

pages for (1) ion trap
(2) X ray shield
(3) vapor collector

June 1, 1965

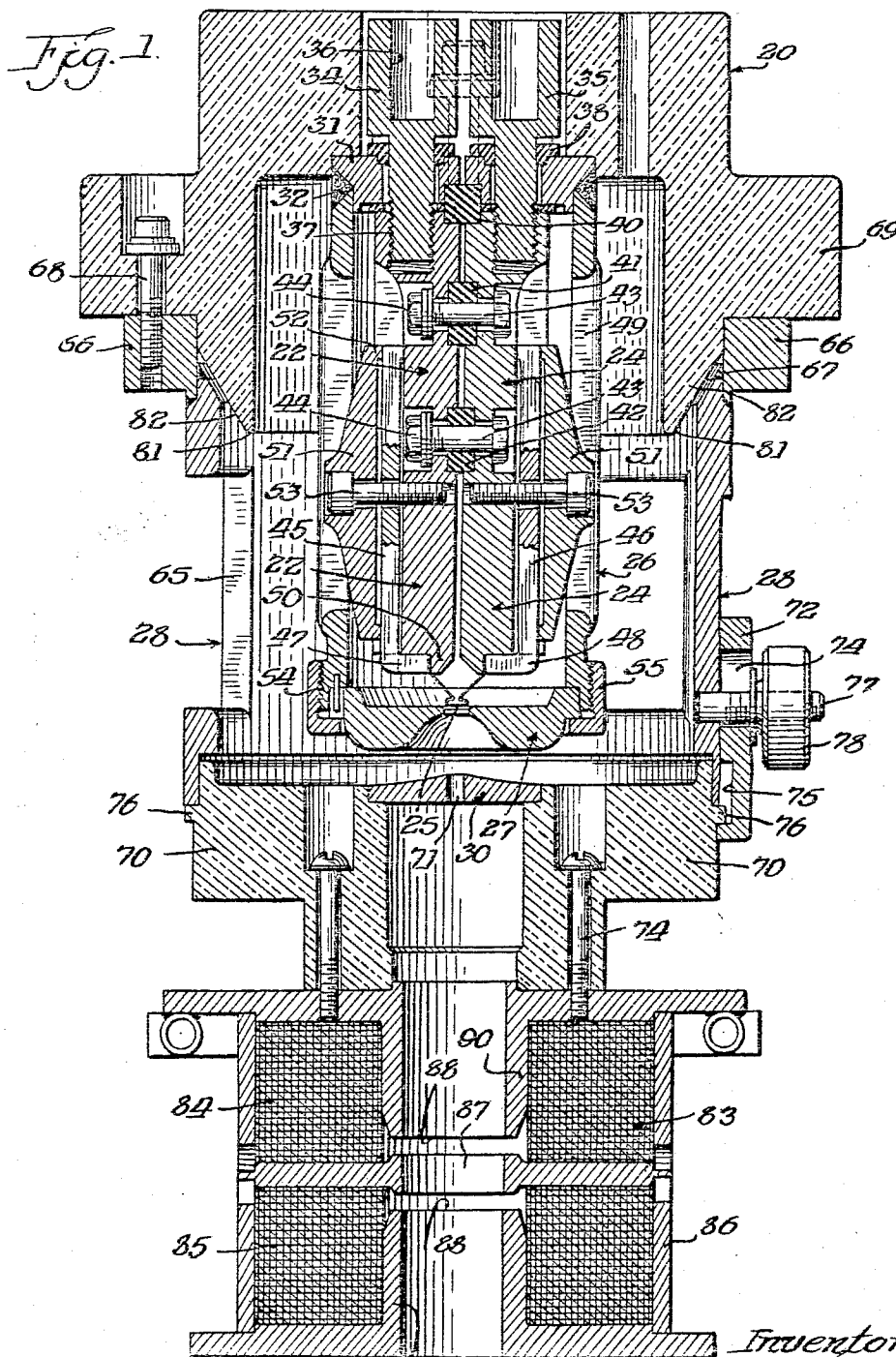
D. SCIACKY

3,187,216

ELECTRON GUN HAVING A RELEASABLY CLAMPED
ELECTRON EMITTING ELEMENT

Filed May 12, 1961

3 Sheets-Sheet 1



