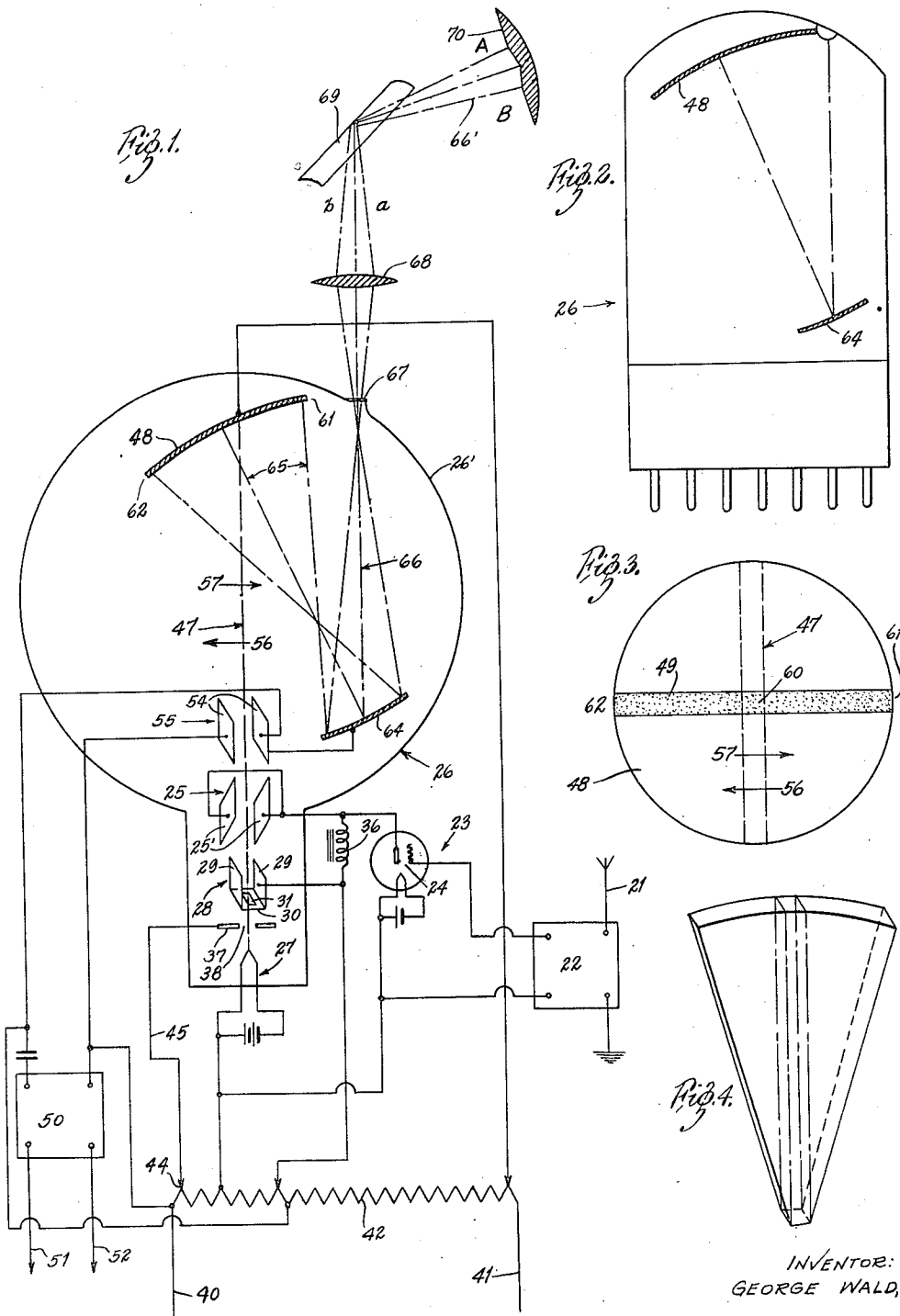


Aug. 11, 1942.

G. WALD
TELEVISION APPARATUS
Filed Aug. 3, 1940

2,292,979

3 Sheets-Sheet 1



INVENTOR:
GEORGE WALD,

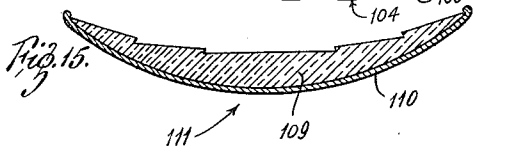
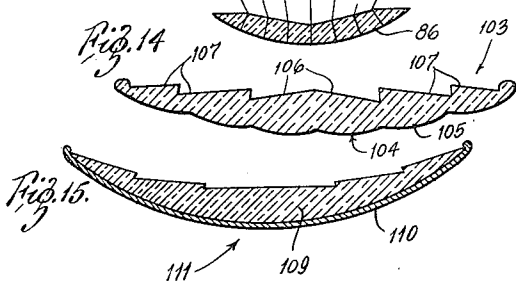
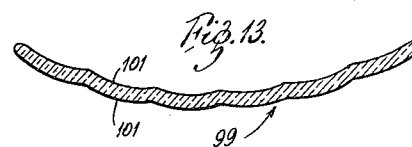
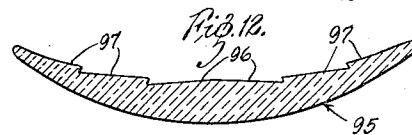
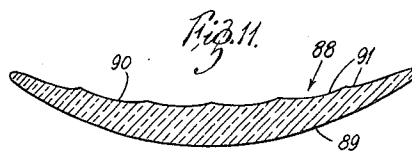
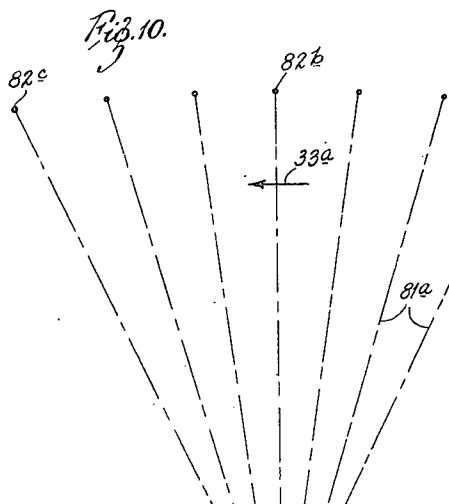
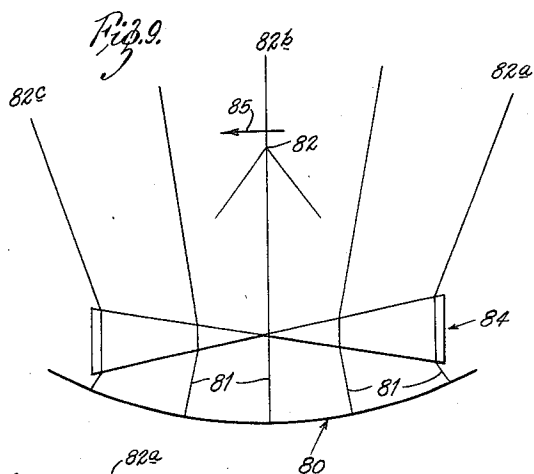
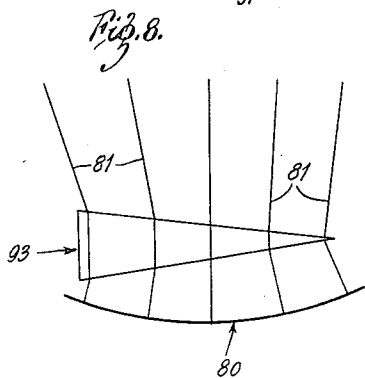
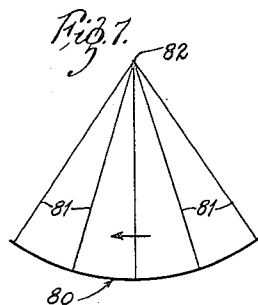
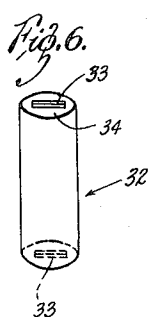
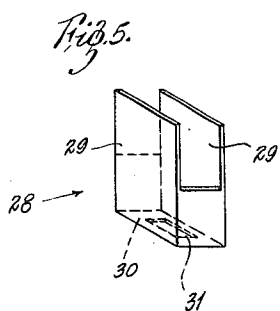
By *Lawrence C. Knigland*
ATTORNEY.

