June 27, 1967 L. E. WILSON 3,328,618

HIGH-VOLTAGE ACCELERATION TUBE WITH INSERTS FOR THE ELECTRODES

Filed Sept. 13, 1965 3 Sheets-Sheet 1

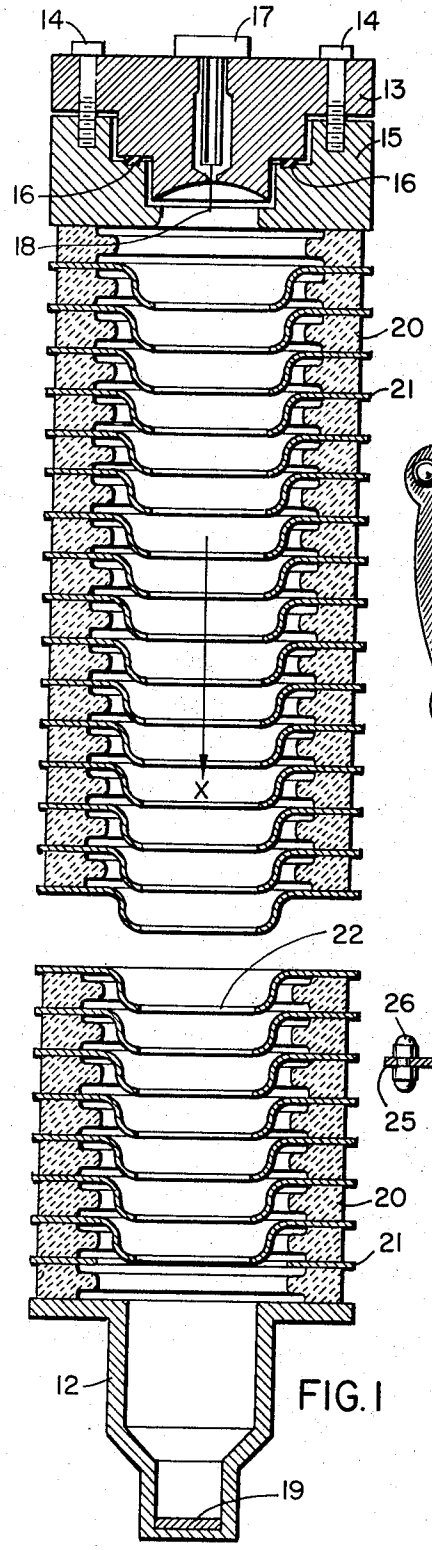


FIG. 1

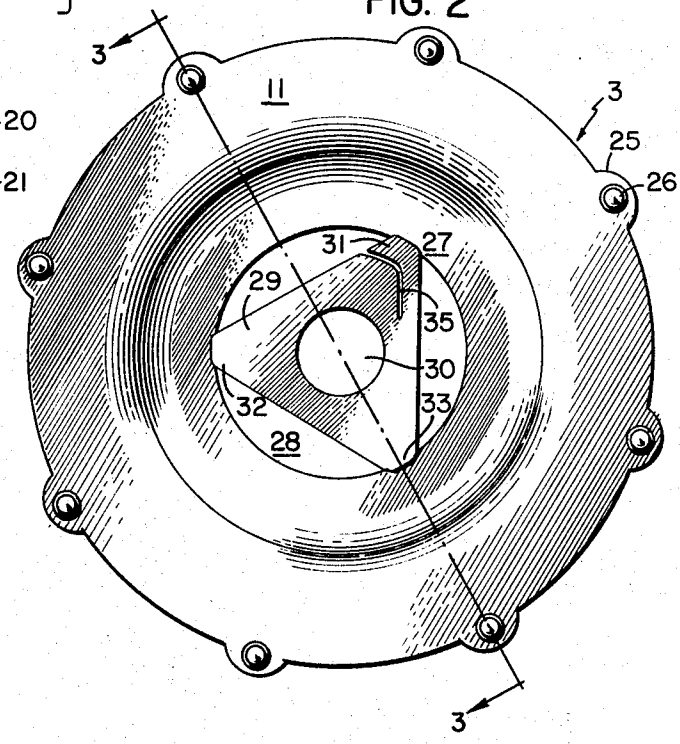


FIG. 2

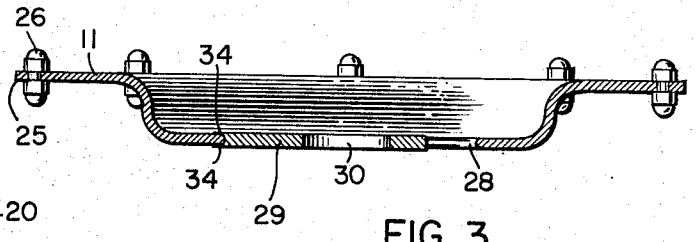


FIG. 3

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June 27, 1967 L. E. WILSON 3,328,618

