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ELECTRIC DISCHARGE DEVICE STRUCTURE

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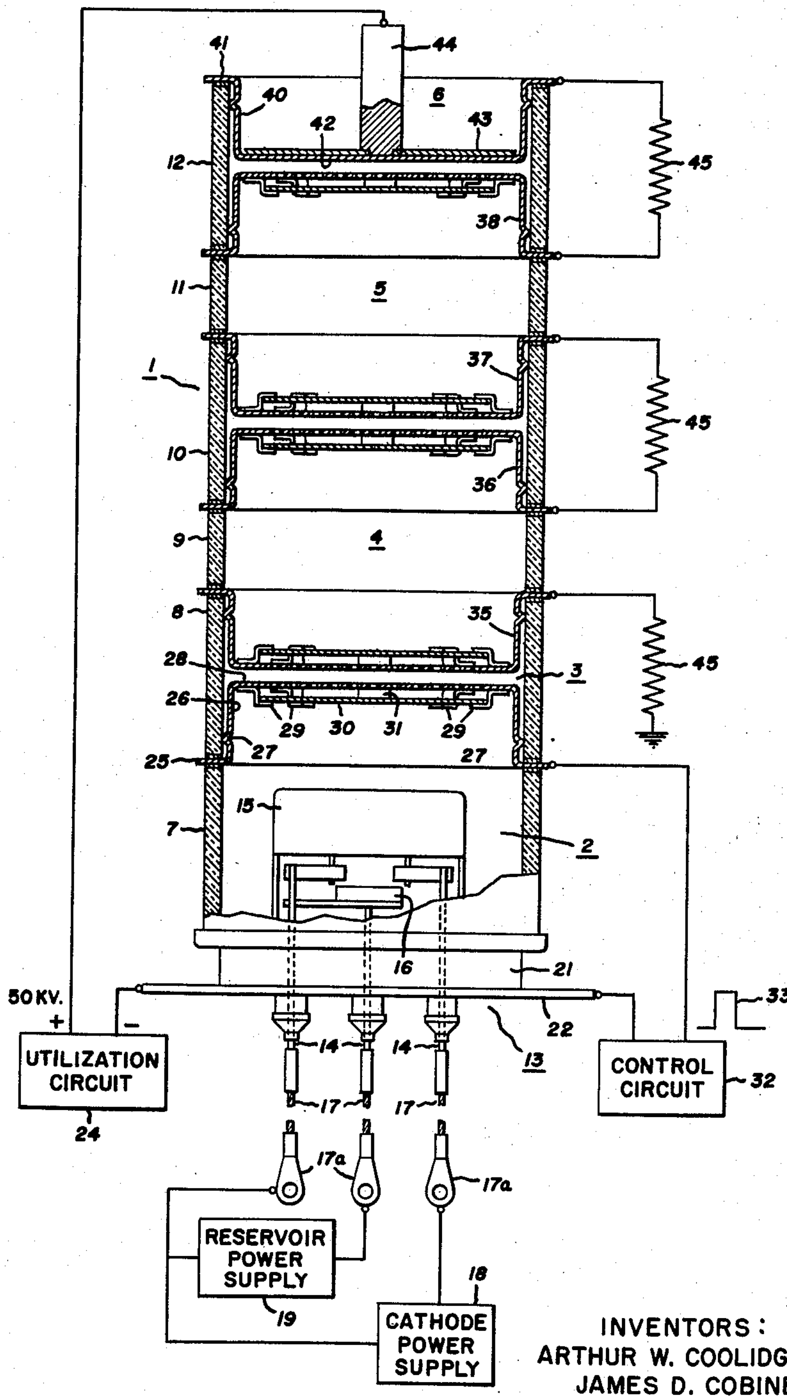

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ELECTRIC DISCHARGE DEVICE STRUCTURE

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Our invention relates to gas or vapor-filled electric discharge devices and pertains more particularly to such devices of the type incorporating gradient grid arrays or multiple grids operable at different potentials.

