

July 21, 1953

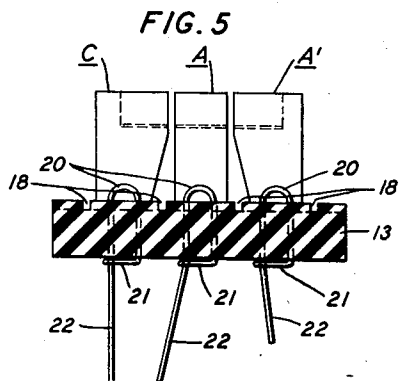
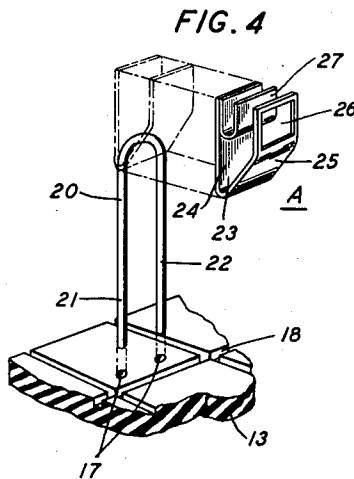
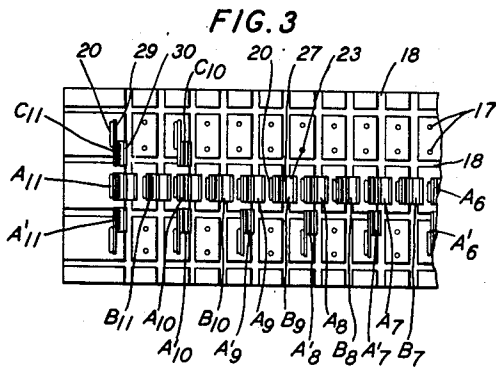
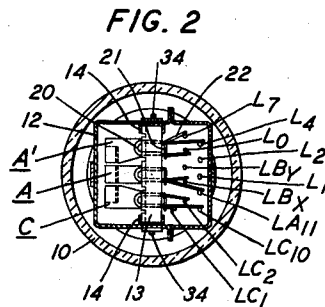
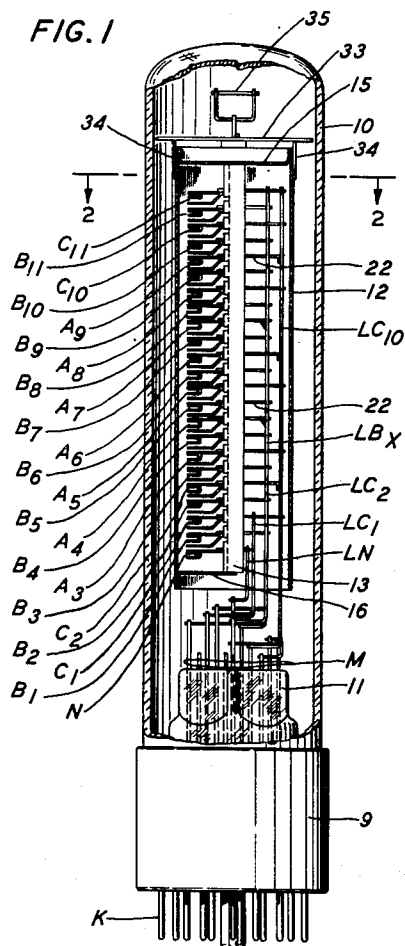
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2,646,523

