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VISUAL TUNING INDICATOR

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My present invention relates to visual tuning indicators, and more particularly to an improved type of tuning indicator device of the variable shadow type.

In the past there have been widely employed tubes of the so-called variable shadow type, or 6E5 type, for tuning indication in a radio receiver. In such use there is applied to the ray control electrode a direct current voltage whose value depends on the detector input voltage of the receiver. An increased range of indication has been provided in the 6E5 tube by constructing the amplifier section of the tube so that it has a remote cut-off characteristic. Increased indication range, or a remote cut-off characteristic, has also been proposed for the indicator section of the 6E5 tube. In this case there is utilized a pair of shadows; one shadow responding to strong signals, while the opposite shadow indicates weak signals with greater sensitivity.

One of the main objects of my present invention is to provide a single shadow electronic indicator constructed and arranged to respond to weak input voltages with high sensitivity and having the delayed overload advantage at strong input voltages whereby the benefits of the aforesaid double shadow indicator are secured without the disadvantage of shifting attention from one shadow to another.

Another important object of my present invention is to provide an electronic indicator of the variable shadow type, wherein the effectiveness of electron control is varied along the length of the ray control electrode so that the portion of the shadow controlled by one end of the electrode changes rapidly with small changes of applied voltage so long as the voltage is small, while the shadow portion controlled by the other end of the control electrode does not disappear but continues to give an indication even after the applied voltage has attained large values.

Another object of the invention is to provide an electronic indicator of the variable shadow type wherein the ray control rod is composed of a material whose resistivity is sufficiently high so that the shadow closure is greatly delayed for very strong signals.

Still other objects of my invention are to provide varied ray control electrodes for electronic shadow indicators, wherein the control electrode may assume any desired geometrical configuration capable of having one portion of the electrode exert a substantially different control on the electron stream to the fluorescent target than the remainder of the electrode.

Other objects of my invention are to improve generally the efficiency and simplicity of tuning indicators, and more especially to provide a variable shadow-electronic indicator, which is reliable in operation and is economical to construct.

The novel features which I believe to be characteristic of my invention are set forth in particularity in the appended claims; the invention itself, however, as to both its organization and method of operation will best be understood by reference to the following description taken in connection with the drawing in which I have indicated diagrammatically several circuit organizations whereby my invention may be carried into effect.

In the drawing—

Fig. 1 is a circuit diagram showing one form of the invention,

Fig. 2 shows a modified embodiment of ray control electrode,

Fig. 3 shows still another modification of the control electrode,

Figs. 4a to 4d show in a qualitative manner the appearance of the indicator shadow, for various values of signal amplitude, when employing the invention,

Fig. 5 shows another embodiment of the invention.

Referring now to the accompanying drawing, wherein like reference characters in the different figures indicate similar elements, Fig. 1 shows a typical superheterodyne receiver of the broadcast type, the various networks being schematically represented. The signal collector 1 is coupled to a converter, through tunable signal amplifiers if desired, by a tunable signal circuit 2. The numeral 3 denotes the tunable local oscillator tank circuit, and the variable condensers of both circuits 2 and 3 are uni-controlled. The resulting intermediate frequency energy (I. F.) is applied to one or more I. F.-tuned amplifiers 4, and the amplified I. F. signal energy is applied to detector 6 through the transformer 5 whose primary and secondary windings are each resonated to the operating I. F. value. The second detector load resistor 7, bypassed for I. F. currents, develops audio and direct current voltages. The audio voltage may be used in any desired manner, while the direct current voltage is employed for automatic gain control (AVC) of earlier amplifiers in order to maintain the carrier amplitude at the second detector input circuit substantially uniform.

