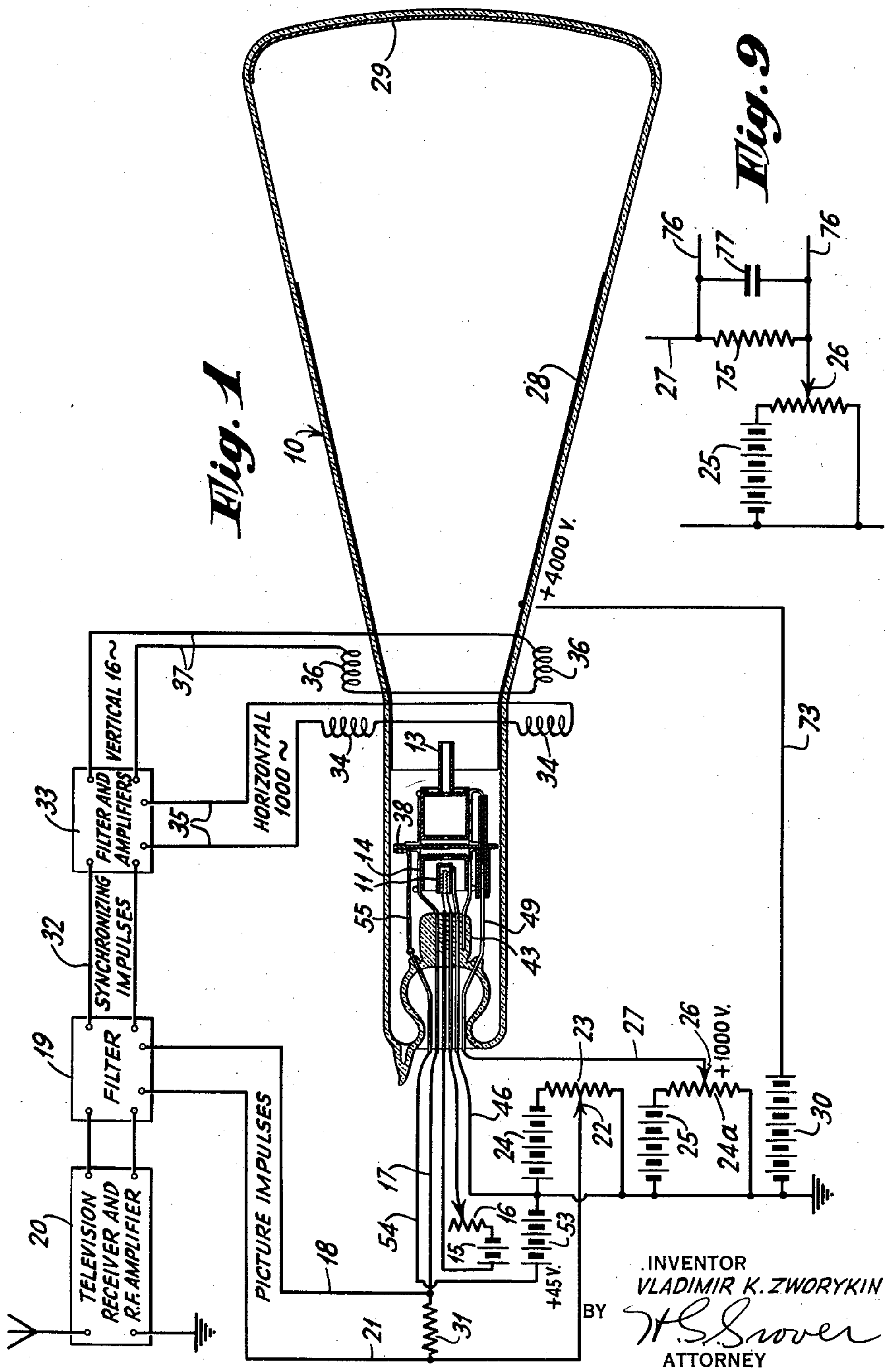
July 15, 1941. V. K. ZWORYKIN 2,249,552

ELECTRON TUBE

Original Filed Dec. 24, 1930 4 Sheets-Sheet 1




.INVENTOR
VLADIMIR K. ZWORYKIN
BY H. S. Grover
ATTORNEY

July 15, 1941. V. K. ZWORYKIN 2,249,552

ELECTRON TUBE

Original Filed Dec. 24, 1930 4 Sheets-Sheet 2

Fig. 2