Gradient grid arrays can be and have been employed in gas and vapor-filled electric discharge devices such, for example, as grid-controlled rectifiers and thyratrons to increase the maximum anode voltage thereof. For example, one or more grids in addition to a control grid can be interposed between the anode and cathode of a device and adapted for operation at different potentials intermediate those of the other electrodes, and the device can be operated such that the maximum anode voltage which may be applied to the device will be equal approximately to the maximum voltage that may be applied between adjacent grids multiplied by $(n+1)$, where n equals the number of grids provided in addition to the control grid. Thus, it would appear a simple matter to increase anode voltage merely by increasing the number of grids employed.

However, as the number of grids is increased to provide higher anode voltage capabilities, the length of the device is necessarily substantially increased. This substantial increase in length is required due to the fact that, while in devices containing an ionizable filling internally located portions of multiple grids that differ widely in potential are preferably maintained in closely spaced relation to accord with Paschen's law, the external spacing of the grid seals or external portions must be substantial in order to prevent undesirable voltage breakdown across external wall sections of the device. In prior art types of arrangements including gradient grid arrays the requirements of small internal spacings and large external spacings between portions of adjacent grids has led to the use of a plurality of nested, mutually spaced and cup-shaped grids, which grids, in order to provide the substantial spacing between external portions, are required to be increasingly deeper as the number of grids employed increases. Also, as the number of grids increases the difficulties of manufacturing the deeper grids and of maintaining same satisfactorily positioned in a nested, mutually spaced arrangement increases.

Accordingly, a primary object of our invention is to provide a new and improved electric discharge device including an ionizable filling and improved grid means for increasing the anode voltage capability of the device.

Another object of our invention is to provide a new and improved electric discharge device including an improved hollow grid structure.

Another object of our invention is to provide an improved multiple grid arrangement for use in gas discharge devices and including multiple cup-shaped grid elements all of which can be shallow and of the same depth regardless of the number used.

Another object of our invention is to provide a new and improved gaseous discharge device including improved means for accelerating conduction ionization of the ionizable filling thereof and facilitating ignition of a conduction discharge through the device.

Another object of our invention is to provide a new and improved gradient grid gas discharge device including improved electrode arrangements whereby the possibilities of spurious discharges between adjacent elements exposed to high voltages are minimized.

Still another object of our invention is to provide an electric discharge device of an improved stacked ceramic and metal construction, whereby production manufacture is facilitated.

Further objects and advantages of our invention will become apparent as the following description proceeds and the features of novelty which characterize our invention will be pointed out with particularity in the claims annexed to and forming part of this specification.

In carrying out the objects of our invention we provide an electric discharge device comprising an envelope including alternate insulative wall sections and metallic electrode contacts and containing an anode element and a cathode element at the opposed ends, a control grid interposed between these elements and adjacent the latter, and an ionizable filling. Interposed between the anode and control grid are one or more hollow electrodes each comprising a pair of perforate grid elements bonded to the opposite end of a wall section of the envelope. Means are provided whereby the grid elements of each hollow electrode are operated at different potentials to provide ionization of the substantially limited portion of the ionizable filling contained in the hollow electrode in advance of a conduction discharge ionization of the filling. Thus, a conductive discharge through the device is facilitated when an ignition signal is placed on the control grid. Baffle means serve to minimize straying of the advanced ionization in each hollow electrode. Additionally, grid elements are cup-shaped to dispose adjacent portions thereof located internally of the device and operating at widely different potentials in closely spaced relation and to dispose portions thereof located externally of the envelope and operating at widely different potentials in substantially spaced relation. Further, this arrangement enables the use of substantially shallow grid elements and disposes the side walls of the elements in closely spaced relation to the side walls of the ceramic wall section in which the cup-shaped elements are re-entrant. The cup-shaped configuration of the grid elements also facilitates manufacture and assembly of the device.

For a better understanding of our invention reference may be had to the accompanying drawing which constitutes a schematic and partially sectionalized elevational view of an arrangement constructed in accordance with an embodiment of our invention.

Referring to the drawing, there is shown a high-voltage, electric discharge device of stacked construction which for purposes of illustration may comprise a high-power hydrogen thyratron including an envelope **1** provided with a hydrogen filling. The disclosed device includes a cathode and reservoir assembly generally illustrated and designated **2**, a control or triggering grid assembly **3**, first and second gradient grid cavity assemblies **4** and **5**, respectively, and an anode assembly **6**. Herein the term "gradient grid cavity assembly" is used to refer to a hollow electrode assembly including spaced grid elements adapted for being operated at different potentials to effect ionization of an ionizable filling in the hollow-electrode assembly.

