

Feb. 5, 1946.

W. G. H. FINCH
CATHODE RAY RECEIVER

2,394,435

Filed March 25, 1944

2 Sheets-Sheet 1

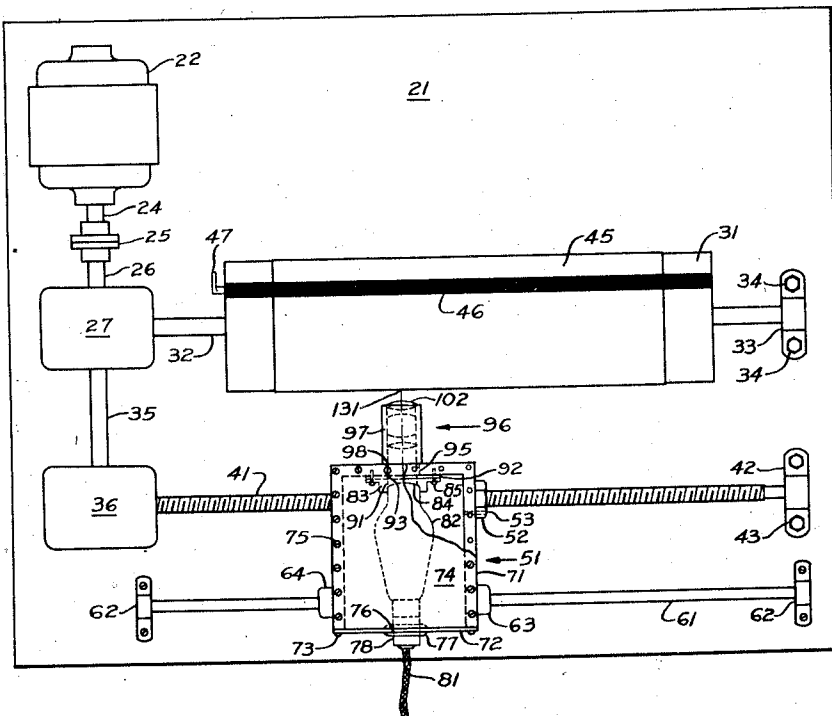


FIG. 1

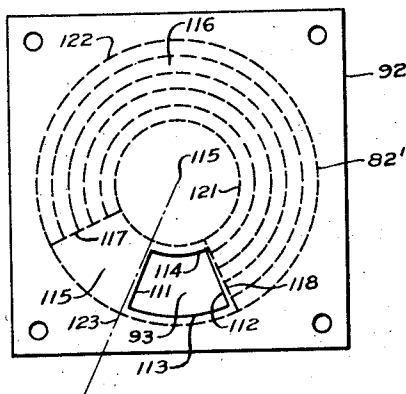


FIG. 2

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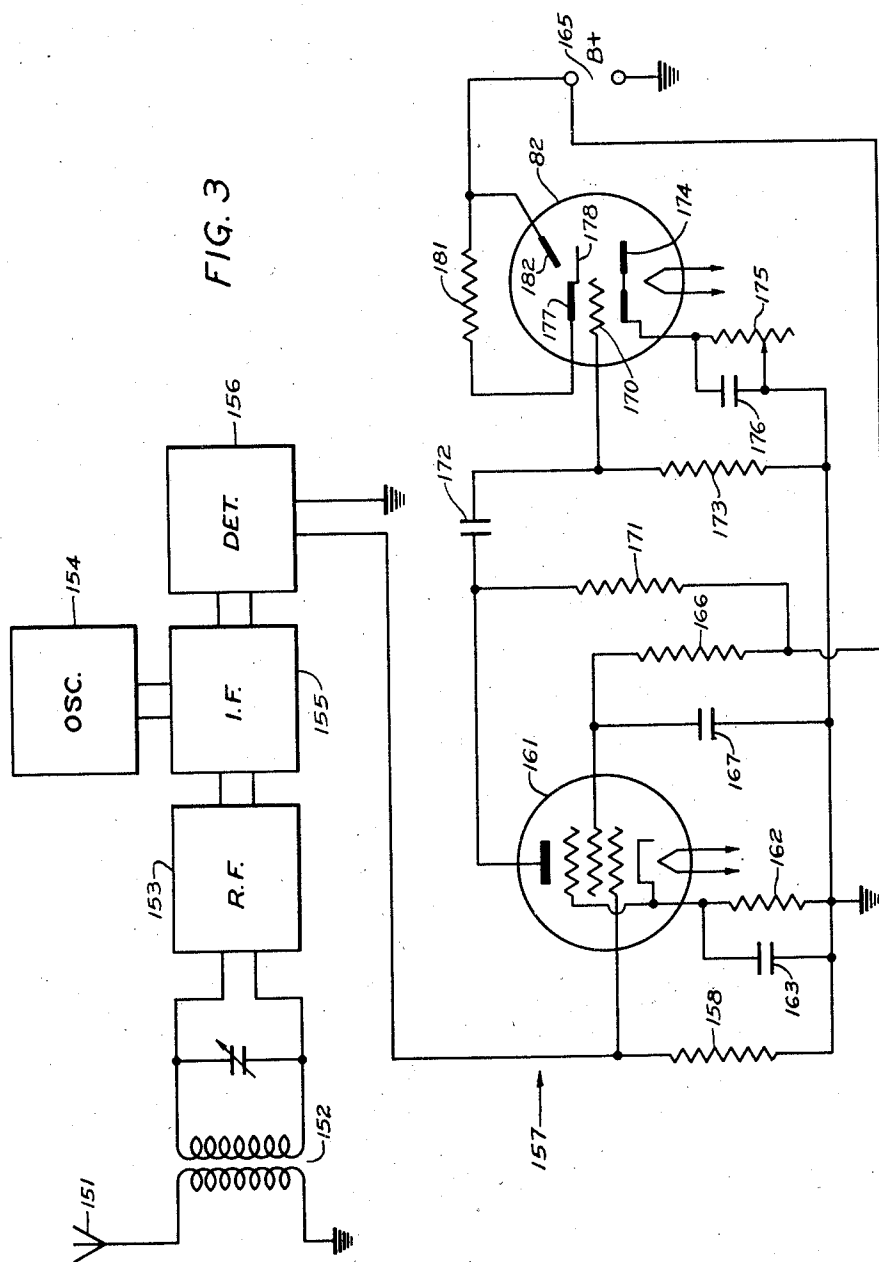
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CATHODE-RAY RECEIVER

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13 Claims. (Cl. 178-7.4)

My invention relates in general to the field of picture transmission and reception and more specifically concerns a novel facsimile recorder.

In conventional picture transmission systems, the transmitter may comprise a rotatable drum supporting the picture to be transmitted.

This drum is helically scanned by an electro-optical system which focuses a sharply defined light spot upon the image. Light reflected from this spot is collected by a photo-electric cell and converted into picture currents which during the rotation of the drum correspond at each instant to the intensity of the picture at that point.

These picture currents are amplified by suitable electronic devices and are transmitted by radio frequency carrier currents or by transmission lines to a remote recorder whereat they are received and amplified for recording.

The recorder comprises essentially a mechanism similar in most respects to the transmitter. Thus a photographic film is supported upon a rotatable drum driven from a suitable source of power.

