March 18, 1941. W. SOLLER 2,234,987

PICTURE REPRODUCING APPARATUS FOR TELEVISION SYSTEMS

Original Filed Jan. 31, 1935 4 Sheets-Sheet 1

FIG. 1

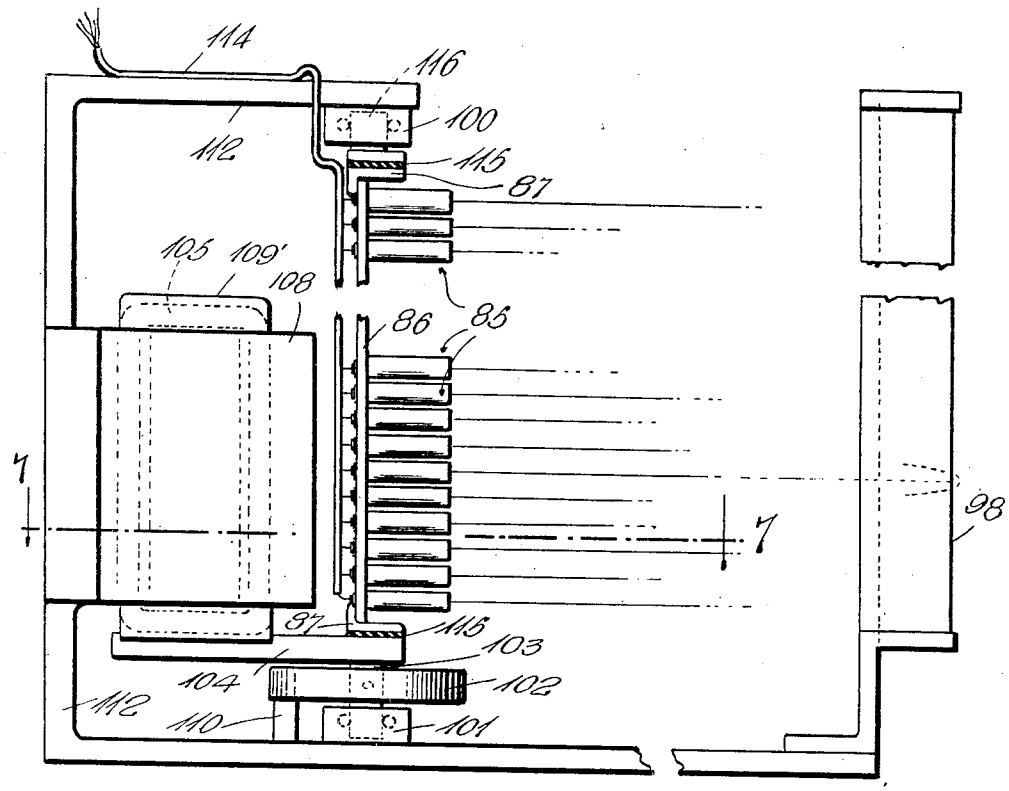


FIG. 2

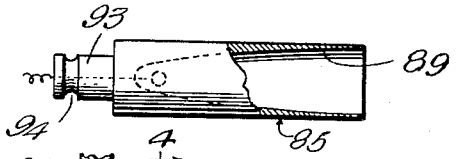
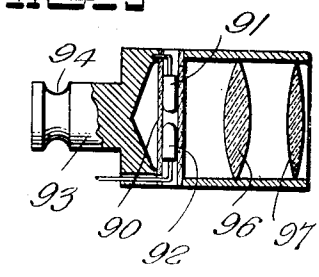


