

April 5, 1966

R. A. MILLIKEN
CHARACTER REPRESENTING GLOW DISCHARGE TUBE AND SYSTEM
FOR SELECTIVE EXCITATION OF THE CHARACTER
REPRESENTING ELECTRODES THEREOF

3,244,923

Filed Sept. 14, 1962

3 Sheets-Sheet 1

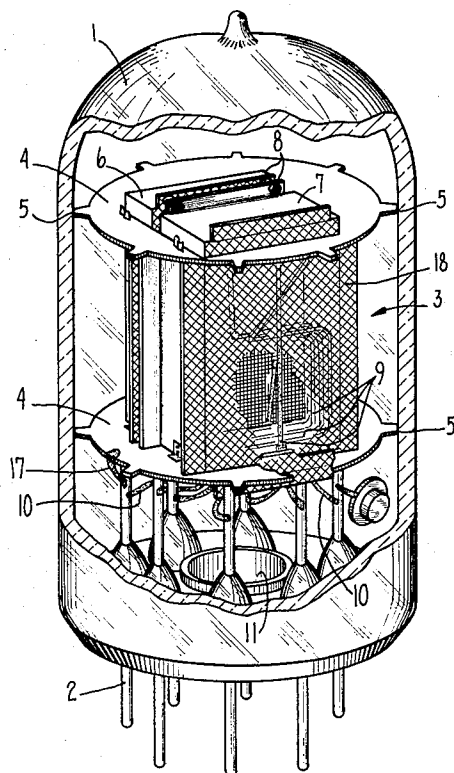


FIG. 1

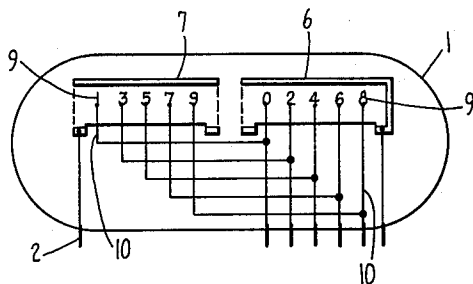


FIG. 2

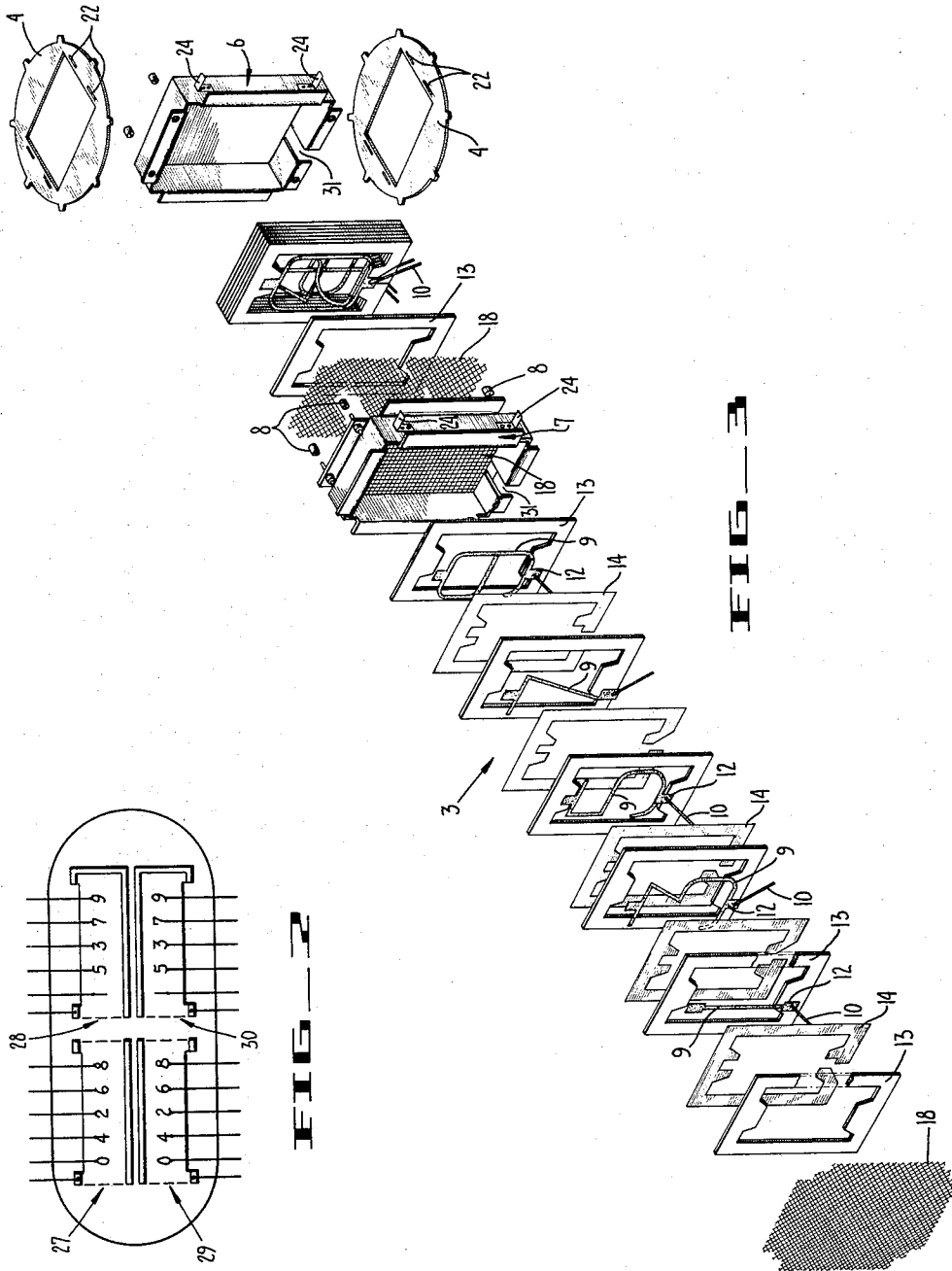
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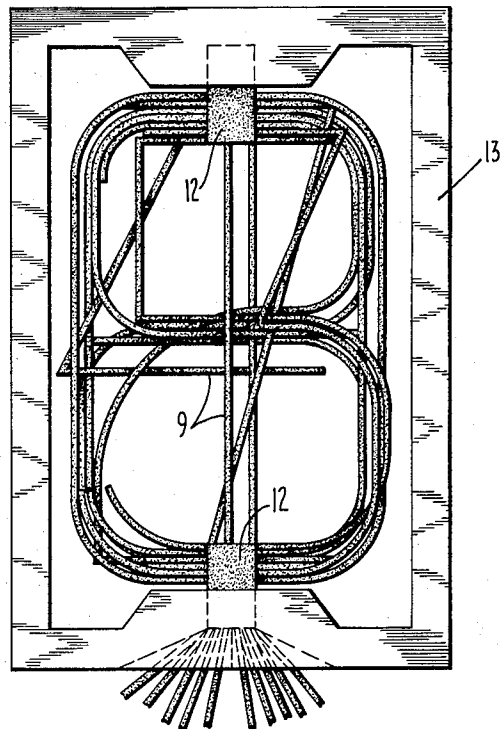


FIG. 4

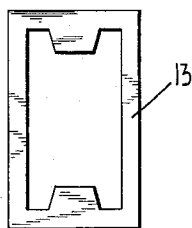


FIG. 5 a

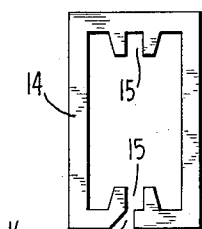


FIG. 5 b

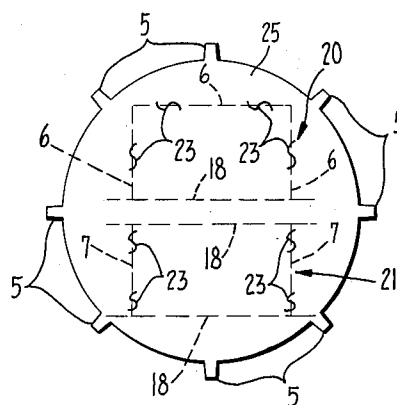


FIG. 6

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3,244,923

CHARACTER REPRESENTING GLOW DISCHARGE TUBE AND SYSTEM FOR SELECTIVE EXCITATION OF THE CHARACTER REPRESENTING ELECTRODES THEREOF

