March 4, 1947. W. C. BROWN 2,416,899

ELECTRONIC DISCHARGE DEVICE OF THE MAGNETRON TYPE

Filed Sept. 24, 1943 2 Sheets-Sheet 1

FIG. 1.

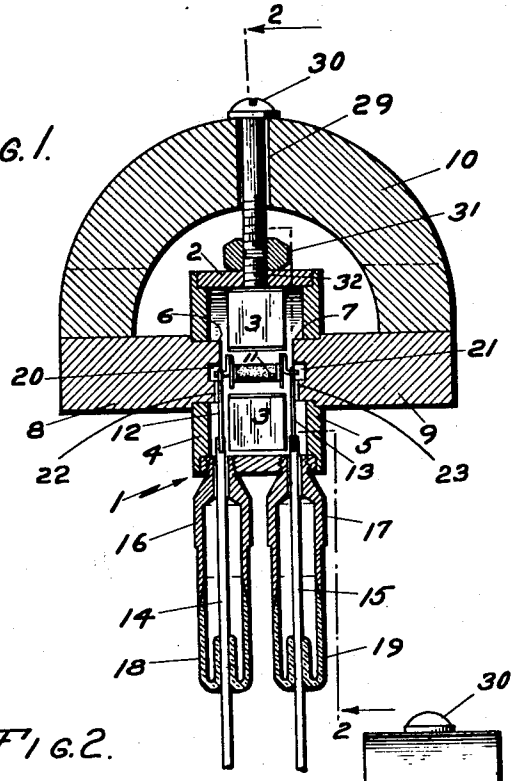


FIG. 2.

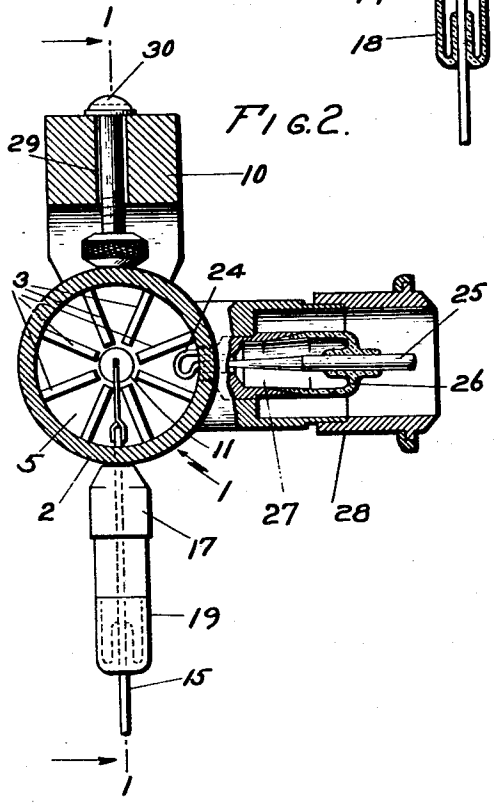
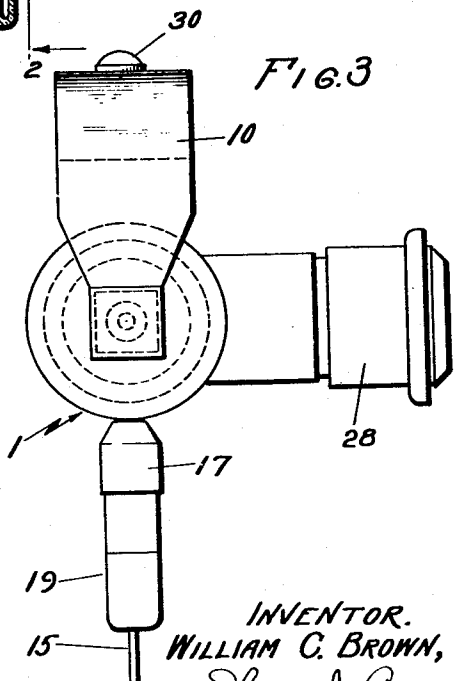


FIG. 3.



