

May 19, 1953

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2,639,398

ELECTRONIC TUNING OR INDICATING TUBE

Filed Nov. 29, 1950

5 Sheets-Sheet 1

Fig. 1

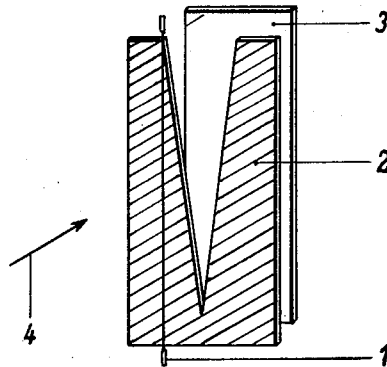
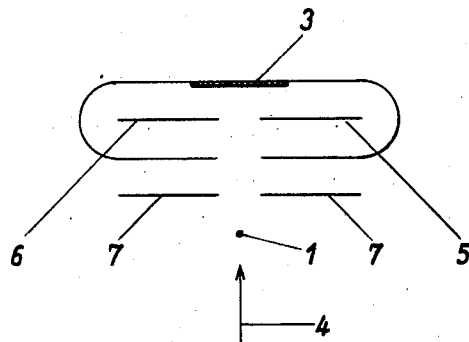


Fig. 2



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Fig. 3

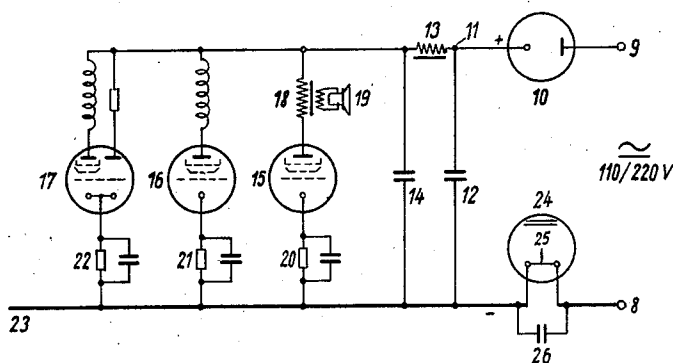


Fig. 4

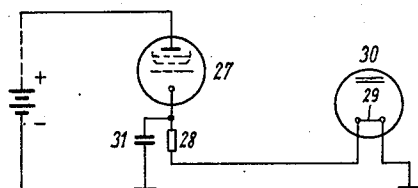


Fig. 5

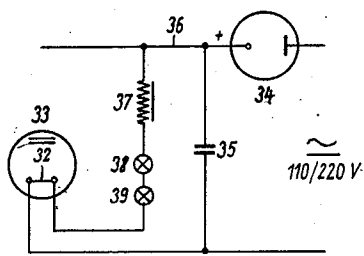
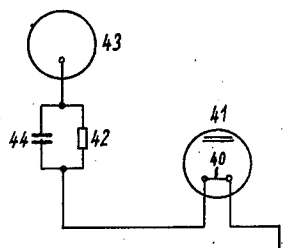


Fig. 6



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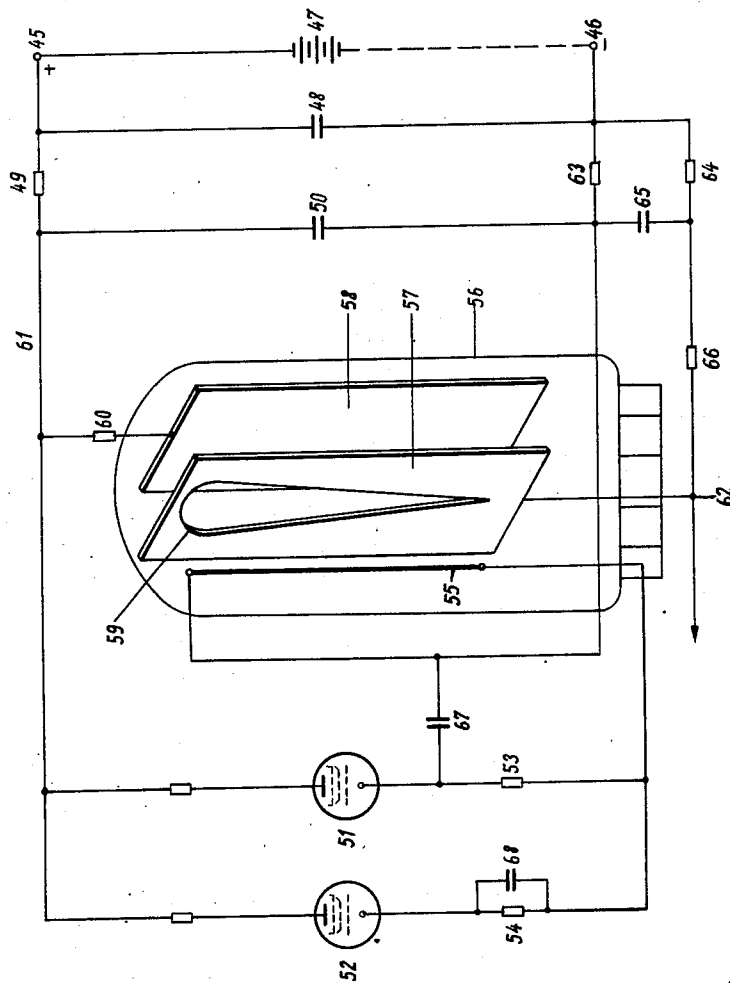
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Fig. 7



