

April 12, 1938.

J. C. BATCHELOR

2,114,136

CATHODE RAY TUBE

Filed Jan. 6, 1932

Fig. 1.

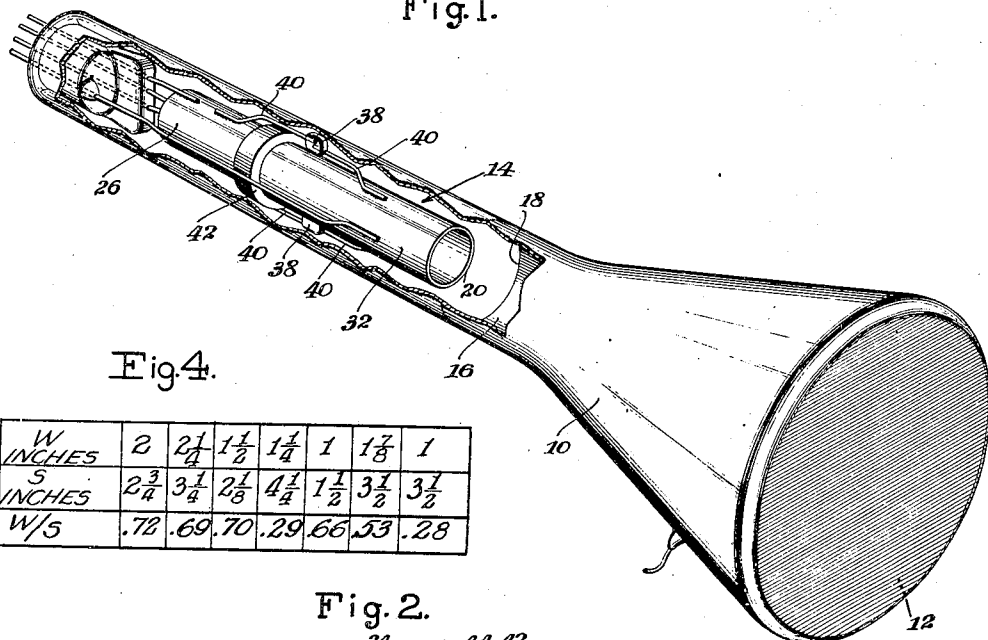


Fig. 4.

W	2	2 1/4	1 1/2	1 1/4	1	1 7/8	1
INCHES							
S	2 3/4	3 1/4	2 1/8	4 1/4	1 1/2	3 1/2	3 1/2
INCHES							
W/S	.72	.69	.70	.29	.66	.53	.28

Fig. 2.

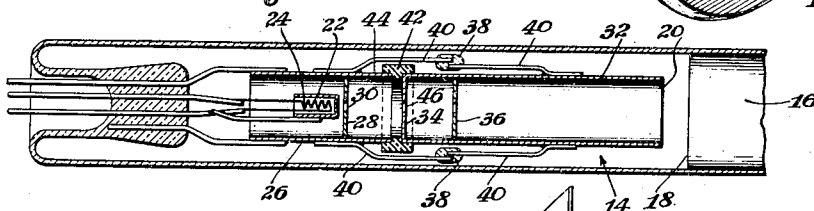
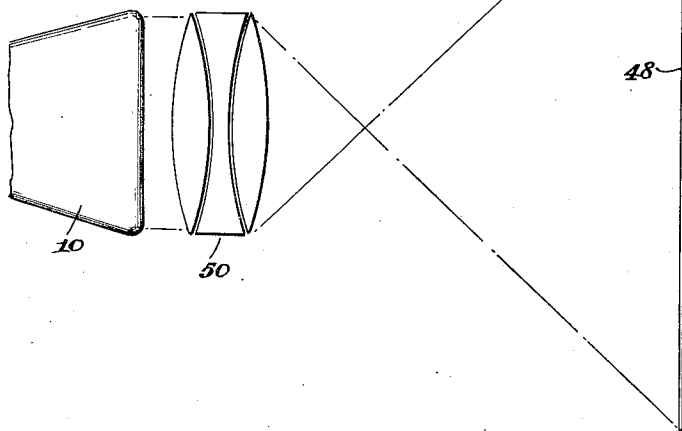


Fig. 3.



