Jan. 18, 1949. C. H. FULLER 2,459,422

EXCITING MEANS FOR HIGH-FREQUENCY DISPLAY TUBE

Filed May 31, 1947 2 Sheets-Sheet 1

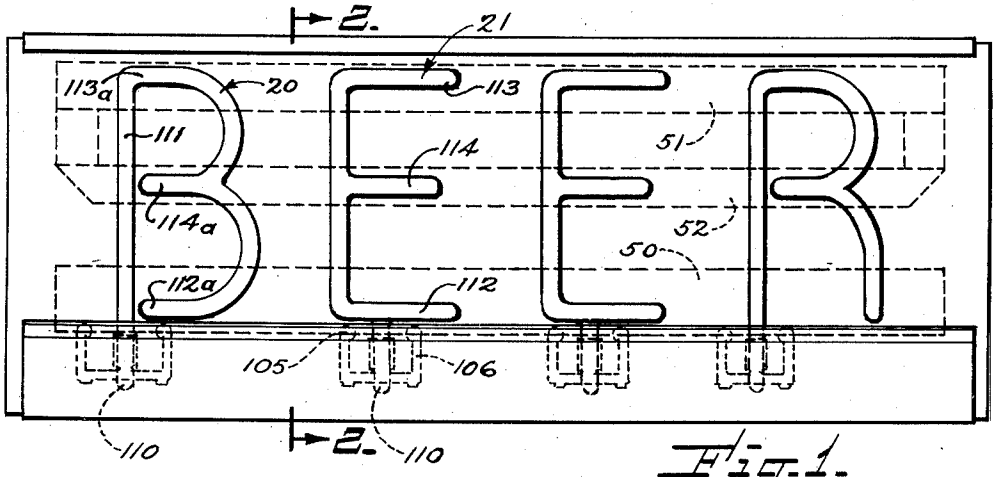


Fig. 1.

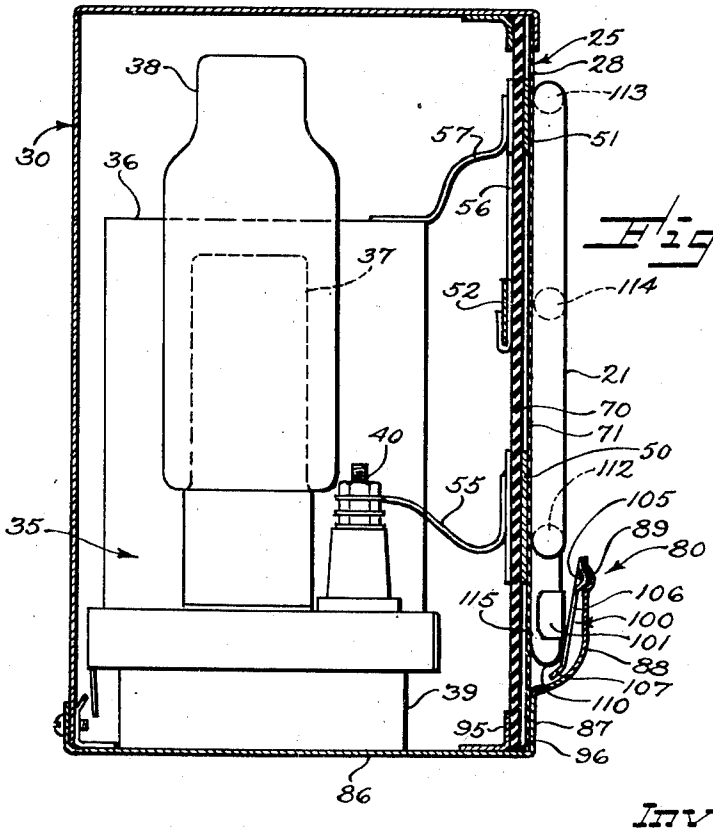


Fig. 2.