Aug. 11, 1942.

G. WALD
TELEVISION APPARATUS
Filed Aug. 3, 1940

2,292,979

3 Sheets-Sheet 2



INVENTOR:
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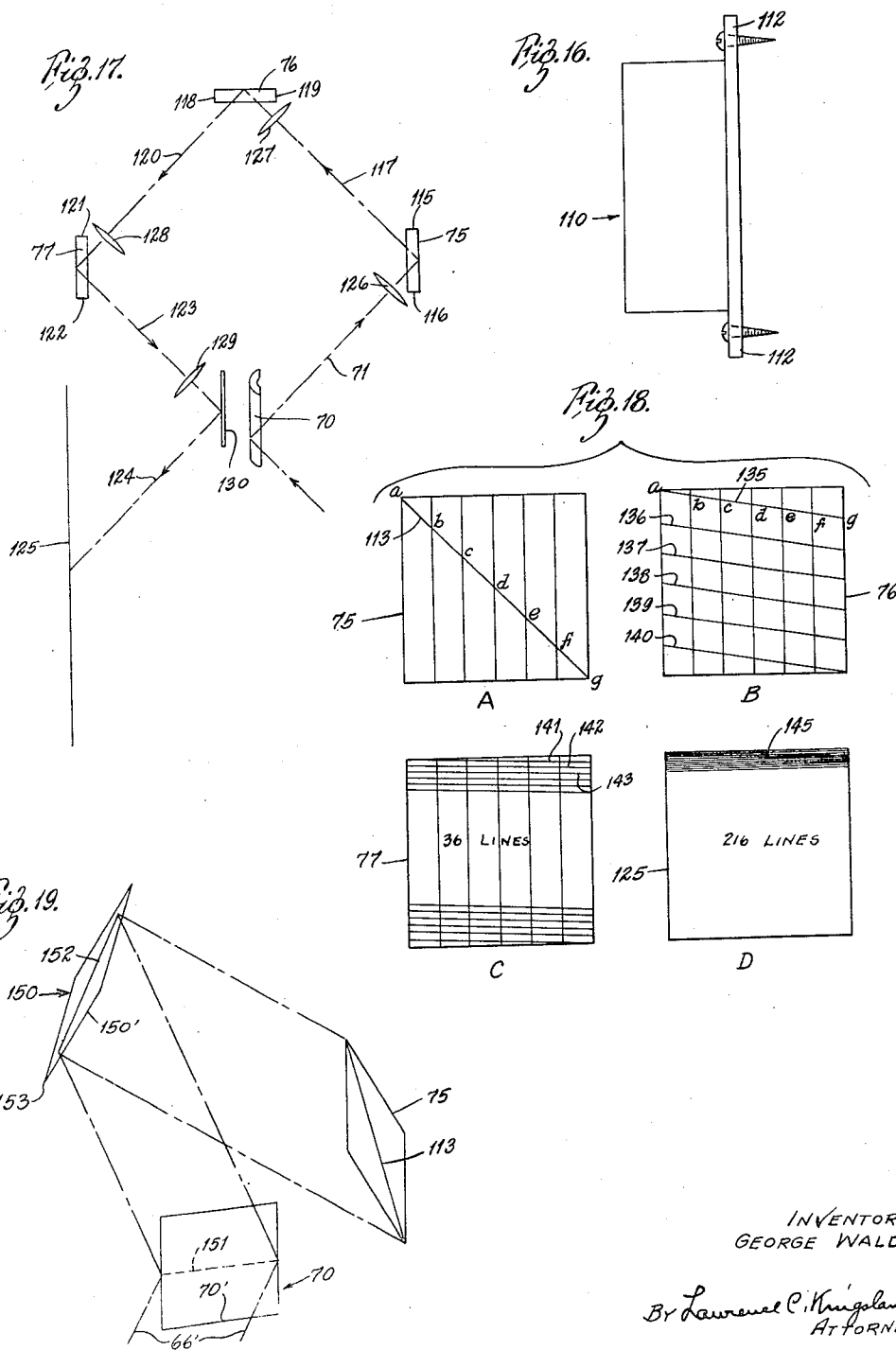
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Aug. 11, 1942.

G. WALD
TELEVISION APPARATUS
Filed Aug. 3, 1940

2,292,979

3 Sheets-Sheet 3



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UNITED STATES PATENT OFFICE

2,292,979

TELEVISION APPARATUS

George Wald, New York, N. Y.

Application August 3, 1940, Serial No. 350,410

11 Claims. (Cl. 178—7.5)

The present invention relates generally to television apparatus, and more particularly to television receivers and to elements comprising the same.

In one form of the television receiving apparatus the cathode ray tube employed has an internal volume of over one cubic foot, which must be maintained at a high vacuum and presents a danger of explosion. The fluorescence employed as a screen must be applied on the glass very thin, for fluorescent material is opaque and the light generated by the electronic beam striking the interior of the fluorescence must show through the fluorescent material, and so, even if a high voltage could be employed to produce a more brilliantly illuminated image, it could not be used as a practical matter, as the very thin fluorescent material would be damaged permanently thereby and the tube would become useless. A large size of the image means that the cathode ray electronic stream has to cover a much larger area and the tube must be so much larger. In a 24" screen, the tube contains several cubic feet of volume and will require 30,000 to 50,000 volts. The danger involved with such voltages and large vacuum containers used in residences need not even be stated. Even a 12" x 12" image tube requires voltages too high and vacuum containers too large for use in residences.