MULTICATHODE GASEOUS DISCHARGE DEVICE

Filed Jan. 28, 1950

2 Sheets-Sheet 1



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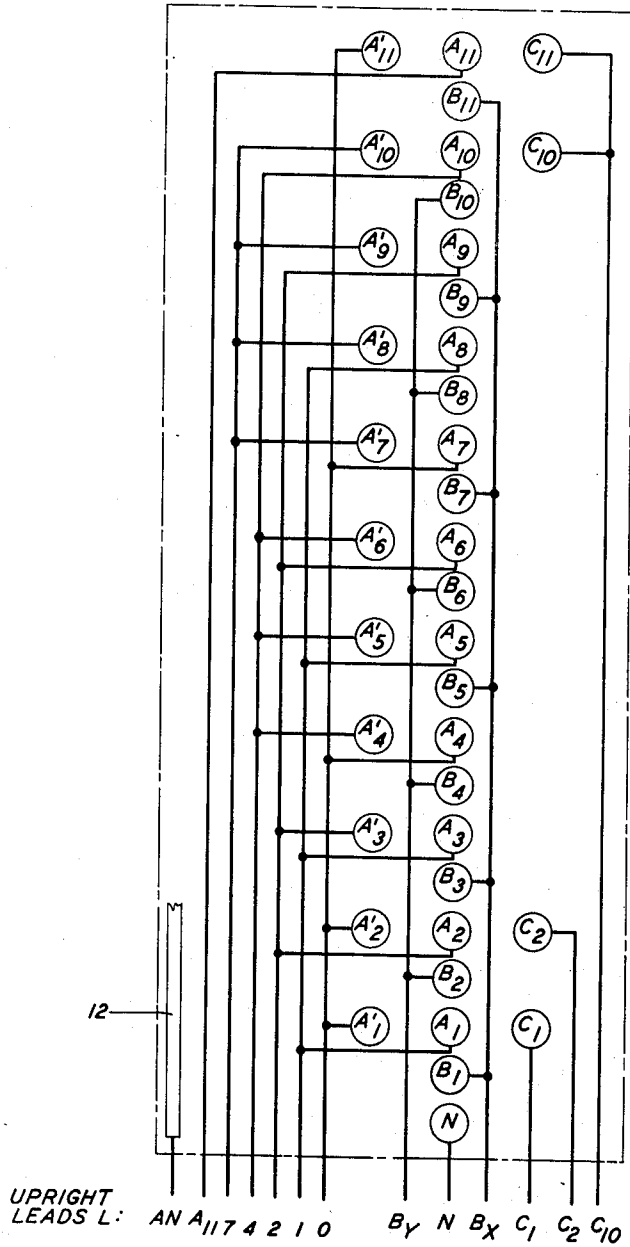
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MULTICATHODE GASEOUS DISCHARGE DEVICE

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2 Sheets-Sheet 2

FIG. 6



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MULTICATHODE GASEOUS DISCHARGE
DEVICE

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Application January 28, 1950, Serial No. 141,123

15 Claims. (Cl. 313—196)

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This invention relates to gaseous discharge devices and more particularly to multiple cathode glow discharge devices of the type disclosed in Patents 2,575,370 and 2,575,371, issued November 20, 1951, to M. A. Townsend, Patent 2,618,767, issued November 18, 1952, to H. L. von Gugelberg and in application Serial No. 117,316, filed September 23, 1949, of H. L. von Gugelberg.

Devices of the general type disclosed in these above-identified applications comprise, in one form, a plurality of cathodes mounted successively and an anode in cooperative relation with the cathodes. The cathodes are constructed and arranged so that, in response to signal pulses applied to certain of the cathodes, the anode-to-cathode discharge is stepped along the row of cathodes, advancing one position each pulse. The position of the discharge may be noted by alternate cathodes positioned adjacent the main cathodes, as disclosed in the above-mentioned Patent 2,575,371.

In such devices as, for example those particularly suitable for use in dial telephone systems, ten or more stages of counting are advantageously placed within one envelope. It is further advantageous to have separate indicating cathodes also adjacent some of the main cathodes to provide separate indications of the position of the discharge, to other apparatus.

In such devices with ten or more counting stages, difficulty has been encountered in mounting all the main cathodes, transfer cathodes, alternate cathodes, and indicating cathodes in accurate spatial relation with respect to each other and to the anode. Further, each of the cathodes must be properly connected to leads brought out through the envelope and provision made for the mounting of these leads.

Devices having these many cathodes and leads when subjected to induction heating processes to cleanse the metal parts are found to have the heat concentrated in the larger metal parts within the device, whereby a proper cleansing of the smaller parts is rendered very difficult if not impossible.

One general object of this invention is to improve multiple cathode glow discharge devices.

Another object of this invention is to improve the mounting of the multiple cathodes of such a device. Specifically, it is an object of this invention to enable the accurate stable positioning of an array of such cathodes in constant spatial relationship to each other and to the anode.

A further object of this invention is to facilitate interconnections of such cathodes and their

connection to the lead conductors. Specifically, it is an object of this invention to obviate use of intricate lead connections.

A still further object of this invention is to improve the cleansing of the electrode and other parts during the processing of the device.

A still further object of this invention is to simplify the electrode structure whereby the cathode and the preference mechanism are incorporated in a single compact and easily fabricated unit.