HIGH-VOLTAGE ACCELERATION TUBE WITH INSERTS FOR THE ELECTRODES

Filed Sept. 13, 1965 3 Sheets-Sheet 2

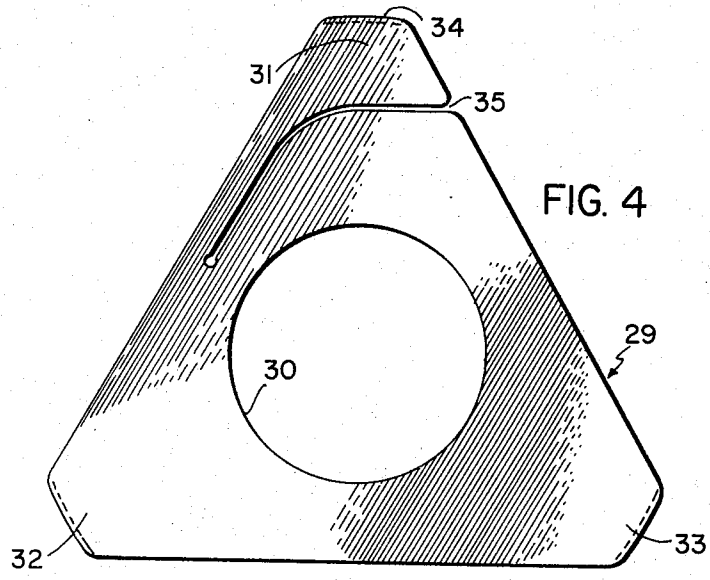


FIG. 4

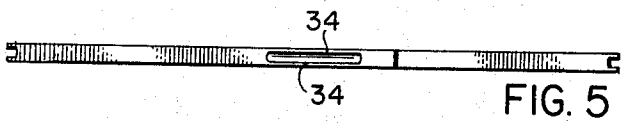


FIG. 5

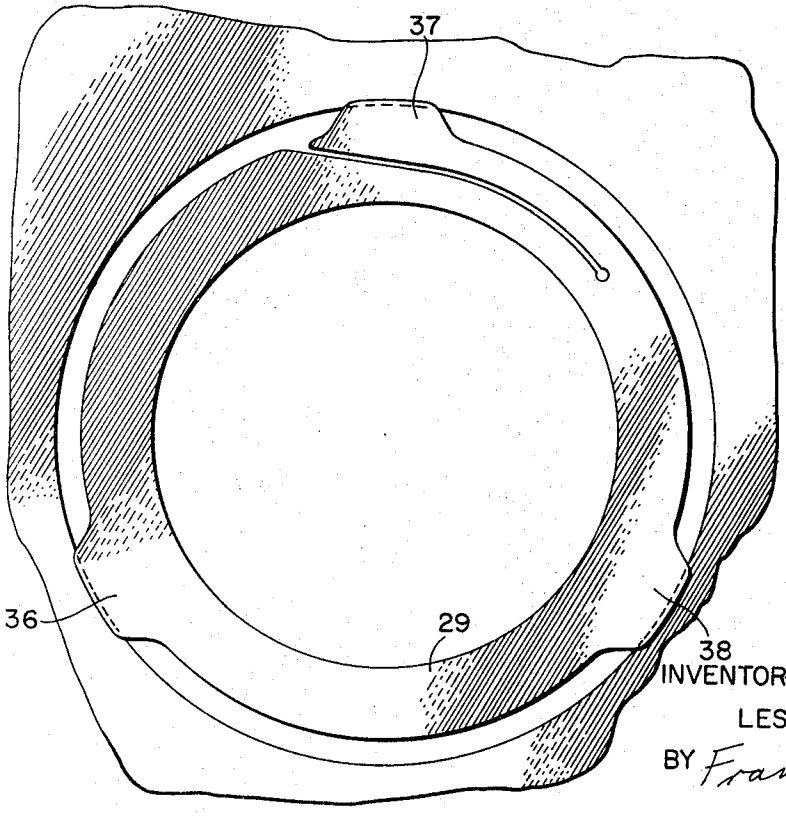


FIG. 6

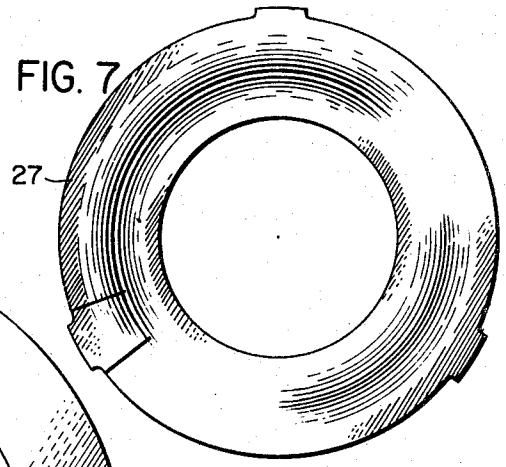
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Filed Sept. 13, 1965 3 Sheets-Sheet 3

FIG. 7



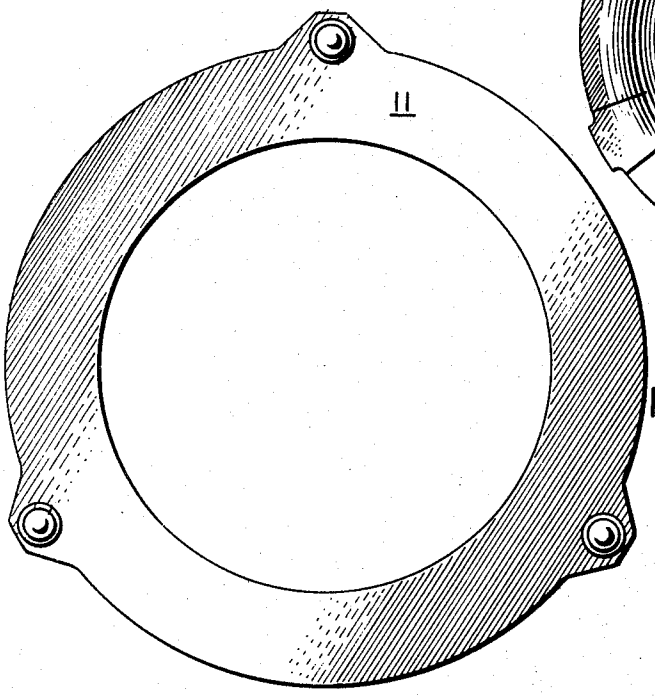


FIG. 8

FIG. 9

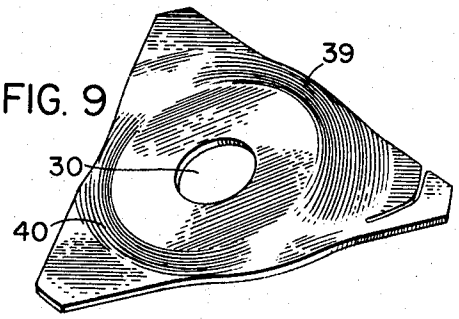
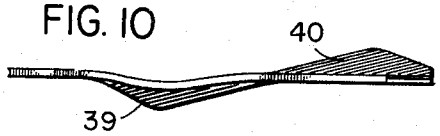


FIG. 10



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3,328,618

HIGH-VOLTAGE ACCELERATION TUBE WITH INSERTS FOR THE ELECTRODES

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4 Claims. (Cl. 313—63)

This invention relates generally to evacuated high voltage acceleration tubes and more particularly to the electrode members of said tubes.