The AVC bias is, also, utilized for indicating

the state of resonance of the receiver. As is well known to those skilled in the art, this is accomplished by utilizing a tube of the 6E5 type which is generally represented in Fig. 1 by the numeral 8. Such tube is shown in detail in U. S. Patent No. 2,051,189 granted to H. M. Wagner on August 18, 1936. For the purposes of the present application it will be sufficient briefly to describe the construction of tube 8, particular reference being made to the aforesaid Wagner patent for construction details. The indicator tube generally comprises a direct current voltage amplifier section, and an independent variable electronic shadow section. A common electron emission element is used for both sections, and is denoted by numeral 9. The cathode 9 has an emission section 10 in the amplifier section of the tube 8, and a control grid 11 surrounds the emission surface 10. The cathode 9 is connected to ground through a biasing resistor 12 which is appropriately by-passed by condenser 13. The control grid 11 is connected through the audio frequency filter network 13 to a negative potential point on load resistor 7. In other words, AVC bias is applied to the control grid 11.

The plate 14 of the amplifier section surrounds the control grid 11, and the plate is connected to a source of positive potential through a resistor 15. The indicator section of the tube includes the emission surface 16 which extends axially of a dish-shaped target electrode 17, the latter having an outward flare as shown in the drawing.

The interior surface of the flared portion of the target 17 is coated with a fluorescent material which glows upon being impacted by electrons flowing from the emission surface 16. The target electrode 17 is connected to the more positive end of resistor 15. In other words the target is maintained at a substantially higher potential than the plate 14 of the amplifier section. An electron control electrode 20 is positioned between the emission surface 16 and a portion of the target 17. This electrode 20 is usually a rod interposed in the electron stream flowing from the emission surface 16 to the portion of the fluorescent face of the target in alignment with the electrode 20. The latter is connected to the plate end of resistor 15. Both the plate 14 and electrode 20 are at the same positive potential, and it will also be observed that rod 20 is of necessity less positive than the target 17. Generally, a guard cap 21 is provided in the manner shown in Fig. 1 so that an observer viewing the glowing target 17 from the end of the tube 8 will see a glowing annulus as will be explained later.

Let it be assumed that the electrode 20, instead of being inclined as shown in Fig. 1, is parallel to the emission section 16, and further that the electrode 20 has a uniform circular cross-section. In such case when no signals are being received, or when the signal carrier amplitude is less than a predetermined low value, then the control grid 11 will be at a negative potential which is substantially equal to the voltage drop across bias resistor 12. In such case there will be maximum space current flow between the emission section 10 and plate 14 with the result that the voltage drop across resistor 15 is a maximum. In such case the electrode 20 will be sufficiently less positive than the target 17 to cause deflection of electrons from the portion of the fluorescent target immediately in alignment with electrode 20.

In other words, the appearance of the fluores-

cent surface of the target will be as shown in Fig. 4a. The numeral 21 represents the glowing surface of the target 17, while the numeral 22 represents the wide shadow area which is produced by virtue of the deflection of electrons caused by the substantially less positive control electrode 20. The shadow area 22 will have its maximum magnitude when the magnitude of the voltage applied to control grid 11 from load resistor 7 is a minimum. In other words the appearance of the maximum shadow area signifies the "no-signal" condition. As explained in the Wagner patent as the tuner of the receiver is adjusted to a point such that exact resonance is had, then the AVC bias will be a maximum. That is to say, the voltage drop across resistor 15 is reduced to its minimum value, and therefore, the potential of electrode 20 approaches that of target 17. Under these conditions the shadow area 22 decreases in magnitude by virtue of the fact that the deflection of electrons is reduced. From the viewpoint of the operator of the set as the tuning mechanism is adjusted to tune in a station, the edges of the shadow area will be observed to approach each other until they meet, and even slightly overlap. The point at which the shadow is at a minimum, or its overlap a maximum, is the point at which exact tuning is had.

As previously explained various proposals have been advanced, and employed, for giving the indicator section of the tube a remote cut-off characteristic. The desirability of such a characteristic is based upon the fact that it is desirable to have an indication which is equally sensitive for strong signals as for weak signals. In the past a double shadow tube has been employed by utilizing oppositely positioned electron control rods, and having one shadow function sensitive enough to indicate weak signals while the other shadow function is sufficiently insensitive not to be operated fully by anything but very strong signals.