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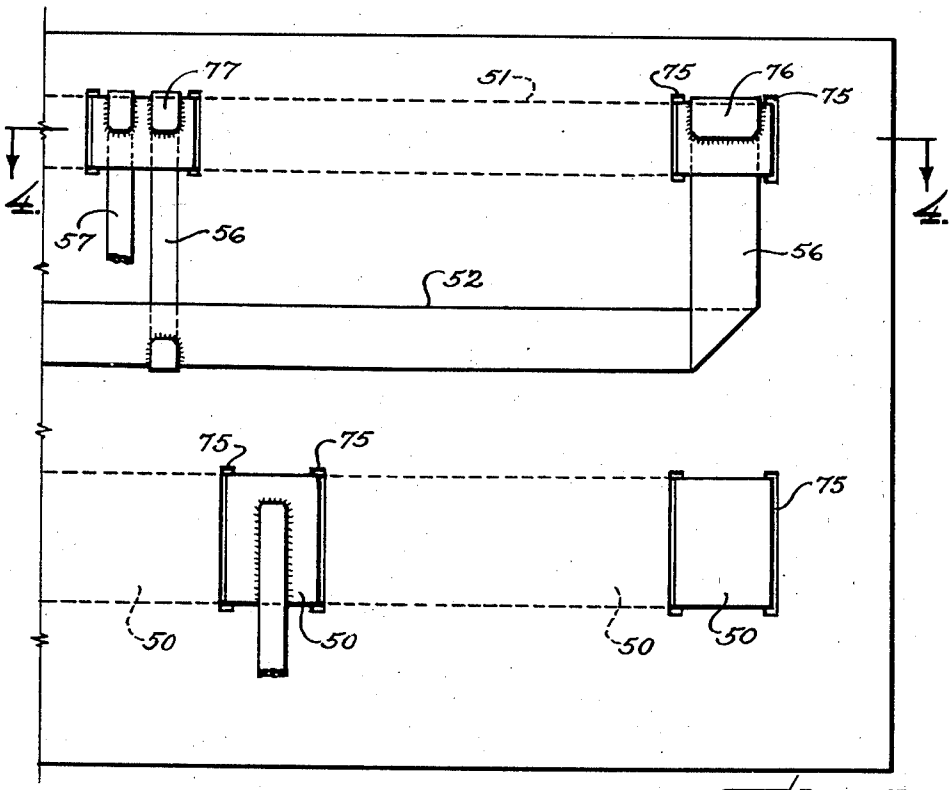


Fig. 3.

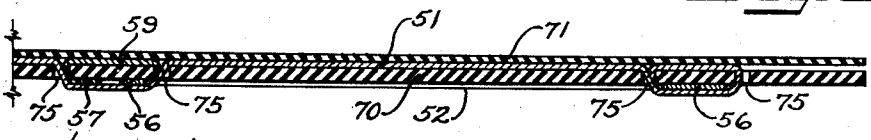


Fig. 4.

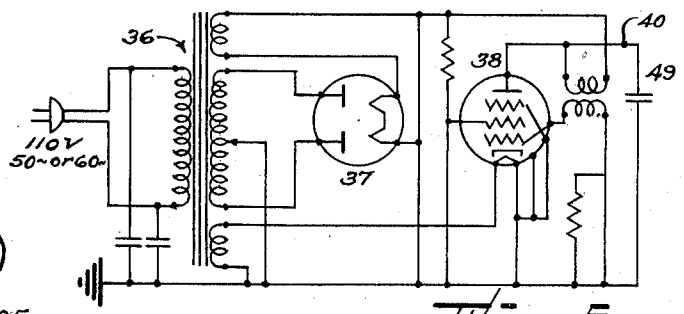


Fig. 5.

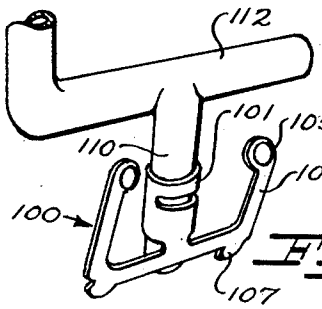


Fig. 6.

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UNITED STATES PATENT OFFICE

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EXCITING MEANS FOR HIGH-FREQUENCY DISPLAY TUBES

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Application May 31, 1947, Serial No. 751,545

8 Claims. (Cl. 315—248)

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This invention has to do with improved means for exciting gas discharge tubes, particularly those which have no internal electrodes. Such tubes are commonly made in the form of letters or symbols and are assembled to form a luminous sign for advertising purposes. Although the present invention is particularly useful in such applications it can be used also for the excitation of other kinds of luminous discharge tubes, such for example as are sometimes formed in table glassware and the like. For clarity of description the invention will be described as it has been applied to a particular type of luminous discharge sign, but I do not intend that the scope of the invention be limited to this application or restricted to the particular structure which I have chosen for purposes of illustration.