Acceleration tubes comprising or including a series of metallic disk or diaphragm electrodes alternating with annular members of glass or other suitable insulating material are known to the art and have been disclosed in the United States patent to Trump and Cloud, Patent No. 2,460,201. An improvement in such electron tubes is shown in United States patent to Trump and Cloud, Patent No. 2,521,426. This latter patent is particularly directed to means for increasing the total voltage which can be applied to the tube for the acceleration of particles to high energy and for increasing the voltage gradient which can be applied along the column of such tube for the progressive acceleration of charged particles to higher energies and means are included in the tube to reduce the unwanted currents in the operation. The means employed, by this patent, consist of varying the diameter of the axial holes in the various metallic disks of the tube with relation to each other to reduce the tendency of an initial charged particle to multiply itself enroute from the cathode of the acceleration tube to the anode by the release of secondary electrons, protons, and positive ions.

This variation in the size of the axial opening in each electrode requires that each electrode be custom made to the specified size and considerably complicates the jigging necessary for the fabrication of the tube. Since each tube must, when using this procedure, be made to the desired specification, any errors in calculation of the axial opening or in the machining of the electrode or errors due to mishaps during jigging which resulted in but one incorrect electrode required that the entire tube be either rebuilt or scrapped. Such tubes are typically about seven feet long and usually have one electrode every inch of their length, thus, it can be readily appreciated that such devices are not only expensive to produce but that the probability of error can be quite high. In an effort to overcome the difficulties associated with the prior art, the present invention was conceived.

The present invention is thus directed toward avoiding all the difficulties of the prior art devices while retaining their advantages. The present invention reduces not only the number of operations required to form such an accelerator tube but also the cost of producing such tubes and further reduces the probability of producing incorrectly formed tubes which would have to be scrapped. The present invention thus permits variations in the axial hole spacing of such accelerator tubes for the purposes disclosed in Patent No. 2,521,426. Still further, the present invention permits modification of the axial size openings of such tubes even after the tubes have been placed or installed in operating position.

The invention is such that uniform, well-formed tube structures can be obtained which have all the advantages of the prior art devices while entirely eliminating disadvantages, such as the custom fabrication of each electrode. The invention further reduces the cost of producing such accelerator tubes for it reduces the scrap rate resulting from errors in calculation, insertion or jigging. Still further, the invention permits the introduction of variations

in the electrode structure of the tube at any time following their fabrication.

Briefly described, the present invention comprises a novel, spring-loaded insert which may be placed in accelerator tube electrodes having standard axial openings so as to vary the size of the beam passage of the electrode, while permitting the tube to be fabricated with electrodes of uniform size.

The inserts of the present invention may be made in many forms, shapes, and configurations, such as to permit the use of inclined plane electrodes, field inserts, field magnet, grids and multiple opening of which several embodiments will be described herein.

The invention will be better understood as the following description proceeds taken in conjunction with the accompanying drawings wherein:

FIGURE 1 is an elevational view of a typiacl accelerator tube in which the invention is to be used;

FIG. 2 is a plan view of one electrode of the tube in FIGURE 1 in which the present invention is employed;

FIG. 3 is a sectional view of FIG. 2 taken along the lines 3—3;

FIG. 4 is a greatly enlarged plan view of the insert shown in FIG. 2;

FIG. 5 is a top view of the insert of FIG. 2; and

FIGS. 6 to 10 show other embodiments of the invention.