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Fig. 8

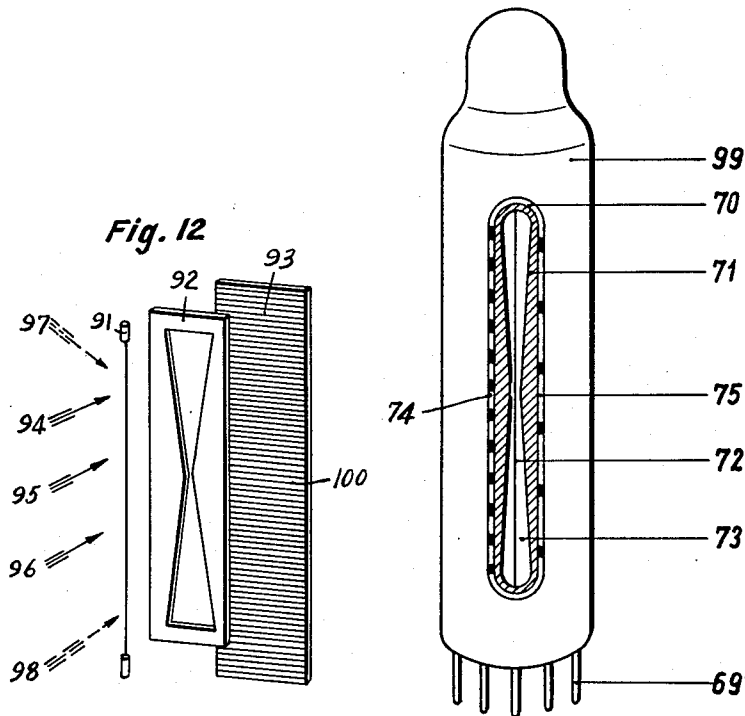


Fig. 12

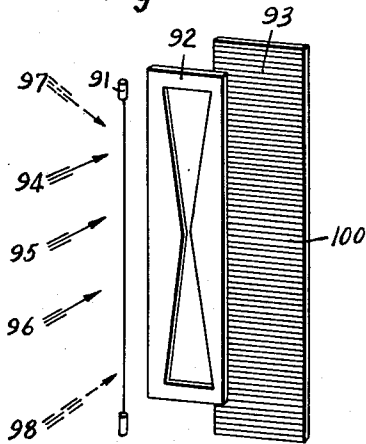
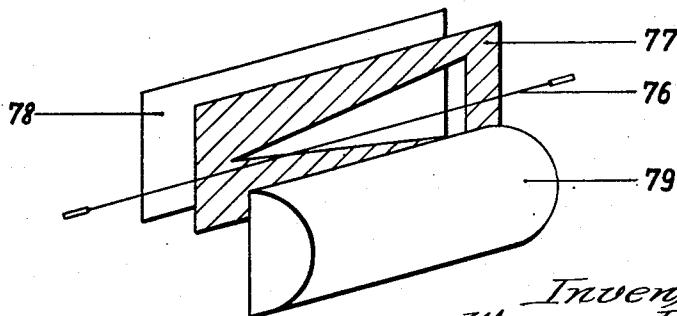