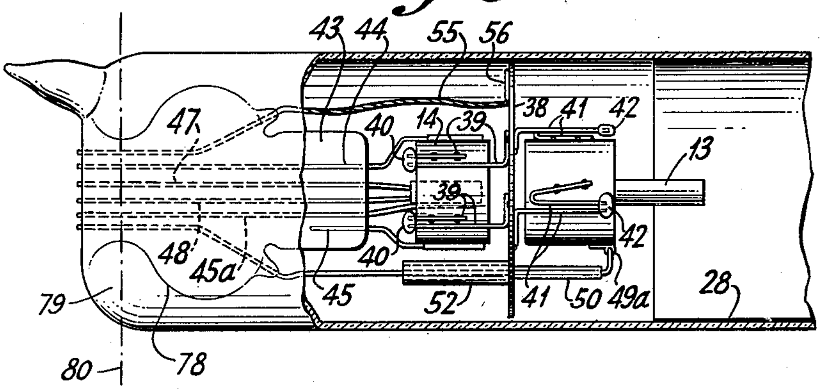
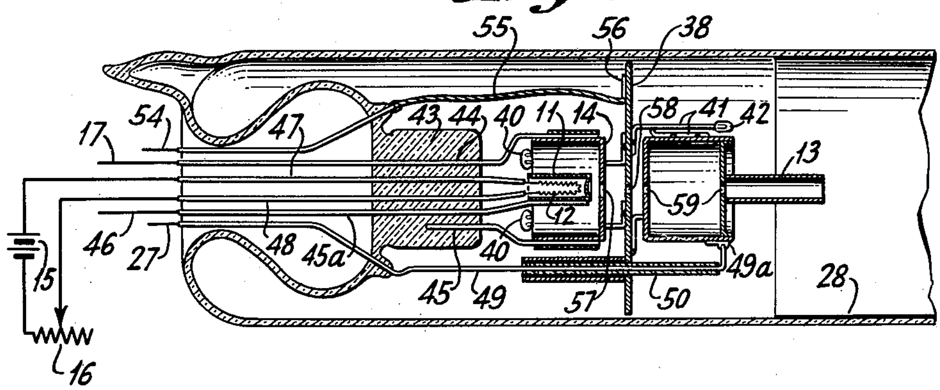



Fig. 3




INVENTOR
VLADIMIR K. ZWORYKIN
BY H. S. Grover
ATTORNEY

July 15, 1941. V. K. ZWORYKIN 2,249,552

ELECTRON TUBE

Original Filed Dec. 24, 1930 4 Sheets-Sheet 3

Fig. 4

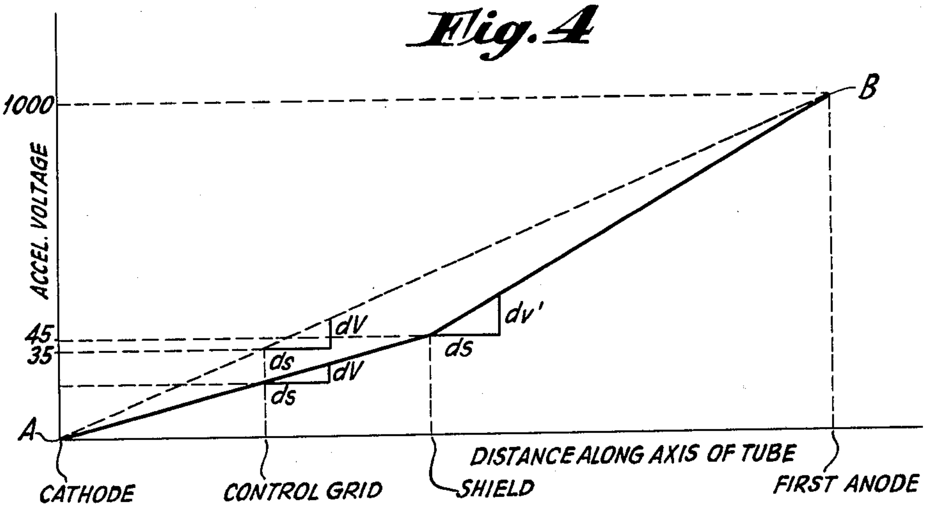
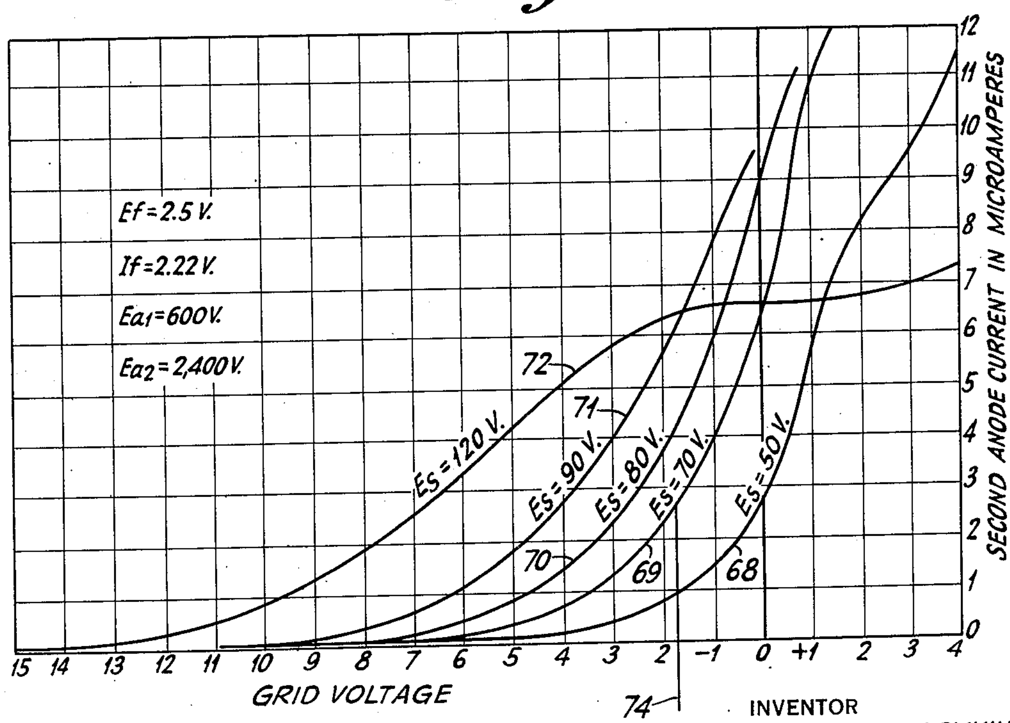