INVENTOR.
John C. Batchelor
BY *J. R. Goldsborough*
HIS ATTORNEY.

UNITED STATES PATENT OFFICE

2,114,136

CATHODE RAY TUBE

John C. Batchelor, Edgewater Park, N. J., assignor
to Radio Corporation of America, a corporation
of Delaware

Application January 6, 1932, Serial No. 584,924

19 Claims. (Cl. 250—27.5)

My invention relates to improvements in television systems, and, more particularly, to those of the type wherein a cathode ray tube is utilized for reproducing an image of the object at the transmitting station.

In practically all of the various prior art television systems embodying a cathode ray tube for picture reproduction, and which have met with any degree of success in the way of reproducing an image having a fair degree of detail, the size of the image, or the frame, has been limited to small dimensions of the order of three or four inches. This has been due to phenomena, which are well known and which must always be taken into consideration in determining upon the practical design of the systems. These phenomena are such that one works against the other in a way that if the design is changed to make the operation conditions such that, other things being equal, a larger and more brilliant image would be produced, conditions would then be such that the other phenomena would change conditions so that the system would, in effect, be inoperative. In other words, it has been found that in each of the various systems proposed heretofore, it is not merely a question of changing the dimensions of certain parts, or of increasing or decreasing the values of the operating potentials on the various electrodes or other electrical parts in the different circuits, or of changing one or more of the various materials making up some of the parts.

With the foregoing in mind, development work in this art has been directed toward the ultimate goal, that is, the reproduction by a cathode ray tube of an image of sufficient size and brilliancy to be comparable with that on the moving picture screen.

In taking up this problem, the various phenomena which have been found to, we will say, interfere with the desired operating action, might be summarized as follows.

In the cathode ray tubes employed heretofore, the light or brilliancy developed by fluorescence of the usual fluorescent screen, upon scanning thereof by the electron ray, is decidedly inadequate for projection on a screen over an area substantially larger than the area of the fluorescent screen. As a matter of fact, the projected image is visible only as a light haze over the screen. Even assuming that the brilliancy or the available light could be used, and the image projected, the lenses comprising the optical system for such purpose would be so large and expensive as to make this alternative prohibitive for commercial exploitation of the systems. It has been proposed to decrease the angle thru which the ray is deflected to decrease materially the size of the image developed on the fluorescent screen and thus increase the overall brilliancy proportionally, but, as in the many and various solutions proposed

heretofore, other phenomena make this solution of the problem impractical. In this case, the difficulty resides in the fact that focusing of the electron ray to a correspondingly smaller spot does not accompany the decrease referred to in the deflection angle, so that upon materially decreasing the size of the image, the picture detail is practically destroyed.

The problem, then, would seem to resolve itself into one of focusing the ray of electrons to a sufficiently fine spot on the screen. Of the two known methods of doing this, one comprises the use of electromagnetic coils for developing a magnetic field whose lines of force take the general direction of the desired travel of the electrons. Experiment has shown that by varying the magnetomotive force or excitation of these coils the point of focus along the axis of the tube can be varied correspondingly over a substantial range. It has been determined that, in focusing by this method, the path followed by any electron in the ray is generally parabolic, and that the point at which the parabola intersects the axis of the tube changes with variation in the magnetomotive force in the coils. The magnetomotive force necessary for this, however, seriously interferes with the deflection of the ray for scanning the screen. This difficulty, in fact, is so serious from a commercial standpoint as to make this solution of the problem impractical.