In accordance with one feature of this invention, the multiple cathodes are all mounted on a support of insulating material and are equally spaced from the anode. The main and translating cathodes may be mounted in a vertical row, and the alternate, main, and indicating cathodes mounted in horizontal rows.

In accordance with another feature of this invention, the cathodes are supported from the insulator support by hairpin supports, one end of the hairpin being bent flat against the back of the insulator support to hold the cathode securely in place and the other end being directly joined to one of the interconnecting leads which extend upright behind the insulator support.

In accordance with still another feature of this invention, the anode encompasses the cathodes, insulator support, and interconnecting leads, and is closed at one end and partially closed at the other. By thus enclosing all the elements within the anode, they may be cleansed by a high frequency heating of the anode alone which causes the heat to radiate from the anode to effect heating of all the varied sized elements.

In accordance with another feature of this invention, the cathodes and grid electrodes are mounted together on a common support.

In one specific embodiment of this invention, the main and transfer cathodes required for ten or more stage counting are mounted on a flat insulator support. Alternate cathodes for determining the position of the discharge are mounted to one side of the main cathodes and special indicating cathodes are mounted to the other side of those main cathodes for which a separate indication of the information from that individual position is desired. The cathodes are secured to a hairpin support which extends through two aligned apertures in the insulating support. One end of the hairpin support is bent flat against the back of the insulator; the other end is attached to the interconnecting lead extending upright behind the insulator. The various ends of the hairpin supports are bent slightly to fan out over a small area to allow direct connections to the dif-

ferent upright leads without interfering with each other. A hollow, for example, square anode encompasses the cathodes, insulator support, and leads and carries the insulator support. The anode is closed at the top and partially closed at the bottom, space being left open for the passage of the upright leads.

A complete understanding of the invention and the various features thereof may be gained from consideration of the following detailed description and the accompanying drawing, in which:

Fig. 1 is a sectional view of a gaseous discharge device illustrating one embodiment of this invention, the section being taken just inside one anode wall;

Fig. 2 is a plan view taken along the line 2—2 of Fig. 1, some of the wire connections to the upright leads being omitted for clarity;

Fig. 3 is a front view of a portion of the insulator support showing the cathodes mounted thereon;

Fig. 4 is an exploded view of a cathode support wire and one type of cathode and preference mechanism that may be employed in the device of Fig. 1;

Fig. 5 is an enlarged sectional view of the insulator support and cathodes shown in Fig. 2; and

Fig. 6 is a schematic drawing of the connections of the cathodes and upright interconnecting leads for the device shown in Fig. 1.

Referring now to the drawing, the device illustrated in Fig. 1 comprises a glass envelope 10 having a tri-armed reentrant glass base 11 supported by an insulating base 9 having projecting therefrom terminal conductors K. These conductors K are secured to leads M which are attached to the bent ends of upright leads L, which shall be further identified below. A substantially square hollow anode 12 is connected to an upright lead LAz, shown schematically only in Fig. 6 which partially supports the anode. The anode, which may advantageously be of nickel or molybdenum though other electrode metals known in the art may be employed, may have a plurality of minute apertures on the front surface adjacent the cathodes to enable an observer to visually check the stepping of the discharge. The anode 12 is fixed to an insulator support 13 by brackets 14 secured to two opposite sides of the anode. The face of the support 13 advantageously has grooves 18 therein to provide a longer leakage path between the various cathodes and between the anode and the cathodes. The anode, while illustratively depicted here as supporting attached brackets 14, may also advantageously be formed of two pieces which maintain the insulator support 13 between them.

The top of the hollow anode 12 is closed by a metal end cover 15 secured, as by welding, to the anode. A bottom metal end cover 16 is secured to the anode 12 and closes the space between the front surface of the anode and the face of the insulating support. Space is left behind the insulating support 13 between it and the rear face of the anode 12 for the passage of the upright leads L.