It is well known that an electrical discharge tube, containing a suitable gas or mixture of gases at reduced pressure, can be excited without the use of internal electrodes by placing it in a rapidly alternating electric field of sufficiently high frequency and intensity. Such an alterating field is readily produced in the immediate neighborhood of the plates of a condenser which is connected in the output circuit of a suitable radio frequency oscillator. The condenser plates can, for example, be parallel rods or strips of conducting material embedded in a sheet of dielectric material. Discharge tubes made in the form of individual letters and the like can then be arranged against the face of the sheet to form the desired message. If the necessary conditions are met, gas within the tubes becomes ionized and supports an oscillating electrical discharge which has the frequency characteristic of the oscillator but produces an apparently continuous luminosity in the tubes. The condenser plates will be referred to as electrodes, since they perform in many respects the functions of the internal electrodes of the more conventional discharge tubes. However, in the present system the electrodes are capacity coupled, rather than directly coupled, to the ionizable gas within the discharge tube.

Luminous signs of the type described have the advantage that the individual letters can readily be replaced when necessary, and can be re-arranged to form any desired message. A disadvantage of such signs has been the difficulty of arranging the electrodes in such a way that the letters of the sign can extend over a sufficiently large area and yet be excited to substantially uniform luminescence. A further difficulty, which becomes particularly important if the voltage amplitude of the oscillating circuit is increased in

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order to insure starting of the tubes and adequate excitation of all portions of the letters, is the tendency of the oscillating circuit to emit radio frequency radiations of appreciable intensity and thus interfere with normal radio reception in the vicinity of the sign. Partly for this reason it is desirable, if not necessary, to design the electrode system so that with minimum voltage and minimum power loss it will initiate ionization reliably and then excite the letters uniformly.

A simple electrode arrangement, which is partially satisfactory for letters of relatively small size, say 2" in height, provides two parallel electrodes, separated by approximately the height of the letters, and connected one to each output terminal of the source of high frequency potential. When letters are placed in a row parallel to such electrodes and immediately in front of them, the vertical strokes of the letters extend generally along the lines of electric forces between the two electrodes. Once the discharge is initiated, the vertical letter strokes are lighted with good uniformity, but the cross-strokes of the letters, and particularly intermediate cross-strokes as in the letter "E," may remain dark. As the separation of the two electrodes is increased to permit the excitation of larger letters, the intensity of the resulting electric field is correspondingly reduced, and the difficulty of lighting the cross-strokes tends to increase. This difficulty cannot be overcome merely by increasing the width of each electrode while maintaining a fixed space between them, because the electric field then tends to concentrate in the space between the electrodes, producing intense luminosity in the central portions of the letters, but leaving the upper and lower extremities of the letters insufficiently excited.

Another arrangement which has been used to extend the effective area of excitation of an electrode assembly employs a plurality of parallel electrode elements, arranged in a common plane, alternate elements being connected together and to one terminal of the oscillator, and the intermediate elements being connected to the other terminal. This method is successful in some respects, but a typical electrode of one polarity then lies between two electrodes of the opposite polarity, whose fields tend to cancel. Thus the portion of a letter which is directly opposite an electrode element is less brightly illuminated than the portion between electrodes, and may even be completely dark.

The present invention retains the basic simplicity of the two parallel electrodes described

above, but permits the successful starting and uniform illumination of larger letters than have previously been available. My electrode system not only maintains full illumination in the central portions of the vertical strokes, but also produces substantially uniform discharge in the horizontal strokes, including those at an intermediate level. An important feature of the invention is the addition of an auxiliary intermediate electrode element, generally parallel to the upper and lower electrodes of certain previous systems, but so arranged that the electrical capacity between it and the ionized gas in a typical discharge tube is less than the corresponding capacity between either of the main electrodes and the ionized gas. For example, the intermediate electrode may be spaced back of the plane of the main electrodes so that there is an increased air gap between it and the discharge tubes, or the capacity may be limited by using an electrode element of small transverse dimensions. The intermediate electrode is connected directly to one of the main electrodes, preferably to the one which is at ground potential. When such an intermediate electrode is used the separation of the two main electrodes can be considerably increased over previous practice, thus increasing the permissible letter height.

