

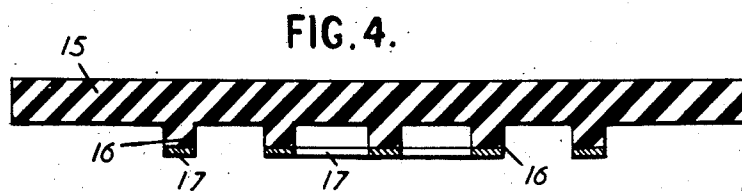
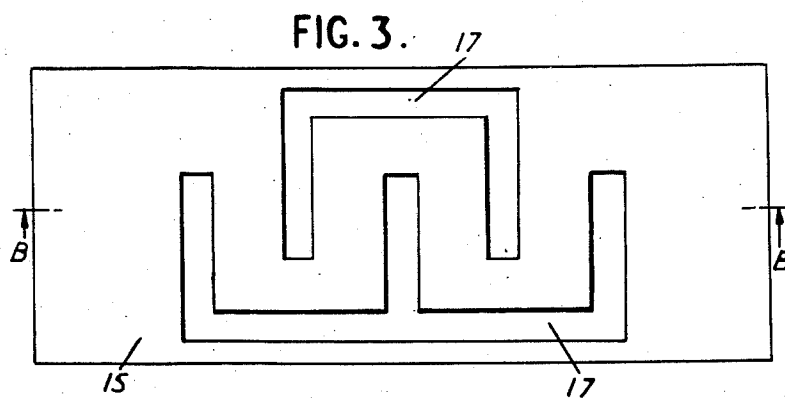
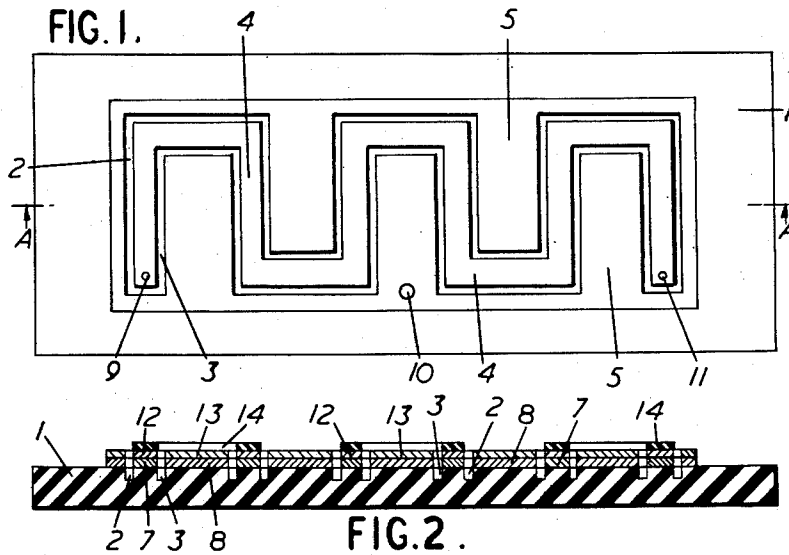
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C. P. SANDBANK
ELECTRON DISCHARGE DEVICES