An object of the present invention is to overcome the foregoing by utilizing the illuminosity produced in the inside of the cathode ray lamp by the electronic stream or beam striking fluorescent material applied on a metal anode, such as, say, nickel. Such a metal anode is placed near the top of the envelope of the conventional known cathode ray television tube. This anode is preferably a concave disc and is secured so that it is slightly tilted to one side in respect to the electronic beam. A second metal reflector of nickel, chromium-plated and highly polished, may be located somewhat lower in the tube in line with the metal anode reflector, so that any light produced in the inside of the tube by the fluorescent material concentrates into this light reflector which, in turn, projects the light outwards from the tube through a suitable window. This latter light reflector may be mechanically and electrically secured to one of the cathode ray tube elements, such as the first anode or deflecting plates for proper degassifying, and is of such a concaveness as to cause the light beam at or near the nodule point to be at the window of the envelope of the tube. The tube envelope may be metal except for a small sealed lens

where the beam passes through, thus shielding the entire tube from outside interference.

Under these conditions, as the anode is being scanned by the electronic beam, the image in the form of scanned light is reflected into the lower light reflector which, in turn, reflects the image outward through the lamp window to be developed ultimately on a screen for the television viewer. The size of the image may be larger and controlled by a lens, to focus at will. The fluorescent material may be applied heavy and need not be of a transparent material. It should, however, be remembered that, as the image is increased on the screen, the illuminosity is decreased in the same proportion, since the light covers larger areas. Hence, the size of a conventional tube thus modified must still be large to produce a large image.

However, with the optical television scanning system described in my copending application for patent Serial No. 264,876, filed March 30, 1939, the tube may be small, may use a comparative low voltage, and yet will produce a large-size highly brilliant image. The cathode ray tube so employed is always at nearly a constant current, but produces light modulation by changing the concentration of the electronic beam.

There may be used either the conventional cylindrical first anode with rectangular slots for the electronic beam to pass through it, or in its place two plates of the same potential may be used to compel the electronic beam to form a fan-shaped ribbon, so that the maximum cross-section of this ribbon electronic beam at the aforesaid second metal anode is, say, 2" x 1/4", while the minimum cross-section is 1/4" x 1/4". The fluorescent material is applied to the concave side of the metal anode only in a diametric line of, say, slightly less than 1/4" width. This anode is so positioned in relation to the elements of the tube as to form a cross between the line of fluorescent material and the cross-section of the electronic beam. Hence, only 1/4" x 1/4" of the fluorescent material can become illuminated at any instant, which is the cross-section where the electronic beam ribbon crosses the fluorescent line.

When there is no incoming television signal, the electronic beam is fan-shaped with a broadside of the two inches at the top and, therefore, only about one-eighth of the total electrons can impinge on the fluorescent material. Further, as the second anode is metal and more electrically conductive than the fluorescent material, actually only a small fraction of the electronic beam is

transformed into light. This represents the dark spot of the image.

Immediately above the first anode plates of the tube is located a set of modulating plates positioned at right angles to the first anode plates or to the rectangular slot in the cylinder should the same be used. Both modulating plates are energized by the same potential, and are electrically connected in series with an amplifier that receives the television signals applied across its cathode and grid. The arrangement, therefore, applies the required television electric impulses to the set of modulating plates only when a television impulse is received. When a strong television signal is received, these modulating plates condense the fan-shaped beam into a narrow beam of, say, less than $\frac{1}{4}$ ", and in combination with the first anode plates they cause the electronic beam to have a square cross-sectional shape of less than $\frac{1}{4}$ " x $\frac{1}{4}$ ", so that all of the electronic beam impinges on the fluorescent material and produces a strong quantity of light. This is the bright point of the image; any intermediate television signal received produces a corresponding contraction of the fan-shaped electronic beam and, in turn, a corresponding quantity of light is produced. Thus, the modulating anode plates modulate the television light by varying the quantity of electrons applied to the fluorescent material and that applied to the metal plate, and thereby vary the light produced.

Above the modulating anode plates is positioned one set of the conventionally used deflecting plates which are disposed at right angles to the modulating plates. These deflecting plates are energized by, say, the 60-cycle house current, or a harmonic thereof, saw-tooth style, to correspond to the transmitter, each plate being charged with opposite potentials, thereby moving the constant quantity electronic beam to and fro along the fluorescent diametric line. The fan-shaped electronic ribbon beam forms the ordinate in the tube (not image) and the fluorescent material the coordinate, and light is produced only where they cross one another, the quantity of light so produced depending on the intensity of that quantity of the electrons of the electronic beam which are impinging on the fluorescent material. When the electronic beam is fan-shaped, the minimum of illuminosity is produced; when the fan-shaped electronic beam is condensed into a bar shape, the maximum of illuminosity is produced.

During one image frame, the electronic beam travels once along the diametric line of the fluorescent material and a line of light is formed dot by dot which corresponds in intensity to the incoming television signal at each instance, each dot overlapping the other, but at each instance it is corresponding in illuminosity to the television signal received. Each light dot as it appears on the second anode is reflected into the lower reflector at about one-third the size and, in turn, reflected outside of the tube through the lens or window in the tube and on a single scanning lens reflector, preferably prismo-concave. This single prismo-concave scanning lens causes the thin light beam to travel a width of about, say, $\frac{1}{2}$ " in the form of a thin light line or beam, as hereinafter explained.

The cathode ray tube with the reflector and the single prismo-concave scanning reflector form "one unit" of the television system. The single scanning reflector is so positioned as to

cause the line scanned to cross the width of the reflector and is tilted either upwards or downwards to cause the light beams, so scanned, to reflect each in turn upwards or downwards and into three scanning reflectors which form the "second unit" of the television system.

The scanning reflectors are positioned as though placed inside of a rim of a wheel. They are aligned one with the other and each one is slightly tilted longitudinally so that the light beam, as scanned, will reflect from one scanning reflector to the other. The elements of the second unit of the system may be positioned at an angle of about 45° to the single scanning reflector of the first unit. That is, the relationship is such that the horizontal light described and scanned on the single scanning reflector describes a diagonal across the six multi-focal faces of the first scanning reflector. Hence, if the first scanning reflector is $4''$ x $4''$, the light line scanned upon the first scanning reflector must be the square root of 4 squared plus 4 squared, or approximately $5\frac{1}{2}''$. Thus, a diagonal light line beam is described on the first scanning reflector.

Each of the three scanning reflectors has six multi-focal prismo-concave, or any other multi-focal, scanning faces. Therefore, one-sixth of the diagonal light line so scanned falls on the next multi-focal lens substantially instantly. As the light beam so scanned by each multi-focal lens of the first reflector reflects into the second reflector, each multi-focal lens scans a full line on same across the full width of the second scanning reflector. Hence, there are six inclined light lines scanned across the second scanning reflector, each line being inclined about $\frac{1}{6}''$ or about $\frac{2}{3}''$, and each light line is described on the second scanning reflector below the preceding one. As the second scanning reflector also has six multi-focal scanning faces, each light line as scanned across the second multi-focal scanning reflector reflects and scans six lines across the third scanning reflector. Therefore, the one diagonal described and scanned across the first scanning reflector describes and scans thirty-six lines across the third scanning reflector and each line is on an incline of two-thirds divided by six, or $\frac{1}{6}''$. As the third scanning reflector also has six multi-focal scanning faces, each line scanned and described on the third scanning reflector describes six lines on the screen. Thus, the single diagonal described and scanned on the first scanning reflector now scans and describes 6×36 , or 216 lines on a screen. If we have a $24''$ screen, each line is inclined $6 \times \frac{1}{6}$ divided by six, or $\frac{1}{6}''$, and each line is scanned and described below the preceding one.

