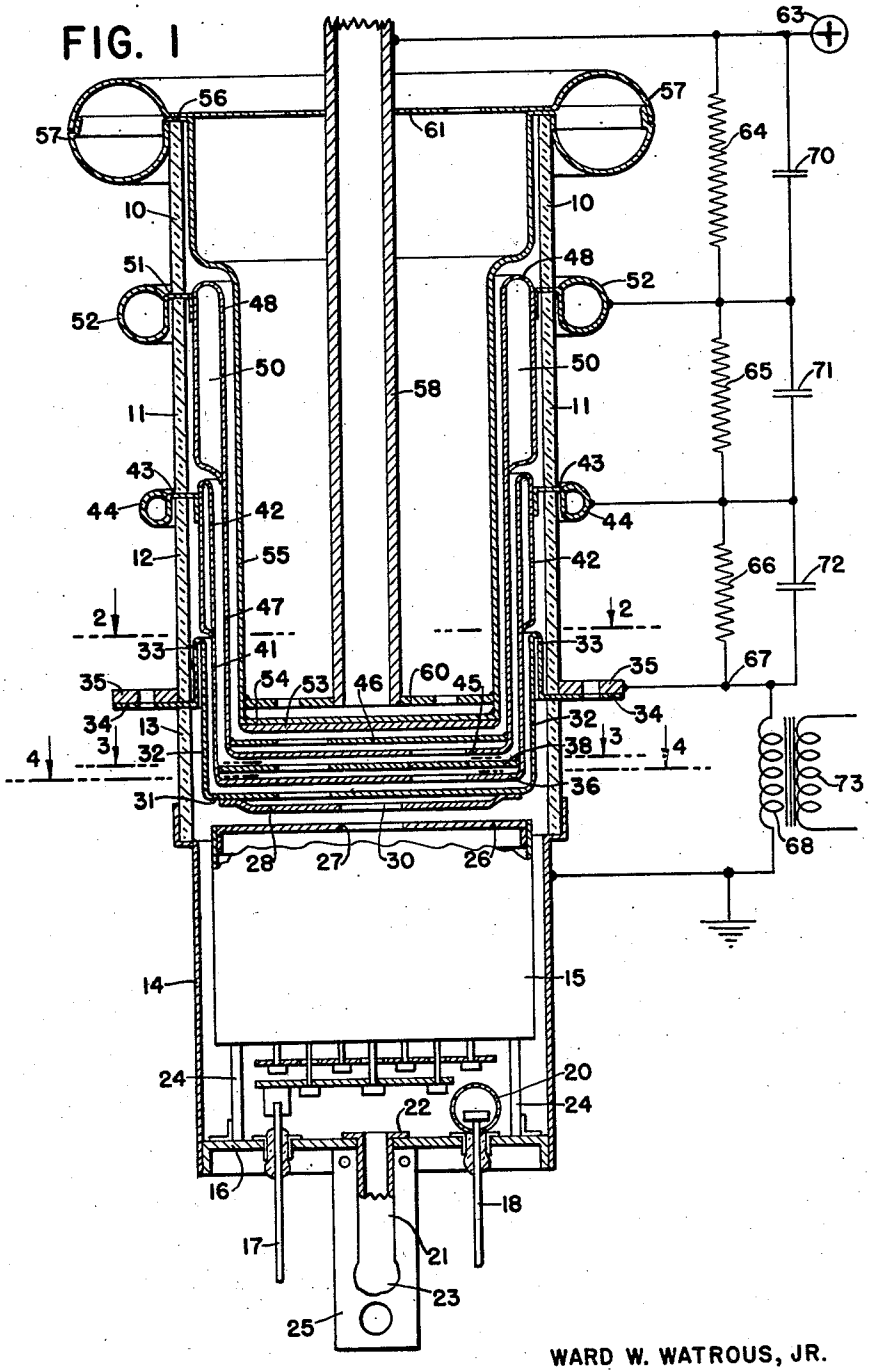
June 25, 1957 W. W. WATROUS, JR 2,797,348

