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ENVELOPE GEOMETRY FOR A MAGNETICALLY CONTROLLABLE FIELD EFFECT TUBE
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Fig- 1

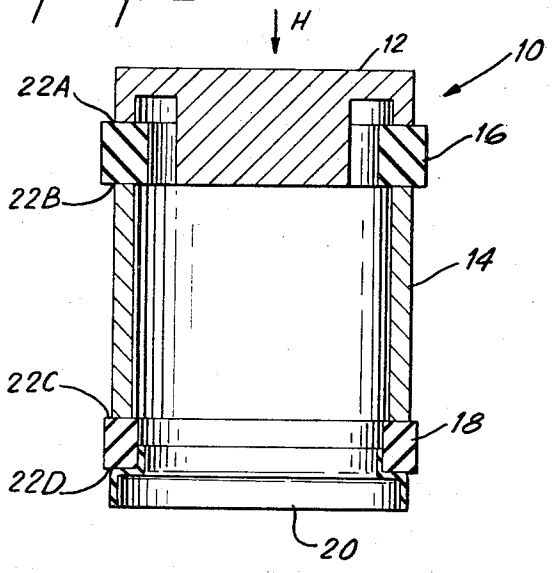
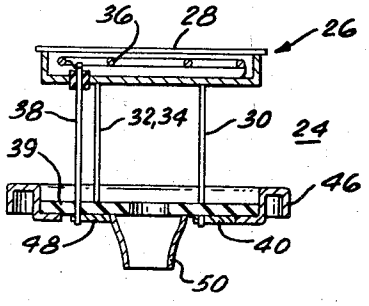