Inventor
David Sciacky
By Byron Hume Green + Clement
Attys

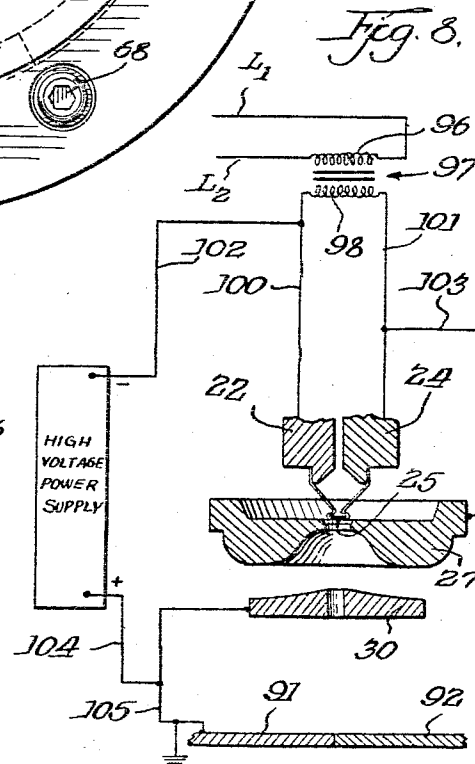
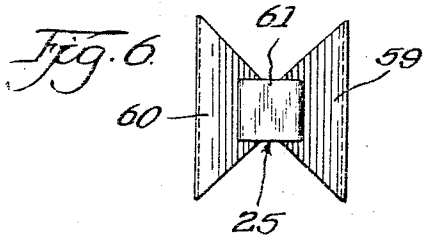
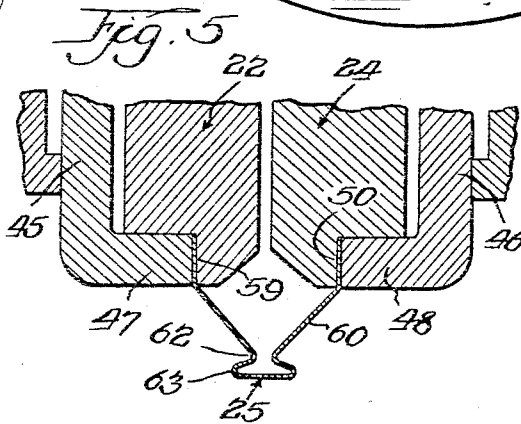
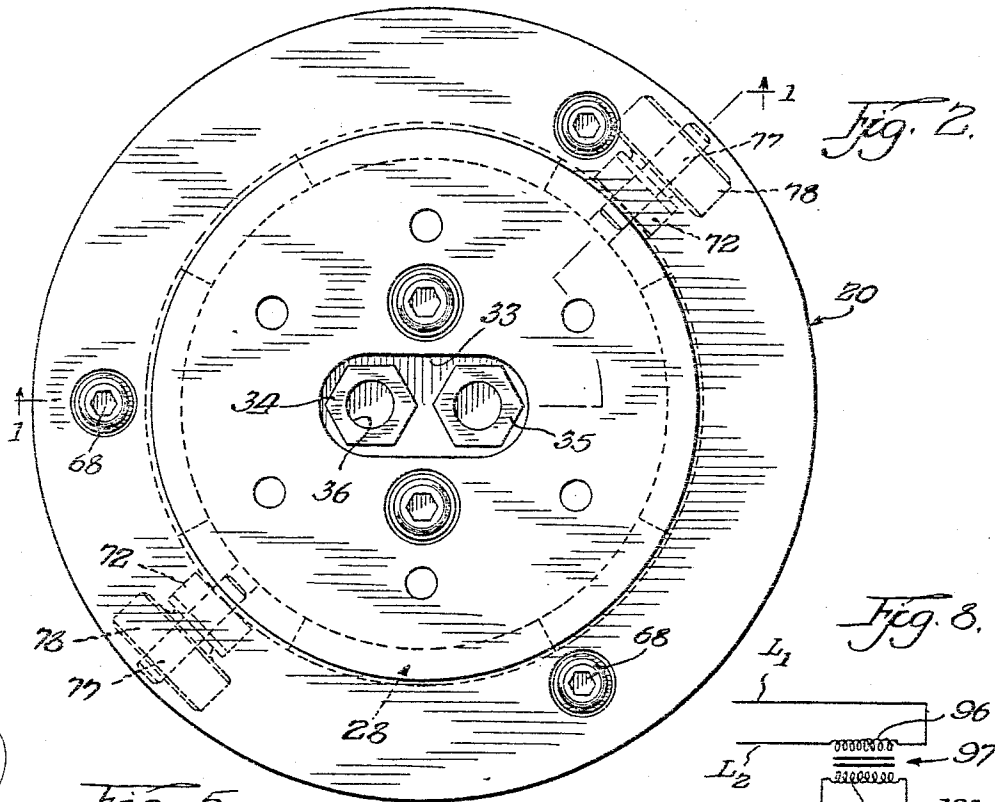
June 1, 1965