The envelope **1** comprises six generally cylindrical or annular insulators or insulative wall sections **7–12**. The insulators **7–12** are preferably formed of any suitable insulative, high-strength and high-refractory ceramic material adapted for being metalized in order to facilitate the provision of ceramic-to-metal bonds or brazes between the ends of these sections and metal portions of the mentioned electrode assemblies. For example, the sections 7–12 can each be formed of ceramic materials generally known in the art as "alumina," which materials are adapted for being provided with metalized areas in a manner disclosed in U.S. Patent No. 2,667,427, issued January 26, 1954, to Henry J. Nolte, and assigned to the same assignee as the present invention.

The cathode and reservoir assembly **2** includes a header closing the lower end of the envelope **1** and generally designated **13**. The header **13** supports in a suitably mutually insulated manner a plurality of conductive leads **14** which extend through the header in a sealed manner and, internally of the envelope, make suitable electrical connections to an incandescible cathode **15** and a hydrogen reservoir **16**. Secured to the outer ends of the leads **14** are flexible conductors **17** each carrying a connector lug **17*a***. Two of the leads **14** are connected to the ends of the cathode **15** and one of these two leads and a third are connected to the hydrogen reservoir **16**. The cathode **15** when energized provides a source of electrons and the reservoir **16** when energized provides a source of hydrogen to replenish the filling of the envelope when the pressure thereof is reduced as by clean up or absorption of hydrogen by the materials of the device. By means of the flexible conductors **17** and the lugs **17*a*** the cathode is connected to a cathode power supply generally illustrated and designated **18**. Additionally, the hydrogen reservoir is similarly connected to an adjustable reservoir power supply **19**.

The header **13** further includes a sealing ring **21** which is bonded to a suitably previously metalized lower edge of the insulative section **7**, as by means of a silver-copper brazing material. Also, suitably bonded to the exterior of the ring **21** is an annular metallic flange **22** adapted for facilitating mounting of the device. Internally of the envelope and in a manner not shown, the sealing ring **21** is suitably electrically connected to the cathode **15** through the metal portions of the header and cathode support means. Thus, the ring **21** and associated flange **22** are adapted for conjointly serving as the electrical contact for the cathode **15**. Through this contact the cathode **15** is connected to the negative side of a utilization circuit generally designated **24**. The utilization circuit **24** can be one of any number of well-known and readily available types such, for example, as a high-voltage, high-current power supply in the order of 50 kv. and an appropriate load, and it need not be shown or described herein. However, the operation of the disclosed device in this type of circuit will be described in detail hereinafter.

Sealed between the opposed edges of the ceramic insulators **7** and **8**, as by substantially the same brazing process described above, is a sealing ring or electrode contact **25**. The sealing ring **25** comprises a rim-like portion or flange of an inverted cup-like grid **26** formed preferably of copper or any other material which is suitably conductive electrically and thermally and can be readily formed to a cup shape. The grid **26** is substantially shallow and extends re-entrantly into the ceramic section **8**. Additionally, the dimensions of the grid **26** are such that the side walls of the grid are in laterally closely spaced relation to the inner wall of the ceramic section **8**. Formed in the side wall of the grid **26** are a plurality of circumferentially spaced outwardly extending protrusions **27**. The protrusions **27** are provided on all of the other cup-like elements of the device also and are engageable with the inner wall of the ceramic insulator during assembly of the device for insuring substantial centering of the grid in the device and to insure maintenance of a desired minimum space relation between the side walls of the cup-like elements and insulators.

The grid **26** also includes a planar bottom portion **28** which extends, as mentioned above, into the insulator **8** and is perforate for transmission of electric particles therethrough. Additionally, the grid supports, by means of a plurality of circumferentially spaced brackets **29**, an imperforate disk or shield **30**. Disposed centrally between the grid bottom wall and shield, for the purpose of maintaining a desired spaced relation therebetween, is a spacer element **31**. The diameter of the shield **30** is such that the shield extends laterally beyond the pattern of perforations in the grid bottom and, thus, the shield is effective for impeding ion migration through the grid. The purpose for this will be brought out in detail hereinafter.