The support 13 has a plurality of pairs of apertures 17 extending through it, advantageously arranged in rows as best seen in Fig. 3. A hairpin-shaped cathode support 20 having end portions 21 and 22 extends through certain of the apertures 17. The main cathodes A, alternate cathodes A', transfer cathodes B, and indicating cathodes C are each supported at the center of a hairpin support 20. The end portion 21 of each

hairpin 20 is bent flat against the back of the insulator 13 and cut short as best seen in Figs. 2 and 5. The end portion may also be secured, as by welding to the other end portion 22, the end 21 being cut at that point. The ends 22 of the hairpins 20 extend out from the back of the cathode and fan out over a small area to be connected to the appropriate leads L in a manner to be described below. As is best seen in Fig. 2, the upright leads L extend in approximately two rows behind the insulator support 13. The rear row, adjacent the rear surface of the anode 12 comprises upright leads L4, L2, L1, LA11, and LC10. The front row adjacent the rear surface of the support 13 comprises upright leads L7, LO, LB7, LBx, and LC2. Additional short leads LC1, LN, and LAz, the latter two best seen in Fig. 6, are adjacent these two rows. These leads L support the assembly comprising the anode, insulator supports, and cathodes from the base of the device.

The main and transfer cathodes are mounted alternately in a row down the center of the support 13, as best seen with respect to main cathodes A11 down to A6 and transfer cathodes B1 down to B7 in Fig. 3. These cathodes A and B may advantageously be of the construction shown in Fig. 4. As there shown, these cathodes comprise a U-shaped member 23 having a back plate or leg 24 which is secured to the center portion of the hairpin support 20. A front plate or leg 25 extends at an angle from the back leg 24 and has an aperture 26 therein forming a grid or extension electrode integral with the back leg. A U-shaped cathode member 27 is directly secured to the back leg 24 behind the aperture 26. The front leg 25, acting as a grid or extension electrode, provides for stepping in one direction along the row of main and transfer cathodes, as disclosed in my patent 2,618,767 above referred to. This construction, whereby the aperture may be punched out of the front leg of the support member 23 and the channel-shaped cathode element supported by the back leg directly behind the aperture, enables these electrode units to be expeditiously and rapidly produced in large numbers.

It is to be understood of course that other preference mechanisms and other cathode shapes may be employed in the general combination of this invention. Thus, the cathode may comprise a channel-shaped member, a tail, and a mounting portion secured to the support 20, the cathode being of the general form set forth in M. A. Townsend Patent 2,575,370 above referred to. Or again the cathode may be asymmetrically shaped, comprising a substantially triangular-shaped flat portion and a support flange, as disclosed in my application Serial No. 117,316, above referred to. Thus, various shapes of cathode and preference mechanisms can be employed with this invention.

The alternate cathodes A', which are mounted by the support 13 to one side of the main cathodes A, and the indicating cathodes C, which are mounted to the other side of certain of the main cathodes A, may advantageously comprise a back plate 29 with a substantially U-shaped cathode member 30, similar to cathode member 27, secured to the back plate 29. But other cathode shapes may advantageously be employed. The normal cathode N, which is positioned at one end in the row of the main and transfer cathodes, as best seen in Figs. 1 and 6, is advantageously of the shape of the alternate and indicating cathodes. The normal cathode provides establishment of an

initial discharge prior to the counting operation. Thus, when such a device is employed for telephone dialing operations, a discharge may be established to the normal cathode upon removal of the telephone receiver from its cradle, thus preparing the device for the counting of the dialing pulses.

An insulator plate 33, which may advantageously be of mica, is secured to the top of the anode 12, as by wire supports 34 welded or otherwise secured to the side walls of the anode, and itself supports a getter assembly 35. The device is advantageously filled with neon at 40 to 50 millimeters of mercury, though other gases, such as rare gases, hydrogen, or others known in the art, may be employed.

As priorly mentioned, the end portion 22 of the hairpin support 20 serves as a connecting lead for each cathode. These end portions 22 project through the support 13 and fan out over a small area whereby they are directly connected to the appropriate upright leads L. Referring now to Fig. 6, one method of connecting the cathodes to appropriate leads whereby a small number of leads is employed is depicted for the device as herein illustratively described. As there shown the main cathodes A, transfer cathodes B, alternate cathodes A', indicating cathodes C, normal cathode N, and anode 12 are schematically arranged as they are mounted on the face of the support 13. They therefore appear as shown actually mounted in Fig. 3. As disclosed in Patent 2,575,370 the main cathodes A and alternate cathodes A' are interconnected by the upright leads L so that ten positions may be indicated by means of five output terminals K. Such interconnections may be referred to as a two-out-of-five reading arrangement. The device illustrative of this invention which is depicted herein has ten counting stages and five leads employed to provide indication of the stage being counted. These leads have been designated as L0, L1, L2, L4, and L7. A sixth lead LA11 is connected only to the main cathode A11 which cathode does not take part in the regular counting operation but may be included for purposes set forth fully below.