Fig. 9



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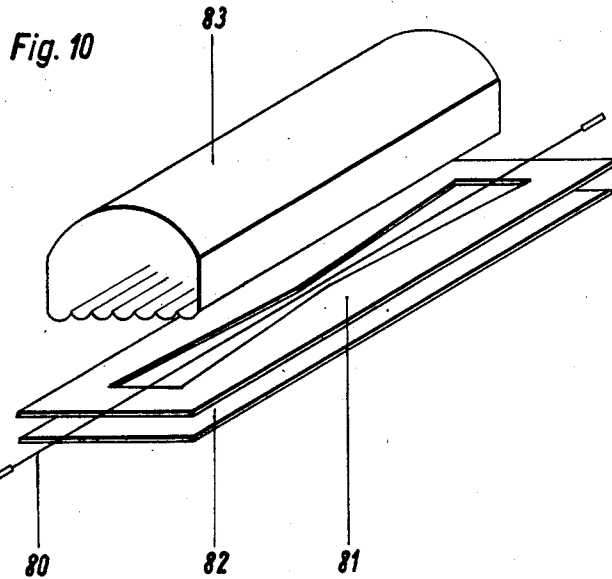
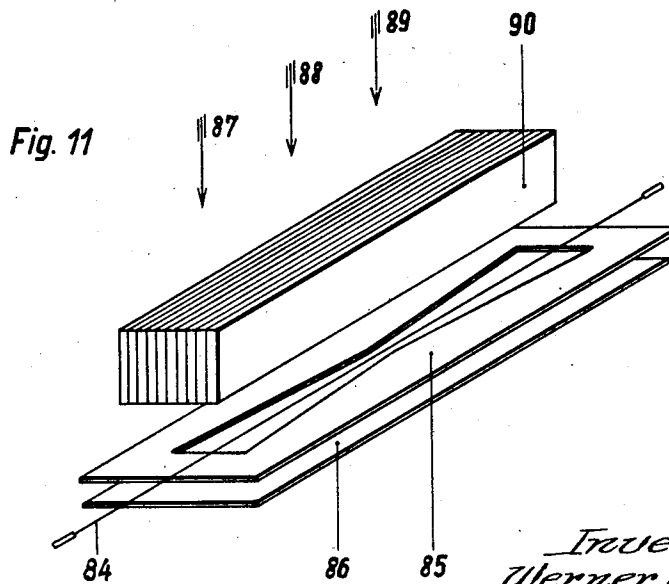
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ELECTRONIC TUNING OR INDICATING TUBE

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UNITED STATES PATENT OFFICE

2,639,398

ELECTRONIC TUNING OR INDICATING TUBE

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Application November 29, 1950, Serial No. 204,122
In Germany December 9, 1949

13 Claims. (Cl. 313-107.5)

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This invention relates to electronic tubes comprising luminescent shields or electrodes carrying a luminescent substance which is selectively affected by electrons, depending on the voltage differential of a control electrode relative to a cathode, and is particularly concerned with tubes of this kind which are suitable to function as indicator or tuning tubes, for example, for wireless receivers or the like.

Indicating or tuning tubes have been proposed in which the luminescent shield is of narrow, elongated form, providing for an indication in a manner that may be likened to the indication of a thermometer. A control system is in such structures disposed between the cathode and the luminescent anode, which provides for differential electron action of the anode so that a variable area of the shield is caused to luminesce, depending on the voltage placed on the control electrode.

The object of the invention is to facilitate the legibility of the indication in such indicating or tuning tubes.

One of the requirements in realizing this object is to make the luminescent shield clearly visible within a large angular area without requiring the use of transparent or translucent conductive surfaces. Some of the previously proposed structures have the drawback of requiring observation of the luminescent shield from the rear so as to obtain distinct legibility of the limited luminous spot. To overcome this drawback it has been suggested to employ in the proposed structures a backing for the luminescent shield in the form of a glass body or a wire netting or the like.

Another previously proposed structure provides for the viewing of the luminescent shield obliquely from the side thereof. The direction of viewing and the flow of electrons form thereby an angle so that the luminescent shield is disposed obliquely to the electron flow as well as to the direction in which the shield is viewed or observed. As a disadvantage in such structures may be mentioned the fact that the angle of observation is relatively small and that the space between the luminescent shield and the control electrode cannot be made as small as desired, due to the necessary oblique position of the shield.

The invention overcomes the above indicated disadvantages by equipping the indicating tube with a very thin threadlike cathode and disposing such cathode in front of the luminescent shield in a position in line with the direction of observation. The observation of the luminescent shield is either not at all or only negligibly affected if the cathode is made in the form of an extremely thin band, filament or the like. The

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cathode is preferably made in the form of a directly heated cathode, since it forms in such case merely an extremely thin, threadlike faintly glowing streak which is hardly perceivable by the unaided eye.