The grid **26** constitutes the control or triggering grid of the device and the ring **25** constitutes an external eleccal contact therefor; and through the ring **25** the grid **26** is electrically connected to a control or triggering circuit generally designated **32**. The circuit **32** is adapted to provide preferably a rectangularly shaped ignition pulse or signal indicated by the curve **33**. Any one of a number of available circuits of prior art types is suitable for providing such a signal in a predetermined timed relation. The effect of a signal **33** on the grid **26** will be described in detail hereinafter in conjunction with the description of the overall operation of the device.

The above-described grid **26** is structurally identical to the grid elements utilized in providing the aforementioned first and second gradient grid cavity assemblies or cavities designated **4** and **5**, respectively, and, accordingly, in the following description of the cavity assemblies **4** and **5** the grid structures or elements utilized in forming the gradient grid cavity assemblies will merely be referred to as "grids" with the reader being aware from the drawing and from what has just been stated that each of such "grids" is identical to the grid **26** structurally in that it, too, is cup-like, includes a perforate bottom and carries an imperforate shield or baffle in the bottom thereof.

The first gradient grid cavity assembly **4** comprises a lower grid **35**, an upper grid **36** and the insulator **9** brazed at the opposite end thereof between the ends of the upper and lower grids. This assembly provides for a cavity or hollow electrode assembly in which the upper and lower grids can be maintained at different potentials, the reason for which will be brought out hereinafter. The cavity **4** is sealed in the device by brazing the rim of the lower grid **35** to the upper edge of the insulator **8** and the rim of the upper grid **36** to the lower edge of the insulator **10**. As seen in the drawing, the lower grid **35** extends re-entrantly in the insulator **8** and the upper grid **36** extends re-entrantly in the insulator **10**, with the side walls of the grids in closely spaced relation to the inner surfaces of the corresponding insulators in which the grids extend.

The second gradient grid cavity assembly **5** comprises a lower grid **37**, an upper grid **38**, and the insulator **11** brazed at the opposite ends thereof between the rims of the grids. This assembly also provides for a cavity gradient grid in which the proposed grid elements can be maintained at different potentials. Additionally, this cavity is sealed in the device with the lower grid **37** extending re-entrantly in the insulator **10** and brazed at the rim thereof to the upper edge of the insulator **10** and with the upper grid **38** extending re-entrantly in the insulator **12** and brazed at the rim thereof to the lower edge of the insulator **12**. The re-entrant disposition of the bottom portions of the various grids in the insulators enables these portions of adjacent grids to be arranged internally of the envelope in closely spaced relationship while the external rim portions are substantially spaced and disposed on opposite ends of the interposing insulators. Thus, electrical breakdown between the external portions of the grids is avoided.

The anode assembly **6** comprises a cup-like anode member **40** preferably formed of copper, also, so as to include a rim **41** and a planar bottom **42**. The rim **41** is bonded to the previously metalized upper edge of the insulator 12 and is re-entrant therein for thus disposing the planar body 42 in closely spaced relation to the bottom of the upper grid 38 of the second cavity. Bonded to the external surface of the bottom of the anode 40 is a backing or reinforcing plate 43 which is of such a thickness as to avoid distortion of the planar bottom of the anode. Suitably bonded centrally in the plate 43 and in satisfactory electrically conductive relation with the anode 40 is an upstanding stud or connector 44. The connector 44 is adapted for serving as the anode contact and through it an electrical connection is effected between the anode 40 and the positive side of the utilization circuit 24.

Additionally, in the arrangement illustrated the anode is electrically connected to the upper grid 38 of the second gradient grid cavity 5 through an external high-resistance element 45 in the order, for example, of 15 megohms. Similarly, the lower grid 37 of the second cavity 5 and the upper grid 36 of the first cavity 4 are connected through an external high-resistance element 45. The lower grid 35 of the first cavity 4 is connected through a high-resistance element 45 to cathode potential which in the present case is ground potential. It is to be understood from the foregoing that while we have shown and described an arrangement including a plurality of resistors 45, the high-resistance electrical connections between the various electrodes can be effected by other suitable means, such, for example, as high resistance conductive envelope wall sections or painted high-resistance conductive stripes across the appropriate insulators.