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FIG. 4.

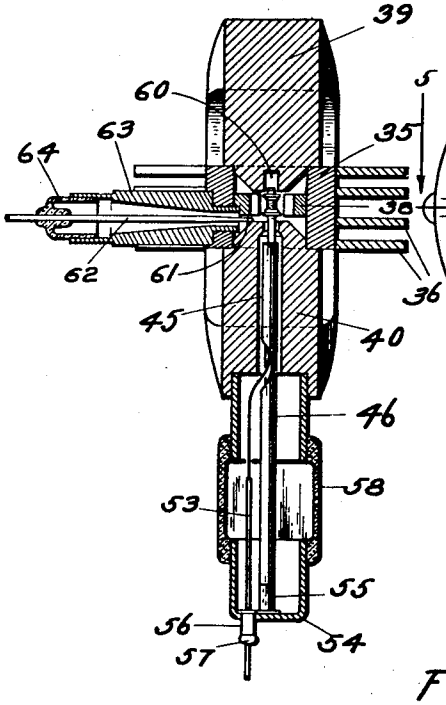


FIG. 6.

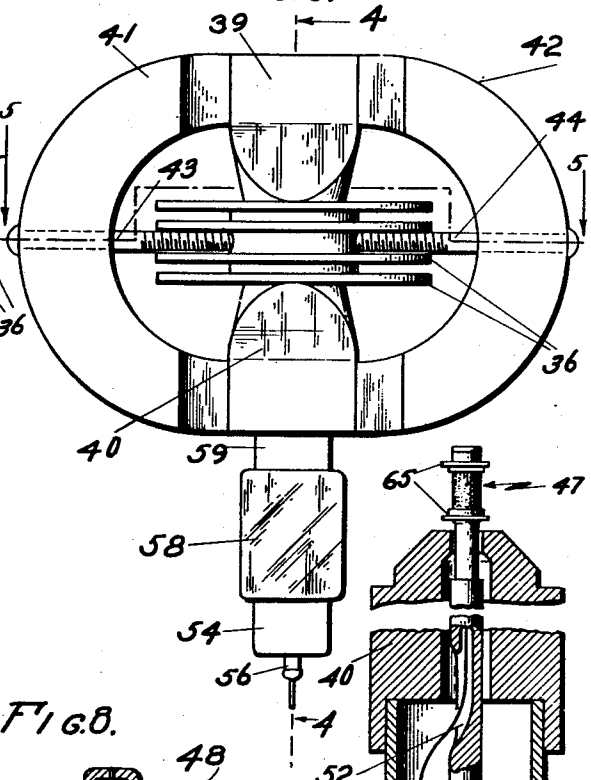


FIG. 5.

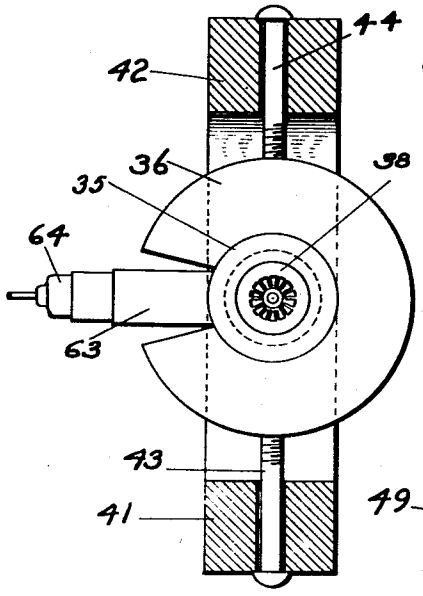
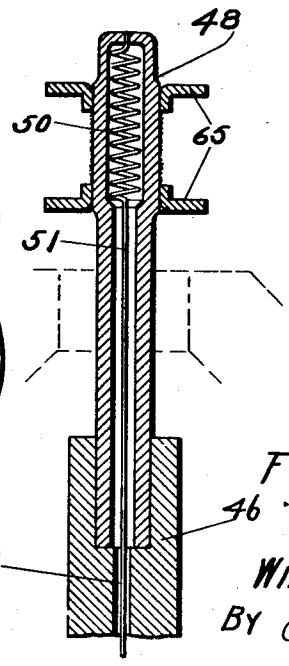


FIG. 8.