Referring now to the drawings and more particularly to FIGURE 1, there is illustrated a sealed off or continuously pumped acceleration tube typically of several million volts or greater, having as a part thereof a cathode assembly indicated generally at **10** and an anode assembly **12**. It should, of course, be understood that although a negative particle tube is depicted in this figure that the invention is directed to all types of acceleration tubes and is not to be limited by the charge of the particle passing through the tube. The cathode assembly **10** comprises a removable cathode head **13** secured by bolts **14** to the main portion of the body **15**, having a suitable sealing gasket **16** between the head **13** and the body portion **15**. An insulated filament lead **17** is provided through the cathode head **13** and terminates in filament **18** disposed within the body of the tube. The anode assembly **12** comprises an anode target **19** and is secured to the column or envelope of the acceleration tube which is composed of a multiplicity of alternating glass, porcelain or other annular insulating members **20** and metallic electrode disks or diaphragm **21**. The manner of making such a tube is well known to the art and will not be described herein.

Each of the metallic electrodes **21** are in planes perpendicular to the axis of the acceleration tube (shown by arrow X) and are placed at equal distances apart and each is provided with an axial hole **22** therethrough. In the first of such produced tubes, the axial opening **22** was of a uniform size. However, it was later found that particle multiplication was prevented if this aperture progressively increased in size from a smallest value at the cathode end to a large value at the anode end. Based on this finding, such tubes now have axial openings in their electrodes varying in size from a smallest of about 1 inch to a larger of about 7 inches.

A number of variations in the arrangements of the axial openings have since been found to be beneficial. For example, the opening size can be largest at the cathode and smallest at the anode or smallest in the center and largest at each end.

Prior to the present invention, the method of making the necessary electrodes for such tubes consisted of stamping out the electrode in rough form and machining the axial hole to the desired size, which meant that each electrode was custom made.

The present invention, however, resolves all the problems associated with the prior art while retaining the beneficial aspects of the prior art by providing a means whereby the axial openings in the electrode may readily be varied. The means employed are inserts which may be placed in each electrode of such a tube so that each electrode will have a different size axial opening therethrough. By use of such inserts, each electrode may now be made of a standard size having a uniform aperture therein, thus permitting easier fabrication and less probability of scrap. Furthermore, such an insert permits easier evacuation of such acceleration tubes, for additional openings are provided without extra expense, which give a continuous easily evacuated passage down the entire length of the tube.

The manner in which the present invention provides such a varying axial relationship in the holes **22** to obtain the benefits of the prior art, while retaining each of the electrode members **21** of the same configuration to avoid the disadvantages of the prior art, is clearly depicted in FIGS. 2 through 5 which show various views of one embodiment of the present invention.

With reference now to these figures, there is shown an electrode plate **11** having a multiplicity of ears **25** disposed about the plate, each of which has a spark gap **26** located thereon. The electrode has a central dished portion **27** which contains an opening **28** located about the axial center of the electrode in which there is an insert **29** having an aperture **30** of any desired size.

The aperture in each insert may be varied from the size depicted. Although the insert is shown, in this embodiment, as an equilateral triangular plate, other configurations may be used. The plate is made slightly larger than the opening **28** so as to provide a means whereby the insert may be readily and easily secured in the opening **28**. The securing of the insert **29** in the opening is accomplished by undercutting the apexes **31**, **32** and **33** of the plate so as to provide on each apex a pair of lips **34** which will extend over the edges of the opening **28** on either side of the electrode **11**, thereby locking the insert in the electrode and preventing motion of the insert. To permit the ready insertion of the insert **29** into the opening **28** a slot **35** which undercuts one of the apexes, or corners of the triangle and extends partially down one side of the plate **11** and parallel thereto, provides a springing action which permits the insert **29** to be made slightly smaller than the diameter of the opening **28** so that it can be readily and easily inserted in the opening **28**. This slot **35** further provides a compressive force between each point of the triangle and the walls of the opening **28** to securely hold the insert in the electrode. The size of the overhang of the lips **34** is not particularly significant but need only be of size sufficient to retain the insert **29** in position in the electrode.

By varying the size of the aperture **30** in each insert **29**, structures having all benefits of the prior art can be achieved without any of the attendant fabrication problems and difficulties met in completing a structure in which the axial opening of each electrode is varied.