3,066,236

Filed May 1, 1959

2 Sheets-Sheet 1



Inventor
C. P. SANDBANK
By *R. K. Morris*
Attorney

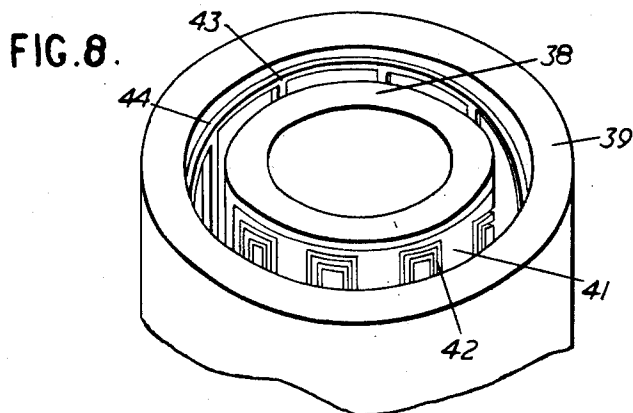
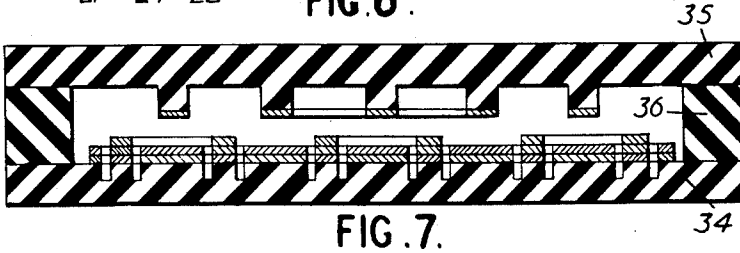
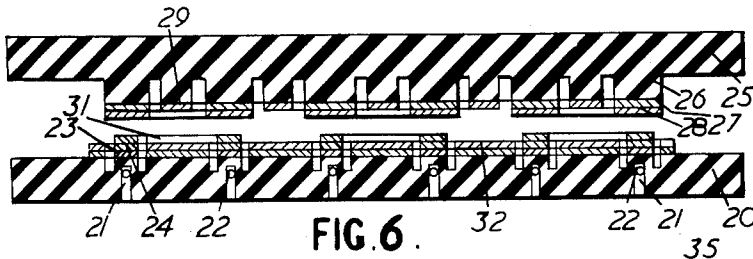
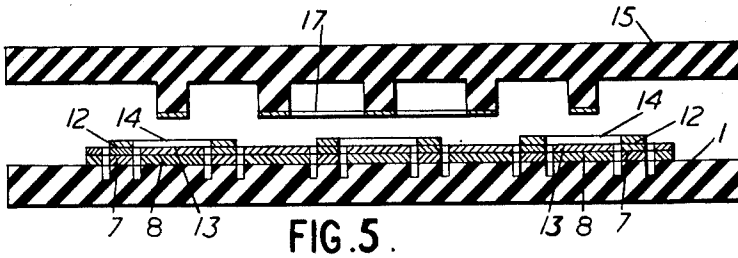
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2 Sheets-Sheet 2



Inventor
C. P. SANDBANK
By *RP. Davis*
Attorney

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ELECTRON DISCHARGE DEVICES

Carl Peter Sandbank, London, England, assignor to International Standard Electric Corporation, New York, N.Y., a corporation of Delaware

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This invention relates to an electrode structure for use in electron discharge devices.

Known discharge devices have structures in which electrodes are supported in a resilient manner by insulators. These structures, as well as requiring considerable skill in assembly, suffer from the disadvantage that under conditions of vibration movements of the electrodes are liable to be caused which produce unwanted modulations of the electron flow through the device.

The present invention provides an electrode structure which is relatively easy to assemble, which is rugged in construction, and in which the effect of vibration of the device upon the electron flow is reduced.

Embodiments illustrating the principle of the invention will now be described with reference to the accompanying drawing, which shows diagrammatically in

FIG. 1 a plan view of an electrode structure on a first insulator,

In FIG. 2 a section through the insulator of FIG. 1 on the line A—A,

In FIG. 3 a plan view of an electrode structure on a second insulator,

In FIG. 4, a section through the insulator of FIG. 3, on the line B—B,

In FIG. 5 the sections of FIGS. 2 and 4 arranged in a particular relationship,

In FIG. 6 a section through an alternative electrode structure,

In FIG. 7 a section through a discharge device, and,

In FIG. 8 a perspective view of a further structure.

Referring to the drawing, FIGS. 1 and 2 show an insulator 1 of ceramic material, upon a surface of which grooves 2 and 3 are formed. These grooves divide the surface into two areas 4 and 5, and a suspension of finely divided molybdenum powder is printed by some means such as a roller on to the surfaces of both of these areas.

In a practical embodiment, the strips of the area 4 are closely spaced and proportionally narrower than shown in FIGS. 1 and 2, in which the dimensions of the strips making up the areas 4 and 5 have been enlarged for ease of illustration. In the practical embodiment mentioned the insulator 1 is made 1.5 inches square, the grooves 2 and 3 are .01 inch wide, and the widths of the strips which form part of the areas 4 and 5 are 0.02 and 0.04 inch respectively. Other embodiments in which successive strips repeat between ten and twenty times per inch have been found to be satisfactory.