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12 Claims. (Cl. 313—109.5)

This invention relates to gaseous indicator glow tubes. More particularly, this invention relates to indicator glow tubes of the type particularly suited for use with circuits which utilize binary principles of operation. Tubes of this type may be designated as decoder-indicator tubes because they are capable, by reason of their electrode arrangement, of not only indicating numbers stored in electronic counters, but of also functioning to "interpret," or decode, the pattern of electrical signals appearing upon the output terminals of an electronic counter of the type in which said pattern of signals does not bear a simple one-to-one relationship to the exciting terminals of said indicating glow cathodes, or at least contributing substantially to this decoding function by way of reduction of apparatus external to the tube necessary for performance of this function.

Tube arrangements of this type may be seen in United States Patent No. 2,906,906, upon which the present invention is an improvement.

Up to the present time, decoder-indicator tubes of this type have not proved completely satisfactory because of the complexity of their electrode configurations, and the consequent need for basing arrangements involving considerable numbers of contact pins.

Accordingly, one object of the instant invention is to provide an improved cathode indicator glow tube having combined anode-shield electrodes which perform several functions hitherto performed by separate electrodes.

Another object of the instant invention is to provide an improved cathode indicator glow tube particularly suited for use in conjunction with binary-type counting circuits, and for providing a direct visible readout therefrom.

Yet another object of the instant invention is to provide an improved decoder-indicator glow tube which may be mounted in an envelope of the standard 7-pin miniature type, having a standard 7-pin basing arrangement, without sacrifice of any of the functional capabilities or sputter protection features of prior devices, though it is to be understood that the invention is by no means limited to such a basing arrangement.

A still further object of the present invention is to provide a structural arrangement of mutually cooperating cathodes, insulators, and exciting electrodes which obviates the necessity of "threading" many cathodes and insulators onto side rods, thereby making possible miniaturized assemblies of a compactness hitherto attainable only at very great cost.

Briefly, the principles and objects of the instant invention may be embodied in a tube which comprises a gas-filled envelope containing a plurality of indicator cathodes shaped in the form of desired, e.g., numerical, indicia, and capable of manifesting their presence by sustaining a cathode glow thereabout. If, for example, this tube is to be used in a decade counter, it may contain indicator cathodes in the form of the numerals "0" through "9." These indicator electrodes may be arranged in groups (e.g., all of the odd-number indicator cathodes constituting one group, and all of the even-number indicator cathodes constituting another group). According to the invention a combined anode-shield electrode will be associated with the first group, and another electrically

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independent combined anode-shield electrode will be associated with the second group. The association between a combined anode-shield electrode and its corresponding group consists in part in the combined anode-shield electrode at least partially embracing, or surrounding, the associated group of indicator cathodes. The extent to which the combined anode-shield electrode embraces, or surrounds, its associated group of indicator cathodes will be determined principally by two factors: (1) the necessary electrical isolation of its associated group of indicator cathodes from the effects of any combined anode-shield electrode associated with any other group of indicator cathodes, and (2) the desired degree of protection of the walls of the envelope, and other structure within the envelope, from sublimation, or "sputtering," of indicator cathode material thereupon. Thus, it will be seen that the combined anode-shield electrodes, or anode-excitation shield electrodes, serve two shielding functions, viz., the function of shielding the associated group of indicator cathodes from excitation by other electrodes outside the associated combined anode-shield electrode, and the function of protecting portions of the tube outside the associated combined anode-shield electrode from sublimation, or "sputtering," of indicator cathode material thereupon. In addition, the combined anode-shield electrode serves the third function of providing an exciting field for provoking cathode glow upon any desired one, or more, of its associated indicator cathodes. This is in contrast to prior art devices wherein the sputter shielding, spurious excitation shielding, and exciting functions were served by distinct and different electrodes for the same group of indicator cathodes. It will be apparent to those skilled in the art, then, that so combining these three functions in a single combined anode-shield electrode for each group of indicator cathodes makes possible the provision of a tube having all the capabilities and advantages of prior art devices, yet at the same time being characterized by a reduced number of the electrodes, and a reduced number of necessary base pins.