A further advantage which is obtained with such an auxiliary electrode is the more effective excitation of intermediate horizontal strokes in letters such as A, E, etc. For this purpose the intermediate electrode is preferably placed directly back of such intermediate strokes. It then serves to attract lines of force from the main electrode of opposite polarity, producing a sufficiently strong field to light the intermediate cross-strokes; and yet, because of its limited capacity, it allows a sufficiently intense field to extend between the main electrodes to insure adequate excitation of the remainder of the letter. The use of an intermediate electrode not only increases the letter height which can be successfully handled, but actually improves the uniformity of illumination, particularly in the intermediate horizontal strokes of the letters. With given typical oscillating voltage supply, letters (made of 8 mm. glass tubing) as large as 6'' in height are successfully excited with my electrode system, as compared with a maximum practicable letter height of about 3'' with previous systems.

Other objects and advantages of the invention will be clear from the following detailed description of an illustrative preferred embodiment. This description is to be read in conjunction with appended drawings of which

Fig. 1 is a front elevation of a typical complete sign, according to my invention;

Fig. 2 is a section at enlarged scale, taken on the line 2—2 of Fig. 1;

Fig. 3 is a partial elevation showing a portion of the rear face of the electrode supporting panel;

Fig. 4 is a partial horizontal section taken on the line 4—4 of Fig. 3;

Fig 5 is a schematic diagram of a typical electrical oscillator circuit suitable for use with my invention; and

Fig. 6 is a perspective view of a preferred form of bracket for adjustably mounting individual discharge tubes.

Discharge tubes, shown in the form of typical letters 20, 21, are removably mounted, by means to be described, in a row 22 across the front face of a panel 25 of dielectric material, such for example as the polymerized phenolic resin known commercially as "Bakelite." Panel 25 conveniently forms the front wall of a case 30, the other sides of which are of metal, and within which is mounted the radio frequency oscillator 35, comprising transformer 36, rectifying tube 37, oscillator tube 38, and associated circuitry, contained in chassis 39. A conventional oscillator circuit such as that shown schematically in Fig. 5 can be used, and is preferably capable of producing an oscillating current of the order of 6 amperes at any convenient frequency above, say, 75,000 cycles per second, and preferably in the diathermy band at approximately 31 megacycles. A direct current plate voltage of about 300 volts is generally sufficient for oscillator tube 38, leading to a peak voltage in the oscillating circuit in the neighborhood of 500 volts. The electrodes (or electrode assemblies) by means of which discharge tubes 20, 21 are excited are connected respectively to the live output terminal of the oscillator, shown at 40, and to ground, which includes the metal case 30 and oscillator chassis 35.

The capacity shown at 49 in the output circuit of the oscillator is substantially the capacity between the tube exciting electrode systems when no discharge tubes are excited, and is substantially the series combination of the separate capacities between the respective electrode systems and the ionized gas in the tubes when the latter are excited. Thus the load capacity of the oscillator varies widely with the conditions of use.

The live electrode in the modification illustrated comprises a single strip 50 of conducting material, preferably copper foil. As shown, this is embedded in panel 25, parallel to and just behind the front panel face 28, and at the general level of the lower edge of the row of letters 22, adjacent the lower horizontal strokes of the letters, shown typically at 112, 112a. Lower electrode 50 is electrically connected by lead 55 to live terminal 40 of the oscillator. The grounded electrode system includes upper electrode 51, embedded near the front face of panel 25 at the general level of the top edge of the letters 22, and adjacent upper horizontal strokes such as 113, 113a; the intermediate electrode 52, which is mounted on the rear face of the panel; and also the letter supporting rail 80 and clips 100, which are more fully described below.

Intermediate electrode 52 is roughly half way between electrodes 50 and 51, and is approximately at the level of the intermediate horizontal strokes of letters 22. Such strokes are shown typically at 114, 114a in Fig. 1. Electrodes 51 and 52 are electrically connected to each other by leads 56 and to any convenient ground, such as the case of transformer 36, by lead 57.

