

Feb. 16, 1932.

P. T. FARNSWORTH

1,844,949

SYNCHRONIZING SYSTEM

Filed April 25, 1928.

2 Sheets-Sheet 1

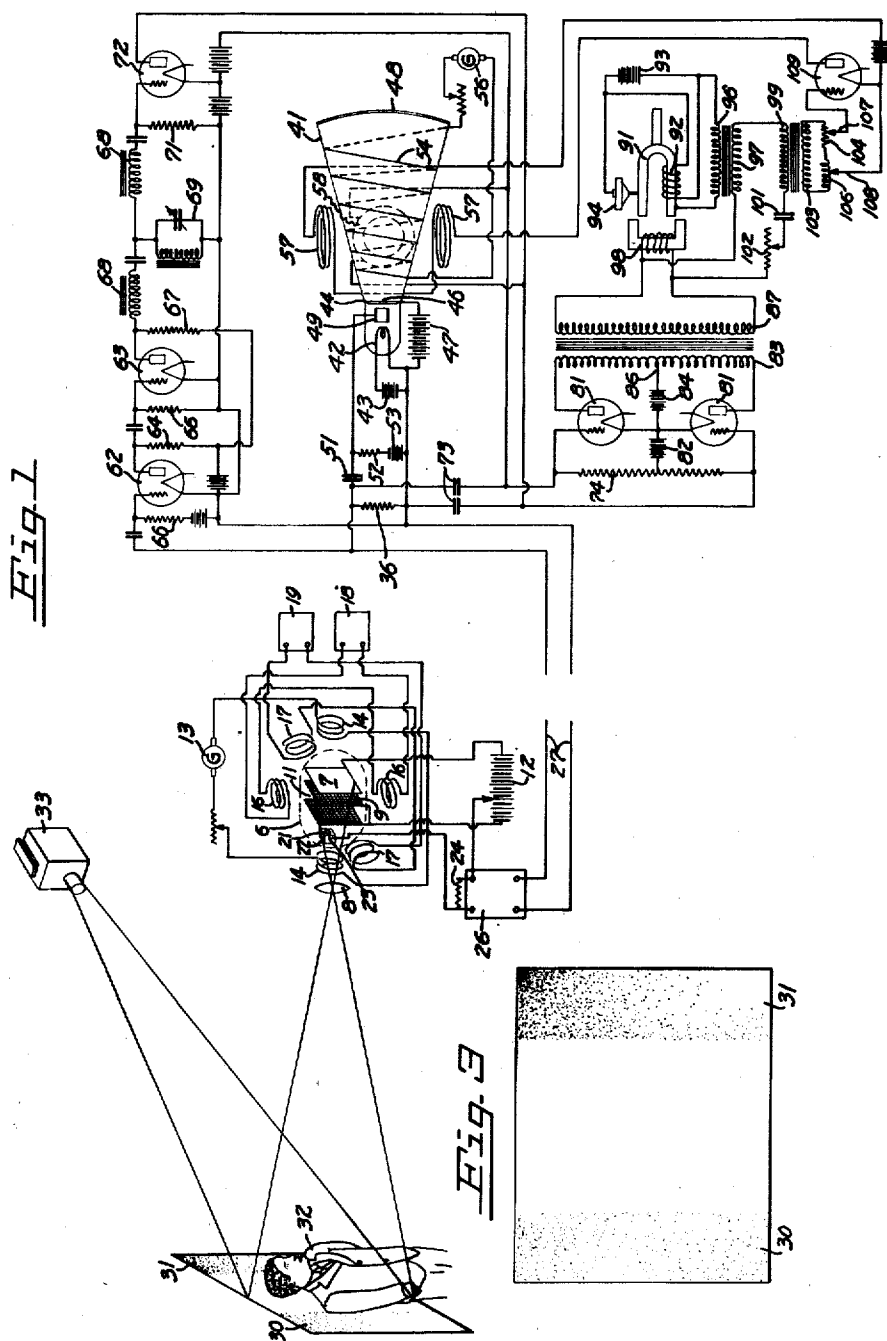


Fig. 3

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PHILO T. FARNSWORTH
Charles S. Evans
BY HIS ATTORNEY.