Use of the triangular structure shown in this figure is but one of many variations in the insert which are beneficial to the end result. This structure is, however, preferred for such a shaped insert can be slightly rotated from the position of each adjacent insert, thus reducing the possibility of arc over problems existing between each electrode because of any discontinuity between the electrode and the insert. Such a triangular form further permits better evacuation of residual gases in the tube. Still further, the use of three points such as are provided in such a triangular form permits easily established positioning of the insert in the openings provided in the electrode. Last but not least, the use of a triangular form permits easier and more rapid insertion of the desired inserts in completed tubes.

Although the number of inserts which much be made up is large because of the varying size required in such devices, the fact that each is a flat plate permits the easiest storage of such inserts. Furthermore, the use of such inserts permits all manner of experimentation with different configurations and sizes of axial openings than could be accomplished by a prior art tube which is more expensive and difficult to make.

Other modifications and variations of the present device may also be used with advantageous results. For example, FIG. 6 shows a modification in which the insert **29** is of circular form having at least three equidistance ears **36**, **37** and **38** protruding therefrom, one of the ears being spring-loaded in a manner analogous to that of the triangular form shown in FIG. 2.

Further variations and modifications of the present invention may be made. For example, FIG. 7 shows an arrangement whereby the entire dished portion **27** may be inserted in the electrode. This arrangement permits the use of electrodes made in the form of a flat circular ring, as shown in FIG. 8.

Still another embodiment of the invention is shown in FIGS. 9 and 10 which depict a field electrode wherein two portions **39** and **40** of the insert are deformed so that the aperture **30** provided in the insert is at an angle to the axis X of the electrode. Such an arrangement has been found in the past to have an advantageous result. Furthermore, other variations in the inserts may be made to include such devices such as grids, field magnets, etc.

Having now described several embodiments of the present invention, it is believed obvious that other embodiments and variations will become apparent to those skilled in the art, and therefore it is respectfully requested that the invention be limited only by the appended claims.

What is claimed is:

1. An evacuated high-voltage acceleration tube comprising a multiplicity of metallic ring-like electrode members and alternating insulating ring-like members bonded together in face-to-face relation to constitute the insulating envelope thereof and having at its respective ends cathode and anode assemblies; the diameters of the axial holes of said metallic electrode members of the tubes being of a uniform size and having therein inserts comprising a plate having a central opening therein for the passage of an ion beam and means for securing the plate in the electrodes.

2. An evacuated high-voltage acceleration tube for the acceleration of particles to high energies comprising a multiplicity of metallic ring-like electrode members and alternating insulating ring-like members constituting the insulating envelope thereof, the tube having at its respective ends cathode and anode assemblies; each of the electrode members having a uniform axial opening therein and inserts in the opening; the inserts having axial holes therein, differentiated among themselves by reason of a gradual increase in size thereof, from the cathode end to the anode end of the tube and means whereby the inserts are adapted to fit into the opening in said electrodes and to make contact thereto in at least three places.

3. An evacuated high-voltage acceleration tube for the acceleration of particles to high energies comprising a multiplicity of metallic ring-like electrode members and alternating insulating ring-like members constituting the insulating envelope thereof, the tube having at its respective ends cathode and anode assemblies; each of the electrode members having a uniform axial opening therein and inserts in the opening; the inserts having axial holes therein, differentiated among themselves by reason of a gradual increase in size thereof, from the anode end to the cathode end of the tube and means whereby the inserts are adapted to fit into the opening in the electrodes and to make contact thereto in at least three places.

4. A high-voltage, high-vacuum electronic tube capable of insulating electrical gradients along its length, comprising a multiplicity of metallic ring-like members and alternating insulating ring-like members constituting the

insulating envelope; the ring-like members having axial openings therethrough, the axial openings in each of the members being identical to each adjacent member; each of the members being adapted to receive an insert therein, an insert in each of the metal members, the inserts being provided with a central opening, the central opening in each of the inserts varying in size and relationship with the opening of each adjacent insert.

References Cited

UNITED STATES PATENTS

2,401,856	6/1946	Brock	85—36
3,036,233	5/1962	Petrie et al.	313—83

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