A convenient manner of mounting the electrodes in the positions described is shown clearly in Figs. 3 and 4. Panel 25 is composed of two layers, main panel 70, providing the principal structural strength, and panel facing 71 which acts as an insulating layer across the front of the panel, and provides a uniform background against which letters 22 can be viewed. In Figs. 2 and 4 the thickness of the panel layers and also that of the electrodes is exaggerated for the sake of clarity of illustration. Electrodes 50 and 51 are threaded through slots 75 cut in main panel 70, and are also glued or cemented in

place. Extra foil sections 59 are inserted to provide a substantially continuous foil surface on the front of the panel. Panel facing 71 is then glued or cemented to the front of main panel 70, covering the electrodes and binding them firmly in place. Intermediate electrode 52 is mounted on the rear face of main panel 70, so that it is spaced back from the plane of electrodes 50 and 51 by the thickness of this panel layer. The position of the electrode on the panel is definitely determined by suspending it from upper electrode 51 by its ends as shown at 76, and by one or more straps as indicated at 77, the straps serving also as connecting leads. Electrode 52 may be further secured to the panel by glue or cement.

I preferably use relatively thin dielectric material, say 1/64" thick, for panel facing 71, so that the upper and lower electrodes are substantially in the front face 28 of the combined panel 25, and yet are electrically insulated from any objects which may come in contact with that face. The thickness of the main panel member 70 can be varied to suit requirements, and in particular is a convenient means of automatically determining the spacing between intermediate electrode 52 and the plane of electrodes 50, 51. In general a panel thickness of about 1/8" is found to give satisfactory results under typical conditions.

The fact that electrode 52 is set back from the plane of electrodes 50 and 51 results in a lower electrical capacity between electrode 52 and the ionized gas in a typical discharge tube than the capacity between electrode 51 and the discharge tube. Because of its lower capacity, electrode 52 does not draw tube current to the exclusion of electrode 51, and hence does not prevent the upper portion of a tube from being properly excited. If electrode 52 is made narrower the capacity is reduced accordingly, and it can then be positioned closer to the plane of electrodes 50 and 51. It can even be placed in that plane if its transverse dimensions are sufficiently reduced, as when a wire instead of a strip of foil is used. However, the arrangement illustrated is preferred to that just suggested, since the latter tends to produce localized excitation of the tube, and hence to be less flexible in use than the preferred form.

Since electrodes 51 and 52 are directly connected together (by leads 56) they function in some respects as a single electrode unit, and may be constructed as an integral unit if desired. However, for most purposes it is preferred to use a structure of the general type illustrated, in which electrode elements 51 and 52 are separate conductors vertically spaced from each other. This gives a smaller total electrode area, tending to reduce the dielectric power loss, and yet concentrates the electric field where it is most needed, namely in the neighborhood of the horizontal letter strokes.

It will be understood that the intermediate electrode 52 may be connected if preferred to live electrode 50 rather than to grounded electrode 51, and that such an arrangement will function in many respects like the arrangement illustrated, particularly in giving improved excitation of intermediate letter strokes such as 114, 114a. However, it is generally advantageous to hold the surface of the live electrode system to a minimum to reduce radiation and power loss.

The length of panel 25 is largely arbitrary, depending upon the requirements of the user. The preferred method of mounting the electrodes in

panel 25 permits them to be extended to any length required, supporting slots 75 being introduced at any desired intervals. In general the power drawn from oscillator 35 increases with the number of letters excited, so that in practice the electrode length that can be satisfactorily employed with a given oscillator is limited. Further extension of the sign can be accomplished, for example, by constructing the electrodes in sections insulated from each other, and powering each section from a separate oscillator.

The electrode system as so far described is advantageous quite apart from the particular method used for mounting the discharge tubes 22 against the front face of panel 25. However, the type of tube mounting illustrated is particularly effective and convenient in its mechanical action, and also cooperates electrically with electrodes 50, 51 and 52 to give improved uniformity of discharge during normal operation and especially to facilitate initiation of the discharge at the start of operation. Certain features of this mounting system are described and claimed in my copending patent application, Serial No. 621,432, filed October 10, 1945.

In the preferred embodiment illustrated, a metal mounting rail 80 parallel to and spaced forwardly from panel 25 is formed integrally with case 30. The bottom 86 of the case extends forward and is bent upward to form first the vertical flange portion 87 and then the curved flange portion 88. Flange 88 carries an inwardly facing shallow channel formation 89 near its upper edge. The entire rail formation 80 is at ground potential, being electrically connected to metal case 30, and preferably integral therewith.

Angle strip 95 is secured to case bottom 86, as by spot-welding, and forms with flange 87 a channel 96 which receives and supports the lower edge of panel 25, insuring a definite spaced relation between the panel and groove 89 of the rail formation.