Fig- 2



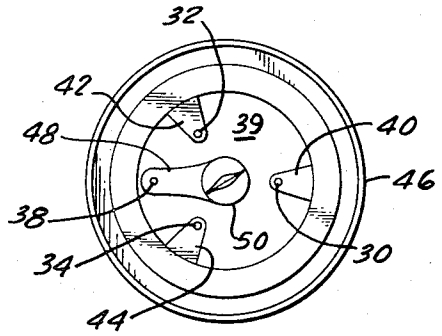


Fig- 3

INVENTORS
EDUARD G. DORGELO
BERTRAM GREEN
BY
Frank R. Trifari
AGENT

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Fig. 4

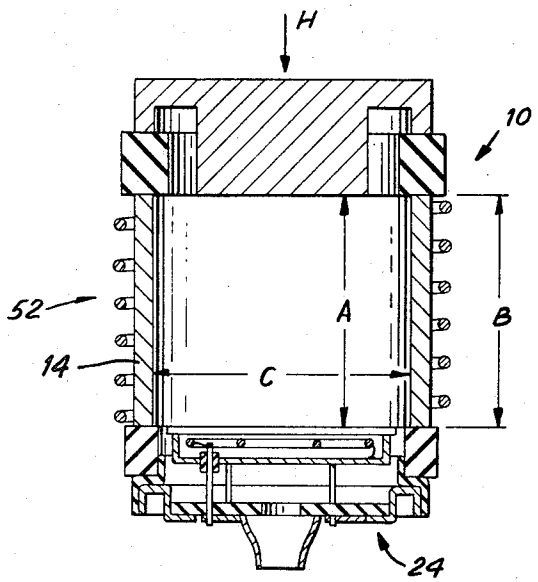


Fig. 5

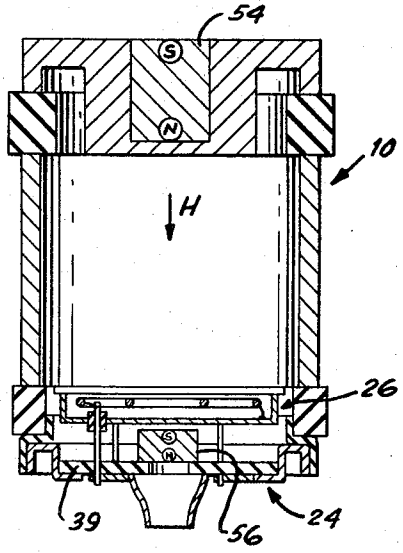
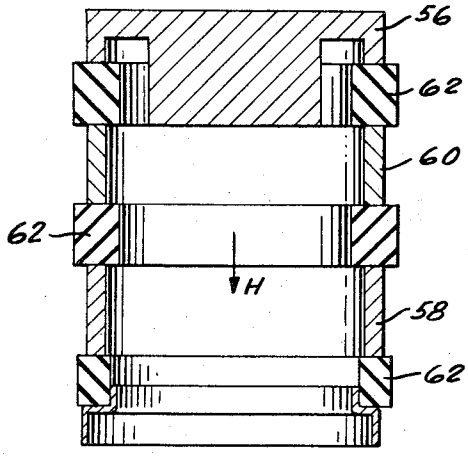


Fig. 6



INVENTORS
EDUARD G. DORGELO
BERTRAM GREEN
BY
Frank R. Trifari
AGENT

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ENVELOPE GEOMETRY FOR A MAGNETICALLY CONTROLLABLE FIELD EFFECT TUBE

Eduard Gerhardus Dorgelo, Huntington, and Bertram Green, Hicksville, N.Y., assignors to North American Philips Company, Inc., New York, N.Y., a corporation of Delaware

Continuation-in-part of application Ser. No. 385,259, July 27, 1964. This application Apr. 30, 1965, Ser. No. 452,063

7 Claims. (Cl. 313—162)

ABSTRACT OF THE DISCLOSURE

A field effect tube, employing an axial magnetic field, is constituted by a cylindrically shaped anode and similarly shaped cathode, separated from each other by a cylindrical control element. The control element includes rings of insulating material at either end, to which the anode and the cathode are respectively attached. A permanent magnetic field is applied axially by means of an electromagnet, coils of which are wound about the control element, or by a permanent magnet, inserted into the anode and cathode assembly. Additional control elements, coaxial with the original control element, may be provided to affect multicontrol element structures such as a tetrode.

Our invention relates to envelope construction of electron discharge tubes and in particular to envelope design and construction techniques of an electron discharge tube employing a field effect mode of operation as described in copending United States application No. 385,259, filed July 27, 1964, to which this application is related as a continuation in part.

The use of conventional electron discharge tubes becomes somewhat limited in higher power applications because of the excessive heat generated when the electron flow impinges upon the control element. The field effect control method described and claimed in the above-identified co-pending application substantially reduces heat generation by removing the control element from the direct path of electrons while still continuing to control the electron flow. Control is maintained by a charged electrical field resulting from a varying potential placed on the control element. This is structurally accomplished by placing the control element around the path of the electrons flowing from cathode to anode. An external magnetic field is axially applied along the electron path to insure substantially no interception of electrons by the control element, even during period of positive potential applications to the control element.

For proper field effect tube operation, and to attain economic feasibility, it is important that the tube be simple and straightforward in assembly, constructed so as to insure correct anode to control element spacing and alignment, and to provide a structure with as low internal loss due to lead inductance and the like as is possible.

It is therefore a primary object of our invention to provide a simplified structural principle for a field effect tube wherein proper alignment and spacing between the control and anode elements is insured.

A further object of our invention is to provide a structural principle for a field effect tube wherein internal inductance due to anode or control electrode leads may be practically eliminated.

It is a still further object of our invention to provide maximum dissipatory effects for whatever heat is generated by the control element.

Another object of our invention is to provide a structural principle wherein a field effect tube may be simply

and economically constructed with as little assembly as possible.

These and further objects of our invention will appear as the specification progresses and will be pointed out in the claims and illustrated in the accompanying drawings, which disclose, by the way of example, the principle of our invention and the best mode contemplated of applying that principle.

In accordance with the structural principle of our invention a field effect tube is constructed by providing a control electrode, surrounding the electron path between the anode and cathode of the tube, as an integral portion of the tube envelope. Suitable insulating material is affixed to both ends of the control element and may be bonded thereto by a brazing operation. The anode is joined to the insulation at one end of the control element, as by brazing. The cathodic heater support assembly is then joined to the insulator at the other end of the control element, thereby completing the tube envelope structure. The insulation electrically isolates both anode and cathode from the control element. A varying potential is externally applied to the control element for controlling the magnitude of the electric field barrier formed about the cathode, thereby modulating the flow of electrons along the cathode-anode path. Because the control element forms a portion of the external area of the field effect tube, the device required to produce the axial magnetic field may be located relatively close to the control element, thereby reducing the size and cost of the device required to produce a field of a given strength within the tube.