The other method of focusing the electrons comprises the use of an electrostatic field. In a practical way, this has been accomplished by providing the cathode ray tube with a second anode in the form of a silver coating on the inside surface of the large end of the tube, and maintaining this anode at a relatively high potential. In this method, it has heretofore been believed and taken as an established fact that the paths followed by the electrons have been substantially the same as in magnetic focusing, that is, generally, parabolic. For this reason, in the various systems proposed heretofore using electrostatic focusing, development work with a view toward greatly decreasing the size of the image and still retaining the same degree of detail, has been confined largely to modification or modifications of the electron gun. This expedient, however, has failed as an answer to the problem of obtaining a very small and very brilliant image on a fluorescent screen and which has the same or even better detail as the larger and substantially less brilliant images obtained heretofore on the fluorescent screen.

With all the foregoing in mind, it is one of the objects of my invention to provide an improved television system, embodying a cathode ray tube wherein the size of the image is greatly reduced and very brilliant to make possible projection of the image on a screen many times the size of the

area of the fluorescent screens in the various cathode ray tubes proposed heretofore, while still retaining good picture detail.

Other objects and advantages will hereinafter appear.

In accordance with my invention, the advantages and improvements referred to are obtained by placing the fluorescent screen in a plane located along the axis of the tube at a point where minimum opportunity is presented for the electrons, by their mutual repulsion with respect to each other, to force themselves into a beam of relatively large cross-section. In other words, the disposition of the fluorescent screen, in my improved apparatus, is such that the electrons, by their mutual repulsion with respect to each other, are not given the opportunity of displacing themselves any appreciable distance laterally from the axis of the ray, the final result being that at the point of impact with the screen, the cross-section of the ray is very small, and the light spot developed is therefore very intense and sufficiently well-defined to provide for good picture detail in a very small frame having an area of the order of one to two square inches. I attribute this result to the possible fact that, in focusing the ray by an electrostatic field, the electrons do not, as previously believed, follow generally parabolic paths as in magnetic focusing, but, on the contrary, follow substantially straight paths which diverge from the source of development of the ray at the end of the usual electron gun and that, by reason of the disposition of the fluorescent screen in close proximity to the end of the gun, the electrons although constantly under the influence of the forces of repulsion between the same, do not have sufficient time to displace themselves laterally away from the axis of the ray. When the ray strikes the screen, therefore, the electrons are still closely spaced within substantially the same small areas as they are at the point of emergence from the gun.

My invention resides in the system, construction and method of operation hereinafter described and claimed.

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

Figure 1 is a perspective view, partly broken away, of a cathode ray tube constructed in accordance with my invention;

Fig. 2 is a central vertical sectional view through the small end of the tube in Fig. 1;

Fig. 3 is a simplified diagrammatic view of a television receiving system embodying the cathode ray tube shown in Fig. 1; and

Fig. 4 is a table of different dimensions and relations in as many different tubes embodying the spirit of my invention.

With reference to Figs. 1 and 2, a tube 10, having the general configuration shown, is provided at the large end thereof with a fluorescent screen 12 which may be applied in the manner disclosed in my co-pending application Serial No. 478,048, filed August 27, 1930, and assigned to the Radio Corporation of America. In the small end or neck portion of the tube, is disposed an electron gun designated generally by the reference numeral 14 and which operates to develop a ray of electrons and to direct the same at the screen 12. The tube is provided with a second anode in the form of a silver coating 16 on the interior surface of the tube from the edge portion of the screen 12 to a plane 18 in proximity

to or coincident with the plane 20 of the adjacent tip of the electron gun. In operation, this anode is maintained at a potential of approximately 4500 volts to accelerate the electrons so that they impact with the screen 12 at a relatively high velocity. This action contributes toward the desired condition of brilliancy.

In the disclosed practical embodiment of my invention, in which a picture has been projected from the fluorescent end of the tube onto a screen of substantially greater area, the large end wall structure of the tube is substantially flat, and approximately $2\frac{1}{4}$ " in diameter. The ray of electrons is deflected horizontally and vertically by the usual circuits and apparatus of the general character disclosed in the co-pending application of Arthur W. Vance, Serial No. 544,959, filed June 17, 1931, and assigned to the Radio Corporation of America, the adjustments and arrangements being such that the ray is caused to scan the fluorescent screen over an area of substantially one square inch.