In order to increase the accuracy of the visual indication, the luminescent shield is made narrow and of relatively considerable length, thus arriving at a cathode in the form of a long filament. However, such dimensioning of the heating filament does not result in a thermally favorable cathode shape. The length of an indirectly heated cathode may of course be increased as desired, without causing any difficulties, but its diameter must not be under a predetermined minimum. The minimum diameter is obtained by taking into account the thickness of the filament and its insulating layer as well as the emission layer, and finally the backing for the emission layer. The heating capacity of such an indirectly heated cathode rises with its length. This characteristic, however, is in many cases undesired. For example, in a wireless A. C.-D. C. receiver, in which the heating filaments of the various tubes are in series relationship, there is only a relatively small partial voltage available for the tuning tube, thus resulting in predetermined heating requirements therefor. Accordingly, it may happen that the available heating current does not suffice for a cathode of relatively considerable length. In accordance with the invention, such disadvantage may be overcome, as indicated before, by forming the cathode as a directly heated cathode.

In accordance with another object, the invention proposes to obtain the heating current for the directly heated cathode from the anode current supply of the corresponding circuit of the device in which the tuning tube is used. In the case of directly heated cathodes, the required heating current is smaller than with indirectly heated cathodes. It is possible, in accordance with the invention, to dimension the heating filaments so as to permit operation with extraordinarily low current, thereby making it possible to conduct over the heating filament of the tuning or indicating tube the anode current of the entire apparatus, or of one or more tube stages thereof. It is furthermore possible to provide a separate circuit for the heating of the tuning tube and to include in such circuit the field circuit of an electrodynamic loud-speaker.

It is particularly advantageous when using the anode current of only one tube stage to employ for this purpose the terminal or final stage. However, the anode currents of the high-frequency and intermediate-frequency tube stages may also be employed. The further advantage

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is thereby obtained that the entire anode current of the corresponding stage is altered incident to accurate tuning as well as at the inception of the fading adjustment.

In accordance with another feature of the invention, the arrangement may therefore be such that the variations of the anode current act upon the tuning indication in a supporting sense; for, if the tuning is carried out so that the entire luminescent shield surface becomes luminous in detuned condition or in badly tuned condition of the apparatus, while the luminous area diminishes incident to accurate tuning, such effect will be supported by diminishing emission. The drop of the anode current signifies in such case a decrease in the heating current and therewith decrease of the emission. The exact tuning is thus accentuated.

There are for the indicating or tuning tube made in accordance with the invention numerous other uses aside from its use as a tuning tube in wireless receivers. It is possible, for example, to equip with such a tuning tube measuring instruments in which bridge circuits have to be tuned relative to one another. The invention may also be used in comparative measurements of voltages and currents, and in the control circuits of amplifiers. Measuring instruments have been usually used heretofore in apparatus for supervising the disconnect control in the case of power amplifiers or the like, employing a suitable measuring device, e. g., a rotary coil device in the anode circuit of a certain stage. The invention furnishes particular advantages, since relatively high anode currents are available in such instances. The anode current varies considerably with the disconnect control, and the different anode currents can therefore be utilized to act in a supporting sense, so far as the indication effect is concerned. This is important, e. g., in the case of B-amplifiers in which the anode current increases with progressive disconnect operation. The operation may therefore be carried out in such a manner that the luminous area increases upon the luminescent shield, with increasing disconnect action. However, the anode current also diminishes in the case of limited disconnect action, and the emission of the cathode diminishes likewise in accordance with the reduced heating capacity, therefore permitting again a supporting action, as indicated.

The objects and features outlined above and additional objects and features will be brought out in the course of the detailed description of certain embodiments, which will presently be rendered with reference to the accompanying diagrammatic drawings. In these drawings,

Fig. 1 shows in diagrammatic perspective manner essential elements in the structure of an indicating or tuning tube made in accordance with the invention;

Fig. 2 indicates a schematic section of the electrode arrangement of another embodiment;

Figs. 3-6 illustrate circuit examples;

Fig. 7 represents diagrammatically the use of the electrode system of one form of the invention in a circuit;

Fig. 8 shows another embodiment of an indicating or tuning tube made in accordance with the invention;

Figs. 9-11 illustrate, in diagrammatic manner, optical aid means for facilitating observation of the indication; and

Fig. 12 represents diagrammatically an em-

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bodiment having a luminescent shield of a modified form.