The thyratron shown in the drawing and described above constitutes a multi-cavity device adapted for achieving an extremely high anode voltage rating and in which the anode rating in kv. might be assumed to be the product $e(n+1)$ where e equals the maximum voltage in kilovolts that may be applied between adjacent grids and n equals the number of cavities provided.

In the operation of this arrangement a high impedance circuit is established from the anode to the cathode externally through the resistances 45 and internally through the volumes defined by the gradient grid cavities 4 and 5. Due to the large spacing between the grid elements of each cavity 4 and 5 a cold discharge or ionization is established between the two elements of each cavity when one element is driven positive with respect to the other. This condition results from the fact that the resistances 45 tend to raise the potential of the upper grid of each cavity toward anode potential and to lower the potential of the lower grid of each cavity toward cathode potential. Thus, when the anode is rendered positive by the utilization circuit 24 each of the cavities 4 and 5 fills with ionization and a small trickle of current flows through the circuit described. The voltage drop across the grid elements comprising each of the cavities 4 and 5 is nominal such, for example, as 100 volts as compared to the anode voltage so that both grid elements of each cavity are placed at substantially the one-third position of a resistance voltage divider connected between the anode and cathode.

Thus, substantially one-third of the anode voltage appears across the small gap between the anode 40 and the upper grid 38 of the cavity 5, one-third across the small gap between the lower grid 37 of the cavity 5 and the upper grid 36 of the cavity 4, and one-third across the small gap between the lower grid 35 of the cavity 4 and the control grid 26. In each of the cavities 4 and 5 a small amount of ionization subsists. This ionization is prevented from adversely affecting the insulating properties of the mentioned small gaps by the substantial baffling afforded by the baffle plates or shields 30 supported in the grid cups. These baffle plates minimize straying of ions into the mentioned inter-electrode gaps. Thus, the volumes defined by the cavities are maintained suitably pre-ionized in preparation for the application of a positive trigger signal or pulse 33 on the control grid 26. In the present application the terms "pre-ionized" and "pre-ionization" are used with reference to the small amount of ionization that occurs in the cavities 4 and 5 at a time or times other than when the main discharge between the cathode and anode is occurring, such as in advance of the main discharge ionization. In the absence of such pre-ionization and without the split gradient grid assemblies described it would be necessary for the ionization to become established at the time of the main discharge of the device by proceeding from one end of the gradient grid to the other by the process of diffusion. This diffusion would be a random process and the time required for ionization to fill the cavity would be slow and unprecise. The build-up of ionization during the main discharge as effected in the present device is rapid and fills the cavities substantially fast as compared with the random process as would be effected by diffusion in the absence of the different potentials on each side of the cavities.

With the gaseous content of each of the cavities 4 and 5 pre-ionized in the manner above described and when the pulse 33 is applied to the control grid 26, a high density of ions is effected which is sufficient to cause some ions to stray around the baffle 30 and into the gap between the lower grid 35 and the control grid 26 and thus cause that gap to lose its insulative properties and to break down or become conductive. This causes the grid 35 rapidly to fall to essentially cathode potential. Then, due to the large spacing between the grid elements 35 and 36 comprising the cavity 4 and the above-discussed pre-ionization of the ionizable filling contained therein, the upper element 36 assumes a potential substantially that of the lower element 35.

Thus, conditions are afforded favorable to a breaking down of or conduction across the gap between the upper grid 36 of the cavity 4 and the lower grid 37 of the cavity 5. Specifically, the cavity 4 is filled with a high density of ionization due to the inrush of charging current to the upper grid 36 of the cavity 4 which is necessary in order to lower rapidly the potential of the grid 36 to essentially cathode potential. The value of the inrushing current is a function of the reluctance of the grid 36 to change rapidly its potential which, in turn, is a function of the capacitive coupling between the upper grid 36 of the cavity 4 and the lower grid 37 of the cavity 5, and any capacitance that may be connected externally of the grid 36. The mentioned high density ionization fosters the breakdown of the gap between the cavities since such ionization tends to provide movement of ions around the shields or the baffle plates 30 in the grid cups and into the gaps between the cavities. Additionally, as the potential of the grid 36 is lowered to essentially cathode potential, the voltage across the gap between grids 36 and 37 is greatly increased.