FIG. 5



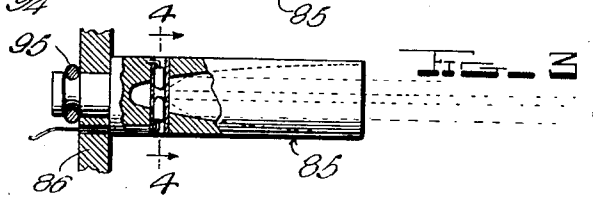


FIG. 3

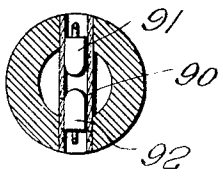


FIG. 4

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PICTURE REPRODUCING APPARATUS FOR TELEVISION SYSTEMS

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Fig. 6

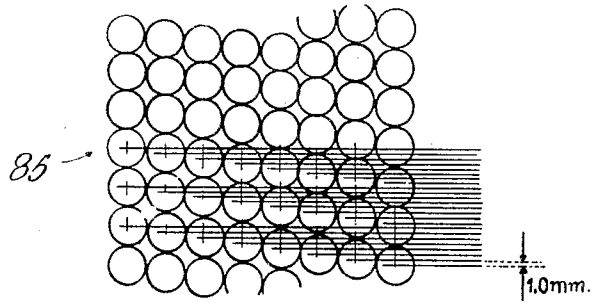
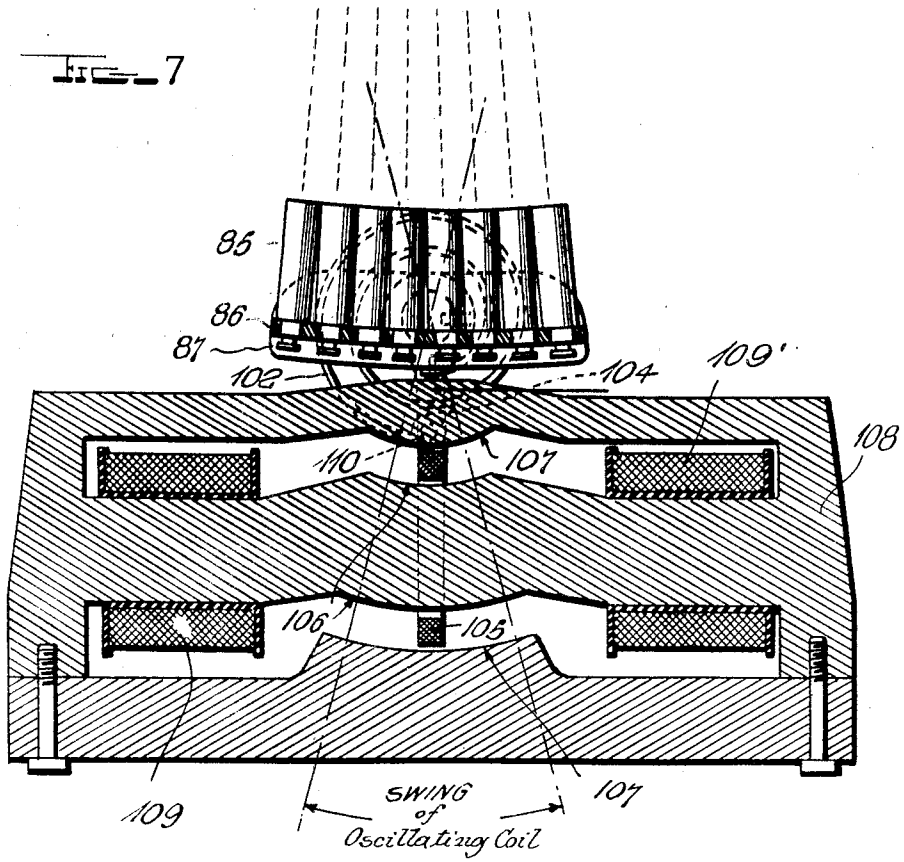


Fig. 7



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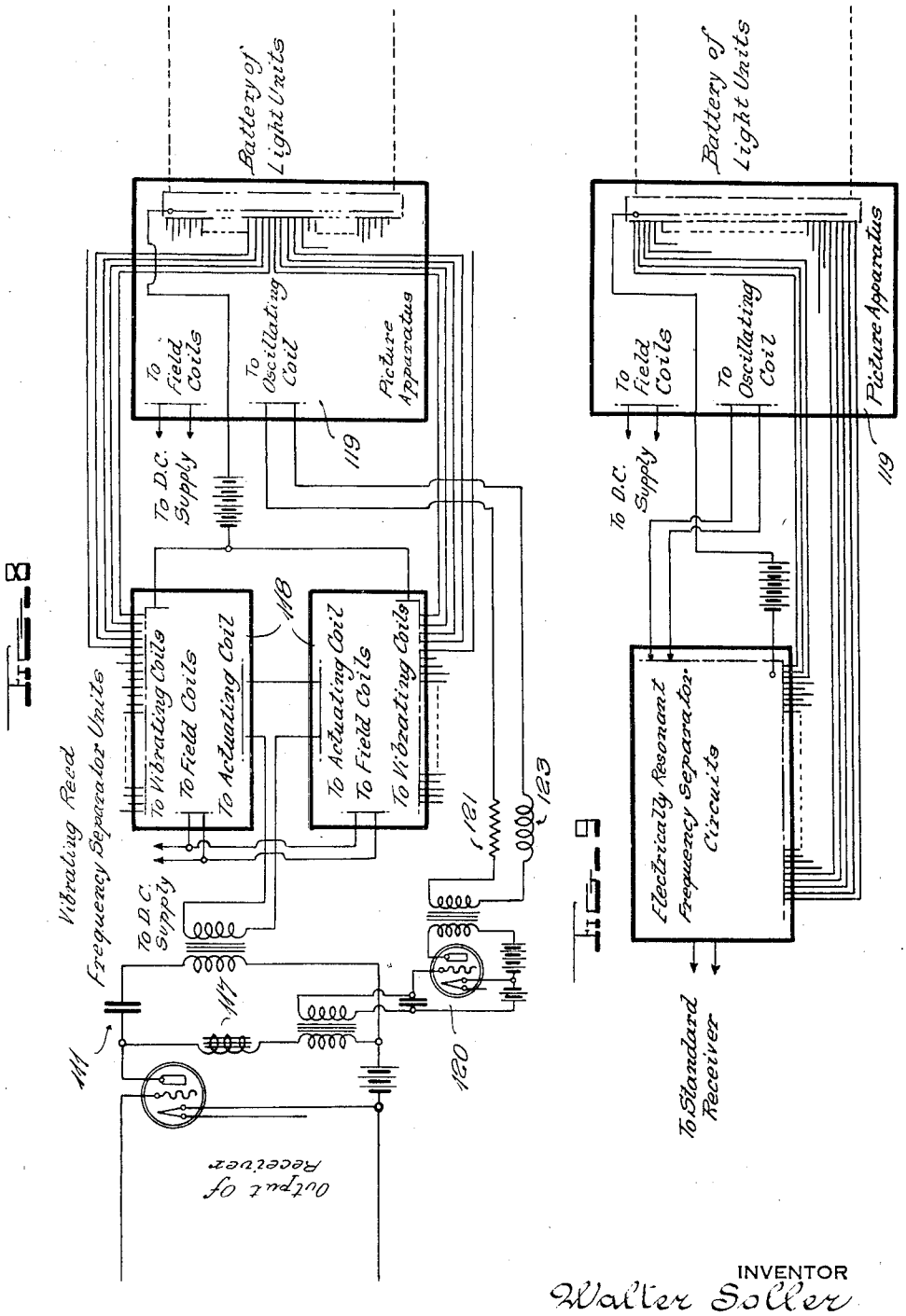
PICTURE REPRODUCING APPARATUS FOR TELEVISION SYSTEMS