GRID SYSTEM FOR GASEOUS DISCHARGE DEVICE

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FIG. 1



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FIG. 2

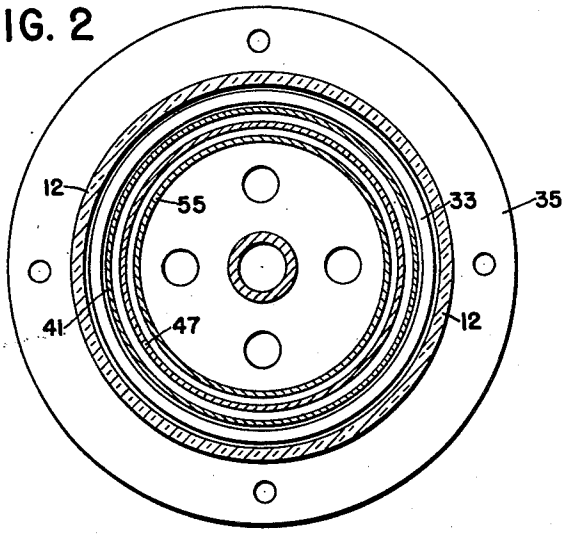


FIG. 3

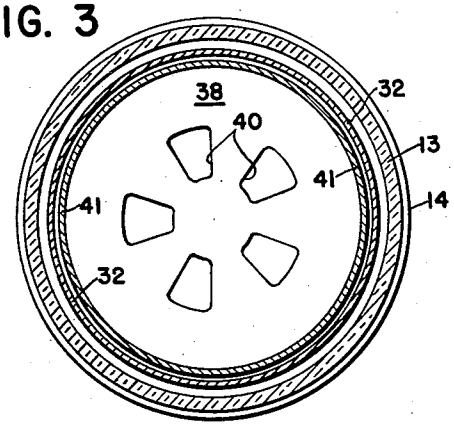
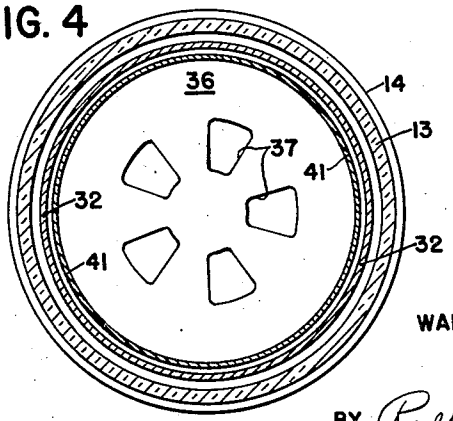


FIG. 4



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2,797,348

GRID SYSTEM FOR GASEOUS DISCHARGE DEVICE

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Application May 17, 1956, Serial No. 585,440

5 Claims. (Cl. 313—194)

This invention relates to a grid system for gaseous discharge devices which operate at high anode-cathode voltages. The invention has particular reference to the arrangement and the connections for a plurality of grids between the anode and cathode in a gaseous discharge device.

Gaseous discharge devices operating at 40,000 volts and comparatively high currents have been common in recent years. Details of these structures have been disclosed in U. S. Patents 2,644,101, issued June 30, 1953; 2,650,998, issued September 1, 1953; and 2,653,261, issued September 22, 1953, all to Ward W. Watrous, Jr.

The development of a gas discharge device which operates at 100,000 volts presents many new problems. The operation of a conventional thyratron designed for 50,000 volts at twice the rated anode voltage is not possible because the grid and baffle system cannot prevent anode-cathode conduction at this higher voltage. Reduction of gas pressure in the 50,000 volt thyratron permits a higher operating anode voltage but when this is done many other difficulties present themselves. Some of these are: (*a*) increased arc voltage, (*b*) the grid firing voltage is abnormally high, (*c*) erosion of the anode surface is increased, (*d*) the total heat dissipation is greatly increased, and (*e*) there is a marked tendency to "jitter."