In addition to these three electrical functions of the combined anode-shield electrodes of the invention, the combined anode-shield electrode may, in a preferred embodiment, also function mechanically to support the indicator cathodes in desired relation within the tube by clampingly engaging a stack comprising said cathodes and supporting insulating means therefor. That is, the combined anode-shield electrodes may not only embrace, or surround their associated groups of cathodes for the above detailed purposes of electrical function, but may also clampingly engage the associated groups of cathodes for the purpose of mechanical support. It is to be understood, however, that the electrical advantages arising from the provision of my combined anode-shield electrode may be embodied in a more conventional tube structure (e.g., having side rods, or support posts, to mount the indicator cathodes as shown in United State Patent No. 3,042,826) without departing from the scope of my invention.

It will further be apparent to those skilled in the art that the number of contact pins, or base pins, necessary may be reduced to a minimum by providing a contact pin for each of the combined anode-shield electrodes and a contact pin for each pair of indicator cathodes which may be selected one from one group and one from the other group. By this arrangement the number of necessary base pins is reduced to seven in a tube capable of providing decoding in a binary coded decimal counter system. Other combinations of indicator cathode electrodes and combined anode-shield electrodes may be made as required by a particular code or circuit application. In addition, several sets, each consisting of two or more

groups of indicator cathodes, a combined anode-shield electrode being associated with each group, may be provided so that a simultaneous readout of a plurality of characters may be achieved from within a single envelope.

In operation of a decoder-indicator tube of the type of the instant invention, a single indicator cathode in a group may be caused to glow by the application of the proper exciting voltage between the selected indicator cathode and the combined anode-shield electrode associated with this indicator cathode. The combined anode-shield electrodes associated with the other groups of indicator electrodes within the common envelope will prevent interaction between the combined anode-shield electrode of the group including the selected indicator cathode and the indicator cathodes of the other groups, thereby preventing spurious, or undesired, glow of an indicator cathode in a group other than the group including the selected indicator cathode.

The invention is described in greater detail by reference to the accompanying drawings wherein:

FIG. 1 is a perspective view of a tube embodying the instant invention;

FIG. 2 is a schematic representation of the tube of FIG. 1;

FIG. 3 is an exploded pictorial view of a preferred indicator tube structure according to the instant invention;

FIG. 4 shows the mutually non-obdurate relationship of typical indicator cathodes which may be used in carrying out the instant invention.

FIG. 5a shows a spacing insulator frame according to the instant invention;

FIG. 5b shows a positioning insulator frame according to the instant invention;

FIG. 6 shows an alternative embodiment of the instant invention wherein the walls enclosing the groups of cathodes are defined in part by portions of insulating spacer means; and

FIG. 7 is a schematic representation of a modified indicator tube embodying the instant invention and adapted to provide multiple numeral readout.

Referring to the drawings, and more particularly to FIG. 1, one form of indicator tube according to the instant invention comprises an envelope 1 which has been evacuated of air filled with an ionizable gas, such as neon, argon, or the like, at a suitable pressure, for example, in the range of about 40 to 120 mm. of mercury, and, if desired, one of the heavier gases or vapors, such as mercury. The envelope includes a base portion, or stem press, through which conductive base pins, or contact pins, extend, and by means of which electrical connection may be made to external electrical circuit means.

The tops of some, or all, of the contact pins 2 may be substantially coplanar, thus being adapted to support tube mount assembly 3 by means of the lower mica end spacer 4, the mount assembly being constrained against the tops of the base pins 2 by means, for instance, of clips such as shown at 17, which may be tweezer-welded to the top of one or several base pins, or by means of frictional engagement of fingers 5 on the mica end spacers 4 with the interior of the wall of envelope 1, or both. It will be apparent to those skilled in the art that it may be necessary to shield the inner portions of base pins 2 associated with indicator cathodes 9, and the indicator cathode leads 10, from the anode-shield electrode base pins and leads and such portions of the combined anode-shield electrodes 6 and 7 as project below lower end mica 4. This may be done, for example, by coating the inner portions of base pins 2 and cathode leads 10 with glass frit, or Alundum, by oxidizing the inner ends of the base pins and the leads 10, by locating the leads 10 sufficiently close to the combined anode-shield electrodes as to require a higher potential to "strike" a glow therebetween than any potentials employed in the usual operation of the tube, or any combination of these expedients found desirable by the tube designer. The envelope 1 also includes a trans-