In the present invention there is provided in a single shadow indicator a high sensitivity to small voltages together with the delay overload advantage at high voltages, thus not requiring a shift of attention from one shadow to another shadow. Basically this invention provides means for causing the effectiveness of control to vary along the length of the control rod so that the shadow controlled by one end of the rod changes rapidly with small changes of applied voltage so long as the voltage is small, while the portion of the shadow controlled by the other end of the rod does not disappear but continues to give an indication even after the applied voltage has reached large values. Three modifications, each of them exceedingly simple in construction, are disclosed in this application.

As shown in Fig. 1 it is merely necessary, where using a control rod 20 of uniform cross-section, to incline the rod 20 with respect to the axis of the cathode section 16 so that the control effect of rod 20 varies along its length. Figs. 4b, 4c and 4d show the effect of the inclined control rod. As the signal carrier amplitude increases (in response for example to adjustment of the tuner device to the desired station setting) the shadow area 22 will decrease in a delayed fashion. Fig. 4b shows that for signals of fair strength the edges of the shadow area come together at the inner circle, while the edges are concave and flare towards the outer circle. In Fig. 4c is shown how the shadow area 22 lingers even after the edges overlap. This is the case when the signals

are stronger. It may be noted that the shadow edges cross over in the manner of scissors.

In Fig. 4d there is shown the appearance of the shadow area 22 when the received signals are very strong. It will be observed that the point of intersection of the luminous edges is very close to the outer circle, and that the shadow area is of minimum magnitude. It will now be seen that there has been provided a delayed closure of the shadow area edges, and that this is due to the fact that one portion of the control rod 20 has a substantially different control over the electron stream than another section thereof. In the case of the inclined rod 20 of Fig. 1 the upper portion of the rod exercises a control over the electron stream to the target for a greater period of time than for the lower section. This is due to the fact that the upper section of rod 20 is closer to the emission surface than the lower section. The operator of the receiver need only watch the shadow area 22 as he tunes the receiver, and when the shadow area has narrowed down to the minimum extent shown in Fig. 4b, he then realizes that the receiver has been accurately tuned. It will, also, be noticed that there is substantially uniform sensitivity of the shadow response for both strong and weak signals.

In Fig. 2 there is shown a modification of the electron ray control electrode, and the latter is designated by the numeral 30. In this case the rod is given a varying cross-section. To point out clearly the advantage of the downwardly tapered rod 30, consider the comparison of a thin rod with a thick one. At the potential at which the thin rod does not deflect the passing electrons in either direction it throws only its small geometrical shadow on the target, and the shadow disappears entirely when the control voltage reaches only a moderate value. However, in the case of the thick rod the geometrical shadow is so great that a relatively large control potential is required completely to close the shadow. Hence, it will be clear that if one part of the rod is made thin, and another part is made thick, then the corresponding parts of the shadows will be well adapted respectively to the indication of small and of large voltages. Preferably the cross-section of the rod will be gradually changed rather than abruptly, so that the eye of the observer can follow the point on the shadow where the shadow is just disappearing, since this is the condition where the indication is most delicate. The inverted cone configuration of the rod 30 in Fig. 2 provides the series of indications shown in Figs. 4a to 4d for the respectively different amplitudes of signals.

It is, of course, not necessary that the cross-section of the control rod 30 be circular. The amount of control may be varied by varying the nature and orientation of the cross-section as well as by varying the diameter. For example, a thin strip will have a different control according as its plane is parallel or perpendicular to the radius from the cathode to the target.