Original Filed Jan. 31, 1935 4 Sheets-Sheet 3



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PICTURE REPRODUCING APPARATUS FOR TELEVISION SYSTEMS

Original Filed Jan. 31, 1935 4 Sheets-Sheet 4

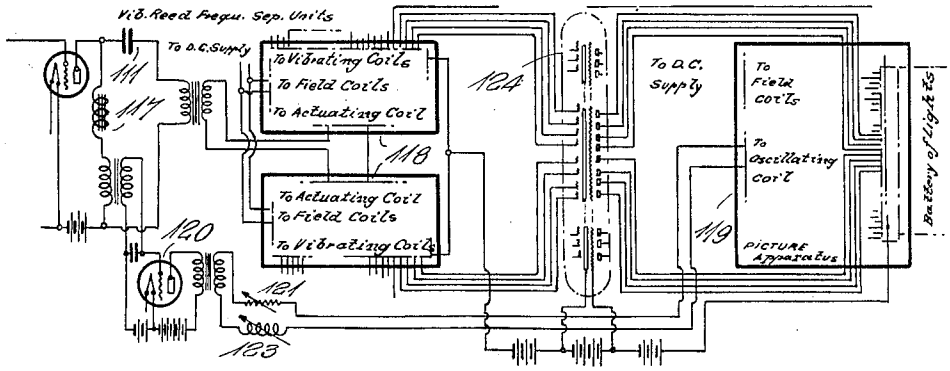
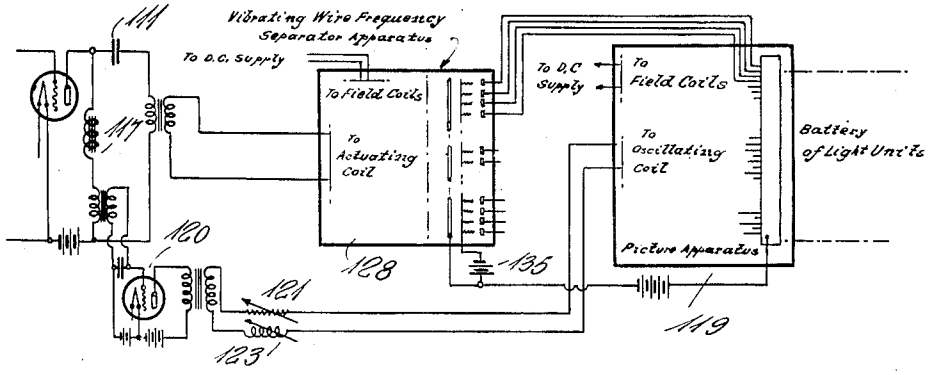