For each of the counting stages, the sum of the lead subnumbers, i. e., 0, 1, 2, 4, or 7, to which the main and alternate cathode are connected is the number of that counting stage. Thus, for example, counting stage six is indicated by L2, to which the main cathode A6 is connected, and by L4, to which the alternate cathode A'6 is connected. Similarly a discharge occurring at counting stage 7 is indicated by currents flowing through leads L0 and L7. A discharge occurring at counting stage 10, however, is indicated by currents flowing through leads L4 and L7, which causes no difficulty as a separate lead LA11 is provided for the main cathode A11.

The special indicating cathodes C may be secured to their proper leads in whatever manner desired to transmit to the proper apparatus the necessary information. In this illustrative embodiment, indicating cathodes are employed by counting stages 1, 2, 10, and 11, and indicating cathodes C10 and C11 are secured to one lead LC10, while indicating cathodes C1 and C2 are secured to their individual leads LC1 and LC2, respectively.

Transfer cathodes B are mounted on the insulator support 13 alternatively with the main cathodes A, as described above. While these transfer cathodes may all be connected to the same upright lead L, difficulty has been encountered in aging them evenly. It is therefore ad-

vantageous to secure the transfer cathodes B to two leads L alternatively. Thus, as shown in Fig. 6, the transfer cathodes associated with the even-numbered counting stages, e. g., 2, 4, 6, may be connected to lead LB_y and those associated with the odd number counting stages to upright lead LB_x. This arrangement has the additional advantage of facilitating testing of backward stepping to measure the ratio of forward to backward stepping voltages.

As the cathodes are supported in the proper array from the front of the insulator support B by wire means, such as the hairpin support 20, extending through the support 13, connections are facily and expeditiously made to the leads L extending behind the support. Specifically, it is a feature of this invention that the array of cathodes be supported from one face of the insulator support and the leads be adjacent the other face of the insulator support, wire means extending through the support connecting the two. In the illustrative embodiment described above wherein both the cathodes and leads are mounted in rows, the connections are facily and simply made by a slight bending of the wire means adjacent the back of the support so that it may be secured to the appropriate lead. As these wires are in separate planes and because of the positioning of the cathodes and the leads, complicated interconnections and the dangers of shorting between connecting wires are both avoided.

A device constructed in accordance with this invention may be used to advantage in various counting, stepping, or pulse reading operations. Thus, the illustrative embodiment just described may advantageously be employed in connection with dial telephone systems. When thus employed each of the main cathodes A represents a digit on the dial phone, A1 representing 1 and up through A10 representing zero. In such an application, as priorly discussed, the removal of the telephone instrument from the cradle may initiate a discharge between the normal cathode N and the anode 12. Upon dialing any digit the discharge may then step to the proper counting stage, the information being taken from the leads and forwarded by appropriate circuits to the central office equipment. The discharge can then be reset to the normal cathode N for the next dialing operation. The main cathode A11 may advantageously be employed in such a device to give information of erroneous dialing operations or of too many pulses. Thus LA11 may be connected to appropriate circuits to give a busy tone upon appearance of the discharge at A11, informing the dialer to begin again.

In one specific illustrative embodiment constructed in accordance with this invention, the rear section of the anode 12 was of .010 nickel sheet 3.375 inches high, .775 inch wide, and .312 inch deep. The front section was .562 inch deep providing space from the various cathodes and apertures .041 inch in diameter were provided adjacent each aperture to visually observe the stepping and counting operations. The top and bottom end covers 15 and 16 were each of .010 nickel plate. The insulator support 13 was of pressed and fired alumina though other ceramic or insulating materials known in the art could be used. The hairpin support 20 was of .030 nickel wire though other materials, such as a nickel-iron alloy, could be employed. The U-shaped member 23 was .010 nickel sheet and the U-shaped cathode member 27 of .010 molybdenum sheet. Other cathode and electrode materials,

or combinations, may be employed as are known in the art. The back of the back legs 24 of the cathodes A and B and of back legs 29 of the cathodes A', C, and N are advantageously coated by a glow inhibiting substance having a low vapor pressure and a high work function such as platinum.