In Fig. 1, which shows in schematic manner the essential parts of one embodiment of the new indicating or tuning tube, there is provided, as seen from the front, in the direction of observation, the cathode 1 which is made in the form of a directly heated threadlike filament. A shutter 2 having a wedge-shaped cutout is used as a control electrode. In back of this control electrode is disposed the luminescent shield or indicating anode 3. The direction of observation is indicated by the arrow 4.

In the embodiment shown in Fig. 2, numeral 1 again designates the threadlike cathode. The observation is along the sides of the cathode in the direction of the arrow 4 toward the luminescent shield 3. The intensity of the luminosity or the width of the luminous area is varied by means of the control shutters or grids 5 and 6. The entire emission of the cathode may, in addition, be affected by the control shutter 7.

Fig. 3 shows in schematic representation a basic circuit diagram which indicates the connections essential for the invention, e. g., for an A. C.-D. C. wireless receiver. The current from a source connected to the terminals 8 and 9 is conducted over the rectifier tube 10 and supplies in usual manner, at the positive terminal 11 of the capacitor 12, the required anode potential which is a direct current potential. The direct current potential is smoothed out by suitable filter means, e. g., a choke 13 and a filter capacitor 14, and is conducted to the various tube stages. Only three tubes 15, 16, 17 are shown for the sake of simplicity. The circuits for the auxiliary electrodes, e. g., the grids, have been omitted. The tube 15 operates as a terminal amplifier tube over the outlet transformer 18 to the loud-speaker 19. The tube 16 may be a high-, intermediate- or low-frequency amplifier tube, and the tube 17 may be, e. g., a mixing or an oscillator tube. The cathode resistances 20, 21, 22 disposed between the cathodes of the individual tubes and the terminal 23 are provided for producing in each instance the required grid bias.

The heating filament or cathode 25 of the indicator tube 24 is disposed in the negative branch of the circuit so that all anode and grid currents flow over it. The capacitor 26 does not merely serve for the decoupling, but in addition to its function as a high-frequency bridging of the heating filament 25, it may also serve the purpose of shunting away from the heating filament the switching-in impulse incident to temporary disruption of operation which may attain high values due to the capacitors 12 and 14.

Only the cathode current of a single discharge tube stage is conducted over the heating filament 29 of the indicating or tuning tube 30 in the embodiment shown in Fig. 4. The discharge tube is designated by numeral 27. The heating filament 29 is in series with the cathode resistance 28, constituting part of the cathode resistance and, together with the cathode resistance 28, is bridged by the common capacitor 31.

In Fig. 5 is indicated an embodiment providing a separate cathode or heating circuit for the heating filament 32 of the indicator tube 33. The anode current source is formed by the rectifier tube 34 and the capacitor 35. The heating current flows from the positive anode terminal 36 through the exciter winding 37 of an electrodynamic loud-speaker and then over the two bulbs

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38, 39 to the heating filament 32 of the tuning tube 33.

Fig. 6 shows a modification of the arrangement illustrated in Fig. 4. In the latter figure, the alternating current is conducted from the cathode over the capacitor 31 to the negative terminal, while in Fig. 6 the output alternating current flows over the heating filament 40 of the indicator tube 41. The cathode resistance 42 of the discharge tube 43 is separate and is bridged by a capacitor 44.

This particular arrangement is believed to be important, e. g., for use with measuring instruments, disconnect meters and the like. The discharge tube 43 may in such cases be an output indicating tube, e. g., a terminal-stage tube feeding into a loud-speaker. It is also possible to use in place of such tube two tubes and to operate them in opposition. As already mentioned, it is possible, by suitably arranging the circuit, to utilize the variations of the anode current so as to operate in a supporting sense with respect to the sensitivity of indication of the indicator tube.

Aside from the above discussed examples, there are numerous other possibilities for using the invention, as will be realized upon considering the utilization of the varying anode currents of amplitude-modulated stages. Such stages are found, in the case of high-frequency and intermediate-frequency amplifiers, e. g., in multi-channel receivers in which the modulation usually includes the mixing tube. The low-frequency modulation stage is often also included. If the entire anode current involved in the modulation, in the case of a plurality of modulation stages, is sufficiently great, it may be desirable to utilize the corresponding part of the circuit for heating the indicator tube so as to obtain the previously described supporting action affecting the indication.

