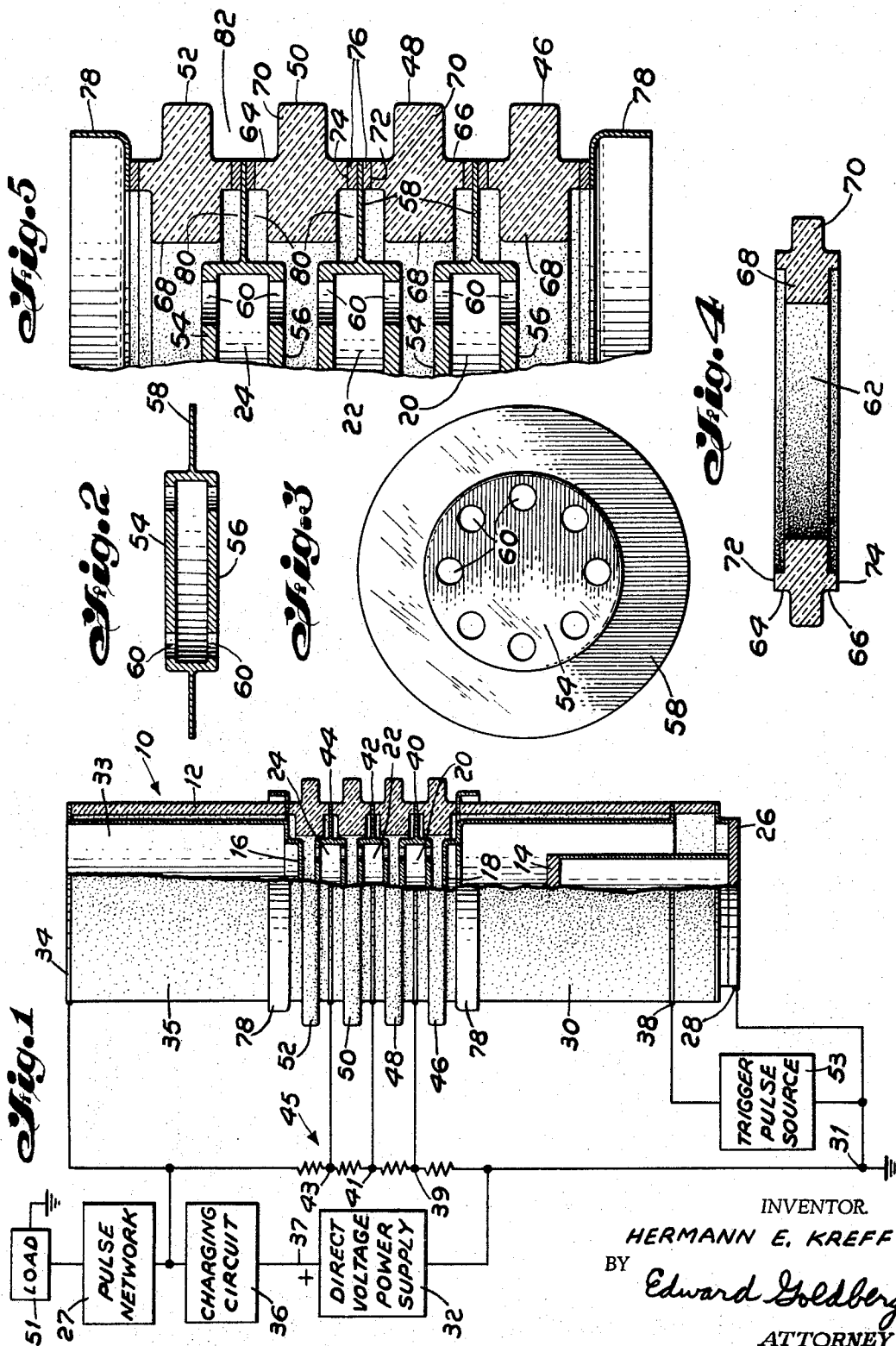


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OF GRIDS SPACED APART ALONG A CERAMIC ENVELOPE
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HIGH VOLTAGE GAS DISCHARGE TUBE HAVING A PLURALITY OF GRIDS SPACED APART ALONG A CERAMIC ENVELOPE

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ABSTRACT OF THE DISCLOSURE

A plurality of planar grids are supported between annular insulating rings in a ceramic gas tube envelope. The rings have transverse extensions into and out of the envelope wall to form recessed areas in which the ends of the grids are secured. The extensions provide long discharge paths to permit high voltage output pulses to be obtained.