Fig. 8




INVENTOR
VLADIMIR K. ZWORYKIN
BY H. S. Grover
ATTORNEY

July 15, 1941. V. K. ZWORYKIN 2,249,552

ELECTRON TUBE

Original Filed Dec. 24, 1930 4 Sheets-Sheet 4

Fig. 5

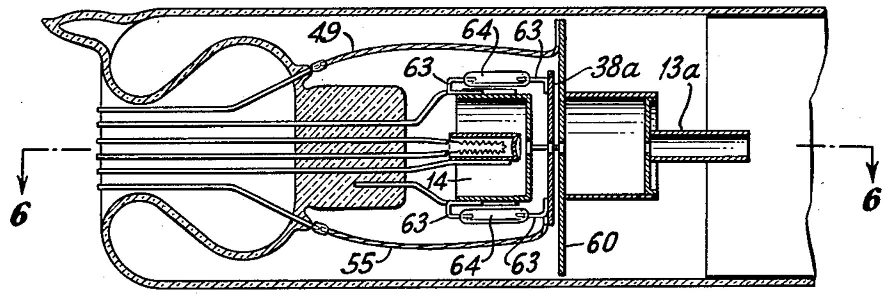



Fig. 6

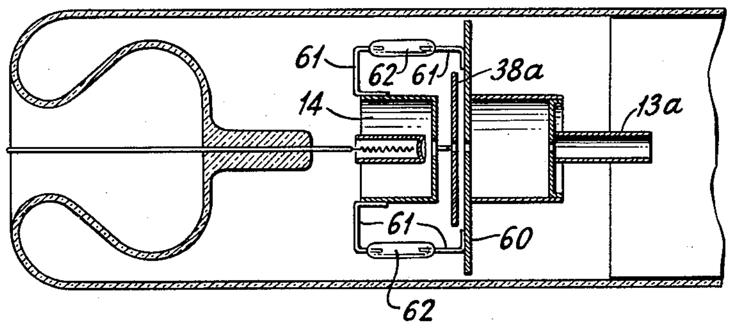
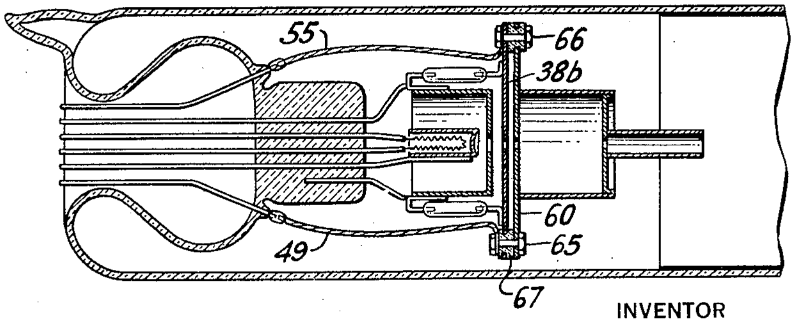



Fig. 7




INVENTOR
VLADIMIR K. ZWORYKIN
BY W. S. Grover
ATTORNEY

# UNITED STATES PATENT OFFICE

2,249,552

## ELECTRON TUBE

Vladimir K. Zworykin, Philadelphia, Pa., assignor to Radio Corporation of America, a corporation of Delaware

Original application December 24, 1930, Serial No. 504,559. Divided and this application June 21, 1937, Serial No. 149,463

6 Claims. (Cl. 250—27.5)

My invention relates to improvements in television systems and electron tube apparatus therefor, and forms a division of my copending application Serial No. 504,559, filed December 24, 1930, and granted on June 22, 1937, as U. S. Patent No. 2,084,364.

