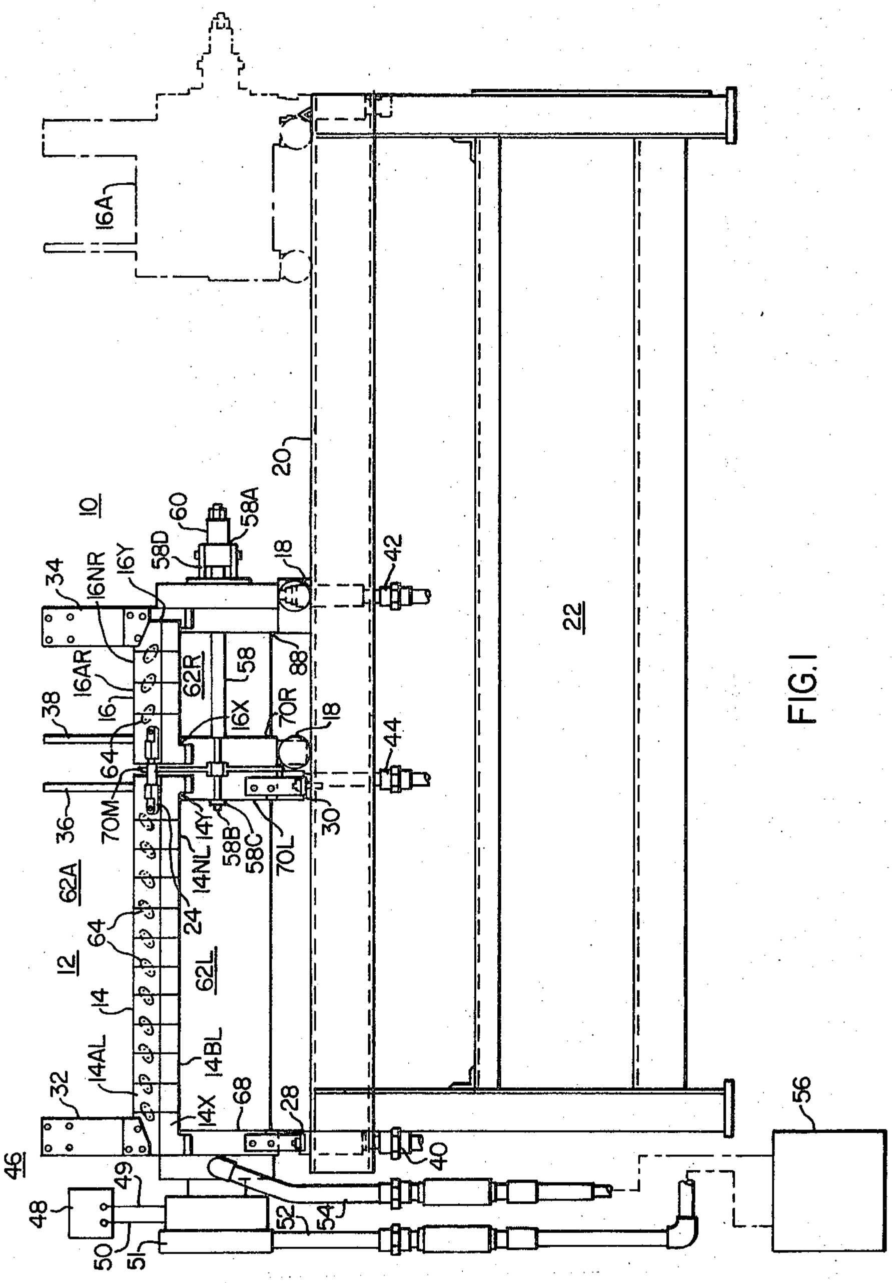

10
12
38
34
58
18
16
60
22
20
62R
58D
58A
46

FIG. 2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20
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58A
58D
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42
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16NR
16Y
16AR
62R
58
88
16X
70R
18
44
38
16
64
36
70M
14Y
58B
58C
70L
30
24
14NL
62A
64
12
14
62L
14AL
14BL
32
14X
68
28
40
46
48
49
50
51
52
54
56
22

FIG. 1

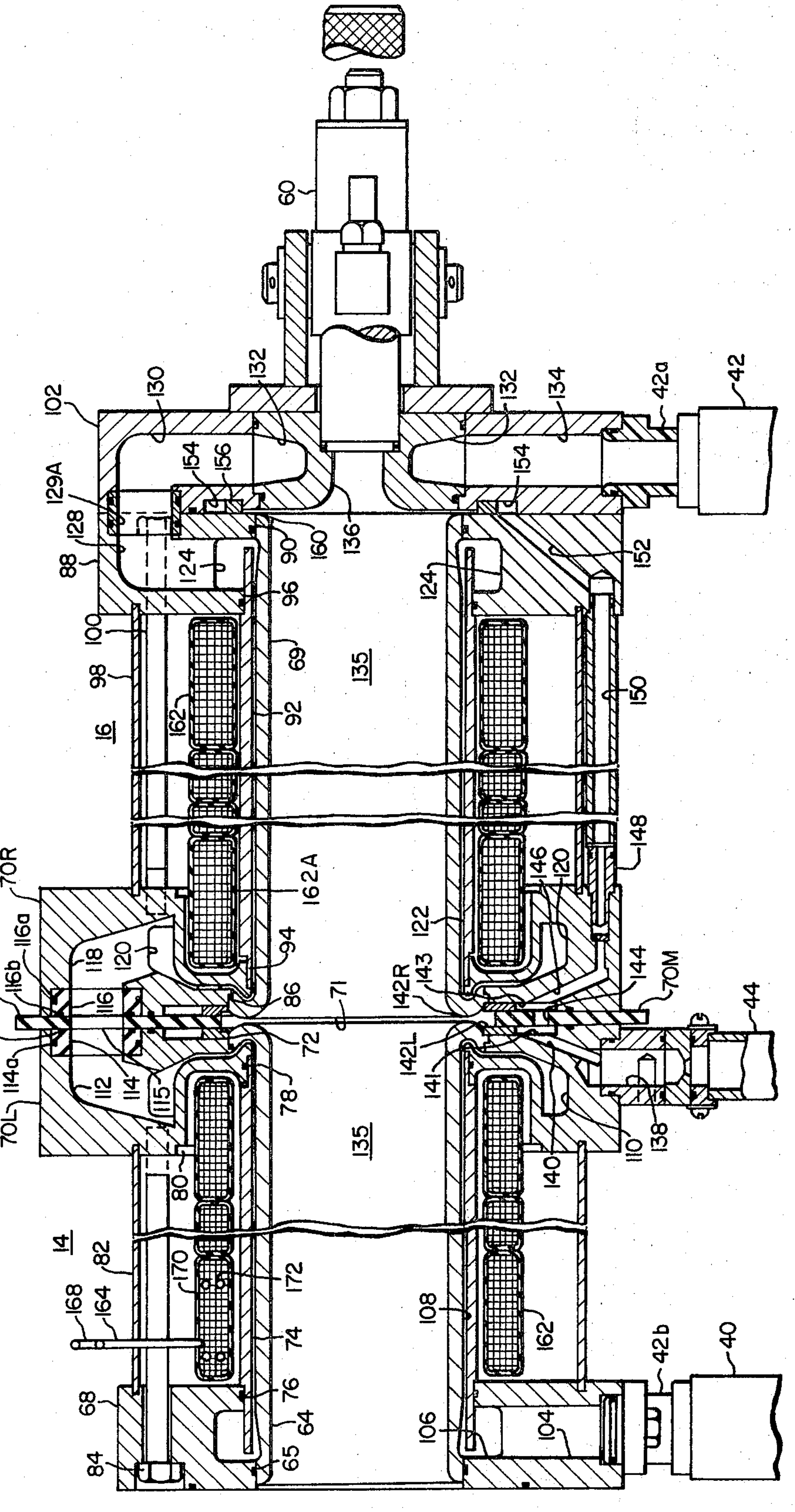
60
102
130
132
132
134
42a
42
129A
154
156
154
128
88
124
90
160
136
124
152
96
100
98
69
135
150
16
162
92
148
70R
162A
122
146
120
70M
116a
118
120
94
143
142R
144
12
116b
116
86
71
114b
114a
112
114
72
142L
141
70L
115
78
110
138
44
135
140
80
14
82
170
172
108
168
164
162
74
42b
40
68
76
106
104
84
64
65