This invention relates to gas or vapor filled electrical discharge tubes which are generally used for rectifying or modulating electrical currents supplied by high voltage sources. It more particularly deals with hydrogen filled thyratrons, which serve as highly efficient modulator switch tubes in the operation of pulsed high frequency circuits.

Hydrogen thyatron tubes are capable of extremely accurate switching of very high current pulses, in the order of several thousand amperes, supplied by pulse forming networks which operate at voltages of approximately 30 kilovolts and higher. Internal voltage breakdown is generally prevented by close spacing of the metal cup electrodes from the ceramic tubular envelope and by the great longitudinal distances between the electrode seals through the envelope walls. More recently these tubes have been made successfully with a relatively simple cylindrical stacked design having one or two grids. The addition of a second grid has increased their voltage capability to the 50 kilovolt range but has made the seals more difficult to protect since the grids must be relatively flat to permit controlled discharge under reasonable pressure and voltage conditions. In pulsed circuitry, the switching of still higher voltages is desirable and the attainment of such would represent an important improvement and provide a much wider field of application for the hydrogen thyatron tube. This performance can only be achieved with an electrode structure which contains at least two grids, and a tube with a planar structure of this nature has not been made successfully, heretofore.

It is, therefore, the primary object of the invention to provide an improved highly precise multi-grid gas discharge tube structure which is capable of operating at very high voltages of 100 kilovolts and more and utilizes a plurality of planar grids which are mounted in a ceramic envelope and protected against electrical breakdown.

This result is obtained by a novel tube structure wherein a cylindrical envelope includes a plurality of planar annular ceramic rings having transverse extensions projecting into and out of the envelope walls and which are stacked alternately with the grids and connected thereto by vacuum tight seals. The seals are positioned in recessed pockets formed in the envelope wall between the rings. The details of the invention will be more fully understood and other objects and advantages will become apparent in the following description and accompanying drawings wherein:

FIGURE 1 is a partially sectioned side view of a multi-

grid gas discharge tube showing schematic connections to the voltage sources;

FIGURES 2 and 3 are side and top views of a grid used in the tube;

FIGURE 4 is a side view of a ceramic plate forming a central section of the tube envelope, and

FIGURE 5 shows an enlarged detailed section of an assembly of three grids in the central area of the tube envelope.

As shown in FIGURE 1, a high voltage gas discharge tube 10 includes a cylindrical ceramic envelope 12 which contains a cathode 14, an anode 16 and a plurality of grids 18, 20, 22 and 24 stacked therebetween. The cathode is preferably of the indirectly heated, oxide coated type and is supported by a metallic base 26 which is connected by a seal 28 to a lower tubular portion 30 of the envelope. The cathode and base 26 are preferably connected to the ground terminal 31 of a direct voltage power supply 32. At the other end of the tube, the anode is supported by a cylindrical cup 33 which is connected, by a seal 34 to the upper tubular portion 35 of the envelope. The upper portion of the anode cup is thus secured to the tube envelope similarly to the base at the other end. The anode is connected to a pulse forming network 27 and, through a charging circuit 36, to the high voltage terminal 37 of the power supply which energizes the network. The grids are preferably positioned at equal distances from each other between the cathode and the anode and are supported and secured to the envelope by ceramic to metal seals 38, 40, 42 and 44. The latter three of these grid seals are connected respectively to voltage taps 39, 41 and 43 on a voltage divider 45 disposed between the anode and ground to provide a stabilized increasing fraction of the anode voltage to grids 20, 22 and 24. The seals are made between planar annular ceramic rings 46, 48, 50 and 52 which constitute the central section of the tube envelope. The tube is filled with a gas, preferably hydrogen, and operated at a pressure of approximately 500 microns.

When operated as a triggered modulator switch in a pulsed circuit, which in this case comprises network 27 and a load 51, a high energizing voltage of 60,000 to 100,000 volts is applied between the anode and the cathode. Although a gaseous atmosphere exists in the tube, a discharge between these electrodes does not occur since the narrow spaces or gaps which exist between the grids and between the anode and the adjacent grid do not become conductive until ionization is induced in these spaces. Consequently, a voltage drop of 15,000 to 25,000 volts is impressed upon each gap if the total voltage is evenly distributed over the four gaps. The first grid 18 is a control grid which is connected to a trigger pulse source 53. When a positive trigger voltage of 500 to 1000 volts, for example, is applied to grid 18, a discharge current is drawn from the oxide coated cathode to this grid and into the adjoining gap. This causes all the gaps to be successively ionized and become conductive and thus permit the building up of a large magnitude current pulse to the anode. The tube thus acts as a closed switch during occurrence of the pulse since the voltage between anode and cathode drops to a very low value. Depending on the characteristics of the pulse network which supplies the electrical energy, the current pulse may have a duration of one microsecond, after which conductivity in the tube ceases. Conduction can then be restored only after the network is again charged and a new trigger pulse is applied to grid 18. In a similar manner, a tube of this configuration may be used as a grid controlled rectifier tube.