The "third unit" of the television system is the expanding mirror and the screen. Hence, the second television unit should be placed at such an angle to the third television unit as to produce straight horizontal lines on the screen in a manner hereinafter described. It is not necessary to physically place each television unit at different angles, as a mirror placed in combination with these units and at a certain angle to each unit will produce equivalent results, as hereinafter described.

Assuming that a 60-cycle house current is superimposed on a direct current voltage and by well-known means is converted to a saw-tooth scanning current and applied to the scanning plates, then in one-sixtieth of a second, the fan-

shaped (or modulated shaped) electronic beam moves slowly across the diametric fluorescent line of the second anode and quickly returns to the starting point. During the return, no television signal is received, and, therefore, the electronic beam is fan-shaped, and there is but a very dim light on the screen. Thus, nearly one-sixtieth of a second is consumed by the slow one-way movement of the electronic beam across the diametric line of fluorescent material. In thirty double interlaced frames per second there are sixty half image interlaced frames per second, which is equivalent to the scanning thus produced, and, since each half frame has 216 lines scanned on the screen, the whole image frame has 432 lines per second. The nine lines less than the conventional standard 441 line image can be absorbed in the return of the electronic beam or in the descent of the saw-tooth scanning current. By changing the number of bifocal faces in each of the three multi-focal scanning reflectors, any number of lines per image can be produced, thus multi-focal scanning lenses with seven concave-prismatic lenses would produce $7 \times 7 \times 7$, or 343 lines per half frame and 686 lines per image frame, and eight bifocal faces would give $8 \times 8 \times 8$, or 512 lines per half frame and 1024 lines per image frame.

The television receiver may be synchronized by the means shown in Figs. 17 and 17a and described in the specification of my copending application Serial No. 264,876, filed March 30, 1939, to any present-day conventional television transmitter.

More specifically, another object of the present invention is to provide a novel television receiver which is adapted to obviate the deficiencies of receivers now known and in use.

Another object is to provide a novel television receiver which is adapted to produce a large-size clear image.

Another object is to provide a novel television receiver which is adapted to produce a large-size clear image at relatively low voltage.

Another object is to provide a novel cathode ray tube for use as an element of a television receiver which is small in size, yet which will produce a large-size clear image at comparatively low voltage.

Another object is to provide a novel television receiver tube which is adapted to modulate the brightness of the moving image spot substantially instantaneously.

Another object is to provide a novel television tube which is entirely screened from outside magnetic or static interferences.

Another object is to provide a scanning system and a method of effecting the same which eliminates ordinate and coordinate scanning.

Another object is to provide a novel combined television tube and prime mover to render the optical television receiver entirely automatic in action, thus eliminating any mechanical or physical prime mover.

Another object is to provide novel scanning reflectors that scan concentrated light beams, and to provide a system of disposition of same to produce an ultimate clear image.

Another object is to provide a novel diagonal scanning system to scan the image to eliminate the ordinate and coordinate scanning signals, and a method of performing the same.

Another object is to provide a novel cathode ray tube which includes a metal anode against

which the electronic stream plays to utilize the complete illuminosity thereof.

Another object is to provide a novel, inexpensive, simple television receiver which produces a large clear image.

Another object is to provide a novel television receiver tube which is small and which functions with a relatively low voltage.

Other objects and advantages will be apparent from the following description, taken in conjunction with the accompanying drawings, in which:

Fig. 1 is a diagrammatic view of a portion (the first unit) of the present novel television receiver, particularly showing the tube;

Fig. 2 is a diagrammatic view of a metal television receiver tube constructed in accordance with the teachings of the present invention;

Fig. 3 is a plan view of the novel metal anode employed in the tube shown in Figs. 1 and 2, disclosing the fluorescent strip;

Fig. 4 is a diagrammatic developed view of the defining shapes of the electronic beam of the tube;

Fig. 5 is a perspective view of one type of anode hereinafter referred to as the first anode;

Fig. 6 is a view of another type of anode employed in the manner of the anode shown in Fig. 5;

Fig. 7 shows diagrammatically a concave reflector with light beams passing through the principal focus thereof;

Fig. 8 illustrates diagrammatically a single prism and a reflector with light beams reflected from the latter and passing through the former;

Fig. 9 illustrates diagrammatically a double prism and a reflector with light beams reflected by the latter and passing through the former;

Fig. 10 is a cross-section of a prismo-concave scanning lens reflector with light beams passing therethrough;

Fig. 11 is a cross-section of a multi-focal scanning lens reflector which is concave at the back and which includes six concavities in the front side;

Fig. 12 is a cross-section of a prismo-concave scanning lens reflector;

Fig. 13 is a cross-section of a concavo-convex multi-focal scanning lens reflector;

Fig. 14 is a cross-section of a prismo-convex scanning lens reflector of multi-convex configuration;

Fig. 15 is a cross-section of a prismo-convex scanning lens in a metal reflector holder;

Fig. 16 is a side view of a lens and holder together with fastening means for securing it in a receiver cabinet;

Fig. 17 illustrates diagrammatically the disposition of the lens reflectors which receive the optical image emitted from the cathode ray tube and develop it on a screen;

Fig. 18 is a front view of the scanning lens reflectors and screen shown in Fig. 17, diagrammatically illustrating the multiplication of a single diagonal scanning light beam, and the developing therefrom of the desired number of image lines on the screen; and,

Fig. 19 illustrates diagrammatically how light lines may be made to ultimately appear at any angle of inclination desired.

Referring to the drawings more particularly by reference numerals, in order that the theory and operation of the apparatus may be understood, there is disclosed in Fig. 1 the first unit of an optical television receiver constructed in accordance with the teachings of the present in-

vention. There is an antenna 21 which is adapted to receive a television radio signal, and a conventional commercial type television receiver 22 which precepts, detects and amplifies the signal. An amplifying circuit 23 is connected to the receiver 22 and includes a grid and cathode 24 across which the television signal is applied. The amplifying circuit 23 is connected to both plates of a modulating anode 25 forming part of a television tube 26 and to a cathode 27 of the tube 26, so that the television signals or impulses are supplied to both.

A focusing anode 28 is disposed below the modulating anode 25. The focusing anode 28 comprises a pair of parallel plates 29 connected by an end piece 30 having a rectangular opening 31 therein (Fig. 5). The rectangular opening 31 permits electrons from the cathode 27 to pass therethrough and the plates 29 concentrate the beam so formed in those two directions only, while permitting it to spread in the directions at right angles thereto. A conventional cylindrical focusing anode 32 having rectangular openings 33 in the ends 34 thereof may be employed if preferred (Fig. 6).