FIG.3

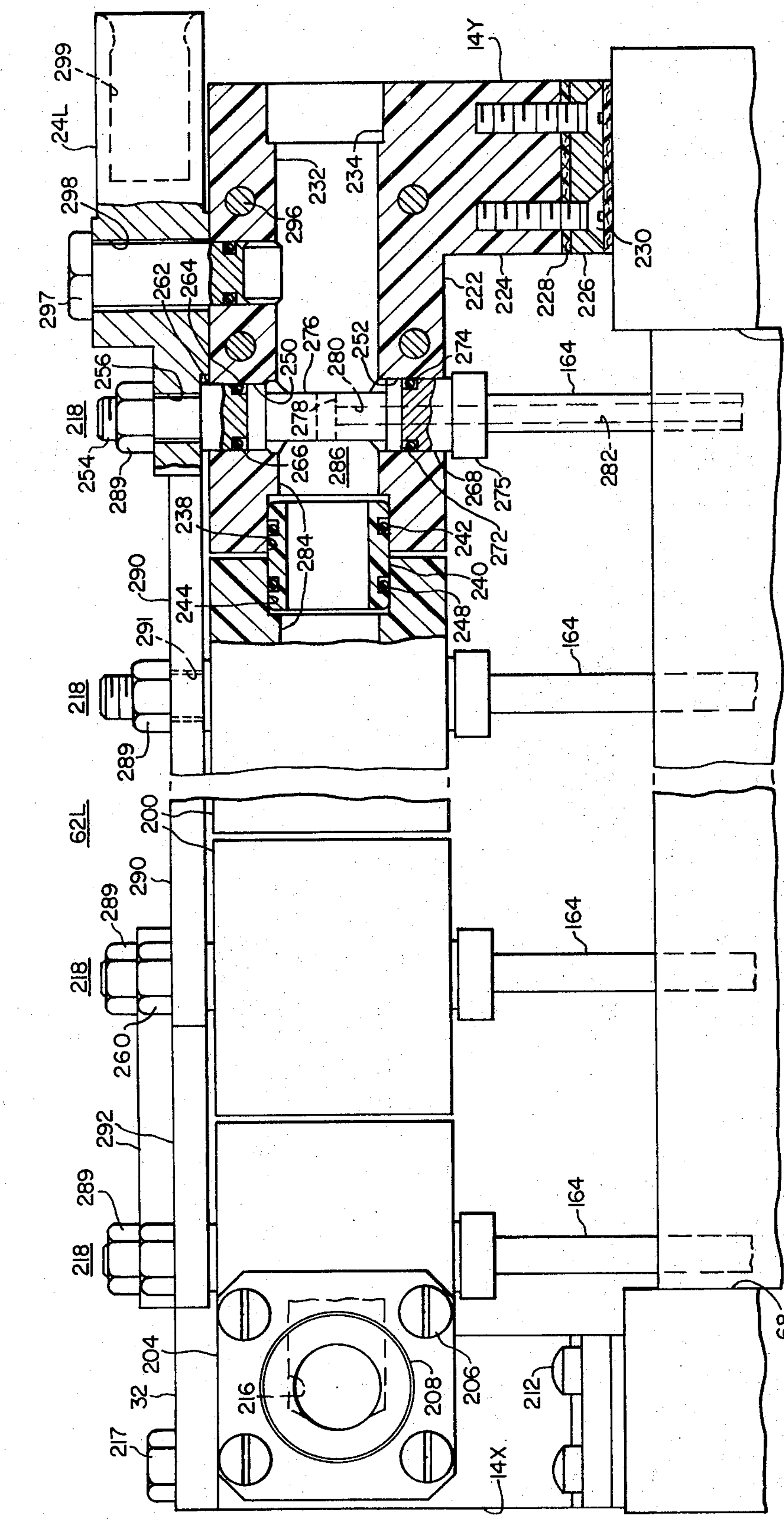
14Y
299
24L
298
297
262
264
256
218
254
289
232
234
296
222
224
228
226
230
70L
276
250
252
280
278
274
266
286
268
275
272
164
282
238
284
242
240
244
248
290
291
62L
200
260
292
204
32
217
216
208
206
212
14X
68

FIG. 4.

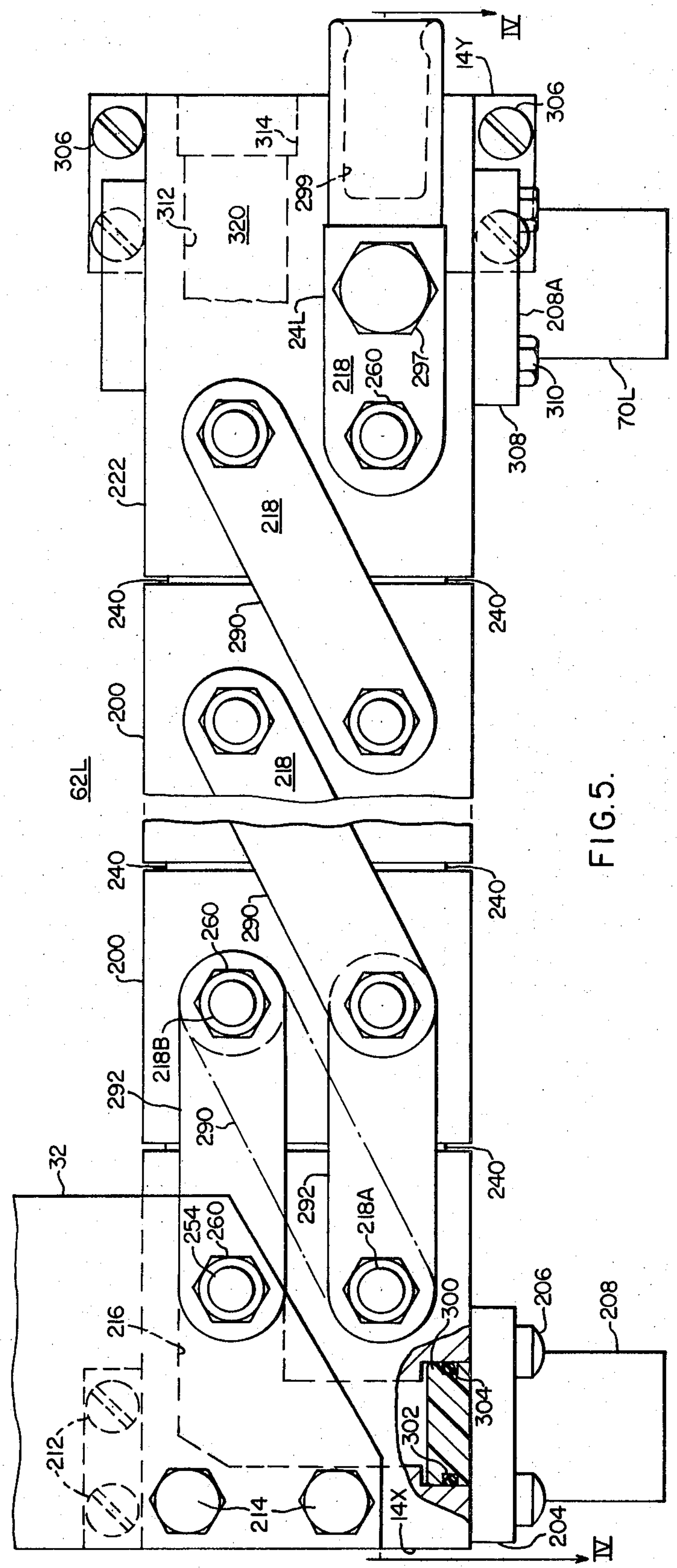
IV
14Y
306
306
314
312
320
299
24L
208A
297
218
260
310
70L
308
222
218
240
240
290
200
218
62L
240
240
260
290
200
218B
292
290
32
240
292
218A
254
260
216
300
206
208
304
302
212
214
14X
204
IV

FIG.5.