Our invention will now be described in greater detail with reference to the accompanying drawing wherein:

FIG. 1 shows a cross-section of a structural embodiment of the anode grid assembly for the field effect tube in accordance with our invention.

FIG. 2 shows an embodiment of the cross sectional structural detail of the field effect tube cathode heater assembly in accordance with our invention.

FIG. 3 shows an end view of the cathode assembly illustrated in FIG. 2.

FIG. 4 illustrates a cross sectional view of the assembled field effect tube.

FIG. 5 illustrates an alternative embodiment of the magnetic structure in a field effect tube.

FIG. 6 shows a cross sectional tetrode embodiment of the assembly of a field effect tube in accordance with our invention.

Referring to FIG. 1 of the drawing the upper envelope structure **10** of a field effect tube includes an anode **12** which may, by way of example, consist of a suitable heat dissipating metal such as copper. A centrally apertured or hollow cylinder having a circumferential side wall defining the central aperture constitutes the control element **14** and forms an integral part of the wall of the tube envelope. The control element may similarly consist of a suitable conductor such as copper. The anode and control elements are structurally unitized by means of an insulating ring **16** which may consist of a suitable ceramic or glass such as a borosilicate, rigidly secured between the anode **12** and the upper end of the control element **14**. Abutting the lower end of the control element **14** and rigidly affixed thereto is a further insulating ring **18** to which is secured a suitable glass or ceramic sealing alloy ring **20** such as is sold under the trademark Kovar.

The above described elements forming the upper envelope structure **10** are each rigidly secured to its adjoining element at four designated junctions **22A**, **22B**, **22C** and **22D** by a standard one operation brazing process utilizing, for example, a brazing filler metal on a molybdenum-manganese metallizing base.

FIG. 2 shows a cathode heater assembly 24 comprising a disc shaped cathode element 26 having a surface area 28 coated with suitable electron emissive material such as an alkaline earth metal oxide and structurally supported by a plurality of legs 30, 32 and 34, preferably arranged at three points equidistant about the under area of the cathode element 26. A filament coil 36 is set within the cathode element 26 and is electrically energized by means of a first filament lead 38 which is secured to and passes through an insulating base disc 39 comprised of a suitable glass or ceramic and a second filament lead, which may, as illustrated in a preferred embodiment, comprise each of the structural support legs 30, 32 and 34. In this case, the filament coil 36 is connected at one end to the body of the cathode element 26, and each of the legs electrically connect the filament coil through the ceramic disc to the respective metallized strips 40, 42, and 44 (FIG. 3) each of which in turn is affixed to a hook shaped metallic ring 46 thereby forming a first filamentary contact. The metallic ring 46 is affixed to the insulating base disc 39 and is comprised of a suitable sealing alloy as is described above. A further metallized strip 48 electrically connects the first filament lead 38 to the tubulation 50, thereby forming the second filamentary contact. Tubulation 50 serves as the atmospheric evacuation path of the tube envelope after the cathode unit 24 has been secured to the tube envelope 10 and is then sealed off to preserve the internal vacuum of the tube. The outer circumference of the ring 46 is only somewhat less than the diameter of the ring 20 of the tube envelope 10. In assembly, the cathode assembly 24 is inserted into the tube envelope 10 until the ring 46 abuts the inner surface of the ring 20, whereupon the two rings are rigidly secured to one another by means of a suitable bonding process.

As will appear, other embodiments of the cathode heater assembly are possible. For example, the number of leg supports can vary, and the filament coil lead terminals need not connect to the ring and tubulation neck, but may be merely fed through the base plate in the form of pins and the like. Further, various other chemical compositions for the particular elements detailed above may be provided and it is understood that various substitutions and omissions may be made therefrom without departing from the spirit of the invention.