The modulating plates 25' of the modulating anode 25 are electrically connected together and with the plate of the amplifying circuit 23 as aforesaid, and are also mechanically positioned at right angles to the plates 29 of the focusing anode 28 and are spaced slightly further apart than the plates 29. A choke coil 36 connected as shown causes the signals or impulses to be applied to the modulating anode 25 only above the potential applied to the focusing anode 28. Between the focusing anode 28 and the cathode 27, which is a heavy duty unit held under red heat and capable of supplying a large quantity of electrons, is a cup-shaped grid 37 having a hole 38 therethrough.

Direct current power supply terminals 40 and 41 supply rectified D. C. electric power from a power pack (not shown) across a resistance 42. The aforesaid grid 37 is held in a negative potential to the cathode 27 at any preferred degree through a movable contact point 44 movably connected to the resistance 42. A suitable lead 45 connects the grid 37 and the contact point 44. Through manipulation of the contact point 44, the quantity of electrons in the electronic beam 47 produced by the cathode 27 may be increased or decreased, as desired. At a selected setting of the contact point 44, a constant electronic current or beam 47 flows between the hot cathode 27 and an anode 48 located at the far end of the tube 26.

The anode 48 comprises a metal plate of dished or concave circular configuration (Figs. 1 and 3). Running diametrically across the anode 48 is a strip 49 of fluorescent material which is preferably of a width of slightly less than $\frac{1}{4}$ ".

The aforesaid constant quantity of electronic current 47 flowing between the heavy duty cathode 27 and the anode 48 is not modulated or changed by the television signals, but continues constant at the rate determined by the setting of the contact point 44. However, the amount of it that is caused to impinge or strike the fluorescent strip 49 is modulated or changed by the television impulses as supplied by the plate of the amplifying circuit 23 to the modulating plates 25'. The shape of the electronic beam 47 when no television signal is being received is shown in solid lines in Fig. 4, whereas the shape when the television signal is strongest is shown

by broken lines in the same figure. In other words, at the strongest signal, the electronic beam 47 is bar-shaped to concentrate all of the electrons on a corresponding cross-section of the fluorescent strip 49, whereas, with no signal being received, the electronic beam 47 is fan-shaped to reduce to a minimum the electrons impinging on the fluorescent strip 49.

A conventional 60-cycle saw-tooth current developer 50 is connected to an ordinary 60-cycle house current by leads 51 and 52 (Fig. 1). The developer 50 includes a device similar to that shown in Figs. 17 and 17a and described in the specification of my copending application Serial No. 264,876, filed March 30, 1939, so that the present device can easily be brought in phase relation with the scanner of a transmitter. As shown in Fig. 1, the 60-cycle saw-tooth current is superposed on the D. C. current and applied to a pair of plates 54 which comprise a deflecting anode 55. As is well-recognized in the art, this arrangement causes the electronic beam 47 to move slowly in one direction, as in the direction of the arrow 56 (Figs. 1 and 3), and quickly in the other direction, as in the direction of the arrow 57.

The fluorescent strip 49 (Fig. 3) need not be of transparent material, inasmuch as the anode 48 is of metal. The material is applied heavily to the appreciable width of about $\frac{1}{4}$ ". As is clear from Fig. 3, only those electrons of the electronic beam 47 within the square designated 60 produce light, inasmuch as the remainder thereof falls on the metallic anode 48. Hence, as stated, when the strongest signal is received, all of the electrons of the beam 47 are concentrated within the square 60 somewhere along the fluorescent strip 49. As the signal weakens, the beam 47 becomes fan-shaped in proportion to the intensity thereof, so that only a proportionate number of electrons strike the fluorescent strip 49 within the square 60.

The deflecting plates 54 move the beam 47 in the direction of the arrow 56 from the end 61 of the strip 49 to the end 62 in slightly less than one-sixtieth of a second. The brightness of the light square 60 advances and recedes in strength from point to point and from instant to instant as modulated by the television signal received by the modulating plates 25'. It is well-known that fluorescence is always accompanied by phosphorescence; that is, fluorescent material when lighted by electrons striking it remains lighted for a short instant thereafter due to phosphorescence. In effect, a lag in the lighted dots of the image is produced and a smeared picture results. The metal anode 48 eliminates phosphorescence as a practical matter, for the fluorescent light dies substantially after the electrons stop striking it. The demarkation between strong and weak light points is very sharp and defined with the present device so that the tube or lamp is sensitive to any number of megacycles and can produce a clear image of any number of lines.

Within the tube 26 suitably located in respect to the anode 48 is a reflector 64 which receives light flux 65 from the anode 48. In turn, a light beam 66 is reflected from the reflector 64 through a window 67 in the metal envelope 26' of the tube 26. The beam 66 passes through a concentrating lens 68 to strike a further concentrating concave reflector 69, whence it passes to a single scanning reflector unit 70. The reflector 64 is metal and is mechanically secured to any ele-

ment of the tube and is electrically connected to the reflecting plates 54. The reflector 64 takes no part in the electric circuit reaction of the elements of the tube 26, but is electrically connected to the deflecting plates 54 or some other element for the purpose of enabling the tube 26 to be completely degasified.

As stated, the light beam 66 is concentrated by the lens 68 so that the incident light beam swings lengthwise on the surface of the one dimensional concave reflector 69 a very short distance, as $\frac{1}{8}$ " (a single light beam is considered herein for purposes of illustration as a matter of clarity). Since the original length of the generated light line caused by the electronic beam 47 moving between the points 61 and 62 (Fig. 3) is 2" and the length of the line at the reflector 69 is but $\frac{1}{8}$ ", manifestly the dot light beam has been concentrated to one-sixteenth its original size and is manifestly sixteen times as bright. As the cross-sectional area of the light line at any instant was less than $\frac{1}{4}$ " squared, the light dot on the reflector 69 is less than $\frac{1}{4}$ " x $\frac{1}{16}$ ", or less than $\frac{1}{64}$ " in cross-sectional area. In the perpendicular direction of the light beam 66, the instantaneous dot light beam is still further concentrated by the concavity of the reflector 69. As the incident light beam 66 swings from *a* to *b* (Fig. 1), it forms a certain incident angle with the normal to the straight dimensional side of the reflector 69 and produces a light beam 66' at a reflected angle of twice the deflection. The angle effected by the beams 66 and 66' is very large and varies as the beam 66 swings from *a* to *b*, thus making the corresponding swing of *A* to *B* of 66' of sufficient width to cover the entire width of the prismatic part of the prismo-concave lens reflector 70. The lens reflector 70 is silvered on the convex side to reflect and deflect the concentrated light beam 71 (Fig. 17) through a wide angle to scan a line of, say, $5\frac{1}{2}$ " in length, whereby it scans the whole width of a first scanning reflector 75 along a diagonal line 113 (Fig. 18).

Before proceeding to a descriptonal analysis of the second unit of the present receiver, it is well to consider specific lens reflector elements and combinations which can be employed.

Referring to Fig. 7, there is shown diagrammatically a concave reflector 80. Any light beam 81 reflected by the reflector 80 will pass through the principal focus 82 thereof. All of such light beams 81 will be concentrated at the principal focal point 82.