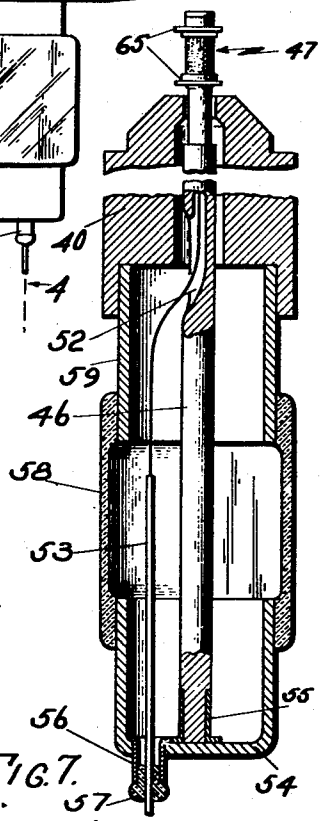


FIG. 7.

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ELECTRONIC DISCHARGE DEVICE OF THE MAGNETRON TYPE

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Application September 24, 1943, Serial No. 503,622

7 Claims. (Cl. 315—40)

This invention relates to an electronic discharge device, and more particularly to one of the type in which a magnetic field is imposed upon the discharge space of the device.

In some electronic discharge devices, for example, magnetrons, it is necessary to provide a magnetic field in the space through which the discharge occurs. Heretofore it has been necessary to use heavy magnets or field coils for this purpose in order to impose a field of sufficient strength. Such heavy magnets or field coils greatly increase the overall dimensions of the device and add materially to its weight. This is very undesirable, particularly where the device is intended for use on vehicles, aircraft, or other places where the size and the weight of the device are important factors.

It is among the objects of the present invention to provide a device of this type in which the size and weight of the magnet providing the magnetic field may be greatly reduced without reducing the intensity of the magnetic field in that portion of the discharge space where the field is desired.

It is a further object of the invention to reduce the number of parts required in the construction of devices of this type and thereby simplify their manufacture as well as reduce their cost and weight.

The above and other objects and features of the invention will be made fully apparent to those skilled in the art from a consideration of the following detailed description taken in conjunction with the accompanying drawings in which:

Fig. 1 shows a longitudinal section through a magnetron embodying the present invention;

Fig. 2 shows a transverse section taken on the line 2—2 of Fig. 1;

Fig. 3 shows a top plan view of the device of the preceding figures;

Fig. 4 shows a longitudinal section taken on the line 4—4 of Fig. 6 through another embodiment of the invention;

Fig. 5 shows a transverse section taken on the line 5—5 of Fig. 4 with the upper pole piece removed;

Fig. 6 shows the device of Figs. 4 and 5 in side elevation;

Fig. 7 shows, on an enlarged scale, a longitudinal section through a combined cathode and pole piece assembly of the tube shown in Figs. 4, 5 and 6; and

Fig. 8 shows, on a still larger scale, a longitudinal section through the cathode structure of Fig. 7.