The arrangement of the electrodes in the completely assembled field effect tube shown in FIG. 4 constitutes the equivalent of well-known triode in which the cylindrical control electrode 14 replaces the conventional grid.

If the distance between the anode surface and the cathode surface is designated A, the height of the cylinder B, and the diameter of the cylinder C, it has been found that the ratio of A/C preferably should be between 0.2 and 5.0 while the ratio of B/C should be between 0 and 3. As is evident from the satisfactory ratio ranges, the distance B may approach 0, and therefore the tube envelope design is not limited to elongated cylindrical control elements, but to relatively flat elements as well.

While planar anodes and cathodes are preferred, it would be entirely within the scope of the invention to alter the surface configuration of these elements for particular desired applications. Further, the cathode structure may be a compact preformed structural unit wherein the filament wires are embedded within a ceramic block coated with electron emissive material and which may be fitted into the upper tube envelope 10. An example of such a cathode structure is described in U.S. Patent 2,754,445.

The axial magnetic field H described above may be applied in the direction shown, for example in FIG. 1, in any known fashion to insure a continuous electron flow along the long axis of the tube. The greatest advantage to which the tube geometry may be employed is to utilize an electromagnetic device as shown in FIG. 4,

having a plurality of conductor coils 52 adjacent to and surrounding the external wall of the control element 14 whereby a properly oriented axial magnetic field parallel to the electron flow path and perpendicular to the cathodic and anode surfaces would be generated by a flow of current through the coil in the proper direction. However, it will be apparent to those skilled in the art that other modes of applying the requisite axial magnetic field are feasible. A permanent magnetic material such as Alnico (Co-Ci-Al-Fe alloy), barium ferrite, or the like, may be affixed with proper pole orientation and flux return paths along the longitudinal axis of the tube, above and below the anode and cathode elements respectively, or in any other suitable physical position. For example, as shown in FIG. 5, a field effect tube may be provided with a magnetic field by means of a pair of magnetic pole pieces each composed of a permanent magnetic material such as disclosed above. The first magnet 54 will have a pole corresponding to magnetic North inserted in a downward direction within the anode 12 while a second magnet 56 is placed with a pole of opposing polarity facing upward in the spacing between the cathode element 26 and the insulating disc 39. A magnetic sheath may be provided in a known manner about the tube from the anode pole to the cathode pole to insure a higher permeability for a flux return path by reducing the effective air gap in the flux return path. Alternatively, should the tube geometry be small enough to so allow, an air flux return path may be utilized, and the sheath eliminated.

The structural principles of the invention are equally applicable to multielectrode electron discharge devices wherein each electrode normally in the path of the electron flow may, in accordance with our invention, form a part of the tube envelope wall for field effect control. Referring to FIGURE 6, an example of the application of the present invention to the structure of a field effect tetrode tube envelope is illustrated as having an anode 56, a control element 58, and a screen element 60, each electrically insulated from its adjoining member by structural insulation rings designated generally as 62.

While we have described our invention in connection with specific embodiments and applications thereof, other modifications will be apparent to those skilled in this art without departing from the spirit and scope of the invention as defined in the appended claims.

What we claim is:

1. An electron discharge tube envelope comprising a cathode assembly having a substantially planar emitting surface and constituting a first portion of said tube envelope, an anode element constituting a second portion of said tube envelope, and a control element having a central aperture for containing the electron discharge path between the anode element and cathode assembly, and a circumferential side wall defining said aperture, first insulating means joining said control element at one end to said anode element, and second insulating means joining said control element at the other end to said cathode asembly, said second insulating means wholly surrounding the perimeter of said cathode assembly emitting surface, said control element together with said first and second insulating means substantially constituting the remaining portion of said tube envelope, said circumferential side wall forming a portion of the exterior wall of said envelope, and means for producing an axial magnetic field between said anode element and said cathode element.