The just-described conduction leads to a breakdown across the gap between cavities 4 and 5 with the result that the potential of the grid 37 falls rapidly to essentially cathode potential. Then the just-described process repeats itself in connection with the breakdown of the gap between the upper grid 38 of the second gradient grid cavity 5 and the anode 6, resulting in complete discharge across the device for completion of the circuit through the utilization device 24.

It will be understood from the foregoing that in providing the hollow gradient grid cavities each including the two cup-like shaped grid elements separated by an annular insulator and operated at a relatively small potential difference such, for example, as 100 volts, there is, in the process of the device becoming conductive, a voltage gradient inside of the cavities which accelerates the process of ionization build-up from the lower cup to the upper cup of each cavity. This facilitates firing or initiation of the conductive discharge of the device. Additionally, "jitter" or irregularities in firing are reduced due to the fact that the rate of build-up of ionization is more precise in the presence of the voltage gradient in the cavities. Further, the re-entrant disposition of the cups in the insulator wall sections and the close spacing of the side walls of the cups to the inner surfaces of the insulator walls minimizes the possibilities of spurious discharges between these elements when exposed to high voltages.

While we have shown and described a specific embodiment of our invention we do not desire our invention to be limited to the particular form shown and described and we intend by the appended claims to cover all modifications within the spirit and scope of our invention.

What we claim as new and desire to secure by Letters Patent of the United States is:

1. In combination, an envelope, an anode and cathode mounted in insulated spaced relation in said envelope, a control electrode between said anode and cathode, a perforate hollow electrode assembly disposed between said anode and control electrode, said hollow electrode assembly comprising a pair of conductive elements including perforate planar portions extending in spaced relation transversely in said envelope and a tubular insulative member separating said conductive elements, and an ionizable filling in said envelope including a portion in said hollow electrode assembly, said conductive elements being adapted for operating at different potentials for pre-ionizing essentially only said portion of said filling contained in said hollow electrode assembly, thereby to facilitate initiation of a conductive discharge through said device between said anode and cathode upon application of an ignition signal to said control electrode.

2. In combination, an envelope, an anode and cathode mounted in insulated, spaced relation in said envelope, a control electrode between said anode and cathode, a perforate hollow electrode assembly disposed linearly between said anode and control electrode, said hollow electrode assembly comprising a pair of conductive elements including perforate planar portions extending in spaced relation transversely in said envelope and an insulative wall section of said envelope separating said conductive elements, and an ionizable filling in said envelope including a portion thereof contained in said hollow electrode assembly, said conductive elements being adapted for operating at different potentials for pre-ionizing said portion of said filling contained in said hollow electrode assembly in advance of a conductive discharge between said anode and cathode, thereby to facilitate initiation of said conductive discharge through said device between said anode and cathode upon application of an ignition signal to said control electrode.

3. An electric discharge device comprising an envelope, an anode and cathode mounted in insulated, spaced relation in said envelope, a control electrode between said anode and cathode and disposed adjacent said cathode, a pair of transverse perforate conductive elements in said envelope having the rim portions thereof extending through the wall of said envelope and separated by a section of the wall of said envelope and defining therewith a hollow electrode assembly disposed between said anode and control electrode, an ionizable filling in said envelope including a portion contained in said hollow electrode assembly, and means for operating said conductive elements of said assembly at different potentials for effectively pre-ionizing said portion of said ionizable filling contained in said hollow electrode assembly, thereby to facilitate initiation of a conductive discharge through said device between said anode and cathode upon application of an ignition signal to said control electrode.

4. An electric discharge device comprising an envelope, an anode and cathode mounted in insulated, spaced relation in said envelope, a control electrode between said anode and cathode and disposed adjacent said cathode, a pair of transverse perforate conductive elements in said envelope separated by a section of the wall of said envelope and defining therewith a hollow electrode assembly disposed between said anode and control electrode, an ionizable filling in said envelope including a portion contained in said hollow electrode assembly, an element substantially baffling the perforations in each of said conductive elements, and high-resistance means for operating said conductive elements of said assembly at different potentials for effectively pre-ionizing said portion of said ionizable filling contained in said hollow electrode assembly in advance of the ionization of the remaining portion of said filling in said envelope, thereby to facilitate initiation of a conductive discharge through said device between said anode and cathode upon application of an ignition signal to said control electrode.