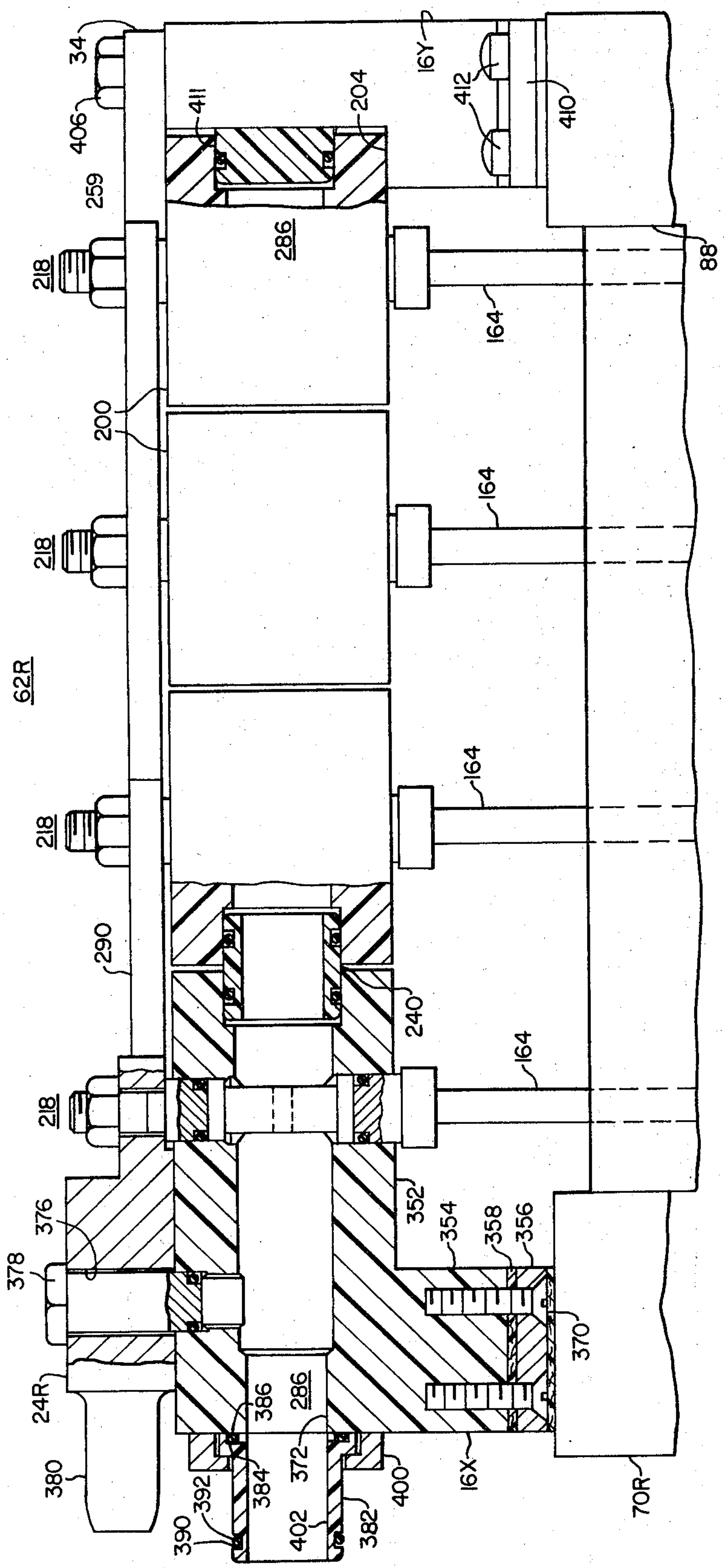
34
406
259
411
204
16Y
412
410
88
286
218
164
200
62R
290
240
352
354
358
356
376
378
370
24R
386
286
380
392
384
372
400
16X
70R
390
402
382

FIG.6.

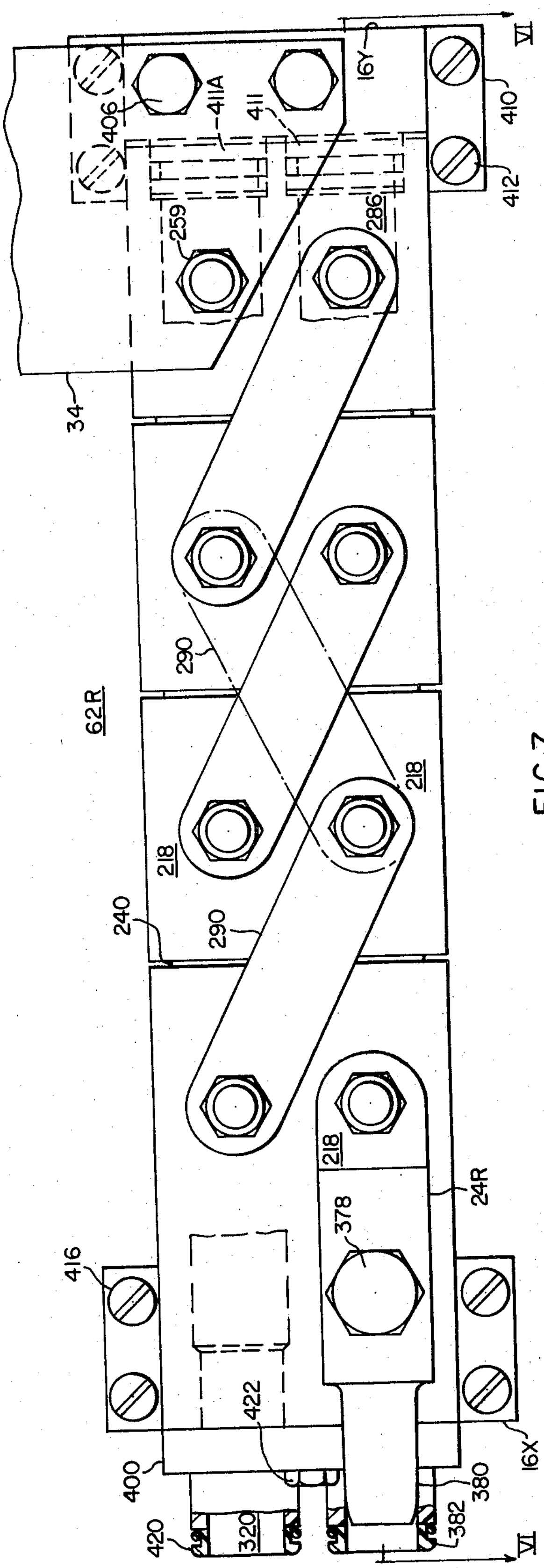
VI
16Y
410
412
406
411A
411
259
286
34
290
62R
218
240
24R
378
416
422
400
420
320
380
382
16X
VI

FIG. 7.

# ARC HEATER WITH INTEGRAL FLUID AND ELECTRICAL DUCTING AND QUICK DISCONNECT FACILITY

## CROSS REFERENCE TO RELATED APPLICATIONS

Certain inventions related to those disclosed in the present application are disclosed and claimed in copending application Ser. No. 279,894, now U.S. Pat. No. 3,760,151, filed concurrently herewith and assigned to the same assignee as the assignee of the present invention.

## BACKGROUND OF THE INVENTION

1. Field of the Invention

This invention relates to arc heaters in general and in particular to arc heaters which may be disassembled quickly and conveniently.