2. An electron discharge tube envelope comprising a cathode assembly having a substantially planar emitting surface and constituting a lower portion of said envelope, a substantially cylindrical anode constituting the upper portion of said envelope, a substantially cylindrical control element having a central aperture for containing the electron discharge path between the anode element and cathode assembly, and a circumferential side wall defin-

ing said aperture, said control element being secured at one end to said anode by first means including an electrically insulating material, said control element being secured at its other end to said cathode assembly by second means including an electrically insulating material wholly surrounding the perimeter of said cathode assembly emitting surface, said control element and said first and second means, together with said anode and said cathode, substantially constituting said tube envelope, said circumferential side wall forming a portion of the exterior wall of said envelope, and means for producing an axial magnetic field between said anode and said cathode.

3. An electron discharge tube envelope comprising a cathode assembly having a substantially planar emitting surface and constituting a lower portion of said envelope, a substantially cylindrical anode constituting the upper portion of said envelope, a plurality of axially aligned substantially cylindrical control elements each having a central aperture for containing the electron discharge path between the anode element and cathode assembly, and a circumferential side wall defining said aperture, said control elements being serially connected and electrically insulated from one another, one of said control elements being secured to and insulated from said anode, and another of said control elements being secured to said cathode at an end remote from said anode by an insulating material, said cathode assembly emitting surface perimeter being wholly surrounded by said insulating material, said control elements together with said anode and said cathode substantially constituting said tube envelope, said circumferential side wall forming a portion of the exterior wall of said envelope, and means for producing an axial magnetic field between said anode and said cathode in a direction substantially perpendicular to said anode.

4. An electron discharge tube envelope comprising a substantially cylindrical cathode assembly constituting a lower portion of said envelope, said cathode assembly comprising a substantially planar electron emissive area, means for activating said area, said means mounted in proximity with said area and having a plurality of electrical leads, at least one of said leads forming a relatively sturdy support, and an insulating base plate, said support mounted between said base plate and said electron emissive area, a substantially cylindrical anode constituting the upper portion of said envelope, at least one substantially cylindrical control element consisting of a hollow tube having a central aperture for containing the electron discharge path between the anode element and cathode assembly, and a circumferential side wall defining said aperture, said control element being secured at its upper end to said anode by first means including an electrically insulating material, said control element secured at its lower end to said cathode assembly by second means including an electrically insulating material wholly surrounding the perimeter of said cathode assembly emissive area, said first and second means, said control element, said anode and said cathode together substantially constituting said tube envelope, said circumferential side wall forming a portion of the exterior wall of said envelope, and means for producing an axial magnetic field between said anode and said cathode.

5. The combination of claim 4 wherein said means for producing an axial magnetic field comprises an electromagnetic coil external to and coaxial with said control element.

6. The combination of claim 4 wherein said means for producing an axial magnetic field comprises a first pole-piece of permanent magnetic material positioned above said anode, and a second pole-piece of permanent magnetic material positioned beneath said cathode assembly, each of said pole pieces mounted so as to create an axial magnetic field.

7. The combination of claim 4 wherein said means for producing an axial magnetic field comprises a first pole piece of permanent magnetic material mounted within said anode, and a second pole piece of permanent magnetic material mounted within said cathode assembly, each of said pole pieces aligned so as to create an axial magnetic field.

References Cited

UNITED STATES PATENTS

2,718,307	5/1956	Hickey	313—246 X
2,762,944	9/1956	Clogston	313—162 X
2,943,234	6/1960	Zitelli	313—84 X
2,953,706	9/1960	Gallet et al.	313—162 X

JAMES W. LAWRENCE, *Primary Examiner.*

S. A. SCHNEEBERGER, *Assistant Examiner.*

UNITED STATES PATENT OFFICE

CERTIFICATE OF CORRECTION

Patent No. 3,370,196 February 20, 1968

Eduard Gerhardus Dorgelo et al.

It is certified that error appears in the above identified patent and that said Letters Patent are hereby corrected as shown below:

Column 1, line 52, "period" should read -- periods --.
Column 5, line 24, cancel "and insulated from".

Signed and sealed this 30th day of December 1969.

(SEAL)
Attest:

Edward M. Fletcher, Jr.
Attesting Officer

WILLIAM E. SCHUYLER, JR.
Commissioner of Patents