The present invention permits the use of a suitable gas pressure, about 400 microns, by the employment of a system of multiple grids closely spaced between the anode and cathode. The anode, grids, and the cathode are preferably connected to a voltage divider in the supply circuit. The division of voltages in equal increments between the grids and the anode presents a voltage which is reduced in proportion to the number of sections used between adjacent electrodes and prevents premature gaseous conduction even at very high voltages. The use of this system increases the delay for the initiation of the conductive discharge but such a delay is reasonably constant and may be counterbalanced by a change in external circuitry.

One of the objects of this invention is to provide an improved grid system for gaseous discharge devices which permits high voltage and high currents to be controlled by the device.

Another object of the invention is the control of a large amount of power without undue heating within the tube envelope.

Another object of the invention is to simplify the construction of high voltage gaseous discharge devices.

Another object of the invention is the provision of external terminals which are spaced far apart and are convenient for connection to an outside circuit.

Another object of the invention is to provide a gaseous discharge device with an internal structure having a plurality of grids and an anode which, with their connected conductors, are spaced apart a distance which is considerably less than the mean free path of electrons in the gas.

The invention comprises a grid system for gaseous discharge devices and includes an envelope containing an ionizable gas at reduced pressure. Also within the envelope are a cathode, an anode, and a plurality of grid electrodes. The grid electrodes have the usual spaced openings for the passage of electrons and ions and are positioned in parallel arrangement with the anode. Each of the grid electrodes and the anode are connected to cylindrical conductors which are spaced from each other a distance which is less than the mean free path of the electrons in the gas. The cylindrical conductors are connected to lead-in conductors which are widely spaced on the exterior surface of the envelope.

One feature of the invention includes openings in the grid electrodes which are in staggered arrangement so that an electric field cannot be formed directly between the anode and cathode.

For a better understanding of the present invention, together with other and further objects thereof, reference is made to the following description taken in connection with the accompanying drawings.

Fig. 1 is a cross sectional view of the high voltage discharge device showing the cathode, three grids, and an anode, together with their external annular terminals and a schematic diagram of connections.

Fig. 2 is a cross sectional view of the tube of Fig. 1 taken along line **2—2** of that figure.

Fig. 3 is a cross sectional view of the device shown in Fig. 1 taken along **3—3** of that figure.

Figure 4 is a cross sectional view of the tube shown in Fig. 1 taken along line **4—4** of that figure.

Referring now to the drawings, the discharge device comprises a cylindrical envelope having five sections, the upper section **10** comprising a hollow cylindrical ceramic insulator, a middle section **11** comprising a similar insulator, a third insulator **12** similar to cylinders **10** and **11**, a fourth cylindrical insulator **13** similar to the above described elements and a fifth cylinder **14** which may be made of ceramic or a conductive material such as copper or nickel. The conductive cylinder **14** contains a cathode **15** which is similar to the cathode described in U. S. Patent 2,650,997, issued to Ward W. Watrous, Jr., September 1, 1953, and contains a plurality of heating elements surrounding a cylinder of electron emitting material. The lower end of conductive cylinder **14** is closed by a metal plate **16** which is securely welded to cylinder **14** at its periphery. Lead-in conductor **17** is for one terminal of the cathode heating system (second terminal not shown in Fig. 1). Another conductor **18** is sealed in bottom portion **16** and is connected to one terminal of a hydrogen reservoir **20** which is used to control the pressure within the envelope.

A metallic seal-off tube **21** is centrally positioned in plate **16** by welding a turned-over portion **22** to the inside plate surface. After the discharge device has been aged, evacuated, and tested, a pinch seal **23** seals the envelope and the device is ready for use. The cathode **15** may be connected to base plate **16** by conductive rods **24** and the cathode terminal **25** comprises a strip of metal which is riveted to the periphery of plate **16**.