2. Description of the Prior Art

Prior art arc heater apparatus often comprise two generally cylindrically shaped, hollow, axially aligned electrodes having a small annular gap therebetween. An electric arc energized from a convenient external source of electrical power is struck between the cylindrical electrodes in the gap. Because of the heat generated by the arc, cooling channels are often disposed against the outer perimeter of the cylindrical electrodes. In addition, in some prior art arc heaters process material or gas is supplied through a convenient ducting means to the annular gap to be introduced radially into the arc chamber. Also, in some apparatus gas and other feed material is provided to the arc chamber at a point upstream of the annular gap so that it may flow downstream past the annular gap internal to the electrode within the arc chamber. Also, in some prior art arc heaters annular or cylindrical electromagnetic field coils are disposed adjacent to the outer surface of the cylindrical electrodes to provide a magnetic field which may be used to rotate the arc around the annular gap. These field coils require a cooling system and electrical power. In most of the prior art arc heaters the electrodes of the arc heater are separable axially at the annular gap. This place is usually chosen because a voltage difference exists between the electrodes for striking the arc. In addition, should the gap need to be varied in size, spacers may be provided in this region for that purpose. Also, as was mentioned previously the annular gap is the place where gas or fluid is quite often introduced into the arc heater for processing and other purposes. Consequently, a separate annular gas introducing ring is usually provided in this region.

Certain problems, however, arise with the use of prior art arc heater apparatus one of which is caused by the means for channeling cooling fluid and conducting electrical power through fluid channels and electrical conductors, respectively, across the annular gap. The arc heater apparatus should be easily disassembled or separated in the region of the annular gap so that the two electrodes can be separated from each other axially for cleaning inspection or replacement of defective parts without necessitating disassembly of relatively permanent piping hardware and electrically connecting fixtures, but this is not usually the case. In some instances attempts have been made to provide for quick disconnect or quick disassembly of the arc heater apparatus by providing separate piping and separate electrical systems for each of the electrodes. In other instances, convenience in separating the electroces is sacrificed for a reduction in the number of hardware fixtures required by providing external innerconnecting piping channels and electrically conducting paths between like parts of the separable arc heater apparatus. Examples of arc heater apparatus employing cooling systems, electrically conducting systems, and fluid admission system of the type previously discussed may be found in U.S. Pat. Nos. 3,400,070 issued to J. T. Naff Sept. 3, 1968 and 3,360,682 issued to R. A. Moore Dec. 26, 1967. In addition, U.S. Pat. No. 3,629,553 by Maurice G. Fey, Charles B. Wolf, Frederick A. Azinger, Jr. and George A. Kemeny issued Dec. 21, 1971, and U.S. Pat. No. 3,663,792 by Maurice G. Fey issued May 16, 1972 which are assigned to the same assignee as the assignee of the present invention are also examples of prior art arc heaters.

It would be convenient to have an arc heater apparatus which was quickly separable between electrodes at the annular gap in such a manner that a minimum number of disconnections of the external piping joints and electrical conductors need be made. One convenient way to do this would be to provide internal quick disconnect electrical conductors, fluid and gas piping connections.

## SUMMARY OF THE INVENTION

In accordance with the invention an electric arc heater apparatus is disclosed which comprises a pair of cylndrical hollow electrodes separated axially by an annular gap having common quickly disconnectable fluid cooling paths for the electrodes, well insulated and fluid tight electrically conducting paths for the electrodes, magnetic field coils surrounding the electrodes with separate electrically connecting paths and fluid cooling paths and process fluid admission ports spaced between the electrodes and at one end of the upstream electrode. The upstream electrode is disposed upon wheels so that it may be moved away from the downstream electrode when disconnected therefrom. The upstream or movable electrode has disposed therein portions of the previously described cooling paths, gas admission paths and electrically conducting paths which may be quickly disconnected from and reconnected to complementary portions of cooling paths, gas admission paths and electrically conducting paths in the downstream or relatively fixed electrode respectively. This is accomplished by providing field coil cooling fluid and electrical power to input and exit ports on the downstream electrode assembly only and by also providing a quick disconnect connector between the upstream and downstream electrodes for the field coil manifold assembly, by also providing a process gas admission input port at the downstream electrode assembly only, and by providing a convenient internal electrode cooling channel bridging path between the upstream electrode and the downstream electrode so that one source of cooling fluid may cool both electrodes serially rather than in parallel as with two separate sources of electrode cooling fluid. Process gas from the downstream electrode entrance port is provided to the annular gap and, through a metering port internal to the arc heater apparatus, to a valved channel in the upstream electrode for provision into the upstream end of the arc chamber either concurrently with or exclusive of the provision of gas into the arc chamber through the admission ring in the annular gap. The electrode assembly is of a construction of the type which may be changed conveniently and easily for changing the size of either the upstream or downstream electrode or both and for changing the number of field coils surrounding either or both of these electrodes. To accomplish the latter purpose a manifolding system for providing cooling fluid to the field coils is provided to service the arc heater apparatus at both the upstream and downstream electrode assembly regions. This manifold system is interconnected by quick disconnect fluid bridging means. In addition, the electrical power for the field coils may be provided serially or in parallel to the field coils by the use of various electrical interlinking members between certain portions of the manifolding apparatus, there also being present in the manifolding apparatus quick disconnecting facilities near the gap for the electrical system.

## BRIEF DESCRIPTION OF THE DRAWINGS

For a better understanding of the invention, reference may be had to the preferred embodiment exemplary of the invention shown in the accompanying drawings in which:

FIG. 1 shows an arc heater station in side elevation;

FIG. 2 shows an arc heater station in rear elevation;

FIG. 3 shows an arc heater section partially broken away;

FIG. 4 shows a view of the downstream field coil manifolding apparatus in side elevation partially broken away and partially sectioned;

FIG. 5 shows a top view of the apparatus shown in FIG. 4;

FIG. 6 shows a view of a section of upstream manifolding apparatus for arc heater field coils partially broken away and partially sectioned and in side elevation; and

FIG. 7 shows a top view of the apparatus shown in FIG. 6.

## DESCRIPTION OF THE PREFERRED EMBODIMENT

Referring now to the drawings and FIG. 1 in particular an arc heater station **10** is shown. Arc heater station **10** comprises an arc heater apparatus **12** having axially or longitudinally separable main sections **14** and **16** which may be known respectively as the relatively stationary downstream electrode assembly **14** and the relatively movable upstream electrode assembly **16.** Movable upstream electrode assembly **16** is disposed upon wheels **18** which move along track **20** of arc heater support assembly **22.** The movable upstream electrode assembly **16** may be moved along the track **20** to the position shown at **16**A in FIG. **1.** The arc heater assembly **12** may be quickly disconnected, that is, movable member **16** may be quickly disconnected from and moved away from relatively stationary member **14.**

A set of connecting rods **58** are provided which are attached at the upstream or right end thereof as viewed in FIG. **1** to a rocker arm **58D** with a nut **58A** threaded to the end of each rod **58.** The left end **58B** of rods **58** extend through aligned axially oriented holes in flanges **70L** and **70R** and in insulator-spacer **70M** to protrude therethrough past the downstream end of flange **80L.** Transverse grooves are placed on the top and bottom of the end region **58B** of rod **58.** The legs of a C-or U-shaped member or clamp **58C** may then be transversely fit on the rod end **58B** in such a manner as to engage the top and bottom groove, previously described, to lock a clamp **58C** to the rod in an axial direction. Consequently, axial motion of the rod toward the upstream end of the arc heater **12** is restrained or prevented by the side portion of the clamp. As it is forced against the downstream end of flange **70L,** the C-clamp **58C** may be prevented from moving transverse to the rod outwardly by fastening the clamp **58C** to the flange with a screw, bolt or similar fastening means. The rod **58** is constrained from moving axially in the downstream direction by the nut **58A** abutting against the upstream side of rocker arm **58D** through which it protrudes.

