Feb. 19, 1963 H. J. LINGAL 3,078,383

ARC CHAMBER

Filed April 29, 1960 6 Sheets-Sheet 1

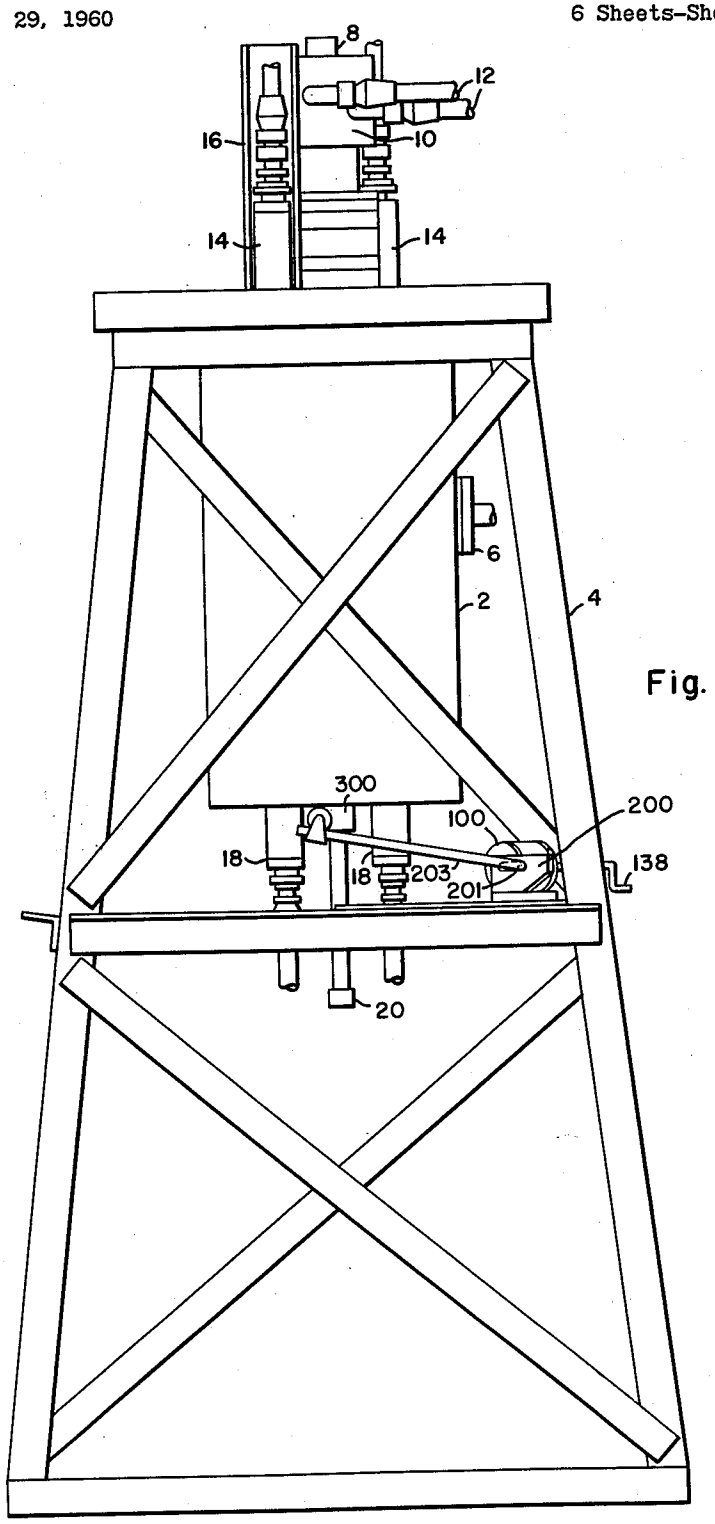


Fig. 1

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ARC CHAMBER