In accordance with the invention, the arrangement just described may be modified to further improve the indication. In the case of an indirectly or partially indirectly heated cathode, the heating filament may be so connected that the positive pole is placed opposite the least control effect of the control system, while the negative pole is disposed at the point of the greatest control effect. Such an arrangement results not only in an improvement of the sensitivity of indication, but also in actions and advantages with regard to different possibilities of use. The luminescence of more or less of the area of the luminescent shield in such a case does not depend proportionally on the control voltage; the indicating action may then be controlled in accordance with other principles. Desired indicating characteristics may be obtained by suitably dimensioning the operating currents and operating voltages. It is furthermore possible to obtain auxiliary dependence of the indication on an additional measuring value.

The operating point for the indication may be favorably placed by suitably choosing the reference point for the bias of the control electrode, making it possible to obtain good initial or terminal sensitivity for the indication. It should also be considered that variations of the anode current do not only cause variations in the emission, but also result in a differential voltage drop along the heating filament. This action may be utilized to support the indicating effect.

Fig. 7 shows an example of a corresponding embodiment particularly for use as a tuning indicating device for a wireless receiver. Only

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that portion within the wireless receiver circuit is indicated which lies normally in back of the rectifier and comprises an anode voltage source. The rectified anode voltage is at the terminals 45—46, the terminal 45 being the positive and 46 the negative terminal. Numeral 47 indicates a battery which is the anode voltage source, and numeral 48 indicates a capacitor. For the filtering there is provided a series element, e. g., a choke or resistance 49, as well as a parallel element, e. g., a filter capacitor 50.

The anode current flows through a plurality of tube stages connected in parallel, only two discharge tubes 51, 52 being shown for the sake of simplicity of representation. The cathode resistances 53, 54 are disposed on the cathode sides, the arrangement being such that the entire cathode current flows over the heating filament 55 of the indicator tube 56.

The tuning-indicating tube 56, of which the drawing shows in perspective representation only the electrodes which are essential for the understanding of the invention, comprises a control electrode 57 and the luminescent shield 58. The control electrode 57 is provided with a shutter-like cutout 59 which may be wedge-shaped. A variable control effect results in accordance with the cutout of the shutter which varies from point to point. The anode 53 forming the luminescent shield is connected with the positive terminal 61 of the anode voltage over the resistance 60, while the negative bias is connected to the control electrode 57 in addition to the control voltages conducted thereto at 62. This negative bias results from the voltage drop at the resistance 63. The resistance 64, capacitor 65 and the resistance 66 are provided for the filtering and decoupling. The cathode resistances 53, 54 are bridged by capacitors 67, 68. Only the capacitor 68 is disposed in parallel with the resistance 54, but the capacitor 67 bridges the cathode resistance together with the heating filament, so that the amplified alternating voltages are conducted to the discharge tube 51 over the threadlike cathode or heating filament 55. The arrangement results in an auxiliary control by the alternating voltages. Such a circuit arrangement is of importance, e. g., for the measuring of disconnect operations and the like, comprising circuits in which flow relatively high normal voltages. The normal alternating current in such circuits may thus be utilized for the auxiliary control of the indication.

Fig. 8 shows an embodiment of a luminescent shield indicating tube having an opaque outer member. This member may be a coating layer upon the glass wall of the tube, or a suitable sheet material member drawn over the glass wall. A slotlike opening may be provided in the opaque member in order to observe the indication. The opening is disposed and dimensioned in such a manner that the observation always takes place in identical direction.

Numeral 99 in Fig. 8 indicates the outer member which may be a cylinder, e. g., made of aluminum, surrounding the tube. At the lower end of the tube are the socket pins 99. In order to observe the indication upon the luminescent shield, there is provided the narrow, elongated window opening 70. The control electrode may be a slot-shaped shutter or frame 71 which is so constructed as to produce, depending on the control voltages, two luminescent areas which move from the top and bottom toward the middle. The cathode 72 which is again, as in all

embodiments disclosed herein, a threadlike filament, is disposed in the direction of observation, also as in all other embodiments, in front of the control electrode 71 and the latter is disposed in front of the luminescent shield 73. The cathode 72 is so thin that it does not obstruct the observation of the indication.

One or more scale calibrations, in accordance with desired division schemes, may be provided marginally of the observation opening. For example, the divisions or gradations may be very fine on one side and in larger increments on the other. Black-white scale gradations are particularly distinct. The scale gradations may be imprinted or etched on the outer cylinder, if desired, in contrasting colors. Two scales 74, 75 are shown in Fig. 8 along the margins of the observation opening 70. They may follow a black-white scheme or may be in contrasting colors, as mentioned before. The scale 74 may have fine subdivisions or gradations and the scale 75 may have marker lines, one to every five or ten of those on the scale 74.