In Fig. 3 the control rod 40 is of uniform cross-section throughout the length of the rod, and the axis of the rod is parallel to the axis of the emission section 15. However, the control rod 40 is composed of any well known material whose electrical resistivity is so high that if the rod is connected at one end only to the control voltage source, then the currents flowing in the rod in the case of a large control voltage produces a large voltage drop between the ends of the rod. This reduces the potential at the un-

connected end, and hence delays the closure of the part of the shadow controlled by that end. In this instance as well the gradually closing shadow area depicted in Figs. 4a to 4d for gradually increasing signal carrier amplitudes may be achieved.

In Fig. 5 there is shown another use to which the invention can be put with great advantage. In frequency modulated (FM) receivers it is well known that it is difficult accurately to tune the receiver. This results from the fact that the FM detector has a characteristic as shown graphically above the schematically represented discriminator 50 in Fig. 5. In other words, let it be assumed that 50 denotes the second detector of a superheterodyne receiver of the FM type, and which detector usually comprises a pair of rectifiers having their output load resistors 51 and 52 in opposed relation. The common input circuit of the rectifiers is constructed so as to convert the frequency modulated wave into an amplitude modulated wave, and possesses various constructions well known to those skilled in the art. One such construction is shown, for example, by S. W. Seeley in U. S. Patent No. 2,121,103, granted June 21, 1938. In Fig. 5 of the latter there is shown an FM detector which can be employed in the rectangle noted as 50 in Fig. 5.

In FM detection the audio modulation voltage corresponds to a variable frequency of the carrier. In other words, the FM detector input circuit must be accurately tuned to the midband frequency or unmodulated I. F. value, and frequency deviations from this value, which deviations are the frequency modulation swings of the carrier caused by the audio modulation, are converted into uni-directional voltages of a magnitude and polarity depending on the amount and direction of frequency swing. In Fig. 5 the graph above the rectangle 50 shows this type of characteristic wherein frequencies as abscissae are related to uni-directional voltages as ordinates. Obviously in this type of receiver it is essential that the I. F. energy applied to the FM detector have a mean frequency which is exactly equal to the predetermined I. F. value. Should the mean frequency be different from the predetermined I. F. value, then serious distortion will result.

Hence, the upper end of resistor 51 is connected through a filter comprising series resistor 60 and shunt condenser 61 to the grid 11 of the indicator tube. It will be understood that since the voltages across resistors 51 and 52 are in opposition, then the potential of point 70 will vary in polarity and in magnitude insofar as the direct current component of voltage is concerned depending on the frequency deviation of the applied I. F. energy. The grid 11 of the indicator tube, is also, connected to a biasing source 80 by means of an adjustable tap 81 so as to provide a normal bias for the grid. In other words, it is desired to provide a normal bias for the grid 11 such that exact tuning of the receiver will be indicated say, for example, by the pattern shown in Fig. 4c. Employing the indicator tube shown in Fig. 1, the shadow area 22 and the luminescent overlap area will be of substantially equal magnitude when the applied I. F. energy has a mean frequency exactly equal to the predetermined I. F. value. In other words, in that case the FM receiver will be exactly tuned to the desired station frequency.

If, now, the receiver is detuned from the exact station frequency, either in one direction or in another, the direct current voltage developed at point 70 in Fig. 5 will either cause the shadow 22 to assume the appearance shown in Fig. 4b, or it will assume the appearance shown in Fig. 4d. In the case of 4b the shadow 22 will increase in magnitude because the grid 11 of the indicator tube assumes a more positive potential with respect to the normal negative bias applied to the grid.

In the case of Fig. 4d the shadow area 22 will become small because the point 70 in Fig. 5 assumes an increased negative potential with respect to the normal bias applied to grid 11. It is not believed necessary to explain in any further detail the construction of an FM receiver, it being only pointed out that the discriminator would be preceded by a limiter tube which functions to eliminate any amplitude modulation peaks which may appear on the frequency modulated I. F. wave and also to provide AVC potentials. It will now be appreciated that the present invention has particular value in the case of tuning an FM receiver, because in the past it has been thought necessary to provide a double shadow indicator tube for such purpose and to provide a phase inverting circuit for the other indicator so that a detuned condition would cause one shadow to increase and the other to decrease. According to my present invention a single shadow area is employed to indicate the direction and extent of mistuning, and what is most important the simplification is accomplished with a minimum change in existing indicator tube construction and no increased circuit complication.