One of the most important characteristics of my improved apparatus, whereby, under the conditions just described, satisfactory picture detail is obtained, resides in the fact that the fluorescent screen is disposed in a plane in close proximity to the plane 20 at the tip of the gun 14. In the practical embodiment disclosed, the distance between these two planes is approximately $3\frac{1}{2}$ ". In Figs. 1 and 2 of the drawing, the other dimensions are in proportion to the two dimensions given above.

In making my improved tube, the same is highly evacuated. In some cases, argon or any other suitable noble gas is introduced at a relatively low pressure.

The electron gun comprises a cathode 22 having the usual electron emitting surface, and heated by a suitable filament 24. A control electrode 26 is provided with an apertured disk 28, and is supported as shown with the aperture 30 in close proximity to the source of electron emission at the adjacent end of the cathode 22. The gun also includes a first anode in the form of a cylindrical tube 32 provided with the apertured disks 34 and 36 and which is supported from the control electrode 26 by a number of glass beads 38 and the associated wires 40 attached, as shown, to the parts.

For the purpose of maintaining alignment of the electrode 26 and the anode 32, an insulating spacing ring 42 is interposed as shown between the adjacent ends thereof, the ring being recessed, as shown, to receive the adjacent ends of these parts.

An important characteristic of my improved gun construction resides in the skirt portion 44 of the control electrode 26 which extends beyond the disk 28 with its edge in close proximity to the disk 34. In operation, during which the control electrode 26 has a negative bias of approximately 10 volts, and the first anode 32 is maintained at a positive potential of about 1000 volts, the skirt 44 provides for development, under such conditions, of an electrostatic field effective to focus the ray of electrons on the aperture 46 so that the greater percentage of electrons which issue from the aperture 30 pass through the aperture 46. This action, I have found, increases the efficiency of my improved electron gun from about 2 percent, as in the various guns proposed heretofore, to about 90 percent. In other words, by electrostatically focusing the ray of electrons on the aperture in the first disk of the first anode

32, the efficiency is increased many times. Furthermore, I obtain this advantage under conditions whereat the ray can be controlled by a relatively low voltage, that is, about 20 volts. The reason for this is that, in my improved tube, the velocity of the electrons at the point of control is relatively low.

The purpose and function of the argon or other noble gas when present, at the relatively low pressure in the tube, will now be explained. In understanding the operating action and the distinction generally over the various gas-filled cathode ray tubes proposed heretofore, such, for example, as is described in Patent No. 1,565,873 to Van Der Bijl, it is important first to understand the operating action and the theory of operation in the latter. In the various gas-filled tubes proposed heretofore, the gas introduced is at a relatively high pressure, that is, within such range and sufficiently high to focus the electrons in the manner explained in the patent referred to. The gas, however, in the prior art tubes having a control electrode for television purposes, causes velocity modulation of the ray when picture signals are applied to the control electrode, and this, in turn, seriously distorts the reproduced image on account of the fact that the deflection of the ray varies proportionately to the velocity. In my improved tube, the gas serves no purpose in the way of focusing the ray on the fluorescent screen for the reason that the pressure of the gas is relatively low and well below the pressure required to cause focusing. Furthermore, in my improved tube, the gas pressure is within a relatively low range and well below the point whereat any detrimental velocity modulation of the ray would occur. Coming now to the function of the gas in my improved tube at the relatively low pressure, it is found that the gas ions are effective to substantially entirely neutralize the space charges which would otherwise develop within the tube and, more particularly, within the electron gun. By neutralizing the space charges in this way, clouds of electrons which would otherwise form within the tube and which would, in effect, retard movement of the maximum amount of electrons through the tube, and in the beam, are removed.

In the practical embodiment disclosed, a current in the electron beam from one to two milliamperes has been obtained.