This film is helically scanned by a light spot in a manner which corresponds to that described for the transmitting-scanning operation and the intensity of the light spot is modulated by the incoming picture signals. It is evident, therefore, that the developed image upon the photographic film will correspond to the image transmitted.

It is, of course, necessary in a picture transmission to maintain the rotatable drums at transmitter and recorder in exact synchronism. This problem is solved in many well-known ways and accordingly will not be considered here.

The type of recording light utilized at the receiver has long been regarded as an important problem. Thus, it is well-known that ordinary filament type bulbs are entirely impractical for facsimile recording, since a filament has a considerable time-lag due to its incandescence, and such a time-lag in heating and cooling would preclude the recording of comparatively high frequency currents.

The principal disadvantage of the discharge type of recording light has been in its comparatively high power consumption for the light energy delivered. This high power consumption has resulted in cumbersome electronic designs for facsimile amplifiers to obtain a current output sufficient to drive this type of recording light at the desired frequency.

Since facsimile receivers may, in many instances, be portable devices where lack of com-

plex amplifier circuits is particularly desirable and where the saving of weight is important, the utilization of gaseous discharge tubes has presented an important disadvantage. In addition, another important disadvantage resulting from the use of gaseous discharge tubes has been that these tubes are designed for extremely specialized purposes and accordingly have been comparatively expensive.