In assembling, the cathodes are secured to the hairpin supports 20 which are then positioned in the apertures 17 and the ends 21 bent over, secured to the ends 20, and cut. The ends 20 are then fanned out, each at the appropriate angle, and secured to the appropriate leads L. The support 13 is inserted into the brackets 14 in the anode 12, the anode secured to lead LA₇ and the leads secured to the input leads M in the glass base 11. The glass base is sealed to the envelope 10 which is then pumped out and the exhaust tubulation in the glass base sealed.

After an initial baking, as is known in the art, the internal elements of the device are outgassed by a high frequency heating of the anode 12 at, for example, 950° C. As the anode 12 substantially surrounds and encloses the various elements, they are all simultaneously heated and cleansed by heat radiation from the anode. Thus, the larger metal parts do not become hot at the expense of the smaller parts, as would be the case if all the elements were directly heated by the high frequency currents. In such cases, it is often the anode which is outgassed properly while the cathodes are not. This is doubly disadvantageous as sufficient outgassing is particularly necessary for proper aging of the cathodes. Thus, the device would be both improperly outgassed, allowing contaminants to evolve during the life of the device, and improperly aged. However, by the use of an encompassing hollow anode substantially enclosing the cathodes, cathode wire supports, upright leads, and insulator supports, all the internal elements are substantially simultaneously cleansed by heating to substantially the same temperature. A heating period of about fifteen minutes has been found satisfactory though other lengths of time may be employed.

The cathodes are then all simultaneously aged by passing high currents or short pulses of high currents, through the device for several hours, as is known in the art. High frequency currents may be employed at the beginning of the process to provide for an even initial aging of all the various cathodes, thereby preventing a few cathodes from aging more rapidly than the remainder and attaining deleteriously high temperatures during the aging process.

One gaseous discharge pulse stepping device constructed in accordance with the illustrative embodiment of this invention disclosed in Fig. 1 with molybdenum cathodes and a neon filling had an initial breakdown voltage between the normal cathode N and the anode 12 of 200 to 220 volts and sustaining voltages between the main cathodes and the anode of 110 volts. Counting currents employed for each cathode were from five to fifteen milliamperes. The pulse impressed on the B transfer cathodes to step the discharge forward was 25 volts for a counter-current of five milliamperes or 15 volts for a counter-current of fifteen milliamperes. These values are higher than is necessary, providing a wide margin of safety. The counting speed depends on both the gas filling employed and the specific structure of the device, especially as to the mounting of the array of cathodes; in the particular illustrative embodiment disclosed in Fig. 1 the maximum counting speed was a thousand steps per second.

It is to be understood of course that the above-described arrangements are merely illustrative of the application of the principles of the invention. Numerous other arrays of cathodes, other forms of individual elements, such as the supports, or other arrangements may be devised by those skilled in the art without departing from the spirit and scope of the invention.

What is claimed is:

1. A gaseous discharge pulse stepping device comprising a plurality of cathodes, an insulator support, means supporting said cathodes adjacent one face of said support, said means extending through said support, a plurality of leads extending adjacent the opposite face of said support and connected to said means, and an anode encompassing said cathodes, support and leads, said anode being closed at its one end and partially closed at its other end.

2. A gaseous discharge pulse stepping device comprising an insulator support, a plurality of cathodes mounted in an array adjacent the front of said support, means supporting said cathodes from the front of said support and extending through said support, a plurality of leads extending adjacent said support and connected to said means, a hollow anode in supporting relationship with and surrounding said support, said cathodes and said leads, a first anode end member closing one end of said anode, and a second anode end member closing the space at the other end of said anode between the front of said support and said anode.

3. A gaseous discharge pulse stepping device comprising an insulator support, a plurality of main and transfer cathodes mounted alternately in a row from the front of said support, preference means to cause the discharge to step from one cathode to the next in one direction, wire means supporting said cathodes from the front of said support and extending through said support, a plurality of upright leads extending adjacent the back of said support and connected to said wire means, a substantially square hollow anode affixed to said support and encompassing said cathodes, said support and said upright leads, a first anode end member closing one end of said hollow anode, and a second anode end member partially closing the other end of said hollow anode.

4. A gaseous discharge pulse stepping device comprising a rectangular insulator block, a plurality of cathodes, wire means supporting said cathodes in specified rows from the front of said block, said wire means extending through said block, a plurality of upright leads extending adjacent the back of said block, said leads being substantially mounted in rows and said wire means extending at various angles from the back of said block connecting to said leads, and an anode in juxtaposition to said cathodes.