parent portion opposite cover mesh 18 (as shown in FIG. 1) through which all of the indicator cathodes in the envelope may be viewed, combined anode-shield electrode 7 being equipped with front and rear cover meshes 18 and combined anode-shield electrode 6 being equipped with a cover mesh 18 for this purpose, all as shown in FIG. 3. A sealed-off exhaust tubulation 11 is provided in the stem press of envelope 1. Further, the combined anode-shield electrodes 6 and 7 may be held in insulated, spaced relation by means of insulator assemblies 8, as shown in FIG. 1, which insulator assemblies, may, for instance, comprise an insulated metal rod having a tubular insulator disposed thereupon and located between ears provided on the combined anode-shield electrodes as shown in FIG. 3. Alternatively, as will be apparent to those skilled in the art, this spacing between the combined anode-shield electrodes 6 and 7 may be provided by means of inwardly-depending ears provided on the shorter edges of the large apertures in end mica 4, these inwardly-depending ears being of just sufficient width to provide the desired spacing.

The electrode elements of a tube according to the invention may be seen to include the following by comparison of FIGS. 1 and 3: a first, or back, combined anode-shield electrode 6 made of conductive material, which may be foraminous to only a sufficient degree to expose its contained indicator cathodes to view through the viewing portion of the envelope, or may be comprised to a larger degree, or entirely, of foraminous material. This combined anode-shield electrode may consist, in greater or lesser part, of insulating material. A second, or front, anode-shield electrode, like the back anode-shield electrode, may be wholly or partly foraminous, and may consist wholly of conductive material, or may be partly of insulating material. A group of associated indicator cathodes is contained in each of said anode-shield electrodes, said anode-shield electrodes serving to excite the associated group of indicator cathodes, to shield the associated group of indicator cathodes against the effects of other electrodes, and to shield the portions of the tube located therewithout from sublimation or "sputtering" of the material of the associated indicator cathodes.

Each of the combined anode-shield electrodes may be directly, weldedly or otherwise, connected to the inner end of one of the base pins 2, which connections may serve to maintain the mount structure 3 in position longitudinally of envelope 1, either in insulated contact with the ends of the remaining base pins 2, or spaced therefrom.

The indicator cathodes 9 of the tube may take substantially any desired shape, for example, they may be in the shape of characters such as numbers, letters, arbitrary symbols, e.g., plus or minus signs, or the like. In one form of the tube, as shown in FIG. 4, the indicator cathodes may be provided in the form of numbers, the total of such indicator cathodes being ten in number, including the numbers "0" through "9." The indicator cathodes may be fabricated from any suitable metal, for example, stainless steel, aluminum, Nichrome, molybdenum, or the like; and they may be made in any suitable fashion, for example, by etching, stamping, forming from wire, or the like.

The indicator cathodes 9 are mounted in an aligned stack, as shown in exploded view in FIG. 3, such that their planes are substantially parallel, and are suitably shaped and of such size that the separate elements thereof are displaced laterally with respect to each other so that none is obstructed by the others, and each is substantially completely visible through the wall of envelope 1 opposite the outer cover mesh 18. In addition, each of the indicator cathodes within envelope 1 is provided, by means of indicator cathode leads 10, with connection to one of the base pins 2 other than

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those used for supplying potential to the combined anode-shield electrodes, one indicator cathode from within the front combined anode-shield electrode, and one indicator cathode from within the back combined anode-shield electrode being connected in common to one of the base pins 2. The arrangement of these electrical connections of the combined anode-shield electrodes 6 and 7 and the indicator cathodes 9 with the base pins 2 is shown in FIG. 2.