My invention contemplates overcoming all of the disadvantages mentioned for filament type and gaseous discharge type recording lamps, and proposes to obviate the difficulty of comparatively high expense and high required receiver power output as previously mentioned. Thus, in accordance with my invention, I utilize a conventional radio electron ray tube of the type normally utilized in radio circuits for tuning response indication.

This type of tuning indicator as is well understood in the radio art, comprises essentially a triode mounted in a conventional glass radio tube bulb having a fluorescent target in the dome of the bulb. This target is operated in such a manner that the electron emission from the cathode causes a glow which covers a sector of the circular area of the target. The extent of this fluorescent glow is determined by the applied grid voltage and of course by the various tube circuit constants.

In normal operation of a tuning eye as in a radio carrier strength detection circuit, it is conventional to operate the tuning eye grid from a source of voltage within the radio receiver which is proportional or characteristic of the signal strength received. This voltage is usually obtained from an automatic volume control circuit as is well known, and is highly damped usually by a resistance-capacitance filter.

Thus, the response characteristic of the tuning eye is extremely slow and follows only the very low frequency variations of the signal strength.

In accordance with my invention, I propose to utilize the ability of the grid circuit of an electron ray tube to control the shadow angle of the fluorescent screen as a source of light for an electro-optical facsimile recorder.

Thus, in my novel facsimile recorder construction, a tuning eye tube is mounted in operative position with respect to a rotatable drum supporting a photographic film at a facsimile recorder. The face of the tuning eye tube is covered by a shield having a small perforation therein. This perforation ordinarily falls within the shadow angle of the tube when no signal is received.

The facsimile electronic recording circuit is arranged so that the incoming facsimile signal as detected in a radio frequency circuit or as amplified from an incoming transmission line, is impressed directly upon the control grid of the electron ray tube. No damping means are utilized, and accordingly, the shadow angle of the tube fluctuates rapidly and follows to a remarkable degree the highest frequency variation of the facsimile signal. This fluctuating shadow angle as viewed through the perforation in the shield of the tuning eye results in a continuous change of illumination of the perforation; and it is this perforation which is focused sharply upon the rotatable drum and its recording film.

Hence, in the manner that the transmitter photo-electric cell receives light fluctuations, the perforation in the shield covering the tuning eye at the receiver is correspondingly illuminated and is focused upon the rotatable receiving drum with the result that the developed photographic image is identical in all respect to the image at the transmitter.

The utilization of an electron ray tube, as just described, as a facsimile recorder light provides many distant advantages over methods heretofore employed. Inasmuch as an electron tuning eye is a sensitive electronic device for converting signal fluctuations into light fluctuations through the agency of a control grid, the total power requirement of the grid of the tuning eye is extremely small and the receiver electronic amplifiers need only be adjusted to provide sufficient voltage sensitivity—that is, sufficient voltage amplification from the input to the grid of the electron ray tube to cause the full variation in shadow angle required.

As will be described later in connection with the electron ray tube, this voltage amplification need be comparatively small, and therefore the complexity of the amplifying system is materially reduced. In this manner, the electron ray tube acts as a sensitive light amplifier in that a small grid voltage signal is utilized to control a large amount of light. This controlled light is that which ordinarily is impressed upon the target of the electron ray tube. This system of light control through the grid of an electron ray tube is contrasted against the light control necessary when the picture signals must supply the full energy to alternately illuminate and extinguish a discharge bulb.

It is accordingly an object of my present invention to provide a novel facsimile recorder.

Another object of my present invention is to utilize an electron ray tube as the source of printing light in an electro-optical facsimile recorder.

A further object of my invention is to utilize the undamped variation of shadow angle of an electron ray tube to photographically record received facsimile signals.

These and other objects of my invention will now become apparent from the following specification taken in connection with the accompanying drawings in which:

Figure 1 is a general view of a facsimile recorder showing the various mechanical features thereof.

Figure 2 is a front view of the electron ray tube shield, and

Figure 3 is a schematic circuit diagram of the novel simplified facsimile recorder.

Referring now to Figure 1, there is illustrated a facsimile recorder which may be utilized to

record picture signals received from a distant transmitter.