5. A gas discharge device comprising an envelope including insulative annular wall sections and containing a gaseous filling, an anode and cathode mounted in said envelope at opposite ends thereof, a control electrode between said anode and cathode and disposed adjacent said cathode, a pair of oppositely extending conductive cup-like grid elements each extending re-entrantly in and in laterally closely spaced relation with a wall section of said envelope, said grid elements having perforate bottoms and being sealed at the rims thereof to the opposite ends of an interposed insulative wall section of said envelope with which said grid elements define a hollow electrode assembly interposed between said anode and control grid and containing a portion of said gaseous filling, and said grid elements being adapted for operating at different potentials for effecting pre-ionization of said portion of said gaseous filling contained in said hollow electrode assembly, thereby to facilitate initiation of a conductive discharge through said device between said anode and cathode upon application of an ignition signal to said control grid.

6. A gas discharge device comprising an envelope including insulative annular wall sections and containing a gaseous filling, an anode and cathode mounted in said envelope at opposite ends thereof, a control electrode between said anode and cathode and disposed adjacent said cathode, a pair of oppositely extending conductive cup-like grid elements each extending re-entrantly in and in laterally closely spaced relation with a wall section of said envelope, said grid elements having perforate bottoms and being sealed at the rims thereof to the opposite ends of an interposed insulative wall section of said envelope with which said grid elements define a hollow electrode assembly interposed between said anode and control electrode and containing a portion of said gaseous filling, a baffle element supported transversely across the bottom portion of each of said grid elements and substantially baffling the perforations therein, and said grid elements being adapted for operating at different potentials for effecting pre-ionization of said portion of said gaseous filling contained in said hollow electrode assembly, thereby to facilitate initiation of a conductive discharge through said device between said anode and cathode upon application of an ignition signal to said control electrode.

7. In combination an envelope including a gaseous filling and annular insulative wall sections, an anode and cathode sealed at opposite ends of said envelope, a cup-shaped control grid interposed between said anode and cathode and a rim thereof sealed between a pair of said wall sections, at least one gradient grid cavity interposed between said anode and control grid and comprising a pair of oppositely extending cup-shaped grid elements each extending re-entrantly in a wall section of said envelope, said grid elements having perforate bottoms and being sealed at the rims thereof to the ends of said wall sections in which they extend and to the opposite ends of another wall section interposed between said rims, said grid elements and interposed wall section defining a cavity containing a portion of said gaseous filling, baffle ele-

ments supported transversely in the bottom of each of said grid elements and substantially baffling the perforations therein for minimizing undesirable straying of ions from said cavity, means for applying positive and negative potentials to said anode and cathode, respectively, means for applying an ignition signal to said control grid, and means for effecting a potential gradient of a predetermined low value between said grid elements of said cavity for pre-ionizing said portion of said gaseous filling therein, thereby to facilitate initiation of a conductive discharge through said device between said anode and cathode upon application of said ignition signal to said control grid.

8. A gas discharge device comprising an insulative envelope, a gas filling contained in said envelope, and a pair of oppositely extending conductive cup-like grid elements each extending reentrantly in a wall section of said envelope, said grid elements having perforate bottoms and being sealed at the rims thereof to the opposite ends of an interposed section of said wall of said envelope to define therewith a hollow electrode assembly containing a predetermined quantity of said gas filling for being pre-ionized independently of the remaining portion of said filling in said envelope when said grid elements are operated at different potentials.

9. A gas discharge device comprising an elongated envelope, an anode and cathode mounted in insulated longitudinally spaced relation in said envelope, a gas filling in said envelope, a pair of oppositely extending cup-like grid elements each extending reentrantly in a wall section of said envelope, said grid elements having perforate bottoms and being sealed at the rims thereof to the opposite ends of an interposed tubular insulator to define therewith a hollow electrode assembly containing a portion of said gas filling adapted for being pre-ionized independently of the remaining portion of said filling in said envelope when said grid elements are operated at different potentials.

References Cited in the file of this patent

UNITED STATES PATENTS

2,489,938 Smith ---------------- Nov. 29, 1949

FOREIGN PATENTS

757,582 Germany -------------- Feb. 15, 1954