FIG. 3 shows the several parts of a tube of the instant invention in exploded view. As may be seen from this figure, the mount structure 3 according to the instant invention is assembled by "stacking" a desired plurality of the indicator cathodes 9, the indicator cathodes being spaced apart by means of insulating spacing frames 13 and held in desired relation to the apertures in spacing frames 13 by means of insulating positioning frames 14. As will be apparent to those skilled in the art from consideration of FIG. 3 the stack made up of the indicator cathodes associated with a given combined anode-shield electrode and the insulating spacing and positioning frames associated therewith is assembled and inserted into the associated anode-shield electrode which first is closed at one end, and after the insertion of this stack the cover mesh at the other end of the anode-shield electrode is fastened in place (e.g., by means of spot welding) thereby clampingly maintaining the associated indicator cathodes in desired spaced relation within the combined anode-shield electrode. As shown in FIG. 3, an opening 31 is provided in the bottom wall of each anode-shield electrode whereby the leads 10 of the indicator cathodes may pass through the combined anode-shield electrode without electrically contacting it. Leads 10 are preferably fabricated separately from the lower ears 12 of indicator cathodes 9, and then welded or otherwise affixed thereto at the proper angle to pass out through channel 16 of insulating frames 14 (FIG. 5b), clearing the edge of slot 31 of the associated anode-shield electrode structure by an amount determined to prevent spurious glow thereat. The insulating spacing frames 13 and the insulating positioning frames 14 may be fabricated from many types of insulating material well known to those skilled in the art. Alternatively, due to the design of these frames, according to instant invention, these frames may be punched, stamped, etched, or otherwise formed from oxidizable metallic materials, and then treated, e.g., by dipping in an oxidizing solution, and subjected to heating in an oven, thereby producing an insulating structure adapted for use as an insulator in carrying out the instant invention, which insulating structure has the advantage of being formed by the simpler processes available for producing metallic parts, as compared with the processes available for producing thin insulating parts. For instance, these insulating frames 13 and 14 may be produced from sheet nickel which is first electroformed, stamped, or punched, and then aluminized and oxidized, such a method being generally suggested in United States Patent No. 2,891,184. Having assembled the back mount structure (comprising the back combined anode-shield electrode and its associated indicator cathodes and insulating frames) into an integral unit, and having similarly assembled the front mount structure, the two may then be assembled into a single, unitary mount structure 3 by passing insulated metal rods through insulators 8 and through holes in the upper and lower ears of the combined anode-shield electrode structures, and placing additional insulating washers on said insulating rods at the opposite side of said ears from insulators 8, if desired, and then distorting the ends of said insulated rods by compression, thereby "locking" the front and rear mount structures insulatedly together in the manner well known in the art (see, for example, the support post structure shown and described in connection with FIG. 2 of United States Patent No. 3,042,826).

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After performing the above steps, the complete mount structure 3 may be adapted for positioning within tube envelope 1 by passing end micas 4 over the ends of mount structure 3 as far as ears 24 provided on the longer sides thereof, passing ears 24 through slots 22 in the end micas, and bending the outer portion of the ears 24 along the outer surfaces of end micas 4. The completed mount assembly 3 and end micas 4 may then be assembled upon the base pins 2 in the stem press by welding the lower ears of the combined anode-shield structures to a pair of base pins 2, by means of clips 17, or both. The cathode leads 10 may then be connected to appropriate base pins 2, as by tweezer welding the stem and envelope sealed, and the envelope evacuated through tubulation 11, which is then sealed off.

When assembled as described above, the indicator cathodes 9 will be nonmutually-interferingly registered as shown in FIG. 4, wherein a part of the cathodes making up the full set, "0" through "9," has been eliminated for clarity of illustration.

The contour of one of the insulating spacing frames 13 is shown in FIG. 5a. It will be noted from this figure that the upper and lower edges of the frame aperture are provided with inwardly projecting portions which serve to maintain indicator cathodes 9 in spaced relation by separating their ears 12, and also serve to present only the numeral-defining portions of cathodes 9 to view through cover mesh 18.