In Fig. 9, there is shown a double prism 84 disposed between the concave reflector 80 and its principal focus 82, the double prism 84 being relatively close to the concave reflector 80. Each beam or line of light 81 will be deflected by the double prism 84, each light line being deflected to a different degree away from the principal focus point 82 except the center one, which, of course, will continue to pass through the central focus point 82. By selecting the respective dioptral strengths of the reflector 80 and of the prism 84, so that the former is slightly more contracting than the latter is diverging, for example, selecting the concavity of the reflector 80 as four diopters and the prism 84 as but about a resultant of slightly less than four diopters, the very narrow beams 81 will still follow the directions compelled by the action of the double prism 84, yet will remain on the whole concentrated. The foregoing is true, due to having the reflector 80 more concentrating of the light beam than the

prism 84 is divergent of it. At specific distances from the reflector 80, a series of principal focal points will be formed and each very thin light beam 81 will have its principal focus at a different location. When a thin light beam is moved across the reflector 80 (Fig. 9) it will reflect and be refracted by the prism 84 so that the principal focal point will move rapidly from 82a to 82c in the direction of the arrow 85, yet the beam 81 will concentrate and become thinner as it is refracted towards 82a. The direction and concentration of the beam 81 are resultants of directions and concentrations of the light beams 81 reflected from the reflector 80 and refracted by the double prism 84.

In Fig. 10, there is shown a single scanning lens reflector 86 which combines the reflector 80 and the prism 84. In a thick mirror lens, such as a $\frac{1}{4}$ " lens reflector, the outer glass becomes a lens superposed upon a mirror and, since the light beam has to pass the glass of the reflector twice (into and out of the reflector), only one-half of the double prism 84 is required to accomplish the same result. The scanning reflector 70 is of the type exemplified by the lens reflector 86. The light line 81a comprises two broader lines which come closer and closer together until the focus point 82a is reached. The slightest movement of the incident light beam to one side as it strikes the reflector portion of the lens reflector 86 moves the nodule point 82a a greater distance in the direction of the arrow 33a.

In Fig. 11, there is shown a lens reflector 88 of the type disclosed in my aforesaid copending application, in which, in a preferred embodiment, the mirrored reflector side 89 has a curvature of five diopters, the general curvature of the exterior side 90 of the lens is of but slightly less than one and one-half diopters, and the individual lens curvatures 91 are of slightly more than two diopters. The scanning lens reflectors 88, when employed as a part of the present receiver, are preferably set at about 15" from each other for proper scanning, assuming the size of each as 4" x 4". The effective light beams are thin and diverging and scan swiftly across the succeeding reflector.

There is shown in Fig. 8 the effect of a single prism 93 on light beams 81 reflected from the reflector 80. The reflection of the light beams 81 is more towards the thicker part of the prism 93. The principle of the single prism 93 and the reflector 80 is employed in the formation of a scanning lens reflector 95 (Fig. 12) to avoid an undesirable characteristic of the lens reflector 88 which requires that the individual lens curvatures 91 be narrower from the center towards the end in order that each covers exactly the same line area of the succeeding scanning lens reflector. In the lens reflector 95, there are two central lenses 96 comprising a double prismatic lens, each with the thicker side of the prism towards the center. At each side of the lens 96 are single prisms 97 to deflect the light more towards the center and the inclination of each prism is such as to cover exactly the same line area as the succeeding scanning lens reflector. The thicker ends of the prisms 97 are disposed towards the center of the scanning lens reflector 95. The correct inclination of each prism 96 and 97 further corrects any slight existing error, so that each scanned line is placed on the exact same width of the succeeding scanning lens re-

flector as the line scanned by the adjacent bifocal face or prism.

In Fig. 13, there is shown a scanning lens reflector 99 having double multi-focal lenses 100 and 101. In this construction, the resultant diopter of the lenses 101 must be less than that of the lenses 100 to produce a concentrated and diverging scanning beam. The lenses 100 are mirrored and concentrate the beams, whereas the multi-focal lenses 101 refract them in a diverging relationship.

In Fig. 14, there is disclosed a convex prismatic lens reflector 103, which includes a reflector portion 104 made up of a plurality of concave reflector segments 105 and prisms 106 and 107. Preferably, the curvature of the reflector segments 105 is about four diopters, while the radius of the lens 103 is about 15".

In Fig. 15, there is shown a lens 109 in association with a holder 110 which together comprise a scanning lens reflector 111. The holder 110 is preferably of chromium-plated metal highly polished on the concave side to reflect light. The lens 109 is of plastic material, such as "lucite." This construction permits the use of plastic material for lenses which molds easily to the desired shape to produce lenses to perform all their intended functions. The disclosed holder 110 has two metal end pieces 112 (Fig. 16) by means of which the scanning lens reflector 111 may be mounted in a suitable cabinet, or the like.

Referring again to Figs. 1 and 17, it has been shown that the light beam 66 swings and scans the single scanning lens reflector 70 from A to B across the width of the double prism thereof. For the purpose of the present analysis, the first unit of the present receiver, which comprises the tube 26 with all of its elements, the lens 68, the mirror 69, and the single scanning reflector 70, is positioned at 45° from the orbital circle of three scanning lens reflectors 75, 76 and 77 (Fig. 17). Hence, the light beams reflected from the reflector 70 is a diagonal line 113 as thrown on the scanning reflector 75 (Fig. 18). The light beam 71 scans at 45° to the plane of the drawing sheet, while the scanning reflector 75 is positioned vertically with respect thereto with the multi-focal lens faces inside directed to receive the light beam 71, the multi-focal lenses extending from the top 115 to the bottom 116 of the scanning reflector 75. In Fig. 17, one-half of the outside of the scanning reflector 75 is observable. The scanning reflector 75 is placed in a position above the reflector 70, so that a reflected light beam 117 is reflected upwardly, as shown. As stated, the scanning reflectors 75, 76 and 77 are in alignment with each other and are positioned as though located on the inner side of the rim of a wheel. Hence, the light beam 117 scans normal to the plane of the drawing within the width of the scanning reflector 76, the multi-focal lenses of which extend from 118 to 119. From the light beam 117 scanning the reflector 76 there is reflected the light beam 120 which strikes the scanning reflector 77, the multi-focal lenses of which extend from 121 to 122, from which there is produced a reflected light beam 123. As aforesaid, the light beams 117, 120 and 123 scan in directions normal to the plane of the drawing through a width of 4", which is the afore-assumed width of the scanning reflectors 75, 76 and 77, which is effected substantially as the light beam 71 moves from 75

115 to 116, describing the diagonal light line 113 across the reflector 75 (Fig. 18). As the vertical angle defined by the light beams 71 and 117 changes, so the corresponding angles defined by the light beams 117 and 120, 120 and 123, and 123 and 124 change accordingly. Thus, each aforesaid light beam moves both across the width of the respective scanning lens reflector 75, 76 and 77 and a screen 125 as many times as refracted by the bifocal lenses, and once across the height of the same for each image half-frame. The light beams 117, 120, 123 and 124 scan each one faster than the other at a direction normal to the plane of the drawing in a manner described in my aforesaid copending application for patent.