Referring to the drawings, and first to Figs. 1, 2 and 3 thereof, the magnetron illustrated comprises an envelope 1 of highly conductive material, such as copper. In the instance shown the envelope 1 comprises a tubular body 2 having radial arms 3 projecting interiorly from the central portion thereof leaving hollow end sections closed by end caps 4 and 5 which are hermetically sealed to the body 2. The end caps 4 and 5 have openings in the center thereof through which the reduced end portions 6 and 7, of pole pieces 8 and 9, are adapted to project. The reduced end portions of pole pieces 8 and 9 project into the space provided by the hollow end sections to points adjacent the inner ends of arms 3, but out of contact therewith. The pole pieces 8 and 9 are hermetically sealed in the central openings of the end caps 4 and 5, as by soldering, and project beyond the outer faces of the end caps for a sufficient distance to provide lateral surfaces conforming to the end faces of a horse-shoe magnet 10. The magnet 10 is preferably of a material having a highly coercive force, such as certain alloys of aluminum, nickel and cobalt, or other materials capable of being highly magnetized. The pole pieces 8 and 9 are of highly permeable material, such as cold rolled steel or soft iron which may be readily machined.

A cathode structure 11 extends between the pole pieces 8 and 9, but out of contact therewith, to provide a cathode surface coacting with the anode faces formed by the arms 3. The cathode structure 11 is supported by wires 12 and 13, which wires are connected to and supported by lead-in conductor rods 14 and 15. The rods 14 and 15 extend through pipes 16 and 17 which are of conductive material and are sealed in the outer ends thereof by glass seals 18 and 19. The pipes 16 and 17 are hermetically sealed in openings adjacent the ends of the body 2 so that the cathode lead-in connections may extend through the free space provided by the hollow end sections of the tube between the arms 3 and the end caps 4 and 5. The pole pieces 8 and 9 are provided with central depressions 20 and 21 in the faces thereof which not only provide clearance for the ends of cathode structure 11, but tend to concentrate the magnetic field in the space between the surface of the cathode structure 11 and the anode arms 3. Grooves 22 and 23 are cut in the face of the

pole pieces 8 and 9 to provide clearance for the cathode lead-in wires 12 and 13.

A coupling loop 24, extending into one of the cavities formed by the arms 3 and having one end thereof fastened to the inner wall of said cavity, has its other end connected to a conductor 25 which passes through a glass seal 26 mounted at the outer end of a pipe 27, likewise hermetically fastened in an opening through the wall of the envelope 1. A conducting pipe 28, electrically connected to the pipe 27, forms with the conductor rod 25 a concentric line through which the high frequency oscillations generated by the magnetron may be conducted to a suitable utilization circuit.

The magnet 10 may have sufficient strength to normally retain itself in position when placed on the pole pieces 8 and 9. However, I prefer to insure that the magnet 10 will not be displaced from its position upon the pole pieces by means of a suitable fastening device. To this end I provide an opening 29 through the central portion of the magnet 10 through which a screw-bolt 30 may extend to secure the magnet 10 to the body 2 of the magnetron by means of a coacting nut 31. The nut 31 may be secured to the body of the magnetron in any suitable manner, as by soldering, or it may be secured, as shown, to a threaded stud-bolt 32 secured in the side wall of the envelope and hermetically sealed thereto.

It will be understood that in magnetrons of the type shown the envelope 1 constitutes the anode of the device and the radial arms 3 provide a plurality of anode faces coacting with the cathode 11. Capacitances exist between the side walls of each of the arms 3, and the inner walls of the cavities, defined by each pair of adjacent arms 3 and the intervening portion of the inner surface of the wall of the body, constitute inductances. The anode, therefore, is so designed that the inductances and the capacitances described constitute circuits which are tuned and thus are resonant at a predetermined frequency. Thus, when the device is energized, while the magnet 10 is in position imposing a magnetic field directed transversely of the direction of electron flow between the cathode and anode, oscillations are set up. These oscillations are the same for each of the circuits formed by the walls of the cavities between the arms 3. Into these circuits energy is fed by the electrons from the cathode 11 and from them energy is received by the coupling loop 24.