The recorder illustrated comprises essentially a base plate 21 supporting a drive motor 22 which is rigidly secured to the base 21. This motor 22 is the source of power for the entire facsimile unit illustrated and is driven at the same speed as a similar drive motor at a remote transmitter. This may be accomplished by utilizing identical synchronous motors operative from the same power supply or by any of the other well known synchronizing means.

Shaft 24 of the motor 22 drives through coupling 25 a shaft 26 controlling the gear-ratio box 27. Gear-ratio box 27 drives at a predetermined proper speed, rotatable drum 31 rigidly supported upon rotatable shaft 32. Shaft 32 is provided with suitable bearings, one within the gear-ratio box 27 and the other bearing 33 which is bolted at 34 to the base plate 21.

Also driven from gear-ratio box 27 is a shaft 35 which in turn drives the members of gear-ratio box 36. A helical feed screw 41 is driven from gear-ratio box 36 and is suitably supported in a bearing within gear-ratio box 36 and another bearing 42 at the other end thereof. Bearing 42 is secured to the base plate 21 by bolts 43. The rotatable drum 31 supports a photographic film 45 by a mounting bar 46 which is operated by handle 47 in the well known manner.

Removably coupled to helical feed screw 41 is an electro-optical system 51 incorporating the electron ray tube as will be described. The electro-optical system 51 is supported upon helical feed screw 41 by a half-nut 52 pinned at 53 to the case of the unit 51.

In normal operative position, the half-nut 52 engages the helical feed screw 41 and accordingly, rotation of screw 41 will cause lateral displacement of the entire unit 51.

Upon the completion of a scanning cycle—that is, complete lateral movement from one end of the drum to the other, the half-nut 52 is lifted by rotation about pin 53 so that the entire electro-optical unit 51 may be restored to its original position.

A shaft 61 is rigidly secured to the base plate 21 by fittings 62 at each end thereof. The shaft 61 is smooth and passes through smooth cooperating bearings 63 and 64 fixed to the sides of the electro-optical unit 51; and it is evident therefore, that shaft 61 provides additional mechanical support for the system 51.

In accordance with my invention, the electro-optical scanning unit 51 comprises essentially a cast case 71 having a rear cover plate 72 secured thereto by bolts 73 and a cover 74 secured to the case 71 by a plurality of bolts 75.

A circular perforation 76 in the back cover plate 72 secures a rubber grommet 77 which in turn secures an electron tube adaptor 78. The adaptor 78 is joined by flexible cable 81 to the facsimile recorder electrical circuit as will be described in connection with Figure 3. Plugged into the adaptor 78 is an electron ray tube 82 which is supported in addition by a rubber cushion 83 which has a depression 84 directly molded therein to support the dome of a conventional type tube as illustrated.

The cushion 83 is securely bolted to the case 71 by a plurality of bolts 85, and accordingly, the electron ray tube 82 is supported in a shock-proof manner which in addition facilitates removal and repair. The cushion 83 is perforated at 91 in order not to obstruct the dome of the tube 82.

A metal plate 92 is, as illustrated, secured to the case 71 of the electro-optical system between the rubber cushion 83 and the front wall of the case. A perforation 93 within the metal plate 92 functions in a manner which will be described in connection with Figure 2.

A circular tapped perforation 95 in the front of the case 71 is in a position coaxial with the electron ray tube 82 and supports an optical unit 96. Thus, the optical unit 96 comprises essentially a metal tube 97 having a shoulder 98 and a threaded extension which engages the thread in the hole 95, to form a rigid mounting as illustrated.

Within the metal tube 97 are securely cemented lens elements 102 which function in a manner to be described in greater detail later. Thus, the electro-optical system 51 due to its simplicity of mechanical construction may be readily disassembled for repair and for adjustment as required during service.

Referring now to Figure 2, the operation of the electron ray tube will be described in greater detail. Thus the metal plate 92 covers as illustrated the dome 82' of the electron ray tube 82. The perforation 93 in the metal plate 92 is formed between the radial lines 111 and 112, and the circular line 113 and 114 which are concentric with the center 115 of the electron ray tube 82. The center 115 normally corresponds to the cathode of this tube.

When the electron ray tube 82 is in operation as in a circuit of the type to be described in connection with Figure 3, a shadow area 115 is formed upon the target of the electron ray tube between a large illuminated area 116 of the same target. This fluorescent area as is well known for electron ray tubes covers the entire circumferential area between the lines 117 and 118 which represent the boundaries of the shadow area 115.