D. SCIAKY
ELECTRON GUN HAVING A RELEASABLY CLAMPED
ELECTRON EMITTING ELEMENT

3,187,216

Filed May 12, 1961

3 Sheets-Sheet 2



Inventor.
David Sciaky.

By Byron Hume Groen + Clement
Att'y's

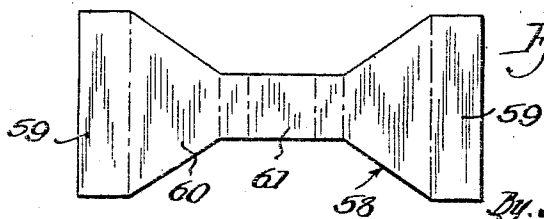
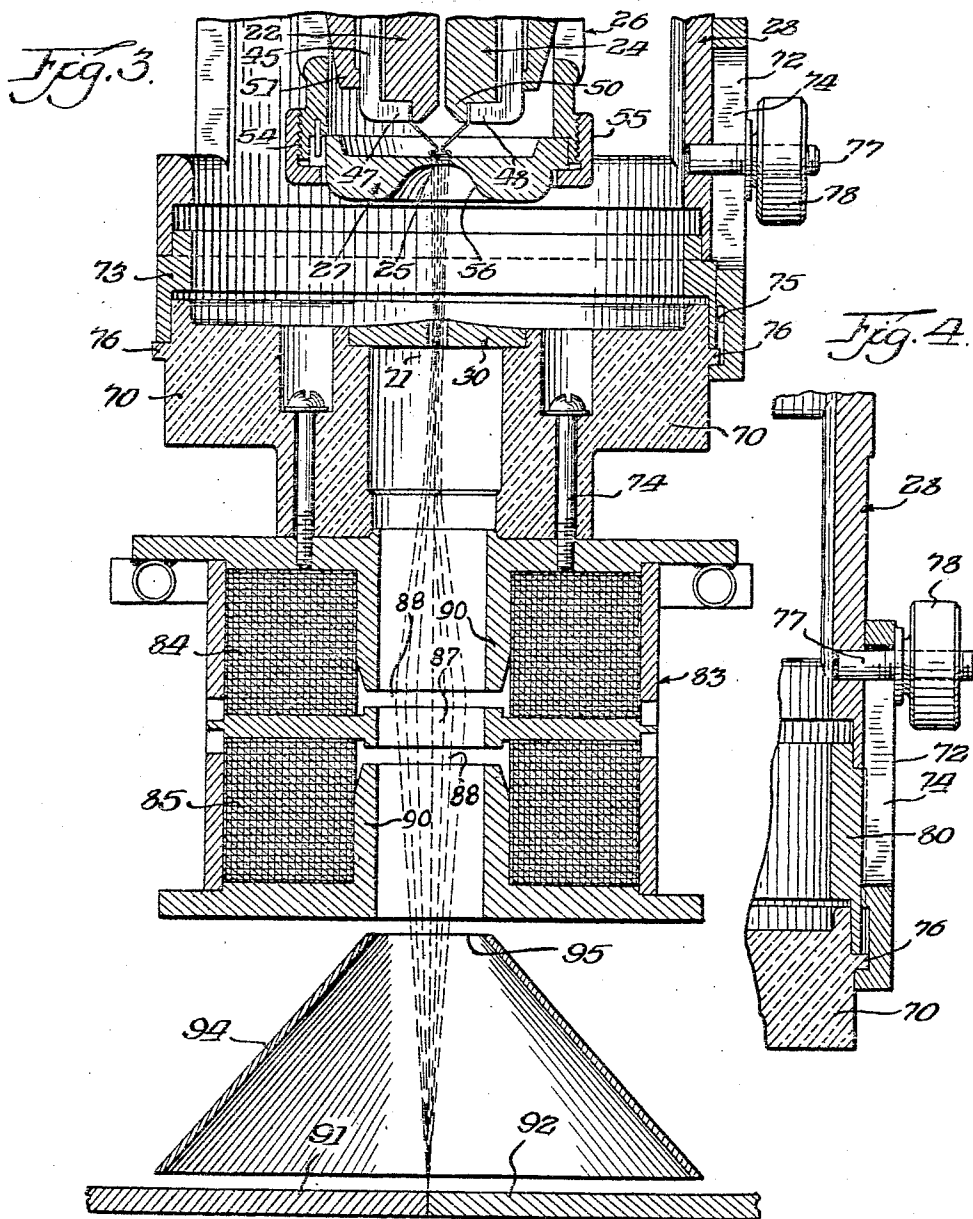
June 1, 1965

D. SCIACKY
ELECTRON GUN HAVING A RELEASABLY CLAMPED
ELECTRON EMITTING ELEMENT

3,187,216

Filed May 12, 1961

3 Sheets-Sheet 3



Inventor.
David Sciacky.

By Byron Hume Groen + Clement
Atty's.

1

3,187,216
**ELECTRON GUN HAVING A RELEASABLY
CLAMPED ELECTRON EMITTING ELEMENT**
David Sciaky, Chicago, Ill., assignor to Welding Research,
Inc., Chicago, Ill., a corporation of Illinois
Filed May 12, 1961, Ser. No. 109,575
12 Claims. (Cl. 313-237)

The invention relates to an electron beam gun, and has reference in particular to apparatus of this nature which will incorporate improved structural features making the same especially applicable for the welding, within an evacuated enclosure, of metals having a high melting temperature.

The electron welding device of the invention produces a stream of electrons, and which stream is accelerated and focused by structure specially designed for the purpose so as to provide a high power density beam for impinging on the work whereby the energy of the beam is transferred to the work, resulting in fusion. The essential elements of such a device comprise a supporting body portion, a filament, a cathode, an anode, and a focusing coil. The said elements have been so designed and have such correlation with each other that various metals and particularly those characterized by high melting temperatures can be satisfactorily welded within a vacuum.

One of the basic objects of the invention resides in the provision of a body portion for the gun which will consist of insulating material of high insulating value, and which in addition will be mechanically strong with low moisture and gas absorption and with good dielectric strength, whereby the body portion will provide a satisfactory mounting for such elements of the gun as the inner and outer shells which have a high potential difference during operation.

Another object of the invention is to provide a filament for an electron gun which will be inexpensive to make, although highly efficient in operation, and which can be easily inserted and accurately located with respect to the cathode by means of improved clamping structure.

Another object of the invention is to provide clamping structure as described, which will employ spring loading action for releasably retaining the filament in place for the most satisfactory electrical connection, which will insure positive and mechanically secure clamping engagement of the filament so that deterioration due to defective contact between filament and holder will be eliminated, and wherein said filament will be so clamped as to enable easy replacement and reproducibility of the electron beam effect.

Another object of the invention is to provide a pair of electrodes and a connecting socket for each electrode which will be electrically effective in connecting the electrodes to the power source for the most efficient operation of the gun, and which will also enable rapid and easy assembly and disassembly of the various parts of the gun.

A further object of the invention is to provide inner and outer shells for the gun, each comprising essentially a cage having large openings for rapid diffusion of the gases and metal vapors produced during use of the gun and which will result in safe operation without any arcing.

Another object is to provide an electron beam gun which will incorporate improved spacing rings for spacing the anode the required distance from the cathode and filament for obtaining various ranges of beam current, and which can be employed selectively since a fast clamping and unclamping arrangement makes the changing of a spacing ring relatively easy while at the same time insuring parallelism between the filament, the cathode and the anode.

A still further object is to provide electromagnetic

2

focusing means for the electron beam of a gun such as described, which will have location below the anode at a convenient distance from the gun to provide the most efficient focusing of the electron beam for welding purposes.

Another object is to provide a funnel for association with the work piece, and which will insure the maximum stability of the gun in operation, since the funnel is effective for absorbing X-rays, for the collection of gases and metal vapors through condensation, and for the trapping of ions before they reach the gun, thus preventing their interference with and impairment of the filament.

With these and various other objects in view, the invention may consist of certain novel features of construction and operation, as will be more fully described and particularly pointed out in the specification, drawings and claims appended thereto.

In the drawings which illustrate an embodiment of the device and wherein like reference characters are used to designate like parts—

FIGURE 1 is a longitudinal sectional view taken substantially along line 1—1 of FIGURE 2 and which shows the structural details of an electron beam gun embodying the improvements of the invention;

FIGURE 2 is a top plan view of the electron beam gun of FIGURE 1;

FIGURE 3 is a fragmentary sectional view illustrating several improved features of the present gun including the spacing ring for the anode and the funnel for association with the work-piece.

FIGURE 4 is another fragmentary sectional view illustrating the adjustable clamping means for the spacing rings;

FIGURE 5 is a fragmentary sectional view showing in detail the clamping arrangement for releasably securing the filament to the current conducting electrodes;

FIGURE 6 is a plan view of the filament as shown in FIGURE 5;

FIGURE 7 is a detail view showing the size and shape of the metal blank prior to the bending thereof to form the filament; and

FIGURE 8 is a schematic view illustrating the electrical connections for the various elements of the present electron beam gun.

Referring to the drawings and in particular to FIGURES 1 and 2 the embodiment selected for illustrating the invention employs a cap or body portion 20 from which the various parts of the gun are suspended. The said body portion is formed of insulating material having good dielectric strength, good heat conductivity, and which is also mechanically strong with low moisture and gas absorption. The body portion accordingly suspends a pair of electrodes 22 and 24 for conducting current to the filament 25. The body portion also suspends a spaced inside shell or cage 26 for supporting the cathode 27 and a spaced outside shell or cage 28 which functions as a holder for the anode 30.

The current conducting electrodes 22 and 24, and the inner cage 26 comprise a unit which is supported from the insulating body portion 20 primarily by the plate members 31 spaced and insulated from each other and to which the cage 26 of stainless steel is welded as at 32. The plate members 31 are secured centrally to the body portion and this central section is cored to provide the elliptical opening 33, FIGURE 2. Said opening receives the sockets 34 and 35 preferably formed of copper and which have a plug receiving recess 36 in their exposed top end whereas their reduced depending end is threaded at 37. This end of each socket extends through a washer of insulating material such as 38 and through its respective plate member 31 and the end is threaded into one of the electrodes. Thus socket 34 is mechanically and electri-

cally connected to electrode 22, whereas socket 35 connects with electrode 24. The sockets 34 and 35 are adapted to receive plugs, not shown, and which electrically connect the sockets and thus the electrodes to a source of current for heating the electron emitting filament 25. Said current may have a voltage of about 5 volts with an amperage which may average approximately 40 amperes.

The electrodes 22 and 24 are thus disposed in a depending, side by side relation relatively adjacent each other and which requires the location of spacers of insulating material such as 40, 41 and 42 for maintaining the electrodes in desired spaced relation. The securing bolts 43 extend through the electrodes and through the washers 41 and 42, respectively, to receive the nuts 44 and which are properly insulated from electrode 22. The electrodes are thus mechanically connected to form a unit and which support on respective sides a clamping arrangement for clamping the filament to the electrodes. Each electrode has a clamping bar such as 45 and 46 disposed in contact with its outside surface and each bar provides a lower flange 47 and 48 adapted to contact a shoulder such as 50 on its respective electrode. A clamping member 51 is provided for each bar and the same contacts its bar at longitudinally spaced locations for which purpose each member 51 is provided with feet 52. A bolt 53 extends through each of the members and through its associated clamping bar and has threaded connection with its respective electrode. The clamping members are preferably formed of metal such as copper and which has some resiliency since upon tightening the bolts 53 it will be understood that a spring loading action is applied to each clamping bar, thus forcing and securely maintaining the flanges 47 and 48 against a shoulder 50 to thus provide a good mechanical and electrical clamp for the filament 25.

The inner cage 26 of substantially cylindrical shape may be constructed of stainless steel and the cage is formed with a plurality of openings 49 whereby convenient access is provided for manipulating the nuts 44 and the bolts 53. Release of the bolts and disassembly of the clamping arrangement will be necessary in the event a filament has to be replaced.

The lower terminal end of the inside cage 26 is threaded as at 54 and this threaded end receives the retaining ring 55 for releasably retaining the cathode 27 in place on the bottom of the cage. The said cathode is maintained at a negative potential of approximately 50,000 volts and the same is provided with a center opening which receives the axially positioned filament 25. It is important that the filament have an accurately aligned relation with the opening for the most efficient production of electrons and also the undersurface of the cathode 27 is shaped at 56 as best shown in FIGURE 3 for the same purpose.

The filament 25 is formed from a strip of metal 58, FIGURE 7, such as tantalum or tungsten, the same having a shape as shown in FIGURE 7. The relatively wide extremities 59 comprise the portions of the same which are clamped between the shoulders 50 and the flanges 47 and 48, respectively. The connecting portions 60 narrow the strip down to a central section 61 and which has a length whereby to permit a bending of the section back on itself while still presenting a surface area adequate for the emission of electrons for the present gun. With the filament in clamped engagement with the electrodes 22 and 24 as shown in FIGURE 5 the connecting portions 60 extend diagonally downward and inward to the bends 62 whereupon the metal strip extends laterally outward to the outside bends 63. This formation of the filament by its non-inductive nature minimizes the magnetic field produced by the filament.

The outside shell or cage 28 is likewise provided with a plurality of openings 65 and the said cage is suspended from the body portion 20 by the encircling clamp 66. The cage at its upper end is welded at 67 to the clamp and which is held to the body portion by the securing bolts 68 being located under the annular flange 69 which com-

prises an integral part of the body portion. The cage provides a support for the ring 70 of insulating material having the same desirable characteristics as the material of the body portion. The anode 30 is supported and accurately positioned by the ring 70 with its opening 71 in alignment with the opening in the cathode 27 and with the filament 25. The anode is given a positive potential and for the most satisfactory results in operation it is preferred to make the anode of tantalum. Since the spacing of the anode 30 from the cathode 27 determines the power ratings for the present electron gun, that is the maximum value of beam current at maximum voltage, the invention provides adjustable hangers 72 and spacing rings such as 73, FIGURE 3, for varying the cathode-anode distance. Two hangers 72 are provided diametrically spaced on the cage 28 and each hanger is slotted at 74 and formed with a groove 75 at its depending end. An annular flange 76 on the anode supporting ring 70 is retained by the groove 75 and a threaded stud 77 extends from the cage through the slot 74 and receives the releasable knob 78.

In FIGURE 1 the anode supporting ring 70 and thus the anode 30 are spaced the minimum distance from the cathode to give the maximum rating for the gun, approximately 300 milliamperes at maximum operating voltage of about 25,000 volts. Since lower currents at the maximum voltage are often desirable, spacing rings are employed and which are interposed between the end of the cage 28 and the ring 70. For example, in FIGURE 3, the ring 73 lowers the anode 30 to an extent which gives a current of approximately 50 milliamperes. In FIGURE 4 the ring 80 is greater in length and thus the cathode-anode distance is increased for a relatively low current of about 25 milliamperes.

Below the annular flange 69 the body portion 20 is formed with a depending nose portion 81 and which presents an inwardly sloping surface 82 exteriorly of the body portion and a relatively long surface within the body portion until the inside cage 26 is reached. In accordance with the invention the nose 81 is interposed between the inside and outside cages 26 and 28, respectively, to present the maximum creep distance between these parts. This is desirable since the parts have a high potential difference during operation. The result of this structure is to insure safe operation of the gun at said high operating potentials and without any arcing.

For focusing and directing the electron beam so as to direct a beam of maximum density for welding the workpiece, a focusing coil 83 is suspended by the screws 74 from the anode supporting ring 70. The said focusing coil essentially consists of a pair of coils such as 84 and 85 encased in an enclosing shell 86 of iron and which have an armature 87 also of iron located between the adjacent inner edges of the coils. An air gap 88 exists on each side of the armature between the same and the interior cylinder of iron 90 for the respective coils. The air gaps are thus located at the central plane of the focusing coil. A relatively low voltage, direct current is caused to flow through the coils 84 and 85 to provide a magnetic effect within the central passage formed by the interior cylinders 90. The focusing coil is located below the anode where the electron beam starts to diverge. The action of the magnetic flux from coil to armature is such as to cause the beam to converge and by adjusting the current flowing in the coils the beam of electrons can be caused to impinge on the workpiece with maximum density for the most satisfactory welding operation.

When the temperature of the filament 25 is increased to a predetermined extent, the kinetic energy of some of the electrons is also increased allowing them to escape from the filament. In a vacuum and under the influence of an electric field as produced by the cathode 27 and the anode 30, the electrons are accelerated and they move in the direction of the field. Because the electron beam has a tendency to diverge, it is necessary to counter this na-

5

tural phenomenon by providing the focusing coil 83. The coil is located a predetermined distance below the anode and even though different spacing rings are used, this distance remains fixed.

From the focusing coil the beam is directed onto the workpieces 91 and 92 as shown in FIGURE 3 for welding the metal pieces together. As a result of the generation of the electron beam and the fusion of the metal workpieces, gases and metal vapors will be produced and some ionization will also occur. If the ions find their way to the filament area, they tend to interfere with the generation of the electrons, and they also have a deteriorating effect on the filament. The metal vapors are deposited on the surfaces of the gun to result in shorter creep distances so that arcing may occur. To minimize these conditions and to thus improve the stability of the gun during operation a funnel 94 of any suitable metal is employed in connection with the welding of the workpieces. Said funnel has an opening 95 at its apex end through which the electron beam is directed onto the work. The funnel will function to absorb X-rays such as may be produced by the electrons and the funnel will also serve to collect a large proportion of the gases and metal vapors through condensation. Also the funnel can be used to trap and contain most of the ions that may be produced, thus preventing them from interfering with the filament.

The electrical circuit for the gun is shown schematically in FIGURE 8. The alternating power supply indicated by the leads L_1 and L_2 includes the primary winding 96 of a transformer 97 which has a secondary winding 98 connected to the conductors 100 and 101, which in turn supply a heating current at the desired voltage to the electrodes 22 and 24, and thus to the filament 25. The high voltage power supply furnishes a direct current at the desired voltage for maintaining the required electrical field between the cathode and the anode. The negative conductor 102 is connected to the conductor 100 and the conductor 103 completes the circuit to the cathode 27. The positive conductor 104 from the high voltage power supply has connection with the anode 30 and a parallel circuit including conductor 105 is connected to the workpiece and grounded.

It is to be understood that the invention is not to be limited to or by details of construction of the particular embodiment thereof illustrated by the drawings, as various other forms of the device will, of course, be apparent to those skilled in the art without departing from the spirit of the invention or the scope of the claims.

What is claimed is:

1. In a device of the character described, in combination, a body portion of insulating material, a cylindrical cage of metal depending from the body portion, a pair of current conducting electrodes extending longitudinally within the cage and being supported from the body portion, clamping means carried by each of the electrodes for releasably clamping an electron emitting element to said electrodes at the depending terminal end of the same, each clamping means including a clamping bar and a member for spring loading the bar, a cathode adapted to be releasably secured to the depending terminal end of the cage and in position for coaxing relation with the electron emitting element, and means for releasably securing the cathode to said cage.

2. A device of the character as defined by claim 1, wherein the cage has a plurality of openings in the cylindrical wall thereof and which extend longitudinally, certain of said openings receiving and providing access to the clamping means respectively.

3. In a device of the character described, in combination, a body portion of insulating material, a cylindrical cage of metal depending from the body portion, a pair of current conducting electrodes extending longitudinally within the cage and being supported from the body portion, each electrode having means depending from the

6

lower terminal end thereof to provide a shoulder, a clamping means carried by each of the electrodes for releasably clamping an electron emitting element to said electrodes and against the shoulders of the same, each clamping means including a clamping bar disposed adjacent and in contact with its electrode and having a flange adapted to contact the shoulder of its electrode, a member positioned and having portions for contact with its bar at spaced locations, means for securing the member to its electrode whereby to spring load its bar, and a cathode releasably secured to the depending terminal end of the cage and positioned for coaxing relation with the electron emitting element.

4. A device of the character as defined by claim 3, additionally including a ring element having threaded connection with the cage for releasably securing the cathode to the cage, and wherein the cylindrical wall of the cage is provided with a plurality of openings and which extend longitudinally, certain of said openings receiving and providing access to the clamping means respectively.

5. In an electron gun, the combination with a body portion of insulating material, a cylindrical inside cage fixed to and depending from the body portion, a pair of electrodes extending longitudinally within the cage in spaced relation with the cage and with each other, means supporting the electrodes from the body portion, clamping means carried by each of the electrodes for releasably clamping an electron emitting element to said electrodes at the terminal end thereof, said clamping means including a clamping bar and a member for spring loading the bar, a cathode adapted to be releasably secured to the terminal end of the inside cage and in position for coaxing relation with the electron emitting element, an outside cylindrical cage also fixed to and depending from the body portion, said outside cage being concentric and in spaced enclosing relation with the inside cage, and an anode releasably supported by the terminal end of the outside cage and positioned thereby a predetermined distance below the cathode and in substantial axial alignment with the cathode.

6. An electron gun of the character as defined by claim 5, wherein the inside cage and the outside cage are each provided with longitudinally extending openings having an aligned relation, certain of said openings providing access to the clamping means respectively.

7. An electron gun of the character as defined by claim 5, additionally including a spacing ring interposed between the outside cage and the anode for increasing the distance between the cathode and the said anode.

8. In an electron gun, the combination with a body portion of insulating material, a cylindrical inside cage fixed to and depending from the body portion, a pair of electrodes extending longitudinally within the cage in spaced relation with the cage and with each other, means supporting the electrodes from the body portion, clamping means carried by each of the electrodes for releasably clamping an electron emitting element to said electrodes at the terminal end thereof, a cathode releasably secured to the terminal end of the inside cage and in position for coaxing relation with the electron emitting element, an outside cylindrical cage also fixed to and depending from the body portion, said outside cage being concentric and in spaced enclosing relation with the inside cage, an anode supporting ring of insulating material releasably secured to the terminal end of the outside cage and positioned thereby below the cathode, an anode supported by the said ring in axial alignment with the cathode, and a focusing coil suspended from the anode supporting ring and being positioned a predetermined distance below and in substantial axial alignment with the anode and cathode.

9. An electron gun of the character as defined by claim 8, additionally including a spacing ring interposed between the outside cage and the anode supporting ring for increasing the distance between the cathode and the

7

said anode and also the distance between the cathode and the focusing coil.

10. In an electron gun, the combination with a body portion of insulating material, a cylindrical inside cage fixed to and depending from the body portion, a pair of electrodes extending longitudinally within the cage in spaced relation with the cage and with each other, means supporting the electrodes from the body portion, clamping means carried by each of the electrodes and operative at the lower terminal end of its electrode for clamping an electron emitting element thereto, a cathode releasably secured to the terminal end of the inside cage and in position for coacting relation with the electron emitting element, an outside cylindrical cage also fixed to and depending from the body portion, said outside cage being concentric and in spaced relation with the inside cage, an anode supporting ring of insulating material releasably secured to the terminal end of the outside cage and positioned thereby below the cathode, and an anode supported by the said ring centrally thereof and in axial alignment with the cathode, the said body portion having a formation interposed between the inside and outside cages such that an adequate creep surface is provided to prevent arcing between the said cages.

11. An electron gun as defined by claim 10, addition-

8

ally including a plurality of hangers carried by the outside cage for releasable connection with the anode supporting ring, whereby the hangers support the ring from the cage and position the same below the cathode.

12. An electron gun as defined by claim 10, additionally including a plurality of hangers adjustably carried by the outside cage for releasable connection with the anode supporting ring, whereby the hangers support the ring from the cage and position the same below the cathode, and wherein a spacing ring may be interposed between the cage and the anode supporting ring for increasing the distance between the cathode and the anode.

References Cited by the Examiner

UNITED STATES PATENTS

1,991,279	2/35	Holst	313—207
2,443,632	6/48	Miller	313—207
2,871,387	1/59	Staerck	313—82.1
2,887,600	5/59	Fyler	313—82.1
2,932,755	4/60	Jeppson	313—237 X
3,034,012	4/62	Gasson	313—341 X

DAVID J. GALVIN, *Primary Examiner.*

ARTHUR GAUSS, GEORGE N. WESTBY, *Examiners.*