Ordinarily the magnetic field for the discharge space between the cathode and the anode must be imposed through the metal or other material forming the end caps of the envelope. Consequently the gap between the end faces of the pole pieces of such structures is large and the magnetic field intensity at points between the cathode and the anode surface is low and large magnets or field coils are required to produce a field of the desired intensity. By the present construction the magnetic field is concentrated in the annular space between the active surface of the cathode 11 and the anode faces provided by the arms 3. The magnetic field intensity at points between the opposed surfaces of the electrodes is high. Therefore, in order to secure a field of the desired intensity the construction herein disclosed may utilize magnets of far less size and weight than those of prior constructions and accordingly the necessity for using field coils is eliminated and only small permanent magnets are required.

In the embodiment of the invention shown in Figs. 4 to 8, inclusive, a very light and compact device is provided by utilizing the pole pieces as end caps for the magnetron. Referring to these figures, reference numeral 35 indicates a tubular body of copper, or other highly conductive material, having heat radiating fins 36 projecting exteriorly thereof and radially extending arms 38 projecting inwardly from its interior surface. The inwardly projecting arms 38 form a web or bridge in the central portion of the tubular body 35 leaving hollow end spaces at each end thereof. Pole pieces 39 and 40 have tapered portions projecting into the end sections of the envelope and extending to points adjacent the bridge. The pole pieces 39 and 40 are shouldered, as indicated, to fit the ends of the tubular portion 35 to which they are hermetically joined, as by soldering. The pole pieces 39 and 40 extend outwardly for a sufficient distance to provide lateral surfaces coacting with the end faces of magnets 41 and 42. As shown, the lateral faces of the pole pieces are flat, but these surfaces may be curved or otherwise shaped to conform to the end faces of the magnets. The magnets 41 and 42 are removably attached to the body 35 of the magnetron by screw-bolts 43 and 44. It will be understood that any suitable fastening means adapted to secure the end faces of the magnets 41 and 42 to the pole pieces 39 and 40 may be utilized for this purpose.

The pole piece 40 has a central longitudinal passage 45 extending therethrough to accommodate a conductor rod 46 which provides a lead-in connection and a support for a cathode structure 47. The cathode structure comprises a tubular member 48, having one end thereof secured in the enlarged end of a passage 49 in the conductor rod 46, and having its other end slightly enlarged to accommodate a filament 50 therein. The cathode structure projects beyond the tapered end of the pole piece 40 and through the central portion of the body 35 with its cylindrical surface in uniformly spaced relation to the ends of the radial arms 38, which arms provide anode faces coacting with said cathode. The active surface of the cathode is coated with an electron emissive material in a manner well known in the art. The filament 50, for heating the cathode, is disposed in the enlarged end of the tubular member 48, and has one end electrically connected thereto. Its opposite end is connected to an insulated wire 51 which extends through the passage 49 in the conductor rod 46. The rod 46 is provided with a slot 52 of sufficient depth to form an opening from the interior end of the passage 49, through which slot the wire 51 emerges from the conductor 46 and is connected to a rod 53. The conductors 46 and 53, together with the wire 51, thus form the lead-in connections for supplying heating current to the filament 50 and also for supplying a biasing potential for the cathode 47. The conductor rod 46 is rigidly secured to an end cap 54 of conductive material by means of an eyelet 55, also of conductive material. The eyelet 55 is brazed or soldered to the cup 54 and thus provides a good electrical connection between said cup and the rod 46, as well as a rigid support for said rod. The rod 53 passes through an eyelet 56 brazed in an opening in the cup 54, and is hermetically sealed therewith and insulated therefrom by a glass seal 57. The cup 54 is insulated from the pole piece 40 and accordingly from the body 35 by means of a glass tube 58 which has one end hermetically joined thereto,

as by fusing, and its opposite end similarly joined with a tubular shell 59. The end of the shell 59, remote from the tube 58, is inserted into an enlarged end of the passage 45 of the pole piece 40 and hermetically joined therewith, as by brazing. The pole piece 40, together with the cathode structure and its lead-in connections and seals, thus forms an integral assembly which may be readily constructed and thereafter easily assembled with the body 35 of the magnetron.