The top of cathode **15** is formed with a conductive baffle plate **26** having a central opening **27** for the emission of electrons. A corresponding baffle plate **28** also with a central hole **30**, is positioned immediately above plate **26**, parallel thereto, and spaced a distance therefrom which is considerably less than the mean free path of the electrons in the gas. Baffle plate **28** is secured by welding to the number **1** grid **31** which is positioned parallel to its baffle plate and the top cathode baffle plate,

This grid, however, is formed with a plurality of openings such as those shown in Fig. 3, each opening positioned at a distance from the center so as not to coincide with openings 27, 30.

Grid No. 1 is connected to a conductive cylinder 32 which contains a turned over portion 33 and a lead-in disk 34. Disk 34 is sealed between cylinders 12 and 13 and is reinforced by a flat disk conductor 35 which may be used as a terminal for the grid.

Grid No. 2 comprises a flat disk 36 made of conductive material and formed with a plurality of openings 37 as shown in Fig. 4. It should be noted that the openings in the second grid are staggered with reference to openings in grid No. 1. The second grid also includes a second plate 38 mounted directly above plate 36 and having staggered openings 40. Plates 36 and 38 are joined near their peripheries and are connected to a cylindrical conductor 41 which contains a turned-over portion 42 and is connected to a lead-in disk 43 which is sealed between insulating cylinders 11 and 12. In order to reduce corona loss, the end portion of lead-in conductor 43 is formed with an annulus 44 having a circular cross section. It will be noted that conducting cylinders 32, 33, 41, and 42, are all closely spaced, the spacing being considerably less than the mean free path of the electrons in the gas. The terminal spacing, however, between terminals 35 and 44 is a considerable distance on the outside of the tube envelope. It should also be noted that the space is restricted between the inside surface of the insulating cylinders 12 and 13 and the adjacent conductors 33 and 42 to eliminate the formation of a discharge in case a cathode spot should be formed at the junction of the insulating cylinders and the adjacent conductors. In addition, the structure of the conducting sleeves is such that the electric field at the junction is reduced, thereby minimizing the tendency to form a cathode spot.

The third grid includes two flat disks 45 and 46, joined at their peripheries and each including a plurality of openings similar to the ones shown in Figs. 3 and 4. Grid No. 3 is secured to a hollow cylindrical conductor 47 which has a turned-over portion 48 to provide an annular volume 50 in order to afford adequate close spacing of the electrode conductors. Grid No. 3 is connected to a lead-in disk 51 similar to disk 43 and is terminated exterior of the tube envelope by an annulus 52 which has a circular cross section.

An anode 53 is positioned within the envelope in parallel relationship to the No. 3 grid 46 and includes a solid disk of metal such as molybdenum or a similar metal having a high melting point. In order to simplify fabrication, the molybdenum disk may be joined to a second disk of copper 54 which is connected to a hollow cylindrical conductor 55 and which is terminated at its upper portion by a sealing disk 56 partially forming the annulus 57.

In order to cool the anode, a stream of air may be directed towards the central portion of the anode by means of a hollow tube 58 which is supported at its lower end by a perforated disk 60 and at its upper end by another perforated disk 61. It will be obvious that liquid cooling of the anode may be effected by structural changes, such structures being well-known in the art.

When the discharge device is connected for operation, the full anode voltage of 100,000 volts is applied between positive terminal 63 and the cathode shell 14 or ground. Resistors 64, 65, 66, are of equal value (about 10 megohms each) and thereby distribute the total voltage between the three grids, 31—28, 36—38, and 45—46. The D. C. voltage drop across point 67 and ground is only a few volts because of the low resistance of secondary winding 68.