Filed April 29, 1960 6 Sheets-Sheet 2

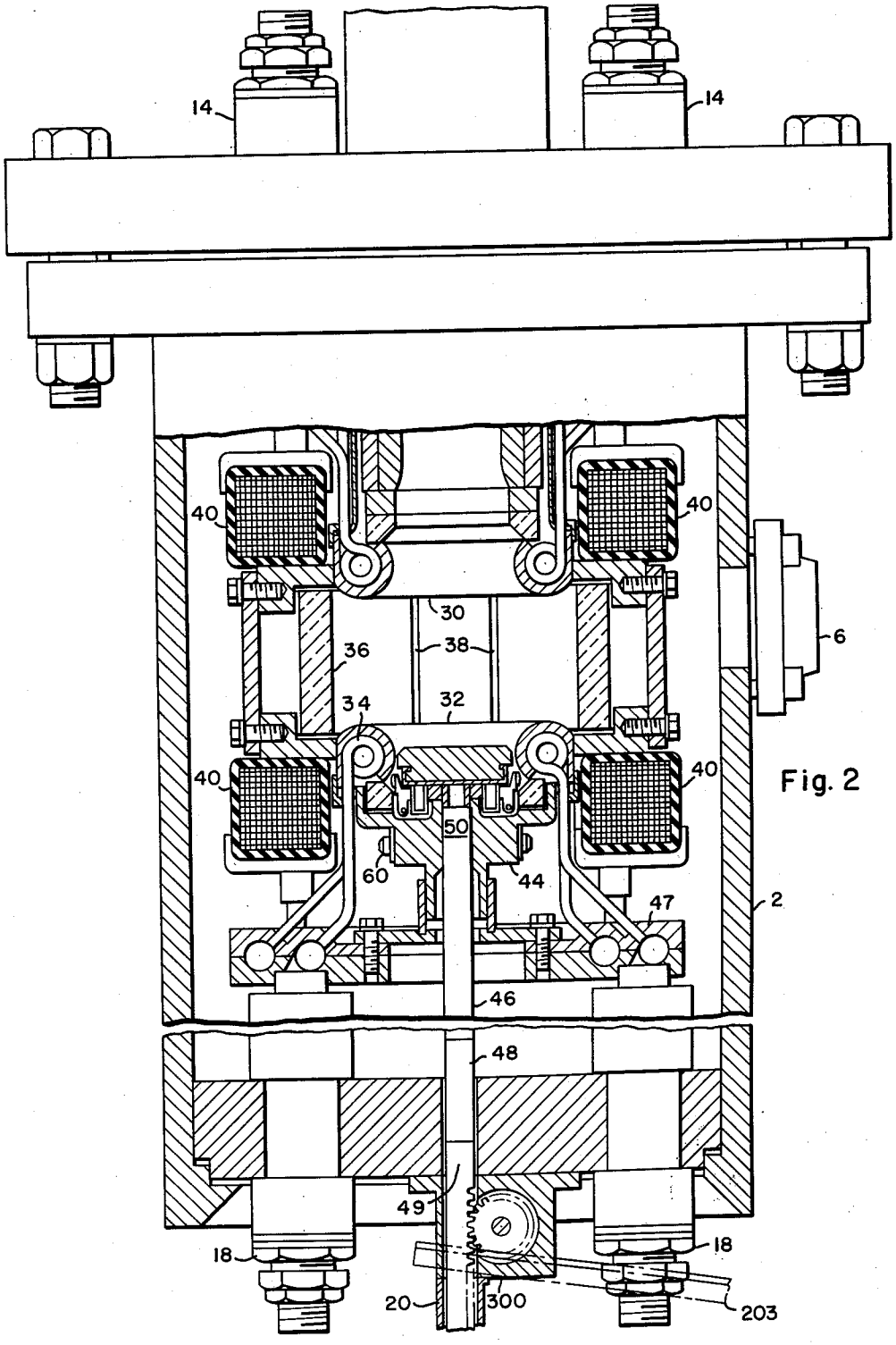


Fig. 2

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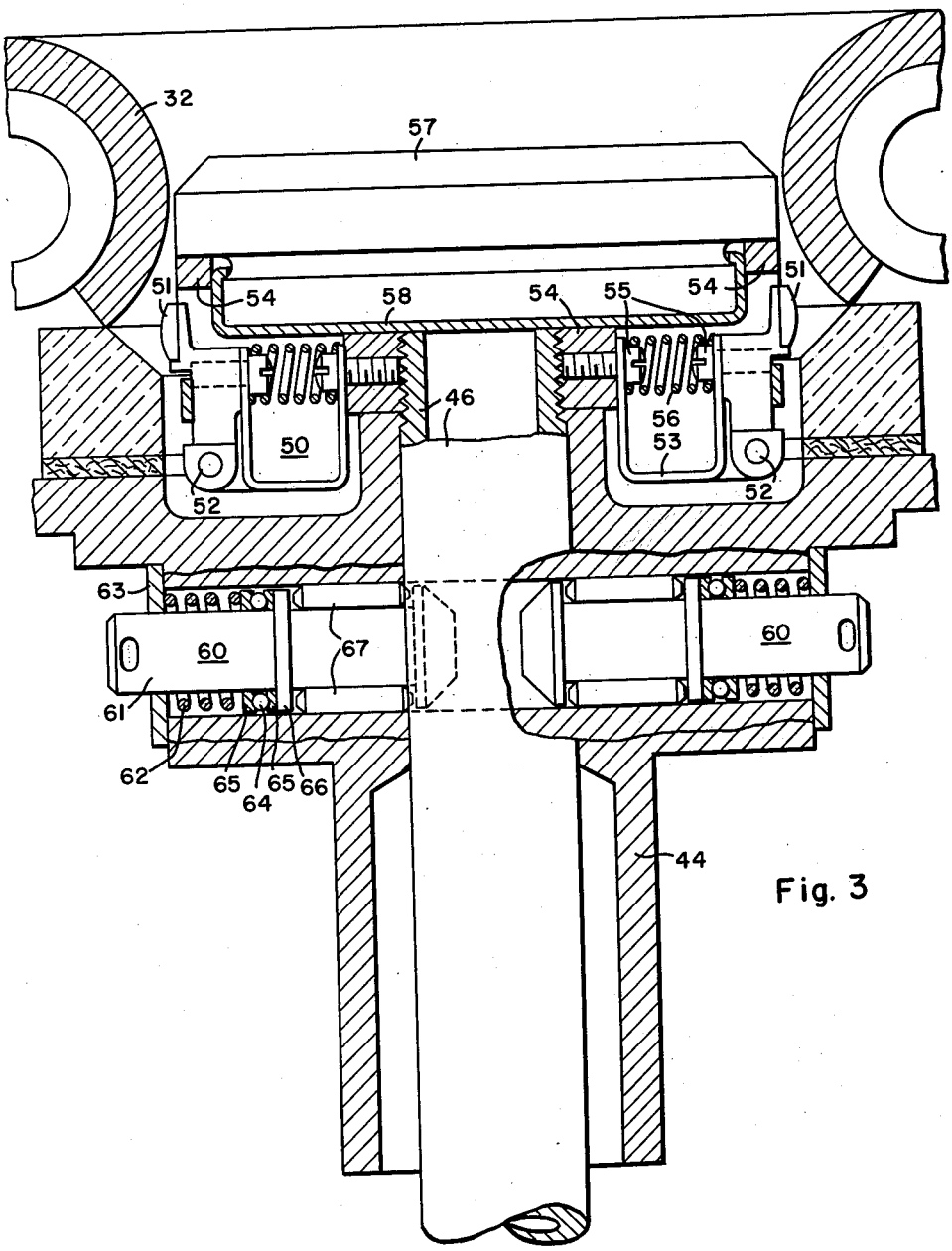