FIG. 11



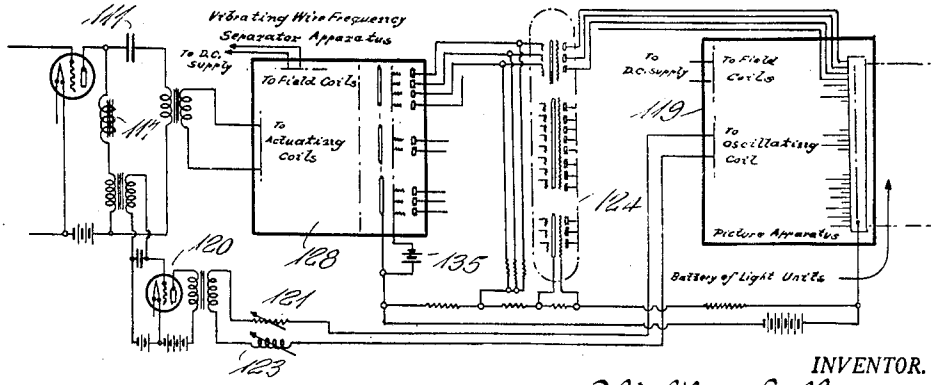


FIG. 12

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Patented Mar. 18, 1941

2,234,987

UNITED STATES PATENT OFFICE

2,234,987

PICTURE REPRODUCING APPARATUS FOR TELEVISION SYSTEMS

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Original application January 31, 1935, Serial No. 4,393. Divided and this application May 5, 1939, Serial No. 271,973

12 Claims. (Cl. 178—7.3)

My invention relates broadly to television systems and more particularly to a picture apparatus for synthetically reproducing television images of large size.

This application is a division of my application 4,393, filed January 31, 1935, for Television system.

One of the objects of my invention is to provide a construction of picture apparatus which is capable of reproducing television images in great clarity and detail and on a large scale.

Another object of my invention is to provide a construction of picture apparatus in which large scale television images may be projected on a screen in the home or in a theater or auditorium for increasing the enjoyment of television reception by enabling details of the objects at the transmitting point to be distinguished in greater detail than is possible with small size television picture reproduction customary from cathode ray tubes.

Still another object of my invention is to provide a method of reproducing television images on a large scale which consists in electronically controlling the emission of light in a plurality of rows of light responsive elements in varying degree in accordance with the transmitted image and sweeping a screen in accordance with a predetermined scanning frequency for synthesizing an image on enlarged scale upon a screen.

A further object of my invention is to provide picture apparatus for producing an image on a screen, in which the apparatus comprises a plurality of light sources individually variable and focused on the screen.

A still further object of my invention is to provide means for individually deflecting the multiplicity of light units in the picture apparatus in accordance with the scanning frequency in order to synthesize the complete image on the screen.

Another object of my invention is to provide a construction of image reproducing apparatus for television systems in which a multiplicity of controllable and variable light sources are employed, arranged in rows corresponding in number to the number of lines to be reproduced in the televised picture and mounted on a carrier constituting the frame width of the picture and adapted to be linearly displaced at a rate synchronous to the scanning frequency at the transmitter.

Still another object of my invention is to provide a construction of image reproducing system for television receivers in which the intensity of the image is determined by the intensity of the local light sources which may be made as brilliant as desired.

Other and further objects of my invention reside in a multiple frequency television image reproducing system as set forth more fully in the specification hereinafter following by reference to the accompanying drawings, in which:

Figure 1 is a side elevational view of a preferred construction of picture producing apparatus embodying my invention showing the relationship of the light producing apparatus and the television screen; Fig. 2 is a plan view partially broken away and shown in cross section and illustrating one of the preferred forms of light producing unit employed in the picture producing apparatus of Fig. 1; Fig. 3 is a longitudinal sectional view taken through one of the light units illustrated in Fig. 2, the light unit being partially illustrated in side elevation; Fig. 4 is a transverse sectional view taken on line 4—4 of Fig. 3; Fig. 5 is a side elevational view partially broken away and shown in cross section illustrating a modified form of light unit constructed in accordance with my invention; Fig. 6 is a partial front view of a battery of light units carried by the swinging carrier of the picture apparatus illustrated in Fig. 1 and showing the close relationship of the light lines capable of being reproduced in the television picture; Fig. 7 is a horizontal sectional view taken on line 7—7 of Fig. 1; Fig. 8 is a schematic view showing the electrical circuit arrangement leading to the battery of light units from the frequency discriminating apparatus of the television system of my invention; Fig. 9 shows the application of the system of my invention to an electrically resonant frequency separator system connected to a standard radio receiver; Fig. 10 illustrates a schematic circuit arrangement showing the application of my invention to a multiple frequency amplifying tube employed in a television receiving system in accordance with my invention; Fig. 11 shows the application of the picture reproducing apparatus of my invention to a vibrating wire frequency separator system operating in accordance with my invention; and Fig. 12 shows the manner of operating the picture apparatus of my invention in association with both a vibrating wire frequency separator apparatus and a multiple frequency amplifier tube arranged at a television receiver, in accordance with my invention.