As can be seen by reference to FIG. **1** and FIG. **2** two sets of nuts or fastening means **58A,** rods **58** and clamps **58C** (not shown) are provided one on each side of the arc heater. As the nuts are tightened on the rods **58,** the upper electrode assembly is compressed against the insulator **70M** and downstream electrode assembly **14.** The rocker arm **58D** may move or pivot about member **60** in an upstream-downstream plane as if member **60** were a fulcrum or pivot. And the nut **58A** may be tightened in sequence to provide an excellent seal of the electrodes assembled against insulator **70M.** In the preferred embodiment of the invention the arc heater may be loosened and the electrodes separated merely by lossening one of the nuts **58A,** because the rocker arm **58D** provides freedom of movement so that the clamp **58C** associated with the rod to which the other nut **58A** is attached may fall loose. This allows for convenient cleaning of, testing of, repairing of, part exchanging in or otherwise performing certain functions on the internal portions of arc heater assembly **12.** It will be noted that an electrical connector **24** is interposed between upstream movable arc heater electrical assembly **16** and downstream arc heater electrode assembly **14.** This provides electrical continuity between the arc heater field coil electrical power terminals which will be identified and described later. The relatively stable or unmovable arc heater electrode assembly **14** is fixed to track section **20** by adjustable support members **28** and **30** at the downstream end and upstream end respectively of the downstream electrode assembly **14.** Adjacent the downstream end of the downstream electrode assembly **14** is an electrical field coil connector or bus bar **32.** Adjacent a portion of the upstream electrode assembly **16** is a similar electrical field coil bus bar or connector **34.** During operation of the arc heater assembly electrical power may flow between terminals **32** and **34** and through the electrical interlock connection **24** to thereby energize the field coils. Adjacent the upstream end of downstream electrode assembly **14** is a main power connector **36.** A similar connector or bus bar **38** may be found on the upstream electrode assembly **16.** Cooling fluid for the electrode or electrodes in arc heater assembly **12** is provided through ports **40** and **42** to ducts adjacent the electrodes within the arc heater assembly **12.** A suitable internal interconnecting means between complementary duct members (not shown) is provided between the upstream and downstream electrode assemblies **16** and **14** respectively. In one embodiment of the invention, cooling fluid may flow into pipe **40** and out of pipe **42** but that is not necessarily the case in all embodiments. In another embodiment cooling fluid may flow into pipe **42** and out of pipe **40.** The cooling fluid may be treated water or some similar cooling substance and may be at a relatively high temperature and may be pressurized super heated water. In some instances it may be a gas such as sulfurhexafluoride. A gas or fluid port piping system **44** is provided to the upstream end of the downstream electrode assembly **14,** process gas or fluid may be provided to a gas admission ring in the gap between electrode assemblies **14** and **16** for introduction into the arc chamber and in one embodiment of the invention to the upstream end of upstream electrode **16** for auxiliary processing purposes.

Adjacent the output or exhaust port of downstream electrode assembly **14** may be a quench tube and materials admission assembly **46** such as the type described in copending application Ser. No. 279,894 now U.S. Pat. No. 3,760,151. This includes a readout and control means **48** connected electrically by way of lines **49** and **50** to the materials admission and quench means tube **51.** Electrical lines or leads **49** and **50** may interconnect with a stray arc detector means within the materials admission means **46.** Flowing fluid for materials admission and quench means **46** may be provided through pipes or fluid conducting paths **52** and **54,** respectively. The fluid may come from a reservoir **56.** A materials admission input duct for supplying quench or other material into the quenching chamber **51** may be present but is not shown for convenience of illustration.

Adjacent the upstream or rear portion of upstream electrode assembly **16** is a plug assembly-pivot means **60** which may be removed for cleaning certain upstream portions of the upstream electrode assembly **16** or for providing an alternative path for the introduction of process fluid into the arc chamber of the arc heater apparatus or for providing an opening into which an electrode may be disposed within the arc heater assembly **12.** The field coil electrical and fluid cooling manifolding system **62A** may have two component parts designated **62L** and **62R** for the left or downstream manifold portion and right or upstream manifold portion respectively. Manifolds **62L** and **62R** may be separated electrically at the connector **24** and the internal fluid ducting paths therein may be also separated or disconnected in this region. The integral members of downstream manifolding system **62L** may be joined by electrically conducting links **64** which are arranged to conduct electrical power for empowering field coil electromagnets within the arc heater apparatus **12.** The downstream end of manifolding system **62L** is supported on downstream flange **68** of downstream electrode assembly **14.** A suitable support member **14X** is provided for this purpose. The upstream end of manifolding system **62L** is supported on a flange portion **70L** by way of a manifold support member **14Y.** An intermediate electrically insulating member **70M** is disposed between downstream flange or support member **70L** and a heretofore unmentioned upstream flange or support member **70R.** The upstream manifolding system **62R** is supported upon flange member **70R** by a support member **16X.** The other end of manifolding system **62** is supported on flange member **88** by a suitable manifold support member **16Y.** Manifold system **62L** may comprise discrete manifolding sections, such as shown at **14AL** and **14BL** through **14NL.** The upstream field coil manifolding system **62R** may comprise discrete manifolding sections **16AR** through **16NR.**

Referring once again only to FIG. **2** a rear or upstream end view of the arc heater station **10** is shown. Arc assembly **12** is shown disposed upon a support structure or frame **22.** The wheels **18** of the upstream or movable electrode assembly **16** are shown disposed upon rails **20** on the frame **22.** Supporting or aligning rods **58** for the upstream electrode **16,** which rods are also shown in FIG. **1,** are shown on either side of the upstream electrode end plug **60.** The upstream or rear or right field coil manifolding system **62R** for upstream field coils is shown disposed on upstream electrode apparatus **16,** and a bus bar or electrically conducting terminal **34** is shown coconnected to a portion thereof. A portion of the downstream quench tube and materials admission assembly with integral arc detector means **46** is shown in rectangular outline in FIG. **2.**