Each discharge tube carries a downwardly extending stub 110, which may be an extension of a vertical letter stroke 111, as in letter 20 of Fig. 1, or may, for example, be connected approximately at the midpoint of a lower horizontal letter stroke 112, as in letter 21. The stub 110 is preferably formed integrally with the main body of the letter, and contains a hollow chamber which is an extension of the main gas filled discharge chamber of the letter.

A special mounting bracket 100 has a resilient clip portion 101 adapted to at least partially enclose and grip the stub 110 of a discharge tube; and rail engaging portions 105 which are so formed as to seat in groove 89 of rail 80. The portions 105 are resiliently related to clip portion 101 in such a way that when a bracket is mounted on a letter as shown in Fig. 6, portions 105 have a relatively free resilient motion in a direction normal to the plane of the letter, but are relatively stiff against motion parallel to that plane, at least in a vertical direction. Such action can be obtained, for example, by mounting portions 105 on arms 106 which constitute leaf springs lying in a plane generally parallel to the plane of the letter. The two rail contacting portions 105 are positioned above and on opposite sides of clip portion 101, and are preferably mounted on independent spring arms 106 of L-shape. Extending downward from each arm 106 near the angle of the L is an ear 107, adapted to contact the lower part of curved flange 88, facilitating the placement of the letters by limiting the downward

movement of the letter, and protecting the stubs 110 during the placement.

When the letters are mounted on the sign as in Fig. 2, portions 105 of brackets 100, resiliently urged into engagement with channel 39 of rail 30, act as spring detents to define the rotational and vertical position of the letter in its plane. The spring action of arms 106 also presses the lower portion of the latter into contact, with panel 25 at a point below the level of channel 39, say at point 115 in Fig. 2. The latter contact in combination with the rail contacts 105 exerts a rotational couple upon the discharge tube as a whole, in a counterclockwise sense as seen in Fig. 2, tending to hold the upper portion of the letter closely against the front face 28 of panel 25. The longitudinal position of the letter along the length of the sign is determined only by friction against panel 25 and rail channel 39, and is readily adjustable manually. An advantage of this method of mounting is that such longitudinal adjustment of the letters along the row 22 can be made with perfect safety while the letters are illuminated. The detent action already described prevents accidental displacement of the letters, and yet permits them to be readily lifted off the sign or pressed down into position on it without the need of first turning off the electrical power.

In addition to providing a convenient mechanical mounting for the letters, brackets 100, contacting the grounded rail 30, provide a grounded electrode which is in direct contact with the stubs 110 of the discharge tubes.

Because of this direct contact there is a relatively intense electric field between live electrode 50 and clip 101 when the power is first turned on. This ionizes gas in the tube, initiating the discharge, which then spreads to the remainder of the tube. Thus the bracket insures reliable starting of the sign even when the mutual separation of electrodes 50, 51 and 52 is relatively large. But because of the relatively small area of the portion of clip 101 which contacts the tube, the capacity between the clip and the ionized gas in the tube is not very great and hence does not draw excessive current during operation.

During normal operation, the field between live electrode 50 and grounded rail 30 (particularly the upper edge of this rail) passes transversely through the lower horizontal strokes 112 of the letters, tending to maintain a strong discharge in these portions, which may otherwise be difficult to excite. Use of a grounded rail 30 thus permits electrode 50 to be at a higher level with respect to the letters than would otherwise be practicable. On the other hand, the rail does not draw tube current to the exclusion of grounded electrodes 51 and 52, since the rail proper is spaced from the surface of the letters, and since the total area of clips 101 which contact the letters is relatively small.

Regarding the terminology used in the present specification and claims, directional terms such as "vertical," "horizontal," "upper," "lower," and the like, refer to directions relative to the letters of the sign as a sign is normally viewed, and not necessarily relative to gravity. Terms such as "the plane of the panel" are not intended to imply that the panel, or the letters associated with it, must necessarily be flat. On the contrary, panel 25 may be curved either cylindrically or spherically, but in practice such curvature is small enough so that any small region of the panel defines a plane with reasonable definiteness. Similarly, if the electrodes are somewhat curved in the plane of the panel, my characterization of them as "generally parallel" will be clearly understandable if any relatively short section be considered.