My invention is directed to that class of television systems set forth more fully in my appli-

cation Serial No. 733,300, filed June 30, 1934, for Television system, and my application Serial No. 160,332, filed August 21, 1937, for Television system and apparatus.

The several modulated frequencies which are selected at the receiver pursuant to the scanning operation at the transmitter are impressed upon the circuits of the picture reproducing apparatus of my invention. The apparatus comprises a bank of gaseous glow light units which may be of the neon tube type arranged in linear relation in rows which correspond in number to the number of lines of the televised picture to be synthesized. The number of light units in each row are determined by the diameter of the light units divided by the line spacing. The glow lamps are of small bore glass tubing with an electrode on each end and gas sealed within. The operation is similar to that of a neon lamp in which the gas is rendered luminous by an electric voltage on the electrodes. Other than neon gas may be employed and I shall, therefore, hereinafter refer to the glow lamps as ionized gas tubes. Either of the two forms of light units described may be employed. The light given off by either of the units can be focused on a screen as a spot of 1 mm. diameter. The first makes use of the property of an elliptical mirror by which a light source placed at one of its foci is focused at the conjugate focus. A mirror such as that shown in the drawing will focus all but $\frac{1}{143}$ part of the light at the conjugate focus, while one ¼ inch longer will focus all but $\frac{1}{256}$ part of the light.

The second form employs two lenses, the first of which forms a parallel beam of light rays from the light placed at its focus, while the second focuses this parallel beam into a 1 mm. spot on the screen. The light units are arranged in an arc so that the lights, when glowing, illuminate a 1 mm. wide line on the screen. The arrangement of the bank of lights to accomplish this is shown in Fig. 6. The vertical spacing of the centers of the light units must be 1 mm., if 1 mm. diameter spots are projected and 1 mm. wide lines are desired for the picture. The horizontal spacing is, at the minimum, equal to the width of a light unit. As many light units are placed in a row as the number of times the vertical spacing is divisible into the horizontal spacing; thus for light units 1 cm. in diameter, ten units must be mounted in a row, the eleventh being mounted immediately above the first. The bank contains one lamp for every modulated carrier frequency. The lamp bank is caused to oscillate on a vertical axis at the scanning frequency as determined by the frequency of the synchronous motor of the camera at the transmitter. With this oscillation, the luminous vertical line constantly traverses the screen, each of the glow lamps changing in light intensity with the variations in the intensity of the light on the corresponding strip in the photosensitive retina of the camera, thus producing the picture on the screen.

The light bank supporting frame is insulated from the rest of the apparatus and forms a common terminal for all the light units. From each light unit, one insulated wire is brought out from one of its terminals. When sufficient voltage is applied to a glow lamp to start its operation, a very small increase in voltage produces a large increase in luminosity. Sufficient voltage to start the operation is, therefore, connected to the light bank supporting frame terminal of the circuit and serves as a common bias for all the glow lamps. This voltage is shown as obtained from a battery when the apparatus is used directly with the vibrating reed units. When amplifying tubes are used, however, the "B" supply for the anode of the tube provides this voltage.

The light bank supporting frame carrying the light bank is caused to oscillate by the reaction between the magnetic field produced by the deflection current in flowing through a coil mounted on the light bank supporting frame and a stationary magnetic field. The magnetic fields are arranged so that the force on each side of the coil produces a torque in the same direction. The light bank supporting frame is mounted top and bottom in ball bearings. A flat spiral spring is attached to this movable frame and the main frame of the apparatus in such a way as to form a rotary pendulum. The inertia of the movable system and the force of the spring are such that the system has a natural pivoting frequency corresponding to the scanning frequency of the camera at the transmitter. A minimum current is, therefore, required to keep the light bank in oscillation. A special resonant circuit to filter the scanning current from the picture currents is not necessary, as this pendulum arrangement in itself is a very selective mechanical filter.

A number of receiving systems may be set up employing the apparatus of my invention herein described. Figs. 8–12 schematically illustrate some of the more feasible arrangements, all of which are practical, uncomplicated systems.

The oscillation current, the synchronous motor current at the transmitter, may be from 10 to 60 cycles, giving an exposure of 20 to 120 views each second, and the frequency of the carrier currents for pictures up to 500 lines can lie within a range of from 501 to 1,000 cycles with no harmonic interference in the reed separators. For 1,000 line pictures, the 1,001 to 2,000 cycle band of carrier currents can be used. This higher band can be used with fewer lines per picture if desired. Both the transmission system and the receiving system, as described in my copending applications Serial No. 733,300, of June 30, 1934, and Serial No. 160,332, filed August 21, 1937, supra, and application 4,393, filed January 31, 1935 can accommodate 1,000 or more lines per picture. The photosensitive retina of the camera can be built of alternate layers of metal and insulation sheets of .003 and .001 inch thickness, respectively. The edge of the metal being photosensitive would make the retina only four inches square for a 1,000 line picture. This construction is entirely practicable. Likewise, the construction of the picture apparatus, as shown in Figs. 1–7, makes a 1,000 line picture 1 meter square. Neither the transmission nor receiving end is limited to 1,000 line pictures, but both can be enlarged without any change in method.