5. A gaseous discharge device comprising a rectangular insulator block, a plurality of main and transfer cathodes mounted in a row within said device, a plurality of other cathodes adjacent said main cathode, wire means for each of said cathodes supporting said cathodes from the front of said block and extending through said block, a plurality of upright leads extending adjacent the back of said block, said wire means being each connected to one of said leads, some of said wire means being bent at an angle from the back of said block to said leads, and a substantially square hollow anode affixed to said

block, said anode substantially enclosing said cathodes, said block, and said upright leads.

6. A gaseous discharge device in accordance with claim 5 comprising a base, means mounting said anode from said base, and means mounting said upright leads from said base in substantially two rows adjacent said block.

7. A gaseous discharge device in accordance with claim 5 wherein some of said cathodes are alternate cathodes and said main and alternate cathodes are connected by said wire means to said upright leads on a two-out-of-five reading arrangement.

8. A gaseous discharge pulse stepping device comprising an insulator support having a plurality of pairs of apertures therein, a plurality of hairpin cathode supports having their two ends extending through said apertures, a plurality of cathodes secured to the center of said hairpin supports, a plurality of leads extending behind said insulator support, one of the ends of said hairpin supports being joined to one of said leads and the other of said ends being flat against the back of said insulator support, and an anode adjacent said cathodes.

9. A gaseous discharge pulse stepping device comprising an insulator support having a plurality of apertures therein, a plurality of hairpin cathode supports having their two ends extending through said apertures, a plurality of cathodes secured to the center of said hairpin supports, said cathodes being mounted in an array along said insulator support, a plurality of upright leads extending behind said insulator support, one of the ends of each of said hairpin supports being joined to one of said leads and the other of said ends being flat against the back of said insulator support, said first ends extending at various angles from the back of said insulator support to said leads, and a hollow anode substantially closed at both ends encompassing said cathodes, said support, and said leads.

10. A gaseous discharge pulse stepping device comprising an insulator block having a plurality of pairs of apertures therein, a plurality of hairpin cathode supports having their ends extending through said apertures, a plurality of main, transfer, and alternate cathodes supported in front of said block and secured to the center of said hairpin supports, said main and transfer cathodes being mounted in a row along the length of said block and said alternate cathodes being mounted adjacent said main cathodes, preference means to cause the discharge to step in one direction along the row of main and transfer cathodes, one of the ends of said hairpin support being connected to said upright leads and the other of the ends being bent flat against the back of said block, and a hollow anode substantially closed at both ends encompassing said cathodes, said block, and said leads.

11. A gaseous discharge pulse stepping device comprising an insulator block having a plurality of pairs of apertures therein, a plurality of hairpin cathode supports having their ends extend-

ing through said apertures, a plurality of cathodes secured to the center of said hairpin supports and mounted in front of said block, a plurality of upright leads extending behind said block substantially in rows, one end of each hairpin support being connected to one of said leads and the other of said ends being flat against the back of said block, some of said ends being bent at an angle from the back of said block to said leads, preference means to cause the discharge to step always in one direction along said cathodes, a substantially square hollow anode affixed to said block and surrounding said cathodes, block, and leads, a first anode end member closing one end of said hollow anode, and a second anode end member partially closing the other end of said hollow anode.

12. An electrode structure for gaseous discharge devices, comprising a channel-shaped cathode element, a supporting member extending from said cathode element, and a plate member extending from said supporting member to opposite one side of said cathode element, said plate member having an aperture therein opposite said side.

13. An electrode unit for gaseous discharge devices, comprising a U-shaped metallic member having an aperture therein adjacent the end of one of the arms thereof, and a U-shaped refractory metal cathode member paraxial with said first member and affixed to the other arm of said first member adjacent the end thereof.

14. A gaseous discharge pulse stepping device comprising a plurality of cathodes, insulator support means, means positioning said cathodes adjacent one side of said support means, a plurality of leads extending adjacent another side of said support means, said leads being electrically connected to said cathodes by said positioning means, and an anode encompassing said cathode, support means and leads, said anode being closed at its one end and partially closed at its other end.

15. A gaseous discharge pulse stepping device comprising support means, means mounting a plurality of cathodes in an array adjacent one side of said support means, a plurality of leads extending adjacent another side of said support means, said leads being electrically connected to said cathodes by said mounting means, and an anode encompassing said support means, said cathodes, and said leads, said anode being closed at its one end and partially closed at its other end.

HANS L. VON GUGELBERG.

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