Fig. 3

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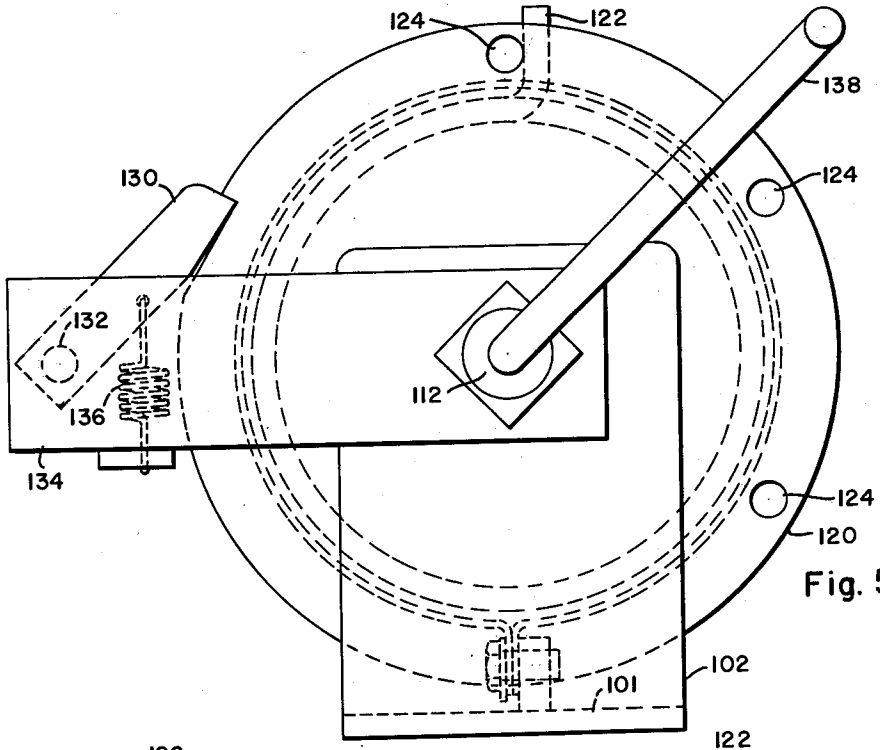


Fig. 5

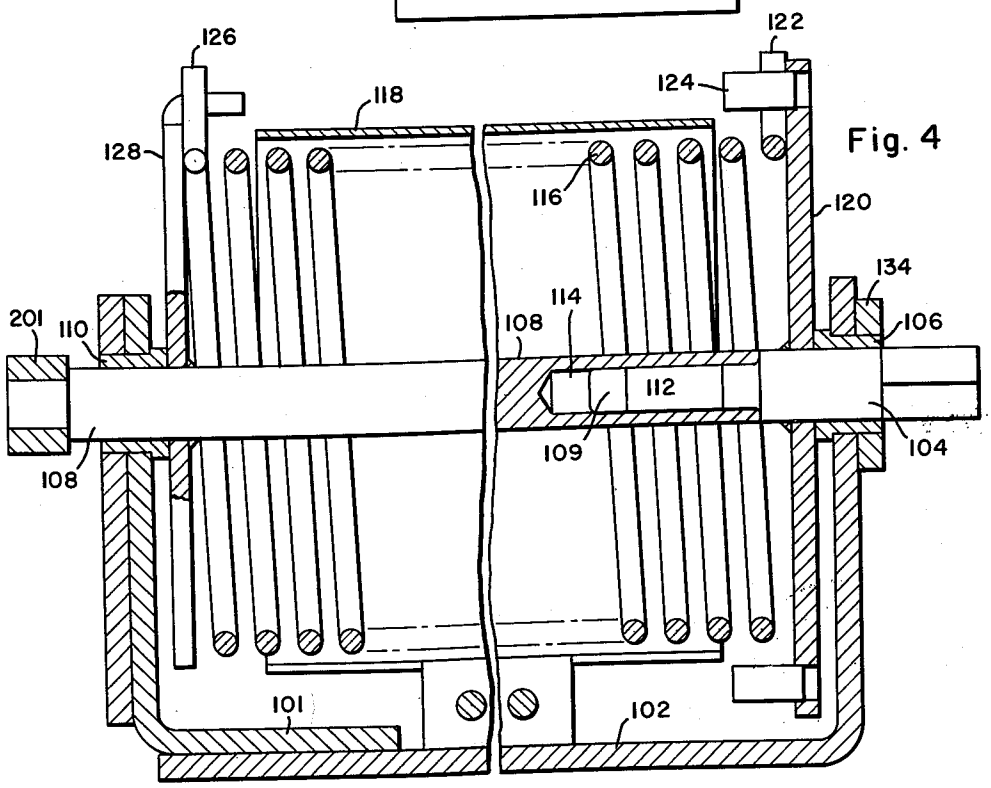


Fig. 4

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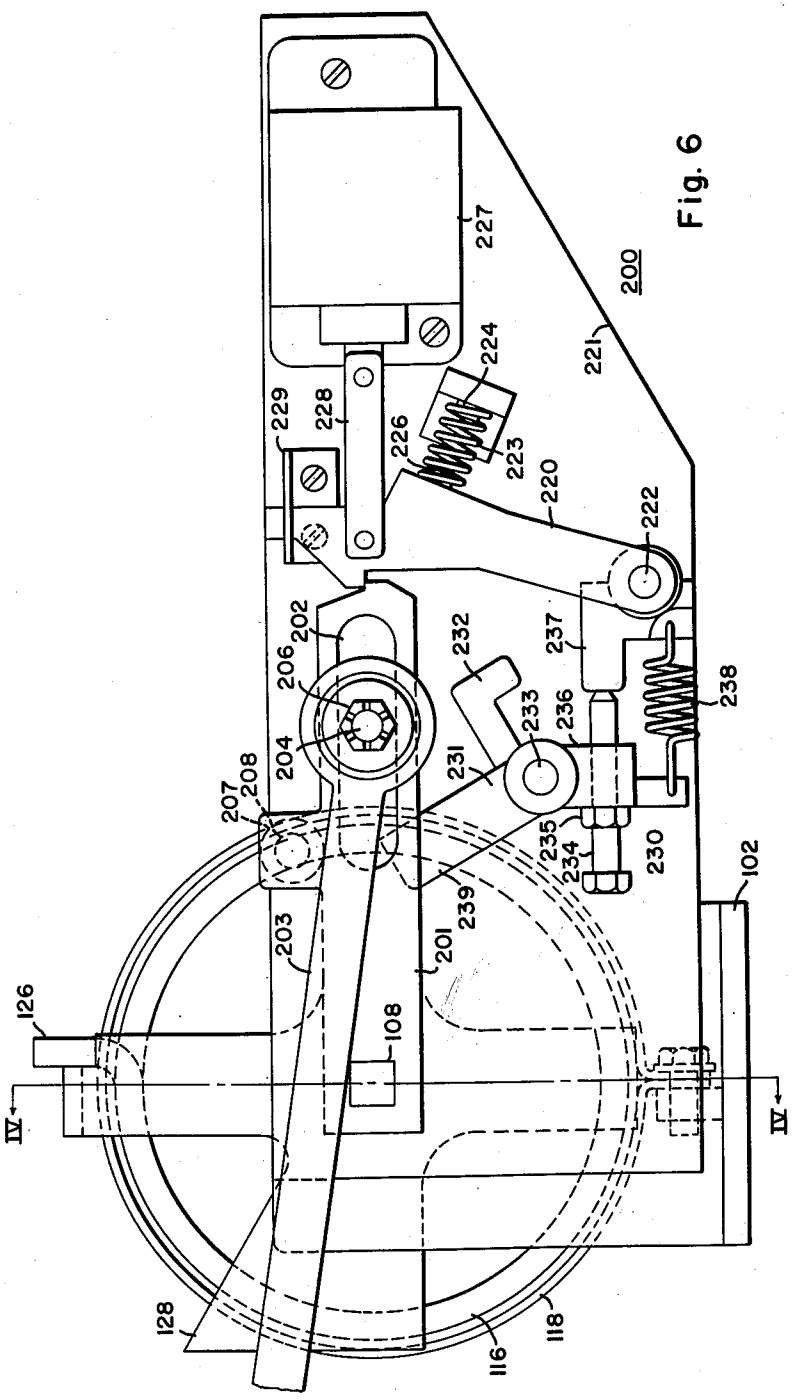