The large difference in frequency between the frequency of the oscillating or scanning current and the frequencies of the light modulated carrier currents allows the simple expedient of a low frequency impedance path and a higher frequency impedance path to separate the scanning current to within one percent which is entirely adequate, as both the reeds or wires of the frequency separator and the rotary pendulum of the picture apparatus, are very selective.

The picture apparatus can be adapted for auditorium use, since it actually projects a picture on a screen, by using larger light units. The

equipment in this use may be mounted behind the screen or in front of the screen, but should be optically arranged to produce a larger picture.

Referring to the drawings in more detail, Fig. 1 shows a side elevational view of picture producing apparatus of my invention which includes a multiplicity of light units 85, mounted in a vertically disposed wall or carrier 86, perforated to receive mounting studs on the light units, and held in a supporting bracket 87.

Fig. 2 is a plan view, Fig. 3 a side view; and Fig. 4 a cross-sectional view of one form of light unit employed in the picture producing apparatus. Each of the light units of this construction comprises a cylindrical member having an inner bore 89 shaped to provide an elliptical reflector. At the focus of the reflector is positioned a source of light which comprises a glass tube 90 filled with a gas and having a pair of electrodes 91 and 92 mounted in either end, the electrode 91 being connected with the cylindrical member and the electrode 92 being insulatingly connected through a wire to one of the modulated signal circuits. A stud 93 of decreased diameter extends from the rear of the cylindrical light unit, and is provided with a circumferential groove 94. The stud 93 is adapted to fit into a hole in the perforated wall 86, and the unit secured therein by a clip 95 engaging the circumferential groove 94. The screen 98, when associated with light units of this type includes the points which are the conjugate foci of the foci of the elliptical reflectors in the light units.

A modified form of light unit, shown in elevation in Fig. 5, employs a system of lenses 96 and 97 in place of the elliptical reflector of the unit shown in Figs. 2–4. This lens system operates to focus the light from the individual light source on the screen 98, the first lens 96, paralleling the rays from the source, which is similar to that already described, and the second lens 97, focusing the parallel rays into a spot on the screen.

Fig. 6 is a partial front view of the bank of light units and shows the staggered formation in which they are disposed, which facilitates the locating of the several spots of light closely adjacent each other so as to present a smooth line of blended yet distinctly variable spots of light to the eyes of the observers.

Referring again to Fig. 1 and to Fig. 7, which is a horizontal sectional view taken on line 7—7 of Fig. 1, it is seen that the perforated supporting wall 86 is formed in an arc to further facilitate the production of a narrow line of light. The bank of light units is adapted to pivot in ball bearing supports 100 and 101 so that the line of light sweeps across the screen 98 in a direction perpendicular to its length. Since the center of the arc of the bank of light units must lie on the screen for every position of the bank in pivoting, the screen is, therefore, also formed in an arc, the center of which lies in the center of the pivot.

A spiral spring 102, mounted on the shaft 103 immediately above the lower ball bearing 101, is adapted to centralize the light beam projected by the light units 85 on the screen 98, and tensioned so as to coact with the inertia of the pivoted structure to cause oscillation of the structure at substantially the scanning frequency. The free end of the spiral spring 102 is anchored on the pin 110 set in the base of the main structure 112 of the apparatus. Immediately above the spiral spring, mounted on the shaft 103, and extending normal to the arcuate bracket 87, is an actuating rod 104, supported on the end of which is a coil 105 adapted to swing between pole faces 106 and 107 of the core structure 108. Mounted on the poles of the core structure 108 are a pair of magnetizing windings 109 and 109' energized from a source of direct current. The swinging coil 105 carries the scanning component of the television signal current and produces thereby a magnetic field which reacts on the stationary magnetic field produced by the field coils 109 and 109' and causes the coil 105 to oscillate and correspondingly oscillate the bank of light units, moving the beam of light across the screen. The natural period of oscillation of the pivoted structure corresponding substantially to the frequency of the scanning current, the comparatively large mass of the pivoted structure is easily maintained in oscillation. The insulated leads from the light units are combined into a cable 114 which, together with the common lead from one side of each unit is fixed to the frame 112 adjacent the upper pivot connection. Insulating pieces 115 are disposed between one of the arcuate brackets 87 and the shaft 103 and the other bracket 87 and the stud 116 which pivots in the upper ball bearing 100.