Because of the adjacent conductors used as lead-in wires for the grids, there will be a distributed capacity between the grids and the anode 53. This inter-electrode capacity is represented by capacitors 70, 71, and 72, and is an important component in the operation of the device. If the inter-electrode capacities are not large enough for optimum operation, external capacitors may be added as indicated.

When the device is in its non-conductive state the anode is held at 100,000 volts; the cathode is at zero or ground potential; the first grid 28—31 is approximately at ground potential, the second grid 36—38 is at 33,000 volts positive potential; and the third grid 45—46 is at 66,000 volts positive potential, the latter two values subject to some slight variation because of the variation in resistance of resistors 65 and 64.

When the device is fired (made conductive) a voltage pulse is applied to primary winding 73 which causes a positive voltage pulse of about 1,500 volts to be applied momentarily to the first grid 28—31. This increase in voltage causes ionization between the cathode and grid 31. The discharge soon extends to baffle 36 and then successively to disks 38, 45, 46, and the anode 53, thereby establishing a plasma of low potential drop between the anode and cathode and permitting the flow of a large current which may be 3,000 amperes or more. The time interval between the firing pulse and the full anode-cathode conduction is of the order of a microsecond but such delay can easily be compensated for by external adjustments in the phase and timing of the voltage pulse applied to primary winding 73.

While the example described contained three grids, it will be obvious that two, four, and five grid discharge devices can be constructed by following the principles of design and construction disclosed above. The invention should not be limited by the number of grids nor the voltage stated but only by the scope of the appended claims.

Having thus fully described the invention, what is claimed as new and desired to be secured by Letters Patent of the United States is:

1. A grid system for a gaseous discharge device comprising; an envelope containing an ionizable gas at reduced pressure, a cathode, an anode, and a plurality of grid electrodes; said grid electrodes having openings for the passage of electrons and ions and positioned in substantially parallel arrangement with said anode; said grid electrodes and the anode connected to axially aligned cylindrical conductors which are spaced apart from each other a distance which is less than the mean free path of the electrons in said gas; lead-in conductors sealed in said envelope material; and external terminals connected to said lead-in conductors for connection to an external circuit.

2. A grid system for a gaseous discharge device comprising; an envelope containing an ionizable gas at reduced pressure, a cathode, an anode, and a plurality of grid electrodes; said grid electrodes having openings for the passage of electrons and ions and positioned in substantially parallel arrangement with said anode; the grid electrodes and the anode each separated from its adjacent grid electrode by a distance which is less than the mean free path of the electrons in the gas; said grid electrodes and the anode connected to axially aligned cylindrical conductors which are spaced apart from their adjacent conductors a distance which is less than mean free path of the electrons in the gas; lead-in conductors sealed in said envelope material; and external terminals connected to said lead-in conductors for connection to an external circuit.

3. A grid system for a gaseous discharge device comprising; an envelope containing an ionizable gas at reduced pressure, a cathode, an anode, and a plurality of grid electrodes; said grid electrodes having openings for the passage of electrons and ions and positioned in substantially parallel arrangement with said anode; said cathode connected to an apertured baffle plate through which emitted electrons move from the cathode emitting surface; said grid electrodes, the anode, and the cathode

baffle plate each separated from its adjacent grid electrode by a distance which is less than the mean free path of the electrons in the gas; said grid electrodes and the anode connected to axially aligned cylindrical conductors which are spaced apart from their adjacent conductors a distance which is less than the mean free path of the electrons in the gas; lead-in conductors sealed in said envelope material; and external terminals connected to said lead-in conductors for connection to an external circuit.

4. A grid system for a gaseous discharge device as set forth in claim 3 wherein each of said grid electrodes include two adjacent disks, mounted parallel to each other and connected at their peripheries, each of said disks having openings for the passage of electrons and ions.

5. A grid system for a gaseous discharge device as set forth in claim 4 wherein each of said disks contains openings which are not in line with the openings of the next adjacent disk.

No references cited.