It may be desirable in many instances to carry out the observation with a greater viewing angle. Optical means may be used to emphasize subjective luminosity and to magnify the dimensions of the indication image. For example, an optical magnifying lens may be disposed in front of the indicating tube. Such a lens will magnify the impression of luminosity and, if optically of good quality, will permit to reach the limits of legibility. The lens may be mounted with a tube or may form part thereof. It may also be made in the form of a cylindrical lens. The optical magnification of the length of the luminous indication image is in such case of secondary importance as compared with the brightness and distinct legibility thereof. The indication may be widened by the use of a cylindrical lens. If the luminous spot produced by the control shutter terminates at its margins in a thin point, such point may be widened for viewing, by the use of a lens. The borderline between bright and dark zones can thus be brought into view and emphasized.

Numerical 76 in Fig. 9 indicates the threadlike cathode disposed in front of the control electrode 77, which is made in the form of a shutter having a wedge-shaped or trapezoidal cutout. In back of the control electrode is the luminescent shield anode 78 having a narrow, elongated shape. The various elements of the electrode system are thus similar to those described in connection with the previous embodiments and are similarly disposed. In front of this electrode system is provided a cylindrical lens 79 which operates in the manner of a watchmaker's magnifying glass. The lens does not produce subjective magnification of the indicating image, but an apparent widening of the terminal points which, as such, are bright and sharply outlined but terminate in thin ends, thus making these points to appear as wide beams.

Other optical means may be used to widen the pointed luminous image to form a broad band of uniform width and brightness. It is desirable to use for this purpose an optical system which causes such an apparent deformation of the luminous image that its momentary position (depending on the control voltage) is either not at all affected or is affected only negligibly, while its width is reproduced in a plurality of astigmatic, preferably overlapping, images. In

order to obtain such effect, there may be provided a system of lenses in place of the single cylindrical lens of Fig. 9. For example, a plurality of lenses disposed side by side may be used. It is also possible to use a transparent body provided with a plurality of grooves or ridges extending in parallel relationship. In order to produce as bright an image as possible, the multiple lens may be combined with a cylindrical lens operating as a magnifier. This may be carried out in simple manner by grinding the underside of a thick cylindrical lens in a flat plane and forming thereon a plurality of grooves or ridges which act in the manner of a multiple cylindrical lens.

Fig. 10 shows an embodiment of such a structure in a view looking upon the indicating system from above, such system comprising the previously described elements including the threadlike cathode 80, the double-wedged or double-trapezoidal shutterlike control electrode 81 disposed in the back of the cathode, and the luminescent shield anode 82 disposed in back of the electrode 81. The control electrode is constructed so that luminous points are produced at the two outer ends which move toward one another more or less symmetrically, depending on the control voltage applied. In front of the electrodes is disposed the optical system 83 comprising a thick body the upper side of which is formed in the manner of a cylindrical lens. On the flat underside are provided equally spaced parallel grooves or ridges to produce the effect of a multiple cylindrical lens. The optical system may be suitably arranged outside or inside of the discharge tube or may form part of the wall thereof.

A distortion in which the position of the luminous image is not affected at all, or only negligibly so, while its width is magnified, may be produced by employing a plurality of transparent plates disposed in parallel relationship, taking advantage of the fact known that light striking a glass plate at one of its edges will by total reflection radiate outwardly substantially only at the opposite edge. It is not necessary that the light strikes the edge perpendicular to its plane; it may strike at an angle thereto. If a plurality of such glass plates are assembled in a pack, light striking the edges of the pack at one side can then be observed at the edges of all the glass plates at the opposite side. The light thus will appear as a correspondingly wide image picture. Such a structure appears in Fig. 11.

The electrode system shown in Fig. 11 corresponds to the previously described structure. It comprises the threadlike cathode 84, the shutterlike control electrode 85 and the luminescent shield 86. The direction of viewing is indicated by the arrows 87, 88, 89. The picture of the luminous images will appear visible at the edge of each of the glass plates included in the pack 90, and the succession of the individual images will be recognized as a wide luminous band.