Fig. 8 is a schematic diagram showing one arrangement of apparatus in a television receiving system of my invention, of the type shown in my application Serial No. 4,393, supra. Condenser 111, connected to the output circuit of the conventional television receiver, offers a high impedance to currents of scanning frequency but a low impedance to currents of light modulated carrier frequency while the choke coil 117 offers low impedance to currents of scanning frequency and high impedance to the light modulated carrier frequency currents. The output of the condenser branch of this filter circuit is connected, in this arrangement, to vibrating reed frequency separator units 118, of a type shown in my copending application Serial No. 4,393, supra, wherein the several frequency components of the picture current are separated. The output of the vibrating reed units is connected through the multiple electron tube hereinbefore described and schematically shown at 124 in Fig. 8, to the picture producing apparatus here designated by reference character 119, which is of a type shown in my application Serial No. 4,393, supra. The scanning component of the current is conducted through an amplifying tube 120, to an oscillating coil in the picture producing apparatus. Means for adjusting the amplitude and the synchronism of this current are provided at 121 and 123, respectively.

Fig. 9 shows an arrangement employing the electrically resonant frequency separator circuit described in my copending application Serial No. 733,300 and the picture producing apparatus 119, herein described, connected to the output thereof in place of the picture tube shown in my copending application.

Fig. 10 shows a system of my invention similar to that described in connection with Fig. 8, but including the multiple frequency amplifying tube shown more particularly in my application Serial No. 254,301, filed February 2, 1939, for Multiple vacuum tube, and designated here at 124.

Fig. 11 shows the vibrating wire frequency separator apparatus, shown in application Serial No. 4,393, supra, and designated here by reference character 128, associated with the picture producing apparatus 119. The scanning current is

conducted to the oscillating coil, as described in connection with Fig. 8.

Fig. 12 shows the system of my invention which employs the vibrating wire frequency separator 123, and the picture producing apparatus 119, as shown in Fig. 11, but also including the amplifying tube 124 connected between the frequency separator apparatus and the picture producing apparatus.

I have shown the screen 98 in conventional form in Fig. 1 and desire that it be understood that any type of screen may be employed upon which the light from the light units is focused in points upon the screen. The screen may be of customary size employed in theaters, schools and auditoriums or may be of smaller size adaptable for convenient use in the home. The screen in any event is of relatively large size enabling the synthesized television pictures to be readily observed in detail from a distance. The televised picture may be viewed from either side of the screen, either according to the method employed in the usual motion picture projection systems or according to the method employed in the Trans-Lux theaters wherein the projecting machine is located behind the screen and the public views the screen from the rear so far as the position of the projecting machine is concerned. Such a method may be preferable in the smaller size home units. In order to aid the effect of persistence of vision, I may find it desirable under some conditions to employ treated screens having sufficient phosphorescent properties to retain the optical image as the screen is scanned by the optical unit.

I have described the picture reproducing apparatus of my invention in certain preferred embodiments but I realize that modifications may be made in the arrangement of parts and I intend no limitations upon my invention except as may be imposed by the scope of the appended claims.

What I claims as new and desire to secure by Letters Patent of the United States is as follows:

1. In a television receiving system of the class described, picture producing apparatus including a frame structure, a core structure mounted at one end of said frame structure, pole faces formed on said core structure, a bank of light units pivotally mounted in said frame structure and individually energized by light modulated currents, an arm member connected with said bank of light units, a coil supported on said arm member between the pole faces of said core structure, field windings on said core structure energized by direct current, said coil being energized by scanning current and operative in the field produced by said field winding to oscillate said pivoted bank of light units, and a screen mounted on the other end of said frame structure, the rays from said light units being focused on said screen to produce a line of light, said line traversing said screen to integrate an image of the object televised as said bank of light units is oscillated.

2. In a television receiving system of the class described, picture producing apparatus as described in claim 1 which includes a spiral spring member connected with said bank of light units and having the free end thereof secured to a portion of the frame structure, the tension of said spring being matched with the inertia of the pivotally mounted structure to produce an oscillating system having a natural frequency of oscillation substantially equal to the frequency of the scanning current.

3. In a television receiving system of the class described, picture producing apparatus as described in claim 1 in which each of the units in said bank of light units comprises a cylindrical body member having an elliptical mirrored bore in the front end thereof, a point source of light mounted in said body member at the focus of said elliptical mirrored bore, the conjugate focus of the elliptical mirror being located on the screen at the opposite end of the frame structure from said light units, a cylindrical portion of decreased diameter extending from the rear of said body member and having a circumferential groove adjacent the end thereof, said portion of decreased diameter adapted to enter an aperture in the mounting for the bank of light units, and a wire clip fastener adapted to engage said peripheral groove to maintain said light unit in position, and means for making electrical connection individually to each of the sources of light.