I claim:

1. Means for exciting a gaseous discharge tube of substantially plane configuration, said means comprising means for positioning the tube in a given plane, two electrodes spaced from each other and having a relatively high electrical capacity relation with respect to ionized gas in the positioned tube, a third electrode intermediate the said two electrodes and having a relatively low electrical capacity relation with respect to ionized gas in the positioned tube, the third electrode being electrically connected to one of the said two electrodes, and electrical circuit means for applying a high frequency oscillating voltage between the other of the said two electrodes and the pair of connected electrodes.

2. Means for exciting a gaseous discharge tube of substantially plane configuration, said means comprising means for positioning the tube in a given plane, two electrodes spaced from each other and each having a relatively large surface in proximity to the positioned tube, a third electrode intermediate the two said electrodes and having a relatively small surface in proximity to the positioned tube, the third electrode being electrically connected to one of the two said electrodes, and electrical circuit means for applying a high frequency oscillating voltage between the other of the said two electrodes and the pair of connected electrodes.

3. Means for exciting gaseous discharge tubes of substantially plane configuration some of which have a horizontal edge portion and an intermediate horizontal portion, said means comprising means for mounting the discharge tubes in a horizontal row in a vertical plane, an electrode unit having a horizontal limiting edge at the general level of, but spaced from, the intermediate horizontal portions of the positioned tubes and having a portion closely adjacent the horizontal edge portion of the positioned tubes, an electrode adjacent the plane of the positioned tubes and vertically spaced from the said electrode unit, and electrical circuit means for applying a high frequency oscillating voltage between the electrode and the electrode unit.

4. Means for exciting a plurality of gaseous discharge tubes in the form of letters and symbols having a definite maximum height, said means comprising two elongated generally parallel electrical conductors spaced from each other by a distance less than the said height of the letters, a third elongated conductor generally parallel to and intermediate the said two conductors and spaced from them and from their plane, the third conductor being electrically connected to one of the said two conductors, means for removably positioning the discharge tubes in a plane generally parallel to the plane of the said two conductors and on the opposite side of that plane from the third conductor, and electrical circuit means for applying a high frequency oscillating voltage between the other one of the said two conductors and the pair of connected conductors.

5. Means for exciting a gaseous discharge tube, comprising a panel of dielectric material having a front face, means for positioning a discharge tube in front of said panel face, two elongated generally parallel conductors substantially in the

plane of the said panel face and transversely spaced from each other, a third elongated conductor generally parallel to and between the said two conductors and spaced back of the said panel face, the third conductor being electrically connected to one of the said two conductors, and electrical circuit means for applying a high frequency oscillating voltage between the other one of the said two conductors and the pair of connected conductors.

6. Means for exciting a plurality of gaseous discharge tubes some of which have upper and lower horizontal portions and intermediate horizontal portions, said means comprising a panel of dielectric material, means for removably positioning the discharge tubes adjacent the front face of said panel in a horizontal row, a first elongated conductor substantially in the plane of the said panel face at the general level of the lower horizontal portions of the positioned discharge tubes, a second elongated conductor substantially in the plane of the said panel face and at the general level of the upper horizontal portions of the positioned discharge tubes, a third elongated conductor electrically connected to the second conductor and parallel to but behind the plane of the first and second conductors at the general level of the intermediate horizontal portions of the positioned discharge tubes, and electrical circuit means for causing the voltage of the first conductor to oscillate at high frequency with respect to the voltage of the second and third conductors.

7. Means for exciting a gaseous discharge tube of substantially plane configuration, said means comprising a panel of dielectric material, an elongated live electrode embedded near the front face of the panel, an electrically grounded metal rail spaced from the said face of the panel, the upper edge of the rail being substantially opposite the said live electrode, two grounded elongated electrodes generally parallel to the said live electrode and spaced above it, one of the said grounded electrodes being spaced relatively farther than the other behind the said panel face, means for mounting the discharge tube in a plane between the said panel face and the rail, and electrical circuit means for causing the voltage of the said live electrode to oscillate at radio frequency about ground potential.

8. Means for exciting a gaseous discharge tube as specified in claim 7, and in which the said means for mounting the discharge tube include a horizontal groove in the rail facing toward the panel and a bracket comprising a resilient metal clip adapted to receive a vertically elongated portion of the tube and two metal surfaces resiliently related to and electrically connected with the clip and adapted to engage the groove at longitudinally spaced points thereof.

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No references cited.