Close to the scanning reflector 75 is a longitudinal concentrating lens 126. There is a similar concentrating lens 127 adjacent the scanning reflector 76, a concentrating lens 128 adjacent the scanning reflector 77, and a concentrating lens 129 adjacent a reflector 130. The thin light beam 71 scans swiftly the multi-focal lenses of the scanning reflector 75 in the direction 33a (Fig. 10) and normal to the plane of the drawing (Fig. 17). The lens 126 further concentrates each light dot of the monochromatic light beam 71 so that they appear in scanning relation to the scanning reflector 75 as but fine thin specks of very bright light. The concentrating lenses 127, 128 and 129 produce the same effect on their respective scanning reflectors and reflector. Since the reflected light beam 117 clears the lens 126, it scans the entire width of the scanning reflector 76 normal to the plane of the drawing. Similarly, the reflected beams 120, 123 and 124 clear the respective concentrating lenses 127, 128 and 129, respectively, and each scans the succeeding reflector normal to the plane of the drawing through the width thereof, each beam scanning faster than the preceding one.

Referring to Figs. 17 and 18, the light beam 71, in scanning once across the scanning lens 75, covers the distance a—g in describing the aforesaid diagonal light line 113 (Fig. 18A). As the light beam 71 moves from a to b (one-sixth of the scanning movement), the reflected light beam 117 scans once completely across the face of the scanning reflector 76 to describe a complete light line 135 (Fig. 18B). Similarly, as the beam 71 moves from b to c, c to d, d to e, e to f, and f to g, each time the light beam 117 scans completely across the face of the scanning reflector 76 to describe, respectively, the whole light lines 136, 137, 138, 139 and 140. In other words, each lens of the multi-focal scanning lens reflector 75 causes the incident light beam 71 reflected as light beam 117 to describe a full light line on the succeeding scanning reflector 76 and, therefore, the six light lines 135—140 are described on the scanning reflector 76, each of which has an inclination of but one-sixth that of the diagonal light line 113, the angle comprising the vertical component of the respective light line diagonal segment a—b, b—c, etc.

By the same principle that the six light lines 135—140 are developed on the scanning reflector 76 from the single diagonal light line 113 on the scanning reflector 75, so thirty-six light lines are developed on the scanning reflector 77, and two hundred sixteen light lines are developed ultimately on the screen 125 (Figs. 18C and 18D).

In other words, each of the light lines 135—140 develops six light lines on the scanning reflector 77. The six light lines developed by the light line 135 fall on the scanning reflector 77 within the vertical distance from *a*—*g* on Fig. 18B. The light beam 120, which typifies all of the light beams 135—140, scans completely across the scanning reflector 77, along the full light line 141 as that portion of it designated the light line 135 (Fig. 18B) moves from *a* to *b*. Similarly, the light lines 142, 143, etc., are generated as the light line 135 moves from *b* to *c*, *c* to *d*, etc., respectively. In the same manner, the second full six light lines are generated on the scanning reflector 77 by that segment of the light beam 120 designated the light line 136, the third six light lines by the segment designated 137, the fourth six light lines by the segment designated 138, the fifth six light lines by the segment designated 139, and the sixth six light lines by the segment designated 140. The inclination of each of the light lines 141, 142, 143, etc., is one-sixth of that of the light lines 135—140, or one thirty-sixth of that of the light line 113. As aforesaid, two hundred sixteen light lines 145 are developed on the screen 125, which form the components of the light beam 123, which is reflected by the reflector 130 as light beam 124. Each of the light lines 141, 142, 143, etc., which comprise the light beam 123, 124 develop in rapid succession six full light lines 145 on the screen 125. The inclination of each of the light lines 145 is one-sixth that of the light lines 141, 142, 143, etc., or one two-hundred-sixteenth that of the original diagonal light line 113. It becomes necessary, therefore, only to provide for a small adjustment of the flat expanding mirror reflector 130 to bring the light lines 145 on the screen 125 into straight horizontal positions.

The flat mirror reflector 130 is used to spread the light lines to form an image on a large screen of, for example, 24" x 24". Since, in interlaced scanning, a line of light is placed on the screen alternately with a line of darkness, the scanned lines occupy in surface coverage only a total of one-half of the height of the screen, or 12". In each half image (interlaced) two hundred sixteen light lines are developed so that the width of a light line as scanned on the screen 125 is $\frac{1}{16}$ " (12" divided by 216). The original dot of light produced by the fluorescent strip 49 has a width of $\frac{1}{4}$ ", hence the ultimate corresponding dot developed on the screen 125 is condensed $\frac{1}{2}$ squared, or 20.5 times, so that the aforesaid ultimate dot is 20.5 times as bright as that originally produced in the fluorescent square 60 (the ratio is $\frac{1}{4}$ " squared to $\frac{1}{16}$ " squared, or $\frac{1}{2}$ squared equals 20.5 times as much light). Therefore, a clear very bright image results on a 24" x 24" screen. The width of the light dots on the screen 125 need not be considered, for, as light travels 186,000 miles per second and there are 60 x 216 x 432, or 5,598,720 light dots developed on the screen per second, there is .04 mile (186,000 divided by 5,598,720) of light flux falling on each light dot of the image upon the screen 125. The scanning lens reflectors 75, 76 and 77 may also be slightly concave in a vertical direction to concentrate the scanning beams in a vertical direction also, that is, in the direction at right angles to the scanning direction of the beams 71, 117, 120 and 123.

Referring to Fig. 19, there is shown a method by which the disposition of the first unit at a 45° horizontal angle from the second unit may be

avoided. A flat reflector 150 is interposed between the single scanning reflector 70 and the scanning reflector 75, the reflector 150 being positioned either on a higher or lower level and at a horizontal angle of 60° from the single scanning lens reflector 70 while, at the same time, it is inclined to the horizontal less than 45°. The result is the appearance of the light beam 71 on the scanning reflector 75 as the diagonal light line 113. As shown in Fig. 19, the single scanning reflector 70 is positioned upright or vertically, with the bottom edge 70' in a horizontal plane. The light beam 66', therefore, in scanning across the reflector 70, describes the horizontal light line 151, which is deflected into and across the flat reflector 150. An inclined light beam 152 is, therefore, developed on the light reflector 150, inasmuch as the flat reflector 150 is positioned lower or higher than the single scanning reflector 70 with the side edge 150' at the bottom displaced 60° horizontally from the single scanning reflector 70, and inclined towards the latter about 45°. It is to be noted that the face of the single scanning reflector 70 is not observable. The scanning reflector 75 like the single scanning reflector 70 is positioned vertically and at a horizontal angle of approximately 60° from the single scanning reflector 70. Hence, the reflected light beam 71, as scanned by the single scanning reflector 70, describes the required diagonal light line 113 on the scanning reflector 75, even though both reflectors 70 and 75 are positioned vertically. By tilting the single scanning reflector 70 slightly away from the reflector 150, the degree of inclination of the latter to the horizontal can be reduced. Further, by using the corner point 153 of the reflector 150 as a pivot and changing the inclination or the horizontal angle of the same, any inclination of the light beam 113 from vertical to horizontal may be obtained. The reflector 130 (Fig. 17) is so tilted to produce straight lines on the screen 125.