In television receiving systems proposed heretofore, and in which a cathode ray tube, of the general type disclosed in my copending application Serial No. 407,652, filed Nov. 16, 1929, now United States Patent No. 2,109,245, is utilized, the received picture impulses are impressed on the grid of the tube to control the intensity of the ray in accordance with conditions of illumination of the individual spots or regions making up the object at the transmitter. The electrons making up the ray move from the cathode, and pass through a relatively small aperture in the control grid to the so-called first anode of the tube, from whence they are directed toward a fluorescent screen at the larger end of the tube. The electrons are caused to travel from the cathode to the first anode at a relatively high velocity, which is increased or stepped up to a much higher velocity by a second anode which, for this purpose, has in some cases been maintained at a positive potential of about 4,500 volts, the first anode, in such cases, being maintained at a positive potential of about 1,000 volts. The relatively high volatge gradient along the axis of the tube between the cathode and the first anode, corresponding to conditions whereat the potential on the first anode is maintained at about 1,000 volts, has heretofore made necessary the provision for relatively high voltages on the grid to control the cathode ray completely, the voltage variation lying in a range between 30 and 45 volts.

For the purpose of providing for these relatively high grid-control voltages, it has been necessary to utilize high gain audio amplifiers in the radio receiver. These amplifiers are expensive, and furthermore, operate to distort the received picture appreciably.

In the various constructions of cathode ray tubes used heretofore in television receiving systems, the maximum effect or influence of the electrons making up the cathode ray has not been effective with respect to the fluorescent screen to develop the light image. This is attributed to substantial leakage of electrons from the cathode to the second anode, around the first anode. That is, in these cathode ray tubes constructed heretofore, the electrons, after passing through the control grid, have a more or less pronounced tendency to depart from their path of travel in the ray and take a new path of travel around the first anode instead of passing through the anode aperture for effective impact with the fluorescent screen.

With the foregoing in mind, it is one of the objects of my invention to provide an improved television system of the general character referred to, and apparatus therefor, wherein the grid voltage for complete control of the cathode ray is substantially lower than that required in the various systems proposed heretofore, the grid voltage in the present improved system being sufficiently low to permit direct connection of the control grid with the radio receiver and the associated radio-frequency amplifier, thereby obviating the high-gain, expensive and troublesome audio amplifiers required in the systems of the prior art.

Another object of my invention is to provide an improved television system, of the general character referred to, wherein the cathode ray tube, forming part of the system, functions as its own detector of the incoming modulated carrier wave to supply picture impulses to the control grid, and, if desired, to supply simultaneously the synchronizing impulses to the electromagnetic or other means for causing the ray to scan the fluorescent screen structure.

Another object of my invention is to provide an improved television system of the general character referred to, which has advantages over the various systems proposed heretofore in the way of simplicity, cost of manufacture and electron control.

Another object of my invention is to provide improved cathode ray apparatus of the general character referred to wherein the percentage of electron leakage from the cathode to the second anode, around the first anode, is practically negligible, so that there is substantially maximum efficiency in the way of complete utilization of the electrons for the purpose of developing the light image on the fluorescent screen.

Other objects and advantages will hereinafter appear.

In accordance with my invention, the voltage gradient along the axis of the cathode ray tube, from the cathode to the first anode, is made to vary, the arrangement being such that the voltage gradient is relatively low at the region where the electrons pass through the aperture in the control grid, thereby permitting of complete control of the ray by an input voltage substantially lower than has been possible heretofore.

More particularly, in accordance with my invention, an auxiliary anode, in the form of an apertured shield maintained at a positive potential substantially below that of the anode of the electron projector, is interposed between this anode and the control grid of the projector.

My invention resides in the features of constructions, proportionment, arrangement and combination of the character hereinafter described and claimed.

For the purpose of illustrating my invention, an embodiment thereof is shown in the drawings, wherein

Figure 1 is a diagrammatic view of a television receiving system embodying the present improvements, one of the parts being shown on an enlarged scale in sectional elevation;

Fig. 2 is an enlarged fragmentary view, partly broken away, of the smaller end of a cathode ray tube forming part of the present improved television system;

Fig. 3 is an enlarged fragmentary view taken from Fig. 1;

Fig. 4 is a graphical representation of the voltage gradient along the axis of cathode ray apparatus constructed and operated in accordance with my invention;

Fig. 5 is a view similar to Fig. 3, showing a modification;

Fig. 6 is a section taken on the line 6—6 in Fig. 5;

Fig. 7 is a view similar to Fig. 3, showing another modification;

Fig. 8 is a graphical representation of characteristics of operation of cathode ray apparatus constructed and operated in accordance with my invention; and

Fig. 9 is a diagrammatic, fragmentary view, showing a modification.

With reference to Fig. 1, the cathode ray tube 10 is provided at the smaller end thereof with an electron projector of the general type disclosed in my copending application referred to, and including a cathode 11 and a heating filament 12 therefor, an anode 13, and a control grid 14 interposed between the cathode and the anode. The anode 13 of the electron projector is commonly referred to as the first anode of the cathode ray tube.

The filament is supplied with heating current by a battery 15 under control of an adjustable resistance 16.

For the purpose of controlling the intensity of the cathode ray in accordance with the received picture impulses, the grid 14 is connected by a lead 17 to an output lead 18 from a suitable filter 19 effective to filter out the picture impulses from a receiver 20 which includes a radio-frequency amplifier of usual type. The other output lead 21 of the filter terminates, as shown, at an adjustable contact 22 of a resistance 23 connected across a battery 24. By adjusting the contact 22, the relation between the potentials on the cathode 11 and grid 14 may be varied to suit particualr requirements.