Fig. 6

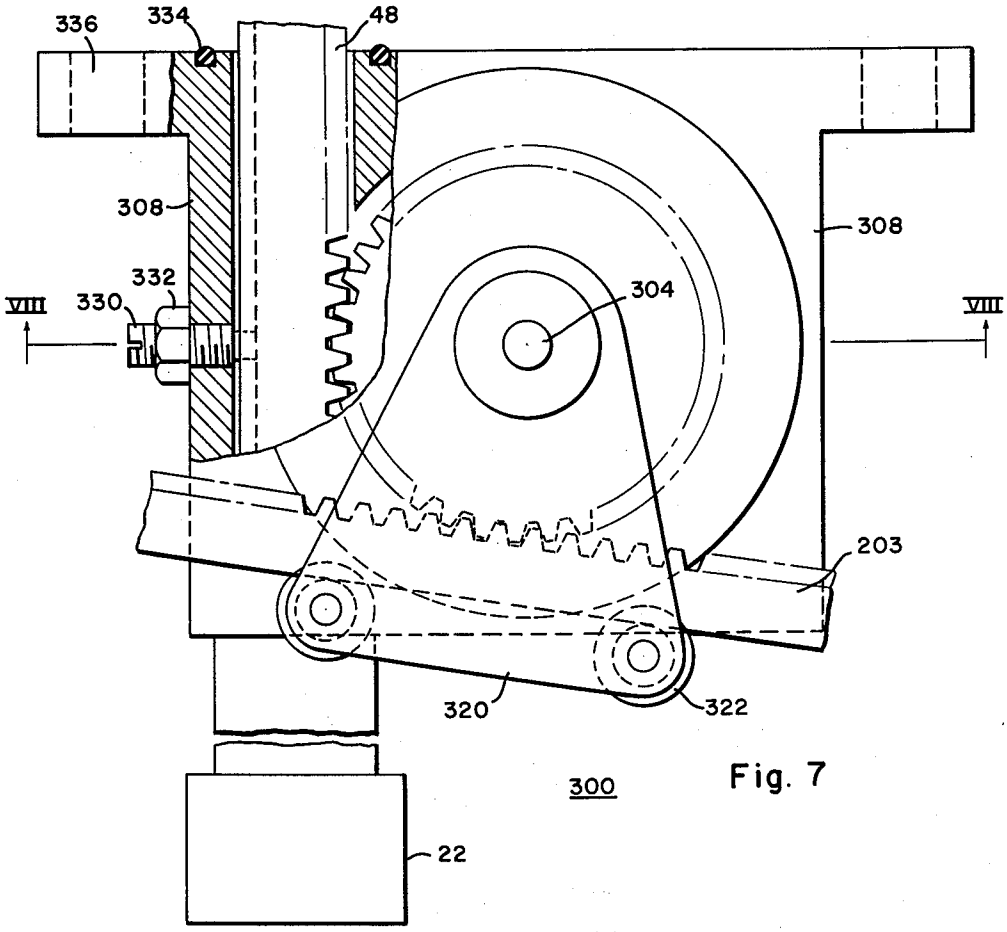

336
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308
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VIII
VIII
304
203
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Fig. 7

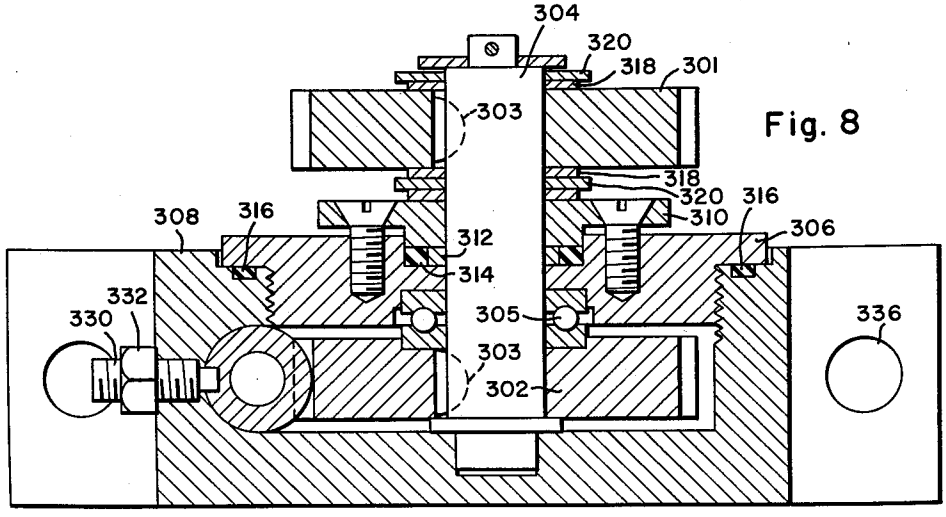

304
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336

Fig. 8

United States Patent Office 3,078,383 Patented Feb. 19, 1963

3,078,383

ARC CHAMBER

Harry J. Lingal, Pittsburgh, Pa., assignor to Westinghouse Electric Corporation, East Pittsburgh, Pa., a corporation of Pennsylvania

Filed Apr. 29, 1960, Ser. No. 25,762
9 Claims. (Cl. 313—152)

The present invention relates generally to arc chambers and more particularly to a mechanism for drawing an arc in a pressurized arc chamber.