Ordinarily, for a tuning eye tube such as the 6E5 or other types, the shadow area 115 for zero signal input is approximately 90° and the fluorescent area 116 approximately 270° of the surface of the target. The fluorescent area 116 is bounded on the inside by a circle 121 representing the cathode shield and other circuit elements within the tube and on the outside by a circle 122 representing the outer edge of the target and which in turn is essentially the edge of the dome 82' of the electron ray tube.

As utilized in my novel facsimile recorder, the perforation 93 is arranged to cover the shadow area, when no signal is received, between the edge 118 of the fluorescent area 116 and the center line 123 of the shadow area illustrated.

Accordingly as viewed from the front of the electro-optical scanning system 51 of Figure 1, the metallic shield 92 will show a dark area of the shape of perforation 93 illustrated in Figure 2, under the condition of zero signal input. As the signal input increases, the fluorescent area 116 will increase and accordingly boundaries 117 and 118 of the shadow area 115 will converge upon the center line 123 which line represents the condition of a signal input large enough to cause the edges 117 and 118 to merge.

For any condition, therefore, of signal input between the extremes of zero signal input indicated by the position of lines 117 and 118 of Figure 2, and the maximum signal input which causes the convergence of edges 117 and 118 at line 123, the perforation 93 will be illuminated by a portion of fluorescent area 116, and at all times this illumination of perforation 93 will be directly proportional to the strength of the incoming signal

as determined by the linearity of the shadow angle versus signal input curve of the particular tuning eye utilized. For the 6E5 tuning eye, the shadow area 115 varies from a maximum of 90° to a minimum of zero degrees for a grid voltage variation of approximately eight volts.

Returning now to Figure 1, the perforation 93 in the shield 92 is focused at all times by properly adjusted optical system 96 to a sharply defined light spot 131 on the surface of the photographic film 45.

In the operation of the facsimile recorder illustrated in Figure 1, the gear-ratio boxes 27 and 36 are so adjusted in connection with driving motor 22 that the rotatable drum 31 rotates at a suitable speed and that the lateral displacement of electro-optical unit 51 is such to cause the spot 131 to trace a continuous helical line about the surface thereof. If during this scanning operation, the incoming signal is applied to electron ray tube 82 to cause a fluctuation in shadow angle or a fluctuation of illuminated area over the area of perforation 93, the spot 131 will record the incoming picture signal directly upon the surface of film 45.

In order to now illustrate how the utilization of the electron ray tube for photographic recording at a facsimile receiver simplifies the construction of the electronic circuit of a facsimile recorder, reference is made to Figure 3.

If the facsimile signals are transmitted in the form of a modulated carrier, then, as illustrated in Figure 3, these signals are received by antenna 151 which through tuned circuit 152 are impressed upon a radio frequency amplification circuit 153.

As is conventional, the output of the radio frequency unit 153 and the output of a local oscillator 154 are impressed upon a conversion circuit to produce an intermediate frequency within the circuit 155. After suitable intermediate frequency amplification within the intermediate frequency stages 155, these received signals are demodulated within detector 156 and are then suitably amplified to operate the facsimile printing circuit.

Previously, it has been necessary to resort to considerable voltage amplification in order to operate a power amplifier which would in turn control the light fluctuations of a discharge type tube.

In accordance with my invention, since an electron ray tube such as 82 has comparatively great sensitivity, in that a small fluctuation of grid voltage can control a considerable light intensity as demonstrated in Figures 1 and 2, the output of detector 156 may if desired be utilized directly to operate the electron ray tube 82, or as illustrated in Figure 3, may operate a conventional type of voltage amplifier 157. Thus, the output of detector 156 is applied through resistor 158 to the control grid of vacuum tube 161. The cathode of this tube 161 is grounded through self-biasing resistor 162 and by-pass condenser 163 as is conventional.

The suppressor grid is internally connected to the cathode and the screen grid is connected to a source of high voltage direct current 165 through resistor 166. A by-pass condenser 167 connects the screen grid to ground.