It will be understood that the picture signals are transmitted on a carrier wave at a suitable frequency, and that the synchronizing impulses are transmitted with the picture frequencies on a carrier wave at a frequency beyond the band of picture frequencies. The filter 19 is a high-pass filter adjusted to pass to the filter 33 only the carrier wave modulated by the horizontal and vertical synchronizing impulses. The picture signals and the carrier wave modulated by the synchronizing impulses at 16 and 1,000 cycles, for example, are impressed across the resistance 31 by the connections 18 and 21 from the filter 19. The carrier wave modulated by the synchronizing impulses is demodulated in the usual manner by a demodulator which may be considered as being associated with the filter 33. The horizontal and vertical frequencies are then filtered one from the other by the filter 33 and utilized to synchronize the usual generators of saw-tooth current waves, which may also be considered as being associated with the filter 33. This part of the receiving system per se forms no part of my present invention, and is disclosed in more detail in my copending application referred to.

The resistance 24*a* connected across a battery 25 is provided with an adjustable contact 26 connected to the anode 13 by the connection 27, the contact being adjusted to impress the desired positive potential on the anode.

The tube 10 is provided with a second anode in the form of a silver or other metallic coating 28 on the interior of the tube. The second anode 28 operates to accelerate the electrons in their movement from the first anode 13 to the screen 29, and, also, causes the electrons to come to a good focus on the screen.

The desired positive potential is impressed on the second anode 28 by a battery 30.

A suitable grid leak 31 may be connected across the leads 18 and 21 from the filter 19.

The cathode ray is caused to scan the screen 29 by causing, for example, a saw-tooth current wave at 1,000 cycles to pass through the coils 34, and a saw-tooth current wave at 16 cycles to pass through the coils 36.

The system thus far described is of the same general type as that disclosed in my copending application, Serial No. 484,309, filed September 25, 1930, now U. S. Patent No. 1,955,899.

Coming now more particularly to the structural and electrical characteristics of my improved system to which are attributed the advantages referred to over the various systems proposed heretofore, reference is made to Figs. 2 and 3. An auxiliary anode, in the form of an apertured disc or shield 38, is interposed between the grid 14 and the first anode 13, and is supported and insulated from the grid by a plurality of wires 39 having their adjacent ends connected by glass beads 40, the other ends of these wires being connected respectively to the grid and shield by spot-welding, or in any other suitable manner. The first anode 13 is also supported from the grid 14, and is insulated from and held in spaced relation to the shield 38 by wires 41 having their adjacent ends connected by glass beads 42, the other ends of these wires being spot-welded to the shield and first anode, respectively.

The assembly, comprising the grid 14, the first anode 13, and the shield or auxiliary anode 38, is supported from the press 43 by wires 44 and 45 secured to the grid in any suitable manner such as by spot-welding. The wire 44 extends entirely through the press 43, as shown, for convenient connection with the lead 17.

In like manner, the cathode 11 is supported from the press 43 by the wire 45*a* extending through the latter for connection with the lead 46.

The heating filament is connected across and supported from the adjacent ends of the wires 47 and 48, which also extend through the press 43 for connection with the leads to the battery 15 and the resistance 16.

Connection is made with the anode 13 by the wire 49, which may be spot-welded thereto at the point 49a, which wire extends through a glass or other suitable insulating tube 50, and thence outwardly through the end wall of the tube 10 for connection with the lead 27 to the adjustable resistance contact 26. The insulating tube 50 extends through a suitable aperture in the shield 38, and operates to insulate the anode connection 49, which is at a relatively high potential, from the shield 38 and grid 14 which are at relatively low potentials.

A skirt or protective shield, in the form of a tube 52 of nickel or other suitable material, may be placed over that portion of the glass tube 50 on the grid side of the auxiliary anode 38, and may be welded or otherwise secured to this anode.

The shield or auxiliary anode 38 is connected to the positive side of a battery or other direct current source 53 by a lead 54 connected to a wire 55 extending through the end wall of the tube and spot-welded or otherwise electrically connected to this anode at a point 56.

In a television receiving system embodying the present improvements, and with which are obtained the advantages referred to, the diameter of the grid aperture 57 is approximately .085 inch, and the diameter of the auxiliary anode aperture 58 and the first anode apertures 59 is approximately .055 inch. In this system, the distance between the grid 14 and the auxiliary anode 38 is approximately .03 inch, the distance between the auxiliary anode 38 and the first anode 13 is approximately .09 inch, and the inside diameter of the small end of the tube 10 is approximately two inches. While these various dimensions are found to provide for satisfactory operation, it is to be understood that the same are not critical in any strict sense of the word, and may be varied within wide limits to suit different conditions.