The coated insulator is then fired in a hydrogen atmosphere at a temperature high enough to cause the molybdenum to bond to the ceramic. The duration of the firing and the temperature at which firing takes place depend upon the materials used, but for a particular sample of forsterite coated with molybdenum powder it was found sufficient for the firing to be for 30 minutes at 1250 degrees centigrade in an atmosphere of wet hydrogen. Separate electrically conducting layers of molybdenum 7 and 8 are thereby provided on the areas 4 and 5 respectively. Connection leads for these layers, indicated at 9, 10, and 11, may be hermetically sealed through the insulator during this stage of manufacture.

A layer of nickel 12 is then plated on to the layer 7, to a thickness of approximately .001 inch, by connecting

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the layer 7 as an electrode in an electrolytic plating solution in a known manner.

This layer 12 is subsequently fired on in order to improve adhesion, and it has been found that firing at 1,000 degrees centigrade in an atmosphere of dry hydrogen for ten minutes is satisfactory.

A layer of gold 13 is plated on to the layer 8 to a thickness of approximately .0002 inch by connecting the layer 13 as an electrode in a gold plating solution. The layer 13 is then fired on at a temperature of 800 degrees centigrade in a similar manner to that in which the nickel layer 12 was fired on.

A layer of mixed carbonates 14, commonly used for cathode coatings and consisting of barium, strontium, and calcium carbonate, is deposited to a thickness of the order of .002 inch on to the nickel layer 12 by immersing the insulator in an electrophoretic coating suspension of the carbonates and connecting the nickel layer 12 and the gold layer 13 to such potentials that the suspended particles are repelled from the gold layer and attracted to the nickel layer by electrophoretic action.

In order to reduce the possibility of carbonate adhering to the wrong areas it is advisable to remove the coated insulator carefully from the suspension with the potentials still connected, and it is also necessary to rinse the insulator lightly after removal.

Other methods of applying the carbonate layer, such as spraying through a mask, may be used in order to avoid the carbonates adhering to the wrong areas.

The mask may be cleaned by immersing it in an ultrasonic cleaning bath.

Referring to FIGS. 3 and 4, there is shown an insulator 15 of ceramic material formed so that parts of its surface project as shown at 16. Layers of molybdenum 17 are rolled on to these projections and fired in an atmosphere of wet hydrogen in order to bond them to the ceramic in the manner described for layers 7 and 8. Leads (not shown) may be hermetically sealed through the insulator in order to provide a connection to layers 17.

Referring to FIG. 5, the first insulator 1 and the second insulator 15 are shown, after having been coated and as in FIGS. 2 and 4, positioned with respect to one another in the manner in which they would be arranged as part of the electrode structure of an electric discharge device. The insulators, as shown, may be mounted in a vacuum and a direct current at a low potential passed between the ends of layers 7 and 12, via connection leads 9 and 11, indicated in FIG. 1, in such a manner that the heating produced causes the mixed carbonate coating to break down into oxides. Alternatively the temperature of layers 7 and 12 may be raised by placing the assembly in a radio frequency heating field.

Layer 7 may now be heated by means of a direct current in the normal manner of directly heated cathodes and a high potential may be applied between molybdenum layer 17 and molybdenum nickel layers 7, 12 in such a manner that an electron current tends to flow from the oxide coating 14 to the layer 17. If a potential, negative with respect to the molybdenum-nickel layers 7, 12 which form the cathode of the device, is applied to the molybdenum gold layers 8, 13 which form the control electrode, the change produced in the electrostatic field surrounding the cathode is such that it tends to reduce any flow of electron current from the cathode to the molybdenum layer 17 which forms the anode.

The sensitivity of a change of potential on the control electrode in its effect upon the electron current flow through the device is determined largely by the geometrical shape and relationship of the electrodes, and the sensitivity will tend to be greatest when the electrodes tend to be in the same plane.

Referring to FIG. 6 there is shown a ceramic insulator 20 formed in a manner similar to that of insulator 1 of FIG. 1, but with an extra continuous groove 21, containing a heater 22, running beneath the cathode layers 23 and 24, and a ceramic insulator 25, similar to insulator 15 of FIG. 4, but with additional projections 26 on which there are control electrode layers 27 and 28 similar to layers 8 and 13. The heater 22 may be a wire or it may be a molybdenum coating. The insulators 20 and 25 may be arranged in the relative positions shown, in a vacuum, with the metal anode layer 29 connected to such a potential with respect to the cathode coating 31 that an electron current is caused to pass from the cathode to the anode, the cathode being heated by passing a current through the heater 22 to raise the temperature of the oxide coating 31 in the normal manner of thermionic discharge devices. Control of the electron current through the device may be provided by applying suitable potentials to the control electrodes 28 and 32.