The passage 45 is reduced adjacent the tapered end of the pole piece 40 so that the magnetic field will be concentrated in an annular space adjacent the cylindrical surface of the cathode 47 and the ends of the arms 38. The other pole piece 39 has a cavity 60 in the end face thereof so that its active end surface conforms to the end surface of the pole piece 40 and insures that the magnetic field between the two pole pieces will be concentrated mainly in the space between the cylindrical surface of the cathode 47 and the ends of the arms 38.

A coupling loop 61 is provided in the body 35. The loop may be disposed in any desired manner to receive energy from the primary oscillations of the tube. Thus, it may enter one of the cavities formed by any pair of adjacent arms 38 and the intervening wall of the tube 35 in the manner disclosed in the previously described construction, or as in the instance shown in Fig. 4 it may be disposed in one of the end spaces or sections between one of the pole pieces and the bridge structure formed by the arms 38. One end of the coupling loop 61 is electrically connected to the interior wall of the body 35 and the other end is connected to a conductor 62 which passes through a pipe 63 of conductive material, which pipe is hermetically sealed in an opening in the side wall of the tube. The pipe 63 is closed at its outer end by a glass seal 64 which supports the conductor rod 62 in properly spaced relation to the pipe. A conducting pipe may be electrically connected to the pipe 63 to provide a concentric line through which the high frequency oscillations generated by the magnetron may be conducted to a suitable utilization circuit.

A pair of plates 65 are soldered, or otherwise secured, to the cathode structure 47 on the enlarged end of the tubular member 48 with the active cathode surface therebetween. These function as electron screens and aid in confining the electrons emitted from the coated surface of the cathode to the space between the electron emissive coating and the anode arms 38, and thus reduce undesired losses of electrons to the end sections.

It will be understood that the embodiment of the invention, disclosed in the foregoing in conjunction with Figs. 4–8 of the drawings, functions in a manner similar to the embodiment of Figs. 1–4 with the added advantages that the end caps of the tube are entirely eliminated. The pole pieces 39 and 40 serve as end caps to close the ends of the tubular body and their construction and arrangement are such that the size of the tube and the size and weight of the magnets required to provide a magnetic field of desired intensity are greatly reduced. Furthermore, one of the pole pieces serves as the mount for the cathode structure, including its heater, its lead-in connections, and the seals therefor, so that a unitary cathode-pole piece structure is provided which may be readily assembled as a unit and which further reduces the number of parts required and the cost of manufacture, thus permitting a further reduction in the size and weight of the tube and its associated magnets. For example, in one instance a magnetron originally weighing sixteen pounds with its associated magnets has been reduced to an overall weight of two pounds, and in other instances a still higher weight reduction ratio has been attained by the constructions and arrangements herein described.

While there have been herein described two embodiments of the invention other embodiments within the scope of the appended claims will be apparent to those skilled in the art from a consideration of the teachings herein.

What is claimed is:

1. An electronic discharge device comprising a tubular envelope, a cathode and an anode enclosed in said envelope, magnetic pole pieces having portions projecting interiorly through the ends of said tubular envelope into close proximity to said anode and cathode, one of said pole pieces having a passage therethrough, a cathode lead-in conductor extending through said passage and spaced from the side walls thereof for supporting said cathode, a cathode heater filament within said cathode and electrically connected at one end thereto, a second lead-in connection connected to the opposite end of said filament and extending through a passage in said first-mentioned lead-in conductor and insulated therefrom, and means sealing the outer end of said passaged pole piece.