Referring now to FIG. **3** a view of the internal portion of an arc heater assembly **12** is shown. Downstream electrode assembly **14** is shown on the left and upstream electrode assembly **16** is shown on the right. It will be noted that a portion of the annular gap **71** is shown disposed between downstream electode **64** and upstream electrode **69.** Downstream electrode **64** may comprise a generally cylindrical hollow tubular electrically conducting shell comprised of electrically conducting materials, such as hard drawn copper or alloys of copper or similar materials. A downstream support flange member **68** is provided at the downstream end of downstream electrode assembly **14** and an upstream support flange **70L** is provided at the upstream end of downstream electrode assembly **14.** Electrode **64** abuts or touches the downstream flange **68** at joint **65** and electrode **64** abuts or touches upstream flange member **70L** at joint **72.** A cooling water duct flange member **74** which may also be cylindrical in shape is disposed around or at least partially encloses but does not necessarily touch the outer periphery of the electrode **64.** Flange member **74** abuts downstream flange **68** at joint **76** and it abuts upstream flange **70L** at joint **78.** A spacer, shoulder or abutting portion **80** is shown separating upstream flange member **70L** from a field coil assembly. A similar shoulder exists on flange member **70R.** An outer shell or protective shell **82** for downstream electrode **64** is disposed longitudinally between flange **68** and flange **70L.** A long bolt **84** having its threaded end protruding into a corresponding tapped and threaded hole in flange member **70L** abuts against a lip or ridge in flange member **68** and extends to secure the previously described members into a unitary downstream electrode assembly **14.** As can be seen, the lengths of members **74, 64, 82** and the length of bolt **84** may be changed to accommodate more or less field coils and/or to provide longer or shorter electrodes if that is desired. Upstream electrode **69** abuts the flange assembly **70R** at joint **86.** An upstream electrode flange assembly **88** is provided at the right end of electrode assembly **16.** Flange assembly **88** aubts electrode **69** at joint **90.** A cylindrical tubular member **92** which is similar to member **74** may similarly surround or enclose electrode member **69.** Member **92** abuts upstream flange assembly **70R** at joint **94** and upstream flange assembly **88** at joint **96.** A shielding or protective covering **98** similar to protective covering **82** is interposed and supported between upstream flange member **88** and downstream flange member **70R.** A bolt **100** similar to bolt **84** is disposed between upstream flange member **88** and downstream of flange member **70R** for securing purposes. As with downstream electrode assembly 14, upstream electrode assembly 16 may have the size of its various components varied to a predetermined length. A second upstream flange assembly 102 is secured to the flange assembly 88 for purposes which will become apparent. Previously described fluid cooling input system or pipe 40 is connected to a passageway such as duct, channel, or opening 104 in downstream flange assembly 68. Duct 104 communicates with a manifold or fluid passageway 106 which in turn communicates with the opening or cooling passage 108 between the outer surface of electrode 64 and the inner surface of the cylindrical member 74. Duct or channel 108 communicates with an upstream electrode cooling manifold or passageway 110 in flange member 70L. Manifold 110 then communicates with duct members 112 in flange assembly 70L and with a similar duct portion and sealing means 114 which is also in flange member 70L. An interposed electrically insulating member 70M has a communicating opening 115 therein between sealing member 114 and sealing means or member 116 in flange member 70R. The duct provided by the inner portion of seal 116 communicates with a duct portion 118 also in flange member 70R. Duct 118 communicates with manifold 120 which in turn communicate with a fluid cooling path 122 between upstream electrode 68 and upstream cylindrical member 92. Path 122 then communicates with manifold member 124 in flange assembly 88. A ducting channel 128 also in flange assembly 88, communicates through sealing fluid bridging means 129A in flange assembly 102 with a duct or channel 130 in flange assembly 102. Duct 120 communicates with a manifold assembly passageway 132 which in turn communicates with a duct 134 in flange assembly 102 which communicates with output fluid or gas port pipe 42. Consequently, electrode cooling fluid is conducted through duct 104 to manifold 106 from where it is conducted along the outer surface of electrode 64 through cooling channel 108 for the purpose of removing heat from the electrode. And from there it is provided to manifold assembly 110 where it traverses or flows through ducting members 112, 114, 115, 116 and 118 between the lower or downstream electrode assembly 14 and the upper or upstream electrode assembly 16. From there the fluid will travel through manifold 120 to cooling channel 122 to cool electrode 69 in the upstream electrode assembly 16 and from there the cooling fluid will then flow through manifold 124, through the ducts 128, 129A, and 130 to the manifold assembly duct 132 where it cools the internal surface of the end plug assembly 60, and from there to duct 134 and to the output piping assembly 42. Output piping assemblies 42*a* and 42 contain sealing insulators 40A and 42A for providing electrical isolation between the electrodes and the piping system which may be grounded electrically. It will be noted that a single unitary cooling path exists among both electrodes 64 and 69 and that the sealing means or bushing 114 and 116 provide compressive sealing pressure against insulating member 70M because the force on the larger "O" rings 114*a* or 116*a* is proportional to the area of the fluid flow path they enclose and is larger than the force on the smaller "O" rings 114*b* or 116*a* causing a net force toward insulating member 70M from both sides while concurrently sealing all sides of sealing means 114 and 116 respectively. Sealing means are also provided between flanges 88 and 102 by way of seals 129A. These bushings also provide a larger region of electrical insulation between the separate duct members 70R and 70L. Consequently, the upstream electrode assembly 16 can be quickly disconnected from the downstream electrode assembly 14 without the necessity of disconnecting any external hoses or external piping connector assemblies for electrode cooling channels or ducts. It should be noted that plug assembly 60 communicates with arc chamber 135 by way of opening 136 in flange 102 so that process material may be introduced into arc chamber 135 through plug member 60 if desirable. Downstream electrode assembly 14 has, near the gap portion 71 a process fluid port 44 which is suitable for supplying process gas or fluid into the arc chamber region 135. Piping system 44 communicates with a duct 138 in flange assembly 70L which in turn communicates with a duct 140 which leads to a gas or fluid admission chamber 141 behind an annular gas admission ring 142L so that the gas fluid may flow into arc chamber 135 through openings or slots in the gas admission ring 142L. In addition, spacer or electrically insulating member 70M has therein an orifice or a metering opening 144 so that gas or fluid from header or duct 141 may communicate with a duct 143 in the upstream electrode assembly flange 70R. Heater member 143 communicates with an upstream materials admission ring 142R and with an upstream duct 146. Gas from opening 144 may then flow through slotted openings or orifices in upstream material admission rings 142R into the arc chamber 135 or may flow through duct 146 to a valve 148 in upstream electrode. Valve member 148 communicates with another duct member 150 which communicates with a duct member 152 in upper electrode manifold or pressure header 154. A material admission ring 156 is provided near manifold 154 so that gas or similar fluid material may flow through slots or openings in it into a narrow gap 160 and thence into the cylindrical arc chamber 135. This flow takes place from th upstream end of the upstream electrode assembly 16 toward the downstream exhaust port. Consequently, it can be seen that gas or a similar fluid for processing purposes need be provided to the arc heater apparatus 112 at a single entry port 44 in the lower or downstream electrode assembly 14 but which nevertheless may be channeled or conducted to the upstream end of the upstream electrode assembly 16 for the purpose of being provided to the upstream end of the arc chamber 135. This, of course, may be concurrent with, additional to or exclusive from the provision or forcing of gas through material admission rings 142L and 142R into the annular gap 71 near the center of the arc chamber 135. The valve portion 148 provides a convenient means for controlling the amount of fluid or process gas flowing to the upstream materials admission gap 160. In some instances the valve 148 may be adjusted to allow no gas to flow into this region. Also provided adjacent the outer portion of flange members 74 and 92 in the downstream electrode assembly 14 and upstream electrode assembly 16 respectively are annular electromagnetic field coil assemblies 162 which may be stacked longitudinally or axially in any predetermined or convenient disposition. As can be seen, discrete field coil assemblies 162 are electrically insulated from each other but nevertheless may be interconnected electrically, externally, through the manifolding means which will be described henceforth in more detail. It can be seen that each discrete field coil assembly **162** has includes therein insulated electrical windings or conductors **170** and cooling tubes or duct **172** both of which communicate with a combination electrical lead and fluid duct **164** or **168.** One of these ducts is available for providing cooling fluid to the assembly **162** and the other is available to conduct cooling fluid away from it. The cooling fluid flows through hollow openings in the tubular electrical conductors **164** and **168** and the electrical current for energizing the field coil windings **162** flows through the outer or solid electrically conducting portions of the tubular conductors **164** and **168.** Assembly **162** is insulated with thermal insulating material **162**A.

It will be noted that metering orifice **144** provides a convenient way for providing gas between the downstream and upstream electrode assemblies without necessitating external coupling of gas piping means. The internal coupling of the gas supply means provides another method for quick disconnect of the upstream electrode assembly **16** from the downstream electrode assembly **14** without necessitating excessive mechanical adjustment or operation.