It is possible to coat one or both of these control electrodes 28 and 32 with a coating which emits secondary electrons, and thus to increase the mutual conductance of the device.

In FIG. 7 two coated ceramic insulators 34 and 35, similar to insulators 1 and 15, are shown separated by a ceramic spacer 36. These three insulators are sealed together in any well known manner to form a gas tight structure, with connections made from its outside to the electrodes by leads hermetically sealed either through or between the insulators. The structure may then be evacuated to provide an electron discharge device.

In an alternative arrangement the electrode structure is mounted within a separate glass or ceramic envelope.

The invention has been described with reference to embodiments using planar electrode structures, but there is no reason why the electrodes should be planar. The cathode and the control electrode on insulator 1 need not be in the same plane, one of them could be at a higher level with respect to the base of the insulator than the other, and they could be specially shaped, for example, domed, in order to produce a required field configuration. The coatings may be printed on to the surface by means of an appropriately shaped die.

The surface need not necessarily be grooved, as shown, it could be flat and the coatings could be printed on by a suitably contoured die so that insulated areas are left where required.

Furthermore the insulators need not be flat. In FIG. 8 an electrode structure is shown formed on cylindrical insulators 38 and 39, which correspond to insulators 1 and 15 respectively. A control electrode coating 41 and a cathode coating 42 are formed between grooves on insulator 38, and an anode coating 43 is formed on projections 44 on insulator 39. The electrodes need not be coaxial, as shown, they could be formed on any suitably contoured surface in order to give a required field distribution. The ends of the cylinders may be hermetically sealed by means of ceramic discs, connections to the electrodes may be made either through these discs or through the insulators 38 and 39, and the discharge device so formed may be evacuated in any known manner.

The embodiments described above are of vacuum discharge devices, but an electrode structure according to the invention may also be used for gaseous discharge devices with suitable design of the electrodes.

It is not necessary for the cathode to be heated, it

could be coated with a known self-sustained electrode emissive coating.

Some of the embodiments have been shown as rectangular in plan view, they could be of other shapes, for example circular, and the grooves might be in other forms, for example spiral.

While the principles of the invention have been described above in connection with specific apparatus, it is to be clearly understood that this description is made only by way of example and not as a limitation on the scope of the invention.

What I claim is:

1. An electron discharge device comprising two juxtaposed insulators having closely spaced surfaces, an anode electrode in the form of a metallic layer positioned on predetermined areas of one of said surfaces, a cathode electrode in a form of a metallic layer and coating positioned on predetermined areas of the other of said surfaces, and a control electrode in the form of a second metallic layer positioned on adjacent predetermined areas of one of said surfaces and spaced from the other electrode on the same surface, the electrodes on one surface facing the electrodes on the other surface.

2. An electron discharge device according to claim 1, and further comprising means, located in the cathode carrying insulator, for heating said cathode.

3. An electron discharge device according to claim 1 wherein said surfaces of the insulators are parallel.

4. An electron discharge device according to claim 1 wherein said two insulators are shaped cylindrically and form two walls of the device.

5. An electron discharge device according to claim 1 wherein each of said electrodes comprises a first metal layer formed on the associated insulator surface, and a second metal layer formed on the first metal layer.

6. An electron discharge device as claimed in claim 5 and further comprising an oxide coating on said cathode electrode.

7. An electron discharge device as claimed in claim 1 in which said facing cathode and anode are displaced with respect to each other, and said control electrode directly faces one other electrode on the other surface.

8. An electron discharge device according to claim 7 in which the control electrode is spaced from the other electrode on the same surface by a groove in the surface.

9. The device of claim 7 wherein said cathode and anode form an interleaved repetitive pattern.

10. An electron discharge device as claimed in claim 7 in which the control electrode and the other electrode on the same surface form an interleaved repetitive pattern.

11. The device of claim 10 wherein the electrodes on said surfaces are in the form of repetitive strips positioned alternately with each other on the same surface, and one electrode on one surface is positioned alternately with the electrode on the other surface.

12. The device of claim 11 wherein said strips are positioned on projections on one of said surfaces.

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