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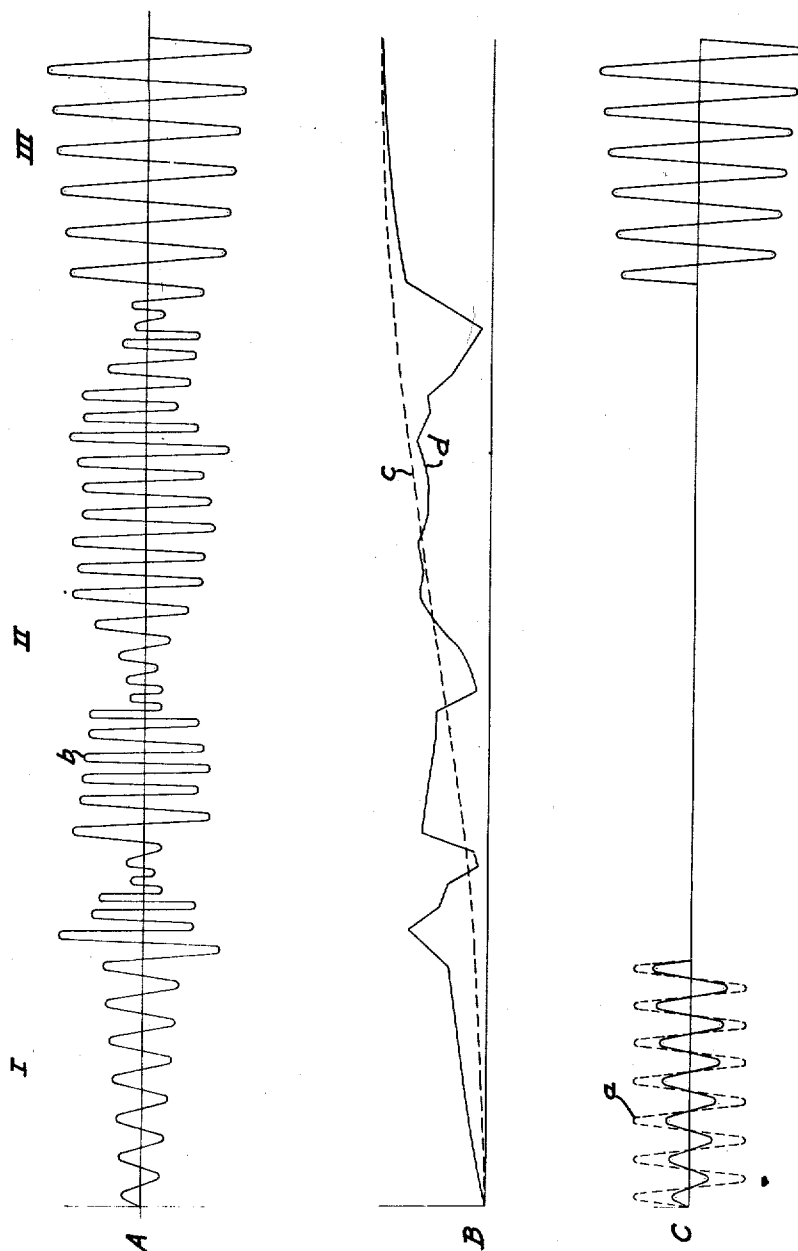
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Fig. 2



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PHILO T. FARNSWORTH
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HIS ATTORNEY.

UNITED STATES PATENT OFFICE

PHILO T. FARNSWORTH, OF BERKELEY, CALIFORNIA, ASSIGNOR, BY MESNE ASSIGNMENTS, TO TELEVISION LABORATORIES, INC., OF SAN FRANCISCO, CALIFORNIA, A CORPORATION OF CALIFORNIA

SYNCHRONIZING SYSTEM

Application filed April 25, 1928. Serial No. 272,690.

My invention relates to systems for the transmission of electrical impulses to produce pictures, and particularly to systems for transmitting such impulses at high speed, as in television.

An object of my invention is to provide a system for transmitting both a picture current and scanning or synchronizing currents over a single channel.

Another object of my invention is to provide a system in which the scanning currents do not react on the picture currents to cause distortion.

Another object of my invention is to provide a system in which scanning currents and picture currents are transmitted alternately, and to provide a means for such alternate transmission which does not involve the use of switching devices or other moving mechanical parts.

My invention possesses other objects and valuable features, some of which will be set forth in the following description of my invention which is illustrated in the drawings forming part of the specification. It is to be understood that I do not limit myself to the showing made by the said description and drawings, as I may adopt varying forms of my invention within the scope of the claims.

Referring to the drawings:

Fig. 1 is a schematic diagram showing both the transmitting and receiving elements of a television system embodying my invention.

Fig. 2 is a diagram showing the form of various currents flowing in the apparatus of Fig. 1 during a half cycle of the low scanning frequency.

Fig. 3 is a representation of the shaded border used for generating the scanning components of the picture current.

Considered broadly my invention involves the alternate transmission of impulses of scanning frequency and impulses corresponding to the illumination from elementary units of area of the object to be pictured. The former impulses are preferably generated by scanning, together with the object to be pictured, an area having a varying or non-uniform light reactive value, placed in effective relation thereto. The scanning of

this area sets up currents by the same mechanism as that by which the picture currents are generated; and by making the light reactive value vary according to a pre-determined system the currents produced thereby may have scanning frequency components which are used to actuate or to synchronize the receiving scanning means.

My invention is generally applicable in systems for the electrical production of pictures, and by the term pictures I include both pictorial representations of a permanent character and transient effects capable of sensory interpretation, such as a moving image on a fluorescent screen. The invention may be used in connection with either radio or line transmission. As a preferred embodiment for detailed description I have, therefore, chosen an arrangement for wire transmitted television, as this involves a minimum of auxiliary equipment and the system is fully illustrated thereby.