The plate of vacuum tube 161 is also connected to the high voltage direct current source 165 through load resistor 171 and the output at the plate of vacuum tube 161 is coupled by coupling condenser 172 and grid resistor 173 directly to

the control grid of electron ray tube 82. The electron ray tube 82 comprises as is well known in the art a cathode 174 which as illustrated is connected through a variable resistor 175 to ground. A by-pass condenser 176 is utilized in connection with resistor 175 to obtain the desired cathode bias to operate the shadow angle of the tube such that it is a maximum at the zero input to the control grid across resistor 175 and is zero angle when the maximum incoming signal is applied to this grid.

The plate 177 and the target 178 are interconnected within the tube and are maintained at a positive potential by a connection to the direct current source 165 through a load resistor 181.

A ray control electrode 182 is directly connected to the voltage source 165.

With the cathode bias properly adjusted by variable resistor 175, the extent of the shadow area 115 as illustrated in Figure 2 is directly controlled, with practically no power whatsoever, by the control grid 170 is sufficient to cause the variation from black in the perforation 93 to full illumination over this area. Since this perforation is comparatively large before being focused down to the spot 131 upon the rotatable drum 31, the amount of light controllable by the grid 170 is comparatively great.

As the incoming signal increases, it is evident in Figure 3 that the plate current of tube 82 will increase, and accordingly, the potential of the plates 177 and the target 178 will decrease when compared with the ray control electrode 182. It is this variation between target voltage and ray control voltage, which as is well known, controls the extent of the shadow angle of the tube 82. The connections to tube 82 as illustrated by flexible connector 81 in Figure 1, need be only those connections required for tube 82 as illustrated in Figure 3.

For the 6E5 electron ray tube such as illustrated by 82 in the figures, the shadow angle varies substantially linearly with the grid voltage. Thus for a plate voltage of 250 volts the shadow angle varies through 90° for a variation of grid voltage of 8 volts.

As the plate and target voltage of the control tube 82 are lowered, the sensitivity shadow angle variation is increased. Thus, if the target and plate voltage is lowered to 100 volts a variation of 3 volts on the grid 170 of the tube 82 will cause the complete variation from zero to 90° of shadow angle as required to reproduce the complete range of black to white in the focused spot 131. Of course, the reduction of the plate and target voltage may effect the intensity of the light spot 131, and therefore, this increase in the sensitivity is accomplished only through a sacrifice in printing sensitivity. However, for extremely sensitive film and for comparatively slow speed recording, this is not a serious objection.

The focused light spot 131 upon the film 45 may, if extremely sharply defined, be an area identical to perforation 93 in the disk 92. It is evident from the consideration of Figure 2, that, as the perforation 93 is positioned, the increase in grid voltage will cause only one side of the perforation to become illuminated; and accordingly, it may result in a focused spot 131 which varies in intensity and in width with the variation in picture signal intensity. However, if the optical system is such as to produce a slightly defocused spot 131, this variation in illuminated area of the spot will cease to be noticeable.

It is evident from Figure 2 that a different

modification of printing perforation 93 may be utilized. Thus, the center of perforation 93 may be disposed directly on the center line 123 of the shadow area, and the tube may be initially biased to produce a shadow angle which corresponds to the angular distance covered by perforation 93. Accordingly, an increase in signal strength would cause both edges 117 and 118 of the fluorescent area 116 to close over the radial edges of perforation 93; and accordingly, if a sharply defined printing spot were focused upon photographic film 45, the spot would consist of a dark center line bordered on each side by a bright line representing the over-lapping area covered by the fluorescent area 116 in the perforation 93. Again, if the spot 131 is de-focused, this effect will not in any way hinder faithful reproduction.

As is well known, if the intensity of the received signals is raised, the lines 117 and 118 bordering the fluorescent area of Figure 2 will converge and if it is increased still further, will overlap to produce a brighter line at the over-lapping area. This effect is not particularly desirable if linearity of recording is to be obtained; and accordingly, it is necessary to adjust the bias of the tube 82 so that the incoming signals will not rise to a maximum to cause such overlapping.

It is also evident in Figure 2 that the particular shape illustrated for perforation 93 was chosen such that the linearity between signals input and light variation over the perforation 93 is obtained.

It is therefore evident that my invention provides means for electronically controlling a considerable amount of light which may be utilized for photographic facsimile recording.

Since these are many modifications of electron ray tubes and many modifications of the circuits in which they may be incorporated, I wish that the electron ray facsimile recording disclosure above be limited not by the specification and drawings, but by the appended claims.