The insulating positioning frames 14 are illustrated in FIG. 5b. It will be noted from this figure that the insulating positioning frames 14 are provided with inward projections of substantially the same contour as the inward projections in insulating spacing frames 13, but provided with ear receivers 15 in which the ears 12 of the associated indicator cathode will be emplaced during assembly. Further, the insulating positioning frames 14 are provided with lead channels 16 communicating from one of the ear receivers 15 through the lower portion of the frame 14. As may be seen from FIG. 3, the indicator cathode leads 10 will pass through the channels 16, and will be constrained by the limited lateral extent of lead channel 16 from contacting the edges of slot 31 in the combined anode-shield electrodes 6 and 7. It will be apparent to those skilled in the art that by the provision of this particular lead channel structure and cooperating orientation of indicator cathode leads 10 with respect to the indicator cathodes, a controlled spacial relation between the indicator cathode leads 10 and the edges of slot 31 may be maintained, thereby taking advantage of the lower limb of the Paschen's law curve for mutual insulation purposes and assuring maximum isolation between the leads of adjacent cathodes.

FIG. 6 indicates an alternative construction which may be employed in fabricating a device according to the invention. In this alternative embodiment the combined anode-shield electrodes 6 and 7 do not pass through a central aperture in the end micas, as shown, for instance, in connection with FIG. 3, but rather the bottom and top walls of the combined anode-shield electrodes are provided by the end micas (one end mica 25 being shown in the drawing). The electrically conductive parts of the combined anode-shield electrodes then comprise flat wall members which are held in mutual fixed, insulated relationship by means of ears 23 comprising a part thereof and being passed through slots in the end micas and then twisted to produce a permanent deformation and consequent interlocking relationship with the end micas. In this construction cover meshes 18 are provided as before, as are the groups of associated indicator cathodes (which groups are not illustrated in FIG. 6 for reasons of clarity).

The principles of the instant invention may also be embodied in a tube which includes more than two sets of groups of electrodes. Such a tube is shown schemati-

cally in FIG. 7 wherein four groups of indicator cathodes are generally indicated, respectively, as 27, 28, 29 and 30, the two groups 27 and 28 constituting one coacting set of electrodes, and the two groups 29 and 30 constituting a second coacting set. It will be apparent from FIG. 7 to those skilled in the art that the set of groups 27 and 28 is capable of displaying any numeral from "0" through "9," while the set made up of groups 29 and 30 is capable of independently displaying any numeral from "0" through "9." A typical binary coded decimal counter system in which the tube of the instant invention may be employed is shown in United States Patent No. 2,906,906.

Since numerous changes may be made in the above-described apparatus, and different embodiments of the invention may be made without departing from the spirit thereof, it is intended that all the matter contained in the foregoing description and shown in the accompanying drawings shall be interpreted as illustrative and not in a limiting sense.

What is claimed is:

1. An indicator tube comprising: a first group of character-shaped indicator cathodes adapted to glow, a second group of character-shaped indicator cathodes adapted to glow, and a combined anode-excitation shield electrode associated with each of said groups of cathodes, each of said combined anode-excitation shield electrodes at least partially surrounding its associated group of cathodes, whereby each of said combined anode-excitation shield electrodes is adapted to excite at least one of its associated cathodes to glow and is also adapted to shield its associated group of cathodes from glowing when any of the cathodes of the group associated with the other anode-excitation shield electrode is excited to glow.

2. An indicator tube comprising: a first group of character-shaped indicator cathodes adapted to glow, a second group of character-shaped indicator cathodes adapted to glow, and an enclosure including a combined anode-excitation shield electrode associated with each of said groups of cathodes, each of said enclosures at least partially enclosing its associated group of cathodes and being adapted to excite at least one of its associated group of cathodes to glow and to prevent its associated group of cathodes from glowing when any cathode of the other of said groups of associated cathodes is excited to glow by its associated combined anode-excitation shield electrode, the walls defining said enclosures being comprised at least in part of insulating material.

3. An indicator tube comprising: a first group of character-shaped indicator cathodes adapted to glow, a second group of character-shaped indicator cathodes adapted to glow, and an enclosure including as part of its defining walls a combined anode-excitation shield electrode associated with each of said groups of cathodes, each of said enclosures at least partially surrounding its associated group of cathodes.

4. An indicator tube comprising: a first group of character-shaped indicator cathodes adapted to glow, a second group of character-shaped indicator cathodes adapted to glow, and an enclosure including as part of its defining walls a combined anode-excitation shield electrode associated with each of said groups of cathodes, each of said enclosures at least partially surrounding its associated group of cathodes and having insulating material as a part of its defining walls.