As is known from the Paschen law in gas discharge physics, a gap in a low pressure gas or vapor atmosphere which is formed by two plane electrodes, is capable of

sustaining a high voltage applied thereto without the gas becoming conductive if the distance between the electrodes is kept sufficiently small. The small spacing thus does not permit a discharge to build up. In a hydrogen atmosphere of 500 microns pressure, under which a switch tube of the present type operates particularly well, this distance is about one tenth of an inch or 2.5 millimeters. The tube therefore, must have plane clearance spacings of this magnitude at all points between its grids, and between the anode and the adjacent grid in order to be able to perform as a high voltage switch or rectifier tube.

One particular type of grid used in the present tube is shown in FIGURES 2 and 3. It consists of two parallel plates 54 and 56 which are preferably made of high conductivity copper and form the top and bottom of a hollow flat cylindrical box. This configuration permits the grids to be made larger in height for improved electric field separation. The supporting ends of the grids are in a tubular form secured between the parallel plates and having a planar flange 58 located in the center plane of this box extending parallel with the plates. As shown in FIGURE 3, each plate has eight equally spaced aligned holes 60 which permit a discharge to pass through the grid when the tube is triggered. Other forms of apertures, such as radial or parallel slots may be used instead of holes, and alignment of these apertures is not required. A grid may also consist of only a single plate if sufficiently thick to separate the electric fields of adjacent gaps. In this case, to provide structural rigidity, the grids should have a minimum thickness of about one sixteenth of an inch.

If the grids are hollow and made of two plates, the maximum height should be approximately between one quarter and one inch depending upon the diameter required, which may be up to several inches. A minimum thickness is required for mechanical, thermal, and electrical purposes to prevent deformation or overheating and provide sufficient baffling to separate the electrical fields of adjacent gaps. Any one of these effects can lead to uncontrolled breakdown of one or more gaps and make the tube inoperable. An upper limit for the dimensions of the grids is set by the requirement that the gas or vapor within the grids become conductive when the tube is triggered so that a discharge current may pass from the cathode through the grid apertures to the anode. This upper limit depends to some extent on the diameter of the grids and on size and shape of the grid apertures and their relative positions.

In order to mechanically support the grids within the envelope, vacuum-tight seals 40, 42, and 44 are provided between the flat flanges and the plane annular ceramic rings in the central section of the envelope. Such seals are also necessary to conduct heat from the grids to the envelope and outside the tube and to connect an external circuit supplying a suitable potential as shown in FIG. 1.

A cross section of a ceramic ring used in the central section of the envelope assembly is illustrated in FIGURE 4. The material is preferably of high alumina ceramic and is in the form of a planar annular plate which has a central aperture 62 and small annular longitudinal projections 64 and 66 on each flat side which are located between the inner and outer diameters of the plate, thus dividing it into inner and outer transverse extended annular portions 68 and 70, respectively, which in the assembled tube, are inside or outside the envelope wall. The faces 72 and 74 of projections 64 and 66 are metallized, as for example by the well known molybdenum-manganese process, for sealing to the grid flanges 58.

In FIGURE 5, the central section of the tube is shown in more detail. It is composed of three identical planar grids 20, 22, and 24, of the hollow type shown in FIGURES 2 and 3, and four ceramic rings 46, 48, 50, and 52. Mechanical connection between these elements is made by vacuum-tight seals between the flat grid flanges 58 and the metallized faces 72 and 74 of projections 64 and 66 on the ceramic rings. When assembling the section

for brazing and sealing, a stack is formed in which rings and grids alternate and in which thin washers 76 made of a suitable brazing alloy, for example, a silver-copper alloy, are inserted between each metallized face and the adjoining grid flange. The assembly is then fired in a hydrogen atmosphere at a temperature somewhat above the melting point of the alloy so that mechanically strong seals are formed by brazing the metallized faces of the ceramic rings onto the grid flanges.