While I indicated and described several systems for carrying my invention into effect, it will be apparent to one skilled in the art that my invention is by no means limited to the particular organizations shown and described, but that many modifications may be made without departing from the scope of my invention, as set forth in the appended claims.

What I claim is:

1. In an indicator tube of the type provided with at least a source of electrons, a fluorescent target at a positive potential and solely a single electron control electrode disposed in the path of electrons flowing to the target thereby to provide a shadow area on said target; the improvement which comprises said control electrode having a control surface inclined to the stream of electrons and target to an extent such that the shadow area edges overlap progressively for varying control electrode voltages whereby the position of the point of intersection of said edges indicates said varying voltages, means to apply a bias to said control electrode to provide a predetermined point of intersection of said edges, and additional means for varying the voltage of the control electrode relative to said bias.

2. An indicator tube of the type provided with at least a source of electrons, a fluorescent target at a positive potential and an electron control electrode disposed in the path of electrons flowing to the target thereby to provide a shadow area on said target; the improvement which comprises said control electrode having a variable cross-section such that the shadow area edges overlap progressively for varying control electrode voltages whereby the position of the point of intersection of said edges indicates said varying voltages and means for varying the direct current

voltage of the control electrode over a wide range of voltage values thereby to provide said variable point of intersection.

3. In an indicator tube of the type provided with at least a source of electrons, a fluorescent target at a positive potential and an electron control electrode disposed in the path of electrons flowing to the target thereby to provide a shadow area on said target; the improvement which comprises said control electrode being positioned in an inclined position to the stream of electrons and target to an extent such that the shadow area edges overlap progressively for varying control electrode voltages whereby the position of the point of intersection of said edges indicates said varying voltages and means for adjusting the normal voltage of the control electrode so that for a predetermined minimum voltage of the latter said point of intersection is halfway between the limits of travel of the point.

4. In a visual voltage indicator of the type comprising a tube provided with at least a cathode, an anode surrounding the cathode and having its interior surface coated with a fluorescent material whereby electrons from the cathode produce a luminous pattern on the anode, a control element positioned between the anode and cathode for providing a shadow area in said pattern, means for applying voltage of variable magnitude to said control element, and said control element having its control surface inclined to the stream of electrons and said anode to an extent such that the shadow area edges progressively overlap as said voltage increases and means to bias the control element to establish a predetermined point of intersection of the shadow edges as a reference point.

5. In an indicator tube of the type provided with at least a source of electrons, a fluorescent target at a positive potential and an electron control electrode disposed in the path of electrons flowing to the target thereby to provide a shadow area on said target; the improvement which comprises said control electrode being positioned at a substantial incline relative to the stream of electrons and target whereby the shadow area edges overlap progressively for varying control electrode voltages whereby the position of the point of intersection of said edges indicates said varying voltages, means responsive to voltages variable over a wide range of values for varying the bias of said control electrode thereby to adjust the said point of intersection, and said responsive means including a voltage amplifier section in said tube.

6. A tuning indicator, adapted for use in a frequency modulation receiver of the type having a detector whose output voltage varies in magnitude and polarity with deviation of signal energy from a mean frequency, comprising a tube having at least a cathode, a fluorescent anode and a control rod, means applying said voltage to said rod, said rod being located in the path of electrons flowing to the anode thereby to provide a shadow area on the fluorescent anode, said rod having its control surface at a sufficient incline relative to said path and anode to cause said shadow area edges to overlap progressively in response to change in said voltage, and means for establishing a normal voltage for the rod such that the point of intersection of the edges is substantially halfway between the limits of travel of the point.

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