In the system referred to, the battery 30 is such as to place the second anode 28 at a positive potential of 4,000 volts, the contact 26 is adjusted to place the first anode 13 at a positive potential of 1,000 volts, and the battery 53 is such as to place the shield or auxiliary anode 38 at a positive potential of 45 volts. With this arrangement or adjustment, a negative potential of approximately 3.5 volts is effective to completely cut off the ray.

In explaining the operating principle of my present improved system, reference is made to Fig. 4, wherein the values of accelerating voltage on the cathode beam are plotted against distance along the axis of the tube from the cathode 11 to the first anode 13. With the cathode 11 at zero potential, and the shield or auxiliary anode 38 at a positive potential of 45 volts, the voltage gradient along the axis of the tube at the region where the electrons pass through the aperture 57 in the control grid 14, at which region the electrons will be under the controlling influence of the grid, is expressed as

$$\frac{dv}{ds}$$

At this relatively low voltage gradient, the ray intensity can be completely controlled by an A. C. input voltage of approximately 2 volts.

After the electrons pass through and beyond the controlling influence of the grid 14, and reach the shield or auxiliary anode 38, the voltage gradient, which is expressed as

$$\frac{dv'}{ds}$$

increases sharply to a relatively high value as a result of the relatively great difference in potential between the shield and the first anode 13. Beyond the first anode 13, the voltage gradient is increased still further by reason of the high positive potential of 4,000 volts on the second anode 28.

From the foregoing it will be seen that the voltage gradient along the axis of the tube is increased in steps between the cathode 11 and the first anode 13. The relatively low velocity of the electrons, corresponding to conditions under which the voltage gradient is

$$\frac{dv}{ds}$$

leaves the electrons highly sensitive or responsive to control at the relatively low voltage on the grid 14, while the subsequent stepping up of the velocity of the electrons causes them to strike the fluorescent screen 29 at a tremendous velocity, the force of the impact being so high that the light or luminescence produced is ample for the development of an image of sufficient brilliancy.

Assuming that the shield or auxiliary anode 38 is ineffective or removed from the tube structure, it will be apparent from Fig. 4 that the voltage gradient along the axis of the tube between the cathode 11 and the first anode 13 will be constant and represented by the slope

$$\frac{dV}{ds}$$

of the broken line AB. Other conditions remaining the same in the system referred to, it will now require a negative potential as high as 35 volts to completely cut off the ray, and an A. C. input potential of about 12 volts to completely control the ray. For the purpose of obtaining this relatively high control voltage, it would be necessary to employ in the receiving system a high-gain audio amplifier, as heretofore.

Without the shield or auxiliary anode 38, therefore, the ratio of the first anode potential of 1,000 volts to the negative potential of approximately 35 volts on the control grid 14 for complete cut-off of the beam, is about 29, whereas this ratio in my present improved system, employing the shield 38, is substantially greater, and equal to

$$\frac{1000}{3.5}$$

or about 286. It is the relatively high value of this ratio in my present improved system which permits of satisfactory control of the beam intensity with a relatively low input voltage.

In this connection, I believe myself to be the first to provide a television receiving system of the character described wherein the ratio of the operating electrical potential on the first anode 13 to the negative potential on the grid for complete cut-off of the beam, is at least 35, or between 100 and 500.

Considering the operating characteristics of my present improved system from another aspect, I believe myself to be the first to provide a television receiving system of the character described wherein complete control of the ray is obtained by input voltages within the range of from 2 volts to 10 volts.

While definite values of potential on the control grid 14 and the anodes 13, 28 and 38 have been given, it is to be understood that this has been done only for the purpose of teaching the art operating conditions in a television receiving system constructed and adjusted in accordance with my invention, and not with the intention of limiting myself in the appended claims to these particular values. On the contrary, it is contemplated to vary these values of potential within wide limits to suit different operating conditions and requirements.

In the modification shown in Figs. 5 and 6, the anode 13*a*, corresponding to the anode 13 in Figs. 2 and 3, has an apertured base element 60 arranged transversely of the direction of travel of the ray and extending outwardly, as shown, beyond the body portion of the anode into close proximity to the interior wall of the tube. The anode 13*a*—60 is supported from the control grid 14 by the wires 61 having their adjacent ends connected by the glass beads 62. The shield 38*a*, corresponding to the shield 38 in Figs. 2 and 3, is supported from the grid 14 by the wires 63 and the interposed glass beads 64, and is of substantially smaller diameter than the anode base 60.

This construction permits of direct connection of the anode lead 49 with the outer edge portion of the base 60, without the necessity of this lead passing through and being insulated from the shield 38*a*, as in Figs. 2 and 3. It is to be noted that the wires 61 and the associated glass beads 62 for supporting the anode element 60 from the grid 14, are disposed entirely on the cathode side of this element. This construction eliminates the possibility of such supporting means interfering with focusing of the electrons to a small spot on the screen 29.

The construction in Fig. 7 is substantially the same as that in Figs. 5 and 6, except that the shield 38*b* corresponding to the shield 38*a*, is of the same diameter as the anode base 60. The anode is secured to the shield 38*b* by bolts 65 and 66 which pass through an interposed spacing ring 67 of soapstone or other suitable insulating material. The anode lead 49 in this construction may be connected to the bolt 65, and the lead 55 to the shield 38*b* may be connected to the bolt 66, for which purpose the bolt 65 is in electrical contact with the base 60 and insulated from the shield 38*b*, while the bolt 65 is in electrical contact with the shield and insulated from the base 60.