It has been found most efficient to seal the central section of the tube separately and to complete the assembly by later adding the tubular portions 35 and 30 which are also sealed separately and which respectively contain the anode and the control grid spaced from the cathode. All three sub-assemblies are provided with end flanges 78, which permit final assembly of the tube by arc welding. In this manner, more accurate alignment and spacing of the electrodes is made possible. Some typical dimensions of the elements may be $\frac{1}{4}$ inch for the ceramic ring thickness, which is capable of withstanding up to 50 kilovolts. The internal and external transverse extensions may also be about $\frac{1}{4}$ inch. The planar gaps between the grids may be about $\frac{1}{8}$ inch, the grid flanges $\frac{1}{32}$ inch thick, the distance between flanges $\frac{3}{8}$ inch, the recesses between flanges and internal extensions 0.050 inch high and the transverse spacing between grid and ring edges 0.050 inch.

As a result of the particular shape of the ceramic rings having internal and external transverse extensions 68 and 70 on opposite sides of the seals and envelope wall, the seals are located in inner and outer recessed pockets 80 and 82, respectively, within the wall. The seals are thus separated from each other by ceramic material of high dielectric strength. The extensions 70 of the rings provide a long external path including the spaces adjacent the flat surface of recesses 82, and outer edge of each ring, effectively preventing electrical breakdown and formation of corona on the outside of the tube which may be exposed to air or immersed in transformer oil. Without this separation provided by the external extensions of the ceramic rings, very high voltage operation of the tube would not be possible as the grid seals are only at a small longitudinal distance from each other. Similarly on the inside, the internal transverse extended portions 68 of the ceramic rings and recesses 80 therebetween inhibit long path discharge conditions between adjacent seals and between the grid flanges which are further apart than the planar grid plates which form the gaps. The danger of damaging the tube by arcing between seals is thus greatly reduced. The transverse spacing of the cylindrical edges of the grids from the internal ceramic ring extensions also reduces the field strength and aids in preventing breakdown.

The novel structure may utilize many other selected arrangements and numbers of such grids, since increasing or reducing the number requires only the addition or subtraction of a corresponding number of ceramic rings. In addition the grids or ceramic rings need not be of identical design, as it may be desirable to employ grids with different dimensions and/or aperture sizes and shapes, or ceramic rings having different thicknesses, tubular extensions and internal and external diameters. While only a single embodiment has been illustrated, it is apparent that the invention is not limited to the exact form or use shown and that many other variations may be made in the particular configuration without departing from the scope of the invention as set forth in the appended claims.

What is claimed is:

1. A high voltage gas discharge tube comprising an insulative envelope containing a gas therein; a cathode at one end of said envelope; an anode at the other end; a plurality of grids disposed in the space between said cathode and anode, and means supporting and sealing the ends of said grids, anode and cathode within the walls of said envelope, said ends extending through said walls to the outside of said tube envelope, said envelope including a wall portion having a plurality of planar annular insu-

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lative rings positioned alternately with and secured to said grids, said rings having transverse extensions projecting internally and externally from said wall and positioned between and spaced from said alternate grid ends, said wall having recesses between adjacent ring extensions, said extensions providing a relatively long discharge path between adjacent said ends.

2. The device of claim 1 wherein said grids include a control grid adjacent said cathode, and including means applying an energizing voltage between said cathode and said anode and to the others of said grids, and means applying a trigger voltage to said control grid.

3. The device of claim 2 wherein said energizing voltage means includes a pulse forming network.

4. The device of claim 2 wherein said energizing voltage means includes a voltage divider connected to said ends outside said envelope and providing an equal distribution of said energizing voltage between said anode and said cathode and others of said grids.

5. The device of claim 4 wherein said envelope and rings are of ceramic material and the ends of said other grids are disposed in said recesses in the wall between adjacent said internal transverse extensions and spaced from the surfaces thereof.

6. The device of claim 5 wherein said annular rings have a central circular aperture and planar faces on each

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side of said transverse extensions, said planar faces having annular longitudinal projections separating said internal and external extensions, said projections abutting and being sealed to said other grid ends and spacing said other grids from said surfaces.

7. The device of claim 6 wherein the ends of said projections are metallized for sealing to said other grids.

8. The device of claim 7 wherein said other grids are in the form of a hollow flat cylindrical box including two apertured parallel planar metal plates and a tubular metal end secured between said plates and having a planar flange extending therefrom, said flange being sealed between said metallized projections of adjacent rings.

9. The device of claim 8 including at least two grids, one of said grids being a control grid, and at least two annular rings.

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