5. An indicator tube comprising: a plurality of sets of groups of character-shaped indicator cathodes adapted to glow and an enclosure including a combined anode-excitation shield electrode associated with each of said groups of cathodes, each of said enclosures at least partially surrounding its associated group of cathodes and being adapted to excite at least one of its associated

group of cathodes to glow and to prevent its associated group of cathodes from glowing when any cathode of any of the other groups of its set is excited to glow by its associated combined anode-excitation shield electrode, the walls defining said enclosures being comprised at least in part of insulating material.

6. An indicator tube comprising: a first character-shaped indicator cathode adapted to glow, a second character-shaped indicator cathode adapted to glow, a combined anode-excitation shield electrode associated with each of said cathodes, and an envelope having no more than seven contact pins for making electrical contact between said cathodes and combined anode-excitation shield electrodes and apparatus located externally thereof passing therethrough.

7. An indicator tube comprising: a first group of character-shaped indicator cathodes adapted to glow, a second group of character-shaped indicator cathodes adapted to glow, a combined anode-excitation shield electrode associated with each of said groups of cathodes, each of said combined anode-excitation shield electrodes being adapted to excite at least one of its associated group of cathodes to glow and to prevent its associated group of cathodes from glowing when any cathode of the other of said groups of cathodes is excited to glow by its associated combined anode-excitation shield electrode, and an envelope enclosing said cathodes and combined anode-excitation shield electrodes and having disposed therethrough n contact pins, where $n=C+2$, and C equals the number of cathodes in one of said groups.

8. An indicator tube comprising: a plurality of sets of groups of character-shaped indicator cathodes adapted to glow, a combined anode-excitation shield electrode associated with each of said groups of cathodes, each of said combined anode-excitation shield electrodes being adapted to excite at least one of its associated group of cathodes to glow and to prevent its associated group of cathodes from glowing when any cathode of any of the other groups of its set is excited to glow by its associated combined anode-excitation shield electrode, and an envelope enclosing said cathodes and combined anode-excitation shield electrodes and having disposed therethrough n contact pins, where

$$n=CS+G$$

and C equals the number of cathodes in one of said groups, S equals the number of said sets, and G equals the number of said groups.

9. An indicator tube comprising: a first character-shaped indicator cathode adapted to glow, a second character-shaped indicator cathode adapted to glow, and an enclosure defined in part by a combined anode-excitation shield electrode associated with each of said cathodes, each of said combined anode-excitation shield electrodes being adapted to excite its associated cathode to glow and to prevent its associated cathode from glowing when the other of said cathodes is excited to glow by its associated combined anode-excitation shield electrode, each of said enclosures at least partially surrounding one of said groups and being further defined by insulating members which also serve in part as supporting means for said combined anode-excitation shield electrodes.

10. An indicator tube comprising: a first group of five character-shaped indicator cathodes adapted to glow, a second group of five character-shaped indicator cathodes adapted to glow, and a combined anode-excitation shield electrode associated with each of said cathodes, each of said combined anode-excitation shield electrodes being adapted to excite its associated cathode to glow and to prevent its associated cathode from glowing when the other of said cathodes is excited to glow by its associated combined anode-excitation shield electrode, and coacting with an insulating spacer member to define an enclosure

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at least partially enclosing each of said groups of cathodes.

11. An electrode assembly for use in a glow indicator tube comprising: a plurality of character shaped indicator cathodes, a first plurality of insulating frames surrounding each of said indicator cathodes, a second plurality of insulating frames insulatedly spacing said first plurality of insulating frames, and a combined anode-excitation shield electrode clampingly engaging said frames and cathodes and maintaining said frames and cathodes in fixed relation without the use of other relation maintaining means.

12. An electrode assembly for use in a glow indicator tube comprising: a plurality of character-shaped indicator cathodes, a first plurality of insulating frames surrounding each of said indicator cathodes, a second plurality of insulating frames insulatedly spacing said first

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plurality of insulating frames, and a combined anode-excitation shield electrode clampingly engaging said frames and cathodes, said frames and cathodes being free of continuous members passing therethrough.

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