An increase of the brightness of the image picture may also be obtained by the embodiment diagrammatically shown in Fig. 12 which comprises again a threadlike cathode 91 and in back thereof the shutterlike control electrode 92. Through the cutout in this control electrode is observed the luminous shield 93. The principal direction of viewing is in the direction of the arrows 94, 95 and 96, but it may also

be at an angle, as indicated by the arrows 97 and 98. The shutter opening is in practice narrower than shown in the figure, i. e., narrower as compared with its longitudinal extent, which is also true of the previously described figures. 5 The line of observation of the luminescent shield may vary along the longitudinal extent of the cutout; if viewed in a direction perpendicular to the cutout, it will of course be limited by the configuration thereof. The luminescent shield may be so constructed, in view of the fact that it is viewed in a definite principal direction, that it permits an increased reflection for a certain angle of viewing or for a plurality of angles lying in a predetermined plane. 15 A somewhat reduced brightness may then be tolerated incident to viewing the shield from other points of observation, and especially in a direction perpendicular to such plane. The backing for the luminescent substance, which advantageously may be silver-coated, may for this purpose be roughened by transverse grooves 100 extending in a direction which is substantially perpendicular to the principal plane or planes of the angles at which the viewing takes place. 20 Such roughening of the backing of the luminescent shield also results in the additional advantage of increasing the strength of adhesion of the luminescent substance. It is therefore possible to employ backings, e. g., 30 silvered surfaces, which, as such, are rather smooth and which otherwise would introduce some hazards so far as adhesion of the luminescent substance is concerned. The parallel roughened grooves may be provided in suitable manner, e. g., by scratching the finished backing body. However, it is also possible to form the grooves prior to finishing the shield body and to thereafter provide the backing with an optically reflecting coating, e. g., a silver coating. 40

Examples of previously proposed structures mentioned in the preamble may be had by considering co-pending applications Ser. Nos. 188,161 and 188,162, filed October 3, 1950, now Patents Nos. 2,594,025 and 2,594,026.

Changes may be made within the scope and spirit of the appended claims.

We claim:

1. An electronic tube, especially for use as a tuning or indicating tube in an electronic circuit, comprising a plurality of electrodes which are structurally formed as specified and which are as seen in the direction of observation by an observer disposed as specified, namely, first, an elongated threadlike cathode, second, a flat control electrode in which is formed a cutout, said control electrode being disposed in back of said cathode substantially in parallel therewith and in its entirety radially spaced therefrom, and third, an elongated generally flat and narrow luminescent anode disposed in back of said control electrode substantially in parallel therewith and rearwardly spaced therefrom. 50

2. The structure defined in claim 1, together with auxiliary electrode means for affecting the luminous image produced on said luminescent anode. 65

3. The structure defined in claim 1, together with opaque outer cover means for said tube, and a slotlike cutout in said outer cover means for observing the luminous indicating action of said luminescent anode inside said tube. 70

4. The structure defined in claim 1, together with opaque outer cover means for said tube, 75

a slotlike cutout in said outer cover means for observing the luminous indicating action of said luminescent anode inside said tube, and scale means disposed marginally of said cutout.

5. The structure defined in claim 1, together with optical means disposed in front of said cathode for magnifying the width of the luminous indicating image on said luminescent anode.

6. The structure defined in claim 1, together with optical means disposed in front of said cathode for magnifying the width of the luminous indicating image on said luminescent anode, said optical means being disposed in front of said tube facing said cathode in line with the direction of observation.

7. The structure defined in claim 1, together with optical means disposed in front of said cathode for magnifying the width of the luminous indicating image on said luminescent anode, said optical means forming part of said tube.

8. The structure defined in claim 1, together with a cylinder lens disposed in front of said cathode for magnifying the width of the luminous indicating image on said luminescent anode. 25

9. The structure defined in claim 1, together with optical means disposed in front of said cathode for magnifying the width of the luminous indicating image on said luminescent anode, said optical means being constructed so as to cause subjective deformation of the width of the luminous image by dissolving such image optically into a plurality of astigmatic preferably overlapping images. 35

10. The structure defined in claim 1, together with optical means disposed in front of said cathode for magnifying the width of the luminous indicating image on said luminescent anode, said optical means comprising a transparent body provided with a plurality of parallel ridges. 40

11. The structure defined in claim 1, together with optical means disposed in front of said cathode for magnifying the width of the luminous indicating image on said luminescent anode, said optical means comprising a plurality of transparent platelike members disposed side by side. 45

12. The structure defined in claim 1, wherein said luminescent anode comprises a reflecting backing carrying a luminescent substance, said backing being roughened by ridges disposed thereon in a plane which extends substantially perpendicular to the direction in which said anode is viewed for observing the luminous indication thereon. 55

13. The structure defined in claim 1, wherein said luminescent anode comprises an optically reflecting backing carrying a luminescent substance, said backing being roughened by ridges disposed thereon at an angle to the longitudinal axis of the shield. 60

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