I claim:

1. In a facsimile recorder, means for receiving picture signals and means for recording said picture signals comprising an electron ray tube having a luminous sector fluctuating in accordance with said picture signals from a complete circle to a predetermined sector, and a shield positioned between said electron ray tube and a photographic film covering the variable luminous sector and having an opening therein for exposing the luminous sector adjacent thereto.

2. In a facsimile recorder, means for receiving picture signals and means for recording said picture signals comprising an electron ray tube having a luminous sector fluctuating in accordance with said picture signals, said electron ray tube being operative from a comparatively low power picture signal voltage amplifier, and a shield positioned between said electron ray tube and a photographic film covering the variable luminous sector and having an opening therein for exposing the luminous sector adjacent thereto.

3. In a facsimile recorder, means for receiving picture signals, means for scanning a light sensitive film, said scanning means including an electron ray tube having a fluorescent screen, means for illuminating a variable sector of said fluorescent screen, and a shield adjacent the position of said screen which is variably illuminated and having an opening therein for exposing the adjacent portion of the screen, and means for sharply focussing said exposed area of said fluorescent screen upon said film.

4. In a facsimile recorder, means for receiving

picture signals, means for scanning a light sensitive film, said scanning means including an electron ray tube having a fluorescent screen, a shield between said electron ray tube and said film, a perforation in said shield, said perforation normally covering the shadow angle of said electron ray tube.

5. In a facsimile recorder, means for receiving picture signals, means for scanning a light sensitive film, said scanning means including an electron ray tube having a fluorescent screen, a shield between said electron ray tube and said film, a perforation in said shield, said perforation normally covering the shadow angle of said electron ray tube, and means for focussing said perforation upon said film.

6. An electron ray tube having a fluorescent target, means for applying a control voltage to said tube to cause a substantial sector of said target to glow, means for light shielding said target to normally render the glowing sector of said tube invisible, said shielding means having an opening therein arranged so that when the glowing sector extends beyond a predetermined limit the glow from said target is visible.

7. An electron ray tube having a fluorescent target, means for applying a control voltage to said tube to cause a substantial sector of said target to glow, means for light shielding said target to normally render the glowing sector of said tube invisible, said shielding means having an opening therein arranged so that when the glowing sector extends beyond a predetermined limit under control of said control voltage, the glow from said target is visible.

8. An electron ray tube having a fluorescent target varying in accordance with received signals, means for applying a control voltage to said tube to cause a substantial sector of said target to glow, means for light shielding said target to normally render the glowing sector of said tube invisible, said shielding means having an opening therein arranged so that when the glowing sector extends beyond a predetermined limit under control of said control voltage, the glow from said target is visible.

9. An electron ray tube having a fluorescent target varying in accordance with received picture signals, means for applying a control voltage to said tube to cause a substantial sector of said target to glow, means for light shielding said

target to normally render the glowing sector of said tube invisible, said shielding means having an opening therein arranged so that when the glowing sector extends beyond a predetermined limit under control of said control voltage, the glow from said target is visible.

10. An electron ray tube having a fluorescent target varying in accordance with received picture signals, means for applying a control voltage to said tube to cause a substantial sector of said target to glow, means for light shielding said target to normally render the glowing sector of said tube invisible, said shielding means having an opening therein arranged so that when the glowing sector extends beyond a predetermined limit under control of said control voltage, the glow from said target is visible, and means for focusing the visible portions of said luminous target.

11. An electron ray tube having a fluorescent member, means for causing a variable sector of said fluorescent member to be luminous, a shield covering the luminous sector, an opening in the shield exposing only a portion of the sector where the luminous ends meet when said means extends the luminous sector beyond a predetermined value.

12. An electron ray tube having a fluorescent member, means for causing a variable sector of said fluorescent member to be luminous, a shield covering the luminous sector, a slot in the shield exposing only a portion of the sector which is normally not luminous, said means operating in response to received signals to extend the luminous sector into the portion exposed by said slot.

13. In a signalling system, a radio receiver including a radio frequency receiving circuit, a radio frequency detector and an electron ray tube having a control grid, means including circuit connections directly from said detector to said control grid, said electron tube having a fluorescent member, means whereby said control grid causes a sector of said fluorescent member to be luminous, a slot in the shield exposing only a portion of the sector which is normally not luminous, said means operating in response to received signals to extend the luminous sector into the portion exposed by said slot.

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