It is to be noted that in the construction shown in Figs. 2 and 3, the shield 38 has a diameter only slightly less than that of the neck of the tube 10, so that the shield extends well out beyond the anode 13 into close proximity to the wall of the tube. This construction is believed to contribute materially toward more efficient shielding of the anode 13 by the shield 38, which appears to give the tube such desirable characteristics that the same can function as its own detector when embodied in a television receiving system as shown in Fig. 1.

With reference more particularly to the wide range of voltages possible on the control grid 14, the first anode 13, the second anode 28, and the shield or auxiliary anode 38, Fig. 8 shows the characteristics of a cathode ray tube constructed in accordance with my present invention, and which is identified as No. 187. In this figure, the curves 68, 69, 70, 71 and 72 were obtained by plotting on the vertical axis the current in the connection 73 from the second anode 28, and by plotting on the horizontal axis the D. C. polarizing voltage on the grid 14. The curves 68 to 72 show the characteristics of the tube with the potentials $E_s$ of the shield or auxiliary anode 38 at 50, 70, 80, 90 and 120 volts, respectively.

During the tests made for the purpose of obtaining the necessary data for these characteristic curves, the resistance 16 was adjusted so that the supply voltage $E_f$ for the filament was 2.5 volts, under which condition the filament current $I_f$ was 2.22 amperes. The potential $EA_1$ on the first anode 13 was 600 volts, and the potential $EA_2$ on the second anode 28 was 2,400 volts.

With the shield potential $E_s$ at 70 volts, the D. C. polarizing voltage on the control grid 14 was found to be best, for this particular tube, at about 1.5 to 2.0 volts, as indicated by the grid voltage line 74. Under these conditions, the voltage variation on the control grid for complete control of the beam, would lie approximately within the range from 1 volt positive to 4.5 volts negative.

With the shield potential $E_s$ at 110 volts, the bias on the control grid 14, for this particular tube, was found to be best at about 5 volts. Under these conditions, the voltage variation on the control grid for complete control of the beam, would lie approximately within the range from zero to 10 volts negative.

With the shield potential $E_s$ above 110 volts, for example at 120 volts, as shown by the curve 72, the maximum illumination of the screen 29 was less than the illumination at conditions as represented, for example, by the curves 69, 70 and 71, and corresponded to a second anode current of about 6.6 microamperes.

The reason for this is due to the fact that, with the shield potential as high as 120 volts, there is only a relatively small increase in the second anode current during the periods of time the grid 14 swings in a positive direction, because the limit of electron emission from the cathode has been reached. This phenomenon is illustrated by the curve 72, from which it will be seen that at a grid potential of about 2.0 volts negative, the curve bends sharply into an almost horizontal slope. On the other hand, it will be seen from the curves 69, 70, and 71, for example, that for lower values of shield potential, the slope of the characteristic curve is relatively sharp throughout the entire operating range of the grid voltage variation.

The data obtained in the tests referred to indicates that for the particular tube tested, having approximately the dimensions given above, most efficient operation is to be obtained by an adjustment or arrangement whereat the potential on the shield or auxiliary anode 38 is 100 volts, and the bias on the control grid 14 at about 4 to 6 volts negative, with a variation in the picture impulse potential within a range of 8 to 10 volts for complete control of the beam. Under these conditions, the cathode ray apparatus operates on the straight-line portion of the curve, and, accordingly, functions as an amplifier, in which case a suitable detector is interposed between the R. F. amplifier and the apparatus 19 to rectify the picture modulations on the carrier wave.

On the other hand, it will be seen from the characteristic curves of Fig. 8 that if the grid bias is so selected that the lower bend of the curve is utilized, rectification, due to assymetric conduction, will take place in the control grid circuit. This inherent rectifying action places the desired signal voltage upon the control grid in a manner identical to that of an external detector. The control grid 14 is then connected directly to the output of the R. F. amplifier, no external detector being required. That is, the connections 18 and 21 would connect directly with the connections shown between the receiver 20 and the filter 19.

The degree of brightness, and character, generally, of pictures received with cathode ray apparatus constructed in accordance with my present invention is substantially better than the degree of brightness and general character of the pictures received with such apparatus constructed heretofore. This is partly attributed to the effect or influence of the shield or auxiliary anode in substantially eliminating electron leakage between the cathode and second anode. The shield or auxiliary anode in the present improved construction, therefore, assures substantially maximum efficiency in the way of complete utilization of the electrons for the purpose of impact with the fluorescent screen 29 to develop the light image.