By reason of the construction and conditions described above, it is possible to project the image reproduced on the large end of the tube onto a screen 48 by means of a suitable lens system 50, the screen 48 having an area many times that of the fluorescent screen.

The present disclosure of a practical embodiment of my invention has been taken from a laboratory sample, identified by the designation #220.

As a result of the construction and testing of many tubes in accordance with the spirit of my invention, it has been definitely determined that the governing dimensions and the relation of these to each other can be varied over a substantial range, as might be required to suit particular requirements. For example, some of these tubes can be said to reproduce a satisfactory picture of 120 lines, whereas these same tubes would not be satisfactory for a picture of 240 or more lines. On the other hand, other tubes in this group can be said to reproduce a satisfactory picture of 240 or more lines, for projection onto an external and larger screen.

From the above it will be seen that in selecting the governing dimensions and the relation of these to each other, for a particular projection tube, the nature of the deflecting circuits to be employed must also be taken into account.

The governing dimensions and the relation of these to each other, in the tubes referred to above, are given in Fig. 4, wherein W is the maximum dimension in inches of the scanned area of the screen 12, and S is the distance in inches along the axis of the tube from the screen to the tip 20 of the electron gun.

I claim as my invention:

1. Cathode ray apparatus comprising an electron-emitting cathode, an anode provided with an apertured disk, and control-grid structure disposed between said cathode and said anode and provided with an apertured disk spaced from and aligned with the anode disk, part of the control-grid structure operating to focus the electrons issuing from said second-named disk onto the aperture in the anode disk.

2. In cathode ray apparatus an electron gun comprising electron control structure and anode structure in the form of aligned tubes supported in axially-spaced relation, an insulating ring interposed between the adjacent ends of said tubes and recessed on opposite sides to receive said ends with a snug fit, the tube constituting said control-grid structure provided with an apertured disk spaced from the ring end of such tube, the tube constituting said anode provided with an apertured disk substantially at the ring end of such tube, and an envelope within which the electron gun is disposed.

3. A cathode ray tube comprising screen structure, and a gun for developing a scanning ray and directing the same at said structure; characterized by the fact that in said tube there is the relation wherein

$$\frac{W}{S}$$

is in the range between 1 and .5, where W is the maximum dimension in inches of the area of said structure scanned by the ray and S is the distance in inches from said structure to the adjacent tip of said gun, and wherein S is of the order of four inches or less and at least equal to one and one half inches.

4. A cathode ray tube comprising screen structure, and a gun for developing a scanning ray and directing the same at said structure; characterized by the fact that in said tube there is the relation wherein

$$\frac{W}{S}$$

is in the range between .8 and .6, where W is the maximum dimension in inches of the area of said structure scanned by the ray and S is the distance in inches from said structure to the adjacent tip of said gun, and wherein S is of the order of 3½ inches or less and at least equal to one and one half inches.

5. A cathode ray tube of the character described comprising screen structure, and a gun for developing a scanning ray and directing the same at said structure; characterized by the fact that in said tube there is the relation wherein

$$\frac{W}{S}$$

is of the order of one or less, where W is the maximum dimension in inches of the area of said structure scanned by the ray and S is the dis-

tance in inches from said structure to the adjacent tip of said gun, and wherein S is of the order of 5 inches or less and at least equal to one and one half inches.

6. A cathode ray tube of the type provided with a fluorescent screen and an electron gun for developing an electron ray and directing it toward the screen, characterized by the fact that the maximum surface dimension in inches of the screen divided by the distance in inches from the screen to the adjacent tip of the electron gun gives a quotient of one or less, additionally characterized in that the area of the screen is within the range of from substantially one square inch to substantially four square inches and still further characterized in that the distance between the tip of the electron gun and the screen is of the order of four inches or less and is at least equal to one and one half inches.