2. An electronic discharge device comprising a tubular envelope, a cathode and an anode enclosed in said envelope, magnetic pole pieces closing the ends of said tubular envelope, one of said pole pieces having a passage therethrough, a cathode lead-in conductor extending through said passage, for supporting said cathode, means exterior of said passage for sealing the same and supporting said lead-in conductor in spaced relation to the side walls thereof, a cathode heater filament electrically connected at one end to said cathode and connected at its opposite end to a second lead-in connection, said second connection extending through a passage in said first-mentioned lead-in conductor and insulated therefrom, and means sealing the outer end of said passaged pole piece.

3. An electronic discharge device comprising a tubular envelope, a cathode and an anode enclosed in said envelope, magnetic pole pieces closing the ends of said tubular envelope, one of said pole pieces having a passage therethrough, a cathode lead-in conductor extending through said passage, for supporting said cathode, means exterior of said passage for sealing the same and supporting said lead-in conductor in spaced relation to the side walls thereof, a cathode heater filament within said cathode and electrically connected at one end thereto, a second lead-in connection connected to the opposite end of said filament and extending through a passage in said first-mentioned lead-in conductor and insulated therefrom, and means sealing the outer end of said passaged pole piece.

4. An electronic discharge device of the type in which a magnetic field is imposed upon the discharge space thereof, comprising a metal envelope enclosing electrode elements between which a space discharge is adapted to take place, said envelope comprising a tubular body portion having a bridge structure on the interior thereof and leaving hollow end sections, a pair of pole pieces extending into said end sections to points adjacent said bridge structure, one of said pole pieces

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having a passage therethrough, a cathode lead-in connection extending through said passage and spaced from the side walls thereof, a cathode supported by said lead-in conductor and projecting beyond the interior end of said pole piece and through said bridge structure, a cathode heater filament within said cathode and electrically connected at one end thereto, a second lead-in connection connected to the opposite end of said filament and extending through a passage in said first-mentioned lead-in conductor and insulated therefrom, and means exterior of said passage sealing the outer end of said passaged pole piece.

5. An electronic discharge device of the type in which a magnetic field is imposed upon the discharge space thereof, comprising a metal envelope enclosing electrode elements between which a space discharge is adapted to take place, said envelope comprising a tubular body portion of non-magnetic metal having electrode elements in the central portion thereof and hollow sections at the ends thereof, a pair of pole pieces one at each end of said tubular body portion to provide a magnetic field through said envelope, said pole pieces having portions projecting into said hollow end sections and outwardly projecting portions extending exteriorly of said body portion, a magnet having a pair of projecting arms, the end faces of said arms contacting lateral surfaces of said outwardly projecting portions of said pole pieces.

6. An electronic discharge device of the type in which a magnetic field is imposed upon the discharge space thereof, comprising a metal envelope enclosing electrode elements between which a space discharge is adapted to take place, said envelope comprising a tubular body portion of non-magnetic metal having electrode elements in the central portion thereof and hollow sections at the ends thereof, a pair of pole pieces one at each end of said tubular body portion to provide a magnetic field through said envelope, said pole pieces having portions projecting into

said hollow end sections and outwardly projecting portions extending exteriorly of said body portion, a U-shaped magnet having the end faces of its arms corresponding to lateral surfaces of said outwardly projecting portions of said pole pieces and magnetically attracted thereto.

7. An electronic discharge device of the type in which a magnetic field is imposed upon the discharge space thereof, comprising a metal envelope enclosing electrode elements between which a space discharge is adapted to take place, said envelope comprising a tubular body portion of non-magnetic metal having electrode elements in the central portion thereof and hollow sections at the ends thereof, a pair of pole pieces one at each end of said tubular body portion to provide a magnetic field through said envelope, said pole pieces having portions projecting into said hollow end sections and outwardly projecting portions extending exteriorly of said body portion, a magnet having a pair of projecting arms, the end faces of said arms contacting lateral surfaces of said outwardly projecting portions of said pole pieces, and fastening means for said magnet tending to force said end faces of said arms against said lateral surfaces of said pole pieces.

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