The transmitter used is that fully described in my co-pending applications, Serial Nos. 159,540, filed January 7, 1927, 245,334, filed January 9, 1928, and 270,673, filed April 17, 1928. It comprises an evacuated tube 6 in which are positioned a light sensitive cathode 7 on which the image to be reproduced is focused by an optical system 8. Arranged in front of the cathode is an anode screen 9 preferably of wire mesh, which forms one face of a hollow anode 11. The anode is maintained at a high positive potential with respect to the cathode by a constant source such as the battery 12. Electrons liberated from the cathode are attracted toward the anode, and pass thru it as a beam of cathode rays which is focused by the field established by the current from a generator 13 flowing in the coils 14. The beam is deflected within the anode by the fields from the coils 16 and 17, which are fed by the scanning frequency oscillators 18 and 19, respectively.

In the focal plane of the cathode ray beam is an aperture 21 in a housing or shield 22 maintained at anode potential and surrounding a target 23. The rays passing thru the aperture strike the target and liberate sec-

ondary electrons which are attracted to the anode, owing to a somewhat negative potential applied to the target by the battery 12 thru the impedance 24. The current comprising these electrons sets up a potential across the impedance, which actuates an amplifier 26 and thence is fed to the transmission line 27.

A shaded border 30—31 is arranged as if bounding the object 32 to be pictured. The actual position of this border is not important. It may be incorporated in a slide in the lantern 33 which illuminates the object; painted on a background before which the object is placed, or a frame thru which the object is pictured; or even arranged within the tube or on the cathode itself. The essential feature is that the border is scanned together with the object.

The border comprises an area or areas of varying light reactive value, e. g. absorption, transmission, or electron emission. The variation is in accordance with a definite system, in which the light reactive value of the elementary units of area is a function of their position in the area and with respect to the object. In one direction the variation will usually be a uniform increase from one side of the area to the other. In the other dimension the variation may be either an increase in mean intensity, or an increase in the contrast between the maximum and minimum values of the first dimensional variation. In the first case the area 30 on one side of the object would be lighter in general shade than the object 32 and the area 31 darker. In the second case the area 30 would have less contrast than the object and the area 31 more contrast. This is the system which I prefer.

The oscillator 18 acting thru the coils 16 deflects the rays to scan the object and border at a high frequency and vertically, i. e., in a direction parallel to the sides of the pictured object on which the borders are arranged. The oscillator 19 acting thru the coils 17 scans in the other direction at a low frequency. If the frequencies of these oscillators be taken, for illustrative purposes, as 1500 cycles and 15 cycles per second, respectively, the entire field of view will be scanned in 1/30th second.

The current delivered by the transmitter will then have a form sometimes like that shown at A in Fig. 2. In this figure the vertical scanning frequency is shown as being much slower than in the example given, to avoid an unduly complicated drawing. As the field is scanned from right to left, the border area 31 is first traversed from bottom to top and back a number of times, the transmitter thereby producing a current of high scanning frequency (1500 cycles per second), and gradually increasing amplitude. This is represented by portion I of the curve A. When the border area 31 has been traversed

the picture is next scanned, and a group of unrelated frequencies comprising the picture current proper is transmitted, diagrammatically represented by portion II of the curve. The third phase of the scanning is the traversing of area 30, giving a train of oscillations of the high scanning frequency, at an amplitude which is larger than that corresponding to the first border area and of increasing amplitude, as shown by portion III of curve A.

In the next half-cycle of the low frequency scanning oscillator the same type of curve is traced in reverse order. The transmitted current then comprises a component (a) of the high (1500 cycle) scanning frequency, alternating with (b) random picture frequencies. Components (a) and (b) are modulated by (c), the fundamental of the low (15 cycle) scanning frequency distorted by (d) components due to the varying amplitudes of the picture current. A carrier may be modulated by this current and the picture transmitted by radio, or wire, or it may be transmitted at its own frequency.

At the receiving end of the line 27 suitable means are provided for separating and utilizing these received components. Bridged across the line 27 is an impedance 36, the potential drop across which actuates the several branches of the circuit.

The receiving device comprises a cathode ray oscillograph having an evacuated bulb 41 in which is a filamentary cathode 42 heated by a battery 43 or other generator. Spaced from the cathode within the bulb is an anode 44 having an aperture 46. A high potential applied to the anode by the battery 47 produces a cathode ray stream thru the aperture which produces fluorescence when it strikes the sensitive screen 48. A control electrode or grid 49 is located between the cathode and the anode, and cathode and grid are connected across the impedance 36 thru a blocking condenser 51. A high resistance 52 and a battery 53 are provided to maintain the grid at a suitable mean potential. The cathode ray is preferably focused by a magnetic field produced by a coil 54 excited by a generator 56