Referring now to FIG. **4**, an enlarged view of the previously described manifold assembly **62**L for the downstream electrode assembly **14** is shown. Manifold assembly **62**L comprises a plurality of disrete unitary manifolding blocks **200,** one for each field coil, aligned axially along the length of the electrode assembly. At the left most end of the manifold assembly **62**L is a support member **14**X which is shown disposed upon flange assembly **68.** Support assembly **14**X has an input piping assembly **204** disposed adjacent to it and communicating therewith and attached thereto with securing means or screws **206.** Pipe assembly **204** includes a piping member **208** which extends horizontally outwardly from t3e manifold assembly **62**L to be connected to a suitable source of cooling fluid for the field coils. Support assembly **14**X is fastened or secured to flange assembly **68** by way of securing means or screws **212.** Communicating with pipe **208** and internal to support member **14**X is a duct member **216** which communicates with similar duct members in the discrete manifold sections **200** as will be described later. Electrical field bus **32** is secured adjacent to the top portion of support member **14**X and is secured thereto through suitable screws or fastening means **217.** Combination electrical conductors and fluid passage means **218** for the field coils are shown in the discrete manifolding blocks **200.** The bottom portion of a combination conductor and fluid providing means **218** communicates with the previously described electrically conducting fluid ducting member **164** or **168.** Adjacent the right portion of downstream manifold assembly **62**L is a manifold support assembly **14**Y comprising a primarily horizontal portion **222** and a primarily vertical portion **224,** where vertical section **224** communicates with a fastening base **226** through a thermal insulating layer **228,** Vertical members **224** and **226** are secured together through suitable securing means such as screws or bolts **130.** Member **14**Y rests upon and is secured to flange assembly **70**L. Support assembly **14**Y has a duct portion **232** of smaller diameter than a similar coaxially aligned adjacent duct portion **234** both of which are useful for communicating with a fluid passage duct and bridging means in a complementary manifolding assembly **62**R not shown. Disposed between each discrete electrically insulating primarily plastic manifold section or block **200** is an electrically insulating primarily plastic fluid conducting bridging or joint member **240** which may be cylindrical and hollow and which may snugly fit in a complementary cylindrical opening or groove **238** in the left portion of one discrete section **200** and groove **244** in the right portion of the next adjacent discrete manifold assembly block **200.** This forms a fluid conducting bridge between blocks **200.** The fluid conducting bridge **240** is made fluid leak proof by providing primarily resilient O rings **242** and **248** between member **240** and surfaces **238** and **244** respectively. Discrete manifold section **200** comprises a pair of upper openings **250** and lower openings **252,** one of each of which can be seen in end block **14**Y. (similar to those existing in manifold block **200**). A combination electrically conducting and fluid providing tube **218** is disposed vertically in each of these holes from the upper portion of a block **200** or support **14**Y to the lower portion of block **200** or support **14**Y. The upper portion of assembly **218** comprises a threaded stud **254** which in one case feeds through an opening or hole **256** in an electrically conducting left jaw assembly **24**L. Stud member **218** comprises a portion **262** residing in a hole **250.** A circular annular opening **264** is provided in portion **262** where a resilient O ring **266** resides which seals opening **250.** In a similar manner stud portion **218** is widened to form a portion **268** in the vicinity of hole or opening **252.** Portion **268** has therein an annular ridge or opening **272** in which a relatively resilient sealing O ring **274** is provided to seal hole **252.** Consequently, the upper and lower portions of block **200** are rendered fluid tight so that fluid or water flowing in block **200** may not escape therethrough. An enlarged member **275** is provided on the bottom of stud member **218.** Stud member **218** is brazed to the tubes **164** and **168** (not shown). Disposed between the relatively wide sealing members **262** and **268** is a central portion **276,** having a horizontal opening therethrough **278** communicating with a vertical opening **280** therein which extends downwardly into a similar opening **282** in th previously described duct **164** so that fluid or water contained in a central horizontal duct **284** in discrete manifold section **200** may flow through conduits **280** and **282** to or from the internal portion of the electric field coil as previously described. At the same time electrical power or energy provided at the top portion of stud **218** may flow into the windings of a field coil. The opening **284** or channel **284** in manifold assembly **200** communicates with the hollow cylindrical bridging member **240** and with central openings or orifices **232** and **234** to form a unitary fluid conducting path **286** which extends from the far right portion of support assembly **14**Y to an end portion not shown in support assembly **14**X. Fluid duct **286** communicates with the horizontal and vertical openings **280** and **282** respectively of the stud means **218.** There may be two stud means per block of plastic electrically insulating material **200.** Stud member **218** is equipped with a fastening nut or similar fastening means **289** where required. Disposed adjacent stud members **218** and adjacent discrete manifold blocks **200** are electrically connecting links **290** each having holes **291** at either end thereof through which portions of the stud members **218** may pass and upon which the nut **289** of stud member **218** may be tightented. The stud members **218** may be linked electrically on the bias such as shown in FIG. **1** to form electrical series connections among all the field coils in the manifold means 62L or may be interconnected axially by relatively shorter electrically conducting linking members 292 such as shown in the left portion of FIG. 4 and in FIG. 5. Should the shorter portions 292 be used in conjunction with the input electrical bus 32, the linking member 292 would be raised above the upper surface of block 200 and an electrically conducting spacer portion or member 260 is provided to support it. The field coil means may be linked on a left right bias or a right left bias or vertical or in any combination thereof to provide the energy requirements for the field coils.

Referring now to FIG. 5 the top view of manifold section 62L is shown. Left supporting portion 14X is shown having an internal duct 216 which bends at a right angle therein to provide fluid to the axially aligned members 200. Pipe member 208 is shown on the left secured by securing or fastening members 206 to a flange member 204 which in turn communicates with seal means 300. Seal means 300 has a central opening therein which communicates with duct 216. Seal member 300 has disposed or cut therein a groove 302 in which a relatively resilient seal or O ring 304 is disposed for providing a fluid type seal between duct 216 and the outer portion of assembly 62L. The bolts 214 are shown for securing bus conductor 32 to a portion of support member 14X. In addition stud support bolt 254 is shown supporting a longitudinally aligned linking section 292 on the upper portion of assembly 62L and a similar linking portion 292 is shown disposed horizontally on the lower portion thereof. In other circumstances an electrically conducting primarily copper linking member 290 shown in phantom lines may be interconnected between corresponding stud members 218A and 218B if that is desirable. Other electrically conducting linking members 290 are shown disposed between adjacent discrete manifold sections 200 and interconnecting stud members 218 in a bias arrangement. In this arrangement the field coils are electrically connected in series circuit relationship. Spacing members 240 are shown between adjacent discrete manifold members 200 and between manifold 200 and horizontal end portion 222 of right support member 14Y. Right support member 14Y is secured to flange member 70L with or by way of a securing means or screws 306. Support member 14X is secured onto the corresponding flange member through or with the screws or fasteners 212. The output port or pipe 208A is shown communicating with the ducts or openings 312 and 314 in support member 14Y and the duct 216 in support member 14X and the rearmost duct portions in the manifold members 200 to form a common path 320 for fluid flow. The means of communication between ducts or channels 286 and 320 are through the tubes in the aligned pair of stud members 218 in each manifold block 200 and internal fluid paths of the field coils connected thereto. As can be seen the electrical connector 24L, which is secured by way of bolt or securing means 297 to end support 14Y and which is electrically connected to a stud member 218, has a central opening 299 therein which may grasp a complementary stud or electrically conducting protrusion on the right manifold assembly 62R shown as in FIG. 6.

Referring now to FIG. 6 a right manifold assembly 62R is shown as formed by combining a plurality of discrete manifold blocks 200 to form a single or unitary manifold member. Manifold 62R is supported on the right side by support means 16Y and on the left by a support means 16X which may be electrically insulating. Support member 16X has a vertical portion 354 therein and a horizontal portion 352 therein. A support flange 356 interconnects with vertical section 354 through a thermal insulating layer or means 358 and is secured thereto by securing means or screws 370. Support member 16X is supported on flange member 70R and support member 16Y is supported by flange member 88. The previously described fluid conducting path 286 includes a mating connector 382 having an internal central opening 402 communicating with an opening 372 in the horizontal section 352 of support member 16X. Member 382 has in the right outside portion thereof a groove or opening 384 in which a resilient seam means 386 is disposed and in the left portion a groove or opening 390 in which a resilient seal such as the O ring 392 is disposed. Member 382 is forced or held against member 16X to form a fluid tight junction, by the action of a bracket means 400 having a bolt therethrough (not shown) threadably insertable into support means 16X. Means 382 is adapted to fit into opening 234 in support means 14X shown in FIG. 4 of manifold means 62L to complete a junction therebetween so that the continuity of fluid path 286 is completed between manifold block 62L and manifold block 62R. This also provides a quick disconnect facility between the two blocks for fluid channels because the blocks may be interconnected and disconnected without necessitating any excessive connecting functions. Resilient ring 392 resides against the inner surface of opening 234 in support block 14Y of manifold 62L as shown in FIG. 4 and provides a fluid tight seal there. As can be seen blocks 200 and the combination fluid supply means and electrically conducting means or stud 218 may be constructed and assembled in the same manner in all manifold blocks 200. In assembly 62R bridging members 240, manifold blocks 200, linking members 290, and adjacent studs or terminals 218 are similar to those corresponding to the element described with respect to manifold assembly 62L. In a like manner, the combination fluid conducting tubes and electrically conducting members 164 extend downwardly into the region of the sealed coils in electrode assembly 16. The right most field bus 34 is shown disposed upon a top portion of support assembly 16Y and secured thereto by a bolt or bolts 406. The bottom portion of one end of the last discrete manifold block 200 on the right resides on or abuts the lip 204 in the support assembly 16Y. Support assembly 16Y is secured by way of a flange member 410 through which bolts or securing members 412 extends into the flange 88. A seal means 411 is provided on the right to terminate or end channel 286 as shown in FIG. 6 and a similar seal means is provided to terminate channel 320 shown in FIG. 5. Electrical connector 24R having an extending member 380 may be inserted into a complementary grasping member 299 previously described in connecting member 24L for a quick electrical connection and disconnection betweem manifold assembly 62L and 62R of the electrical circuits used therein. Electrical conductor 24R is secured to support means 16X by way of bolt or bolts 378 through a hole 376 in member 24R and is sealed therein and threaded in or secured to support member 16X.