In a pressurized gas chamber for hypersonic wind tunnel testing or the like, which uses an electric arc for heating and expanding the gas, it is desirable upon start-up to develop the arc gradually to its full length to avoid developing steep front mechanical shock waves which might cause rupture of the arc chamber walls. Depending upon the power in the arc, the desirable time to develop the arc to its full length may vary between one and several cycles. For this reason it is undesirable to start an arc by melting a short circuiting fuse wire connecting the power electrodes.

The principal object of the present invention is to provide a new and improved arc chamber.

Another object of the present invention is to provide an arc drawing mechanism which starts the arc by parting electrodes at a controlled rate of movement, thereby avoiding the development of severe shock waves.

Another object of the present invention is to provide an arc drawing mechanism which transfers the arc to stationary electrodes upon development of the proper length arc.

Another object of the present invention is to provide an arc drawing mechanism wherein the actuating and controlling part of the mechanism is located externally to the arc chamber.

Further objects and advantages of the present invention will be readily apparent from the following detailed description taken in conjunction with the drawing in which:

FIGURE 1 is an elevational view of an illustrative embodiment of the present invention;

FIG. 2 is a fragmentary assembly view, partly in section, of a portion of FIG. 1;

FIG. 3 is an enlarged detailed view of a portion of FIG. 2;

FIG. 4 is a fragmentary view, partly in section, taken along the line IV—IV in FIG. 6;

FIG. 5 is an end elevational view of FIG. 4;

FIG. 6 is an elevational view of another portion of the present invention;

FIG. 7 is an elevational view, partly in section, of still another portion of the present invention; and,

FIG. 8 is a sectional view taken along the line VIII—VIII in FIG. 7.

A hypersonic wind tunnel using an arc chamber as a generator depends upon electrically increasing the internal energy of the emitted gas and utilizing Brownian movement to obtain directed kinetic energy for the desired gas velocity. Because of the necessarily tremendous power involved, it is desirable to strike an electric arc within the chamber and gradually increase its length so as to avoid excessive shock waves which might cause rupture of the arc chamber walls. The present invention provides apparatus for drawing an electric arc between a pair of spaced stationary electrodes in the desirable manner.

For purposes of clarity, all like parts have been given the same reference characters throughout the several figures.

With reference to FIG. 1, the arc chamber 2 is illustrated mounted on a structural rack 4. Admission of the gas to be heated in the arc chamber 2 is accomplished by

the gas inlet pipe 6. Exit means for the heated gas at the desired velocity is provided by the vent 8, which vent is provided with an exhaust cooling jacket 10 with input and output pipes 12 for a cooling medium.

Electrical connection to the upper electrode 30 (FIG. 2) is made by the upper connectors 14 encased in an insulation barrier 16. The lower connectors 18 provide electrical power to the lower electrode 32 (FIG. 2). Both the upper connectors 14 and the lower connectors 18 also provide conduit means for a cooling medium which flows in heat transfer relationship within the electrodes 30 and 32 to reduce the hot spot temperature of the electrode surfaces.

The actuating and controlling portion of the apparatus for drawing an electrical arc between the upper and lower electrode is secured to the arc chamber 2 and rack 4. An arc starter assembly 50 is slidably mounted within a gas tight container 20 and is actuated by the motion transfer mechanism 300 which is driven by the driving apparatus 100. The gas pressure within the electrode container 20 and within the motion transfer mechanism 300 is substantially equal to the pressure within the arc chamber 2 providing an additional advantage of the present invention. The actuating and controlling part of the apparatus is located externally to the pressurized arc chamber 2. Therefore, the pressurized arc chamber 2 need not be opened between tests to insert a starting fuse wire or to adjust the length and speed of travel of the starting electrode as is necessary with apparatus of the prior art.

FIG. 2 is a fragmentary assembly view, partly in section, of the arc chamber 2. The present invention provides apparatus for drawing an electric arc in the arc chamber 2; which arc chamber is claimed and more fully described in the copending patent application, Serial No. 19,528 dated April 4, 1960, by Werner S. Emmerich and assigned to the same assignee. As more fully described therein, the arc chamber 2 comprises an upper and lower ring electrode 30 and 32, respectively, fixedly mounted and adapted to have an ionizing potential connected thereacross by means of the upper connectors 14 and lower connectors 18 respectively. Cooling coils 34 are embedded within the stationary electrodes to conduct heat away from the electrodes during operation of the arc chamber. A ceramic cylinder 36 encloses the volume between the stationary electrodes, forming an envelope which allows the admission of incoming gases throngh slots 38. A magnetic field is established transverse to the electric arc by means of the magnetic coils 40 so that the electric arc is forced along the ring electrodes 30 and 32 by precession due to the action of the magnetic field.

The arc starter assembly 50 is mounted within the arc starter guide 44 and actuated by an electrical conducting rod 46 which in turn is connected to on electrical insulating rod 48 and thence to a driving rod or gear rack 49 which extends through the bottom of the arc chamber 2, through the motion transfer mechanism 300 and into the sealed rod container 20. A gear rack or connecting rod 203 provides driving force to the motion transfer mechanism 300 which in turn advances and retracts the arc starter assembly 50 to initiate and draw the arc to its proper length within the arc chamber 2.

Tracing the electrical circuit, the arc starter makes electrical connection to the conducting rod 46 and hence to the arc starter guide 44 through a roller contact assembly 60. The arc starter guide 44 is secured to a lower manifold 47 which is at the same potential as the lower connectors 18.

Referring to FIG. 3, the arc starter 50 comprises a plurality of contact fingers 51, each pivotally mounted on individual pins 52. While two contact fingers are shown for the purposes of illustration, it is to be understood

that any suitable number of contact fingers may be used. A shunt 53 electrically connects the contact finger 51 to a piston member 54 and is secured at both ends by securing means such as set screws 55. A resilient member or spring 56 urges the contact finger 51 to make good electrical contact with the top and bottom electrodes 30 and 32, respectively, as the starter assembly 50 advances and retracts between the two stationary electrodes.

A ceramic disc or shield 57 is secured to the piston member 54 by means of a formed receiving member 58. The ceramic insulator 57 assists the transfer of the arc between the upper electrode 30 and the contact fingers 51 to the upper electrode 30 and the lower electrode 32 by wiping the arc onto the lower electrode 32 as the arc starter assembly 42 is retracted past the lower electrode when completing its cycle of operation. The ceramic shield 57 provides a heat insulating barrier for the arc starter assembly 50. Thus, the high temperatures generated within the arc chamber are contained within the desired envelope. The piston member 54 is secured to the conducting rod 46 which in turn makes electrical contact with the roller contact assembly 60.

The roller contact assembly 60 comprises a plurality of electrical contacts 61 which are disposed to straddle the conducting rod 46 and roll along the conducting rod 46 as it advances and retracts the arc starter assembly. The contacts 61 are urged into electrical contact with the conducting rod 46 by means of a compression member or spring 62, rigidly positioned at one end by means of a plate 63. The opposite end of the spring 62 abuts a bearing 64, separated by a washer 65 on each side. The spring 62 applies force against a shoulder 66 urging the contact 61 to make contact with the conducting rod 46. Roller bearings 67 allow the contact 61 to rotate in the assembly 60 as the arc starter assembly 42 advances and retracts.

Electrical connection from the roller contact assembly 60 to the arc starter guide 44 is obtained through the roller bearings 67. Where desirable, additional electrical contact may be secured by use of pigtails (not shown) which are secured to the rolling contact 61 at one end by means of the mounting hole therein and the opposite end of the pigtails secured to the arc starter guide 44 in any suitable manner.

The driving mechanism 100 and latching mechanism 200 to advance and retract the arc starter assembly 50 is illustrated in FIGS. 4, 5 and 6.

The driving means 100 comprises a pair of L-shaped brackets 101 and 102 welded together or secured by bolts or other suitable means to form a cradle. A wind-up shaft 104 is rotatably mounted in the bracket 102 by means of a bushing bearing 106. A driving shaft 108 is rotatably mounted in the end bracket 101 in a similar manner with the bushing bearing 110. The shafts 104 and 108 are independently rotatable and aligned on the same axis by means of a dowel pin 112 integral with the wind-up shaft 104 and a dowel opening 114 within the driving shaft 108 forming a running fit therebetween allowing each shaft to rotate independently of the other.

The shafts 104 and 108 extend through a tension storage means or torsion spring 116 which is enclosed in a metal guard 118, in turn secured to the bracket 102. The guard 118 contains the torsion spring 116 as a safety precaution should the torsion spring fatigue and rupture.

An index plate 120 secured by suitable means, such as welding, to the wind-up shaft 104 and adapted to rotate therewith engages a spring end 122 of the torsion spring 116 by means of a pin 124. To hold the driving mechanism in assembly at a desired preloading, a number of pins are located in the index plate 120. The opposite spring end 126 engages a driving plate 128 which is secured to the driving shaft 108.

Initially, both the index plate 120 and the driving plate 128 are secured against rotation. The driving plate

128 is secured against rotation by means hereinafter to be described. The index plate 120 is secured by the holding latch or pawl 130 which is pivotally mounted by means of a pin 132 secured in an extension 134 secured to the end bracket 102. The pawl 130 is urged against the index plate 120 by a spring member 136 secured at one end to the pawl 130 and at the opposite end to the extension 134. The pawl 130 engages a slot in the index plate 120 to prevent rotation of the index plate in the reverse direction.

Hence, by rotating the crank or operating handle 138 which is secured to the wind-up shaft 104, the torsion spring 116 provides a tension storage of energy, the magnitude of which, it will be shown, controls the speed with which the arc starter assembly 50 advances and retracts between the stationary electrodes in the arc chamber 2. By torsionally winding up the spring 116 a potential driving force is available to act upon the driving plate 128 upon release of the driving shaft 108.

From FIG. 6, a lever arm 201 is rotatably mounted on the driving shaft 108 and is secured from rotating in a counterclockwise direction by means of the latching mechanism 200. The power potential stored in the torsion spring 116 will be released when the lever arm 201 is unlatched.

The lever arm 201 has a slot 202 formed in the free end of the lever arm 201 wherein is secured the opposite end of the gear rack or connecting rod 61 by means of a bolt 204 and castle nut 205. It is to be noted that the effective length of the lever arm 201 is readily adjustable by sliding the secured end of the gear rack 203 within the slot 202 thereby altering and allowing selection of the limit of advance and retraction of the starting electrode within the arc chamber 2.

Securing the lever arm 201 from rotation is a latch 220 pivotally mounted at one end to the base plate 221 by means of a pin 222. The opposite end of the latch 220 is urged into engagement with a shoulder of the lever arm 201 by a compression spring 223 secured at one end by a pin 224 integral with an angle 225. The opposite end of the compression spring 223 is secured to the latch 220 by means of a pin 226 inserted in the latch. To release the lever arm 201 a solenoid plunger-type tripping relay 227 is mounted to the latching frame 221 and adapted, upon an electrical signal, to attract the link 228 with sufficient force to disengage the latch 220 from the shoulder of the lever arm 201. A latch guide 229 provides a track for the latch 220 to engage and disengage.

Since it is desirable that the arc starter assembly 50 advance and retract only once the compression spring 223 and the magnetic relay 227 are so chosen that the latch 220 will reassume its initial position and reengage the lever arm 201 after a single rotation of the arm.

To cushion the shock of the lever arm 201 striking the latch 220 upon completion of one rotation, a decelerator 230 is mounted on the base plate 221. The decelerator 230 comprises a lug 231 and a stop 232 rigidly secured together and pivotally mounted on a pin 233. The lug 231 has a strike surface 239 adapted to receive a roller 207 mounted on the lever arm 201 by means of an integral pin 208. As the lever arm completes one complete revolution, the roller 207 rolls along the strike surface 239 of the lug 231 to decelerate the lever arm as it completes one revolution and reengages the latch 220. To adjust the decelerator 230 a set bolt 234 and engaging nut 235, secured to a third leg 236, rigidly secured to the lug 231 and stop 232 and pivotally mounted on the pin 233, engages a stationary stop 237. A spring 238 secured at one end to the stationary stop 237 and at its opposite end to the third leg 236 provides resilient means for urging the lug 231 to resist the lever arm rotation as the roller 207 rolls along the strike surface 239 of the lug 231. The set screw 234 provides means for adjust-

ing the force with which the decelerator will oppose the lever arm as it completes one revolution.

As the lever arm 201 makes a complete revolution it can be seen that the gear rack 203 will make a reciprocating motion which motion is transferred by the motion transfer mechanism 300 to the gear rack 49 of the arc starter assembly 50. The driving rack 203 engages a driving gear 301 within the motion transfer mechanism 300.

The motion transferring mechanism 300 comprises a driving gear 301 and a driven gear 302 secured by Woodruff keys 303 to a shaft 304 which is rotatably mounted by thrust bearings 305 secured in a bushing 306. The bushing 306 is in turn threaded into the housing 308.

It is to be recalled that the pressure within the housing 308 of the motion transfer mechanism 300 is equal to the pressure within the arc chamber. To contain the high pressure within the mechanism 300 a bushing pressure plate 310 is secured to the bushing 306 compressing a packing seal 312 and an O-ring 314 of suitable material. Additional O-rings 316 seal the bushing 306 to the housing 308. Thus, it can be seen that the high pressure gas within the motion transfer mechanism is contained along the bushing 306 and along the shaft 304 while at the same time allowing connection between the internal and external parts of the mechanism.

A hanger guide 320 is adapted to pivot around the shaft 304 and forces the gear rack 203 into engagement with the driving gear 301. Washers 318 separate the hanger guide 320 from the driving gear 301 to allow the free motion of the hanger guide. The hanger guide utilizes a pair of rollers 322 mounted therein to allow the gear rack 203 to make its reciprocating motion while engaging the driving gear 301. The driven gear 302 is rotated in the same motion. The driven gear engages the gear rack 49 of the arc starter assembly 42 with the result that the conducting rod 46 advances and retracts during a rotation of the lever arm 201. A guide screw 130 secured by a nut 332 to the frame 308 engages a vertical slot extending along the gear rack 49 to position the gear rack so as to engage the driven gear 302. From FIG. 7 it can be seen that the opposite end of the gear rack 49 advances and retracts within the gas sealed container 20 which is also under the same pressure as the arc chamber 2. Suitable sealing means such as O-rings 334 maintain the gas tight seal between the motion transfer mechanism housing 308 and the bottom side of the arc chamber 2, to which it is secured by suitable means such as bolts through the bolt holes 336.

It is a feature of the present invention that the actuating and controlling elements of the apparatus for drawing an electric arc between the stationary ring electrodes are located externally to the pressurized arc chamber 2. The operating connection between elements located inside the pressurized chamber and those located outside the chamber is made through a gas tight seal. The sealing is not accomplished by the use of a sliding seal with its attendant disadvantages but by means of a compression seal of the motion transfer mechanism housing 308, which seal is most efficient.

In accordance with the present invention, upon start-up of the arc chamber 2, the crank or operating handle 138 is rotated so as to wind-up the tension storage means to a desired torsional load. The further the tension spring is wound up, the faster the arc starter assembly 50 will be advanced and retracted within the arc chamber 2. Upon release of the lever arm 201 by a suitable electric signal, the gear rack or connecting arm 203 will undergo an essentially reciprocating motion of one cycle. The hanger guide 320 compensates for any sidewise motion of the gear rack 203 and causes the gear rack 203 to engage the driving gear 301. Accordingly, the driven gear 302 transfers the motion of the gear rack 203 to the gear rack 49 and the arc starter assembly will advance and retract within the arc chamber 2. It is to be noted that the limit of advance of the arc starter assembly 50 may be preset by adjusting the effective length of the lever arm 201. As the arc starter assembly 50 reaches its maximum advancement and starts to retract, the electric power to the upper connectors 14 and lower connectors 18 are energized so that an ionizing potential appearing across the stationary electrodes 30 and 32 will initially appear between the upper electrode 30 and the contact fingers 51. As the arc starter assembly 50 retracts the arc between the upper electrode 30 and the contact finger 51 is gradually lengthened over a desirable preset time with a controlled rate of movement thereby avoiding development of severe shock waves.

Another feature of the present invention is that at the end of the arc starter assembly travel, the terminal of the arc will transfer to the bottom fixed electrode 32. The ceramic disc 57 will assist in transferring the arc by wiping the arc to the bottom electrode. The arc starter 50 is retracted sufficiently to position the ceramic disc 57 to protect the starter from heat damage.

Thus, it is readily apparent that the present invention has provided apparatus for drawing an electric arc between a pair of spaced stationary electrodes in an arc chamber or the like which is subjected to great pressure and temperature extremes. Conventional starting fuse wires have been eliminated. The extent of travel and the speed of advance and retraction of the arc starter assembly is controlled by external means. The pressurized arc chamber 2 need not be opened between tests.

Although this invention has been described with a particular degree of exactness for the purpose of illustration, it is to be understood that all equivalents, alterations, and modifications within the spirit and scope of the invention are herein meant to be included. For instance, the present invention provides apparatus for drawing an electric arc in an arc chamber which is applicable to many uses besides hypersonic wind tunnels. Such an arc chamber may be used for the magnetohydrodynamic generation of electric power. Additional applications include fixation and synthesis of various chemical compounds wherein extreme heat generation is required.

I claim as my invention:

1. Apparatus for drawing an electric arc between a pair of spaced stationary electrodes within a pressurized arc chamber comprising, in combination: a starting electrode adapted to travel from one stationary electrode to the opposite stationary electrode and return transferring the arc therebetween; means for connecting an ionizing potential across said electrodes; a rotatably mounted lever arm; means for rotating said lever arm at a predetermined speed; means responsive to an input signal for allowing the lever arm to rotate one revolution; a link member pivotally mounted at the free end of said lever arm; and motion transfer means connecting said link member to said starting electrode for transferring he motion of said link member to said starting electrode to advance and retract said starting electrode.

2. Apparatus for drawing an electric arc between a pair of spaced stationary electrodes within a pressurized arc chamber comprising, in combination: a starting electrode adapted to travel from one stationary electrode to the opposite stationary electrode and return transferring the arc therebetween; means for connecting an ionizing potential across said electrode; a rotatably mounted lever arm; means for rotating said lever arm at a predetermined speed; means responsive to an input signal for allowing the lever arm to rotate one revolution; a link member pivotally mounted at the free end of said lever arm; means for adjusting the effective length of said lever arm; and motion transfer means connecting said link member to said starting electrode for transferring the motion of said link member to said starting electrode to advance and retract said starting electrode.

3. Apparatus for drawing an electric arc between a pair of spaced stationary electrodes within a pressurized

arc chamber comprising, in combination: a starting electrode adapted to travel from one stationary electrode to the opposite stationary electrode and return transferring the arc therebetween; means for connecting an ionizing potential across said electrode; a rotatably mounted lever arm; means for rotating said lever arm at a predetermined speed; said last-mentioned means comprising tension storage means and means for establishing a predetermined amount of energy in said tension storage means; a lever arm rotatably mounted and connected to said tension storage means for receiving stored up energy urging rotation of said arm upon release of said lever arm; release means responsive to an input signal for allowing the lever arm to rotate one revolution; a link member pivotally mounted at the free end of said lever arm; means for adjusting the effective length of said lever arm; and motion transfer means connecting said link member to said starting electrode for transferring the motion of said link member to said starting electrode to advance and retract said starting electrode.

4. Apparatus for drawing an electric arc between a pair of spaced stationary electrodes within a pressurized arc chamber comprising, in combination; a starting electrode adapted to travel from one stationary electrode to the opposite stationary electrode and return transferring the arc therebetween; means for connecting an ionizing potential across said electrodes; a rotatably mounted lever arm; means for rotating said lever arm at a predetermined speed; said last-mentioned means comprising an index plate and a driving plate rotatably mounted on first and second independently rotatable shafts respectively; a torsion spring secured at its opposite ends to the index plate and the driving plate respectively and peripherally spaced from said first and second shafts; said lever arm connected to rotate with said second shaft; means responsive to an input signal for allowing the lever arm to rotate one revolution; a link member pivotally mounted at the free end of said lever arm; means for adjusting the effective length of said lever arm; and motion transfer means connecting said link member to said starting electrode for transferring the motion of said link member to said starting electrode to advance and retract said starting electrode.

5. Apparatus for drawing an electric arc between a pair of spaced stationary electrodes within a pressurized arc chamber comprising, in combination; an arc starter assembly adapted to travel from one stationary electrode to the opposite stationary electrode and return transferring the arc therebetween; means for connecting an ionizing potential between said opposite stationary electrode and said one stationary electrode; said arc starter assembly including a driving rod and contact fingers adapted to be energized at the same potential as said one stationary electrode and move between said stationary electrodes so as to develop an electric arc gradually to its full length across said stationary electrodes; said arc chamber having an auxiliary chamber through which said driving rod extends; a closure member secured to said auxiliary chamber in gas tight relationship therewith for containing said driving rod as it extends out of said auxiliary chamber; and means for advancing and retracting the driving rod a predetermined distance and at a predetermined speed.

6. Apparatus for drawing an electric arc between a pair of spaced stationary electrodes within a pressurized arc chamber comprising, in combination; an arc starter assembly adapted to travel from one stationary electrode to the opposite stationary electrode and return transferring the arc therebetween; means for connecting an ionizing potential between said opposite stationary electrode and said one stationary electrode; said arc starter assembly including a driving rod and contact fingers adapted to be energized at the same potential as said one stationary electrode and move between said stationary electrodes so as to develop an electric arc gradually to its full length across said stationary electrodes; said arc chamber having an auxiliary chamber through which said driving rod extends; a closure member secured to said auxiliary chamber in gas tight relationship therewith for containing said driving rod as it extends out of said auxiliary chamber; motion transfer means including a driving gear and a driven gear; said driven gear being located within said auxiliary chamber and connected to said driving gear through a pressure tight seal; a gear rack operably connected to said driving gear; and means for driving said gear rack in a reciprocating motion of two to three cycles duration with a predetermined length of travel and speed.

7. The apparatus of claim 6 wherein said arc starter assembly includes an electrically conducting rod; a roller contact assembly including a plurality of roller contacts straddling said conducting rod and adapted to roll along the surface of said rod making electrical contact therewith; and means for connecting said electrical roller contacts to said ionizing potential.

8. The apparatus of claim 6 in which said arc starter assembly consists of at least one electrical contact finger pivotally mounted and adapted to make electrical contact with the first and second stationary electrodes as the arc starter assembly advances and retracts; and a heat and electrical barrier secured to said arc starter assembly and adapted to wipe the arc terminal on the contact finger onto the said one stationary electrode.

9. Apparatus for drawing an electric arc between a pair of spaced stationary electrodes within a pressurized arc chamber comprising, in combination; an arc starter assembly adapted to travel from one stationary electrode to the opposite stationary electrode and return transferring the arc therebetween; means for connecting an ionizing potential between said opposite stationary electrode and said one stationary electrode; said arc chamber having an auxiliary chamber through which said starter assembly extends; a closure member secured to said auxiliary chamber in gas tight relationship therewith for containing said starting assembly as it extends out of said auxiliary chamber; and means for advancing and retracting the driving rod a predetermined distance and at a predetermined speed.

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