7. Cathode ray apparatus including an electron gun constituted by an electron-emissive cathode, an electron-control electrode and an anode, the said control electrode and anode being in the form of aligned tubes supported in axially spaced relation and each being provided with a transversely disposed apertured disc, and the electron-control tube having a skirt portion extending beyond the control-tube disc and terminating in close proximity to the anode-disc, the said electron gun being mounted within a container capable of being evacuated.

8. The invention set forth in claim 7 characterized in that the anode tube is provided with at least one additional transversely disposed interior apertured disc in spaced relation to the first mentioned anode disc.

9. In combination, in a cathode ray tube, a tubular electron control electrode, a tubular anode coaxial with the control electrode, and means for insulatingly supporting the anode from the control electrode.

10. The invention set forth in claim 9 characterized in that the anode supporting means includes a tubular element of insulating material into opposite ends of which the control electrode and the anode, respectively, are telescoped.

11. The invention set forth in claim 9 characterized in that the anode supporting means includes an element affixed to and projecting exteriorly of the control electrode, an element affixed to and projecting exteriorly of the anode and insulating means interposed between said elements and affixed thereto.

12. The invention set forth in claim 9 characterized in that the anode supporting means includes a rod affixed to and extending exteriorly of the anode toward the control electrode, a rod affixed to and extending exteriorly of the control electrode toward the anode, and a glass bead interposed between the ends of the said rods and affixed thereto.

13. A cathode ray tube comprising a cathode, a grid having an apertured end wall, an anode having an apertured end wall confronting the end wall of said grid, yielding supporting wires which carry said grid and anode, and an insulating member mounted on said grid and anode having an apertured insulating wall interposed between the confronting walls of said grid and anode and having opposed recesses in which the confronting ends of said grid and anode are seated and by which they are held against lateral movement

independently of each other, said supporting wires constituting means that maintains said grid, anode and insulating member against longitudinal displacement.

14. A cathode ray tube comprising an envelope having a press, a cathode, a grid and an anode having conductors sealed in the press and being supported by said conductors and press, and an insulating member extended between said grid and anode and holding them against relative lateral displacement, said member being carried by at least one of said anode and grid.

15. A cathode ray tube comprising an envelope having a press, a cathode, a grid and an anode having conductors sealed in the press and being supported by said conductors and press, and insulating members extended between said cathode and grid, and between said grid and anode and holding the cathode, grid and anode against relative lateral displacement, said insulating members being supported by certain of said cathode, grid and anode.

16. A cathode ray tube comprising an envelope having a press, a cathode, grid and anode having conductors embedded in said press and being supported by said conductors and press, and a tubular insulating member closely surrounding the confronting ends of and carried by said grid and anode and holding them against independent lateral displacement.

17. A cathode ray tube comprising an envelope having a press, a cathode, grid and anode having conductors embedded in said press and being supported by said conductors and press, said grid and anode having confronting end walls with aligned apertures therein, and an insulating member carried by said grid and anode having opposed recesses in which said grid and anode are seated and a smaller passage therethrough aligned with said apertures, said insulating member constituting means that holds said grid and anode against independent lateral displacement.

18. An electron gun structure for cathode ray tube apparatus comprising a cathode, an anode comprising an apertured disk and a control electrode comprising an apertured disk disposed between the cathode and the anode disk, said control electrode and anode having their apertured disks in substantially axial alignment and progressively longitudinally spaced from the cathode, and a tubular extension extending from the control electrode toward the anode and disposed between the disk portions of the control electrode and anode for focusing the electrons emitted from the cathode upon the aperture in the anode disk.

19. An electron gun structure for cathode ray tube apparatus comprising a cathode, an anode comprising an apertured disk and a control electrode comprising an apertured disk disposed between the cathode and the anode disk, said control electrode and anode having their apertured disks in substantially axial alignment and progressively longitudinally spaced from the cathode, a tubular member forming a part of the control electrode structure and extending in the direction of the anode for focusing the electrons issuing from the cathode upon the aperture in the anode disk, and means for insulatingly supporting the tubular member and the anode disk in axial alignment.

JOHN C. BATCHELOR.