An important function of the shield 38 is that substantially all of the lines of electrostatic strain, which would otherwise exist between the grid 14 and the anode 13 under operating conditions, terminate on the shield, which is at substantially ground potential for alternating current. This shield 38, therefore, substantially eliminates capacity coupling between the grid and anode, so that any effective impedance appearing in the first anode circuit will not be reflected into the control grid circuit of the tube 10. Therefore, when my improved cathode ray tube is used in place of a detector following the R. F. amplifier, the shield 38 prevents the effect of increased input capacitance due to reflected plate impedance, which would otherwise occur.

Furthermore, when a radio-frequency circuit feeds the tube 10, the overall gain from the antenna to the control grid 14 is considerably greater than would be the case if shield 38 were not present.

Fig. 9 shows a modification of the system in Fig. 1 in which the cathode ray tube not only functions as its own detector of the picture impulses, but also simultaneously detects the synchronizing impulses for the deflecting coils 34 and 36. For this purpose, the bias on the grid 14 is such that the tube operates on the lower bend of the characteristic curve. No external detector is required. The filter 19 is omitted, and the leads 18 and 21 connected directly to the R. F. amplifier contained in receiver 20. A resistor 75, shunted by a suitable by-pass capacitor 77, is connected as shown in the return lead 27 from the first anode 13. The two leads 32, previously connected to the filter 19, are now connected to the leads 76 from the ends of resistor 75. With these modifications of the system in Fig. 1, the detected picture and synchronizing impulses appear across the resistor 75. The capacitor 77 permits the relatively high frequency picture impulses to pass to the grid 14, while the synchronizing impulses at 16 and 1,000 cycles, respectively, are fed to the filter 33 by way of the leads 76.

In manufacturing the cathode ray tube, the ray-projector assembly, before insertion into the open neck of the tube 10, includes the base portion 78 provided with a flange or rim 79 extending radially outwardly therefrom. After insertion of this assembly into the open neck of the tube, the edges of the rim 79 and the neck of the tube are fused together, the line of connection being indicated by the broken line 80 in Fig. 2. The tube is then highly evacuated and sealed off.

By the term "ray cut-off", is meant the condition at which the electron ray is so diminished that no spot of light is perceptible on the screen structure 29.

Having described my invention, what I claim is:

1. A cathode ray tube comprising an electron gun having an electron emitting element, an apertured control electrode and an apertured first anode, each positioned in axial alignment and longitudinally spaced one from the other, a target member supported in the opposite end of the tube from said electron gun assembly, and an apertured shielding electrode positioned intermediate the control electrode and the anode, said shielding electrode extending transversely beyond the transverse extremities of each of said control electrode and said anode and a second anode intermediate the first anode and the target.

2. A cathode ray tube having an envelope, including at one end thereof, an electron gun assembly comprising an electron emitting cathode, an apertured control electrode, and an apertured first anode, each of said elements being positioned in axial alignment and progressively spaced from each other in a longitudinal direction, a target member positioned substantially at the end of the envelope opposite the electron gun, a second anode intermediate the first anode, and the target and an auxiliary shielding electrode interposed between the control electrode and the anode, said shielding electrode having an aperture axially aligned with the apertured control electrode and anode, and said shielding electrode extending transversely of the tube substantially to the tube wall.

3. A cathode ray tube comprising an envelope having a necked portion, wherein is supported an electron gun assembly, said electron gun assembly comprising an electron emitting cathode, a control electrode having an aperture through which the emitted electrons pass, and a first anode electrode also having an aperture axially aligned with the control electrode aperture and longitudinally spaced from said control electrode and said electron emitting cathode, whereby upon the application of suitable voltages between the said anode and cathode an electron beam is developed, a target member supported in the opposite end of the envelope for receiving the developed electron beam, a second anode intermediate the first anode and the target, and a shielding electrode positioned between the control electrode and the first anode, said shielding electrode being of disk formation and extending substantially transverse of the necked porion of the tube and substantially to the tube wall, said shielding electrode also having an aperture axially aligned with the apertures of the control electrode and the anode.

4. An electron tube comprising an enclosing envelope having a stem member at one end thereof, a plurality of support members secured within the stem portion of the envelope and protruding inwardly of the envelope, a cold electrode member supported rigidly from the inwardly extending support members and a cathode member

also positioned within said envelope and at least partially surrounded by the rigidly supported cold electrode, and a plurality of additional cold electrodes rigidly supported from the first named cold electrode independently of the support stem and in coaxial relationship with the first named electrode and the cathode.

5. An electron tube comprising an enclosing envelope having a stem member at one end thereof, a plurality of support members secured to the stem portion of the envelope and protruding inwardly of the envelope, a cold electrode member supported rigidly from the inwardly extending support members and a cathode member also positioned within said envelope and at least partially surrounded by the rigidly supported cold electrode, and a plurality of additional cold electrodes rigidly supported from the first named cold electrode independently of the support member and in coaxial relationship with the first named electrode and the cathode.

6. The method of adjusting the preliminary concentration of an accelerated bundle of cathode rays to be afterwards focussed to produce an electron image in a receiving plane, more particularly in a television tube, by adjusting independently from the subsequent focussing, the speed to which the electrons forming the bundle are first accelerated.

VLADIMIR K. ZWORYKIN.