The afore-described and illustrated television receiver can readily be employed as a transmitter by substituting photoelectric material for the fluorescent material of the fluorescent strip 49.

It is apparent from the foregoing description and analysis, taken in conjunction with the accompanying drawings, that the present invention is adapted to and does fulfill all of the objects and advantages sought therefor. Modifications of the disclosed and described embodiment of the present invention falling within the boundaries of the claims which follow are contemplated as fully within the spirit and scope hereof.

It is to be understood that the foregoing description and accompanying drawings have been given by way of illustration and example, and not for purposes of limitation, the invention being limited only by the claims which follow.

What is claimed is:

1. In the art described, the method consisting of producing an electronic beam, projecting the electronic beam upon a surface partially covered by fluorescent material, receiving television signal impulses, contracting and expanding the said beam under the influence of the said impulses, moving this electronic beam along a fluorescent material track, thereby producing a linear motion of a television modulated light beam, intercepting this linear light beam motion by a plurality of stationary multi-focal multi-lens reflectors disposed in a predetermined relationship to one another, thereby producing concentrated multiple reflections and refractions of the light

beam, intercepting these multiple reflections of the light beam by a screen and reproducing an image corresponding to the television signals received.

2. In the art described, apparatus comprising a surface partially covered with fluorescent material, means to produce an electronic beam, means to project the electronic beam upon the said surface, means to receive television signal impulses, means to contract and expand the electronic beam under the influence of the said signal impulses, means to move the electronic beam along a fluorescent material track to produce a moving television modulated light beam, means to reflect and refract the said light beam comprising a plurality of stationary multi-focal lenses to produce a plurality of movements of light beams, and means to reflect these light beams upon a screen to reproduce an image corresponding to the television signals received.

3. In the art described, the method consisting of producing an electronic beam, projecting the electronic beam upon a surface embodying a track covered by fluorescent material, receiving television signal impulses, contracting and expanding the said beam in one direction under the influence of the said impulses, moving this electronic beam at right angles along the said fluorescent material track under the influence of a periodic deflecting force, thereby producing a linear motion of a television modulated light beam, intercepting this linear light beam motion by a plurality of stationary multi-focal multi-lens reflectors disposed in a predetermined relationship to one another, thereby producing concentrated multiple reflections and refractions of the light beam, intercepting these multiple reflections of the light beam by a screen and reproducing an image corresponding to the television signals received.

4. In the art described, apparatus comprising a surface embodying a track covered with fluorescent material, means to produce an electronic beam, means to project the electronic beam upon the said surface, means to receive television signal impulses, means to contract and expand the electronic beam in one direction under the influence of the said signal impulses, means to move the electronic beam at right angles thereto along the said fluorescent material track under the influence of a periodic deflecting force to produce a linear moving television modulated light beam, means to reflect and refract the said light beam comprising a plurality of stationary multi-focal prismo-concave multi-lens reflectors disposed in a predetermined relationship to one another to produce a plurality of movements of concentrated light beams, and means to reflect these light beams upon a screen to reproduce an image corresponding to the television signals received.

5. A television scanning construction comprising a plurality of stationary multi-focal scanning reflectors disposed in a predetermined relationship to one another, each reflector comprising a plurality of prismo-convex lenses, a moving television modulated light line intercepted by the multi-lenses of the first reflector is successively developed upon the other multi-focal multi-lens reflectors in increasing numbers, depending upon the number of lens elements of each reflector and the number of reflectors, means to direct the scanning light line diagonally across the first multi-focal multi-lens reflector, and means to receive the light lines from the last of the afore-

said disposed multi-focal multi-lens reflector as horizontal line areas of an image.

6. In accordance with claim 1, a method of diagonal scanning comprising developing without mechanical motion a single diagonal light line in accordance with the television impulses received from the scanning of one-half of an image frame, and substantially instantaneously developing from said single diagonal light line without mechanical motion a predetermined plurality of substantially horizontal light lines on a screen to form an image frame.

7. In accordance with claim 5, in combination, a mechanically shielded television tube including means to translate an electronic beam into light impulses in accordance with electrical television impulses received by the tube and means for deflecting the light impulses as light beams from the tube, means concentrating the light beams, and stationary means for diagonally scanning the light beams to produce image frames upon an ultimate receiving means.

8. In the art described, apparatus comprising a surface partially covered with fluorescent material, means to produce an electronic beam, means to project the electronic beam upon the said surface, means to receive television signal impulses, means to contract and expand the electronic beam under the influence of the said signal impulses, means to move the electronic beam along a fluorescent material track to produce a moving television modulated light beam, means to reflect and refract the said light beam comprising a plurality of stationary scanning reflectors each comprising a concave reflector and a double prism disposed in adjacent relationship, and means to reflect these light beams upon a screen to reproduce an image corresponding to the television signals received.

9. In the art described, apparatus comprising a surface partially covered with fluorescent material, means to produce an electronic beam, means to project the electronic beam upon the said surface, means to receive television signal impulses, means to contract and expand the electronic beam under the influence of the said signal impulses, means to move the electronic beam along a fluorescent material track to produce a moving television modulated light beam, means to reflect and refract the said light beam comprising a plurality of stationary scanning reflectors each comprising a concave reflector and a prism disposed in adjacent relationship, and means to reflect these light beams upon a screen to reproduce an image corresponding to the television signals received.

10. In the art described, apparatus comprising a surface embodying a track covered with fluorescent material, means to produce an electronic beam, means to project the electronic beam upon the said surface, means to receive television signal impulses, means to contract and expand the electronic beam in one direction under the influence of the said signal impulses, means to move the electronic beam at right angles thereto along the said fluorescent material track under the influence of a periodic deflecting force to produce a linear moving television modulated light beam, means to reflect and refract the said light beam comprising a plurality of stationary integral scanning reflectors each reflector comprising a plurality of multiconcave multi-prism lenses, each of the prism lenses being disposed with the thicker portion directed towards the longitudinal center line of the scanning reflector, and means to reflect

these light beams upon a screen to reproduce an image corresponding to the television signals received.

11. In the art described, apparatus comprising a surface embodying a track covered with fluorescent material, means to produce an electronic beam, means to project the electronic beam upon the said surface, means to receive television signal impulses, means to contract and expand the electronic beam in one direction under the influence of the said signal impulses, means to move the electronic beam at right angles thereto along the said fluorescent material track under the in-

fluence of a periodic deflecting force to produce a linear moving television modulated light beam, means to reflect and refract the said light beam comprising a plurality of stationary scanning reflectors disposed in a predetermined relationship to one another each comprising a polished concave reflector and a plurality of integral concave prism lenses disposed in contiguous relationship, and means to reflect these light beams upon a screen to reproduce an image corresponding to the television signals received.

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