Referring now to FIG. 7 a top view of the manifold block assembly **62R** shown in FIG. 6 is also depicted. Particular reference is made to the possible bias arrangement of electrical linking members **290** as well as the presence of a second ducting means **420** (not shown in FIG. 6) which is adaptable to connect that portion of duct or channel **320** in manifold **62R** with the complementary portion of duct **320** in manifold section **62L**. Bolt or fastening means **422** which is used to secure bracket **400** is also shown. Bolt or screw members **416** for securing support means **16X** to the flange are also shown as is the electrically conducting bus member **34** and its three fastening means **406**. Bolt member or fastening member or screw **412** is shown in flange member **410** for securing support member **16Y** to an appropriate base or flange. Terminating member **411A** and terminating member **411** are shown in a position to terminate the previously described fluid conducting paths **320** and **286** respectively.

By viewing FIGS. **4, 5, 6** and **7** together, it can be seen that electric power may be provided through bus **32** and thence to each set of electrically conducting studs **218** through linking means, such as conductors **292** and **290** which may be arranged in biased fashion from one plastic block **200** to the other so that the field coils connected therewith are connected in a electrical series circuit relationship. It can be seen that by interconnecting portion **24L** with connector portion **24R** that electrical continuity may be maintained between the field coils in the left electrode assembly **14** and the field coils in the right electrode assembly **16.** The connecting links or strips **290** are shown interconnected with the stud members **218.** In the right-most portion of the manifold assembly **62R** the electrical circuit is completed through electrical field bus or conductor **34.** As was described previously the direction of the bias of the links **290** may be reversed or the electrical connections may be made parallel by providing longitudinally aligned straps or links, such as **292** shown on the left portion of FIG. **5.** This may be done for any convenient purpose such as improved field shaping. Also any combination of the two connecting arrangements may be used. By closely examining FIGS. **5** and **7** it can be seen that input fluid may be provided to intput pipe or port **208** and from there into duct **216,** through the various discrete blocks **200** to the end portion **314** whereupon the continuity between the left most manifold block section **62R** and the right most manifold block section **62R** may be completed through connector **420.** A similar act duct is provided in the right or upstream manifold block **62R** which is terminated in terminating seal means **411A**. This channel is known as channel **320.** Channel **286** is formed in a similar fashion between manifold sections **62L** and **62R**, and channel **286** is terminated at its right-most extension by terminating seal means **411.** Fluid which flows through duct **320** feeds into the openings **278** of the studs **218** and then down through vertical openings **280** therein to the field coil cooling ducts. The fluid comes up or returns through similar ducts **280** in corresponding stud members **218** which communicate with channel **286** from where the fluid is removed through output port **208A**. Of course it is realized that the direction could be reversed and fluid could be supplied through port **208A** and exit through port **208** as shown in FIG. **5.**

It is to be understood that the various features described with respect to this arc heater apparatus may be used in combination with each other or singly. It is also to be understood that the various fluid, gas and electrical paths may be reversed. It is also to be understood that all of the connections and ports referred to with respect to the downstream electrode may be alternately placed in the upstream electrodes. It is also to be understood that the plastic blocks **200** may be any similar electrically insulating material. It is also to be understood that the electrical connectors **24R** and **24L** may be reversed. It is also to be understood that the link means **290** and **292** may be any electrically conducting material, such as hard drawn copper, brass, or the like.

The apparatus embodying the teachings of this invention has many advantages. One advantage is the characteristic of allowing electric arc heater apparatus to be quickly disconnected without the need for an excessive member of external electrode gap bridging electrical conductors, gas feed lines, and fluid feed lines. Another advantage lies in the fact that the size of the electrodes and the field coils associated therewith may be varied from time to time without necessitating the replacements of the arc heater apparatus. Another advantage lies in the fact that the sealing means provided for the electrode cooling path includes a relatively high voltage insulation between the two electrodes while nevertheless allowing a common cooling path to exist therebetween.

What we claim as our invention is:

**1.** Arc heater apparatus, which comprises:

a plurality of spaced electrodes at least two of which are capable of being electrically connected to terminals of opposite polarity of a source of electrical power so that an electric arc may be struck from one electrode to another;

a plurality of electrically conducting cooling ducts with central openings therein for the flow of cooling material therethrough, wherein each of said at least two electrodes has at least one of said cooling ducts adjacent thereto for cooling said electrodes, a first of said cooling ducts communicating with a second of said cooling ducts to provide a common cooling channel for said at least two electrodes;

electrically insulating spacer means disposed between said first and said second cooling ducts to space and electrically insulate said first cooling duct from said second cooling duct, said spacer means having an opening therein communicating with said central opening in each of said first and said second cooling ducts to provide said communication therebetween to form a portion of said common cooling channel;

electrically insulating bushing means disposed adjacent said first cooling duct and said spacer means, said bushing means having a central opening therein which communicates with said central opening in said first duct and said central opening in said spacer means to form part of said common cooling channel, said bushing means providing an increased increment of electrical insulation between said cooling ducts over that amount of electrical insulation provided by said spacer means alone;

first resilient sealing means which encloses a predetermined area and which is disposed adjacent said bushing means and said spacer means for providing a coolant seal therebetween;

second resilient sealing means which encloses a larger predetermined area than said first resilient sealing means encloses and which is disposed adjacent said bushing means and said first cooling duct for providing a coolant seal therebetween, said first and second resilient sealing means reacting to the pressure of coolant material in said cooling channel to provide an increment of sealing force between said ducts and said spacer due predominatly to fluid pressure caused by the presence of said coolant adjacent said bushing means and said spacer in said cooling channel which force is related to the difference in areas enclosed by said first and second resilient sealing means.

**2.** Arc heater apparatus of the type including electrode structures spaced to form a gap across which an electric arc may be struck and shaped to form an arc chamber in which said arc may reside comprising, means for providing process fluid to one of said electrode structures to be provided to said gap for entry into said arc chamber, an electrically insulating spacer member disposed between said electrode structures for electrically insulating said electrode structures from each other, ducting means in another of said electrode structures for providing said fluid to another portion of said arc heater, said spacer member having an opening therein communicating with said ducting means in said another of said electrode structures and said means for providing fluid to said one electrode structure for thereby providing a fluid path from said means for providing fluid to said one said electrode structure to said ducting means in said another of said electrode structures and thence to said another portion of said arc heater.

**3.** The combination as claimed in claim **2** wherein said ducting means in said another of said electrode structures includes a valve for controlling the amount of said fluid provided to said another portion of said arc heater.

**4.** Arc heater apparatus comprising, spaced annular electrode assemblies cooperating to form an arc chamber, a plurality of magnetic field coil assemblies, said latter assemblies having electrically conductive tubular electrical connector leads for providing cooling fluid to said field coil assembly and energizing electrical power to said field coil assembly, a manifold assembly for each field coil assembly having fluid ducts therein communicating with said tubular connector leads and electrical terminals disposed in electrical contact with said tubular connector leads, the manifold assembly for each of said field coil assemblies being disposed adjacent to other manifold assemblies with said ducts of each communicating to form a fluid path between adjacent manifold assemblies and with said terminals being electrically interconnected to provide electrical continuity between predetermined leads of said field coil assembly.

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