4. In a television receiving system of the class described, picture producing apparatus as described in claim 1 in which each of the units in said bank of light units comprises a cylindrical body member, a cylindrical bore having a non-reflective surface cut into the front end of said body member, a first lens mounted in the middle of said bore, a point source of light mounted in the rear of said bore at the focus of said lens, a second lens mounted in the front of said bore and operative to focus the rays from said source of light on the screen at the opposite end of the frame structure from said light units, a cylindrical portion of decreased diameter extending from the rear of said body member and having a circumferential groove adjacent the end thereof, said portion of decreased diameter adapted to enter an aperture in the mounting for the bank of light units, and a wire clip fastener adapted to engage said peripheral groove to maintain said light unit in position, and means for making electrical connection individually to each of the sources of light.

5. In a television receiving system of the class described, picture producing apparatus as described in claim 1 in which each of the light units in said bank of light units includes a point source of light which comprises a tubular member, an electrode sealed in each end of the bore in said tubular member, a quantity of gas contained in the bore in said member and subject to ionization as said electrodes are charged, one of said electrodes being connected in common with an electrode of each of said light sources to a single conductor, the others of the electrodes in said light sources being insulatingly and individually connected to separate conductors.

6. In a television receiving system of the class described, picture producing apparatus as described in claim 1 in which the light units in said bank are arranged in echelon in groups and mounted adjacent each other, and said bank is disposed in an arc parallel to the axis of oscillation for focusing the rays from said light units in a line on the screen, said screen being formed in an arc of the same curvature as the said arc of the bank of light units, said bank and said screen being disposed the length of the common radius of the arcs apart, the distance being measured to the centers of the sources of light in said bank of light units.

7. Television picture reproducing apparatus comprising in combination a swingable carrier, a multiplicity of light units mounted on said carrier with a source of light in each of said units disposed substantially on the axis of said

carrier, a screen spacially related to said light units and parallel to the axis of said carrier, said light units being optically focused on said screen for reproducing individual points of light thereon, means for variably exciting said light units simultaneously in accordance with variable picture currents related to the light and shade characteristics of lines in the picture to be reproduced, and means for swinging said carrier for sweeping the points of light focused from said light units linearly with respect to said screen.

8. A television image reproducing system comprising in combination a screen, a carrier angularly shiftable on an axis parallel with respect to the screen, a multiplicity of light units mounted on said carrier and optically focused to reproduce points of light on said screen, each of said units having a source of light disposed substantially on the axis of said carrier, and means for variably controlling the intensity of light from said light units according to the shading of a televised object for reproducing corresponding variable light intensities from said light units on said screen, and means for oscillating said carrier for sweeping said points of light linearly across said screen.

9. In a television image reproducing system, a screen, a synthesizing unit angularly movable on an axis parallel to said screen synchronously with respect to a multiple scanning system, said synthesizing unit comprising a multiplicity of light units equal to the number of scanned lines of the televised object, each of said light units having a source of light disposed substantially on the axis of said synthesizing unit and focused on said screen, and means for controlling the light intensity of each of said light units according to the shades and shadows of the object being televised for varying the intensity of corresponding points of light on said screen, and means for moving said synthesizing unit on its axis for sweeping said points of light linearly across said screen.

10. Television image reproducing apparatus comprising in combination a screen, a carrier angularly shiftable on an axis parallel to said screen, a multiplicity of light units mounted on said carrier, each of said light units comprising a gaseous discharge tube disposed substantially on the axis of said carrier and focusing means associated with said gaseous discharge tube, said light units corresponding to the number of scanned lines of the televised object, and means for angularly shifting said carrier for sweeping focused points of light from said focusing means across said screen.

11. A television image reproducing system comprising in combination a screen, a carrier angularly shiftable on an axis parallel with respect to the screen, a multiplicity of light units mounted on said carrier and optically focused to reproduce points of light on said screen, each of said units having a source of light disposed substantially on the axis of said carrier, means for variably controlling the intensity of light from said light units according to the shading of a televised object for reproducing corresponding variable light intensities from said light units on said screen, and magnetic means for angularly shifting said carrier for moving said points of light transversely with respect to said screen.

12. A television image reproducing system comprising in combination a screen, a carrier angularly shiftable on an axis parallel with respect to the screen, a multiplicity of light units mounted on said carrier and optically focused to reproduce points of light on said screen, each of said units having a source of light disposed substantially on the axis of said carrier, means for variably controlling the intensity of light from said light units according to the shading of a televised object for reproducing corresponding variable light intensities from said light units on said screen, and magnetic means for synchronously shifting said carrier for moving said points of light transversely with respect to said screen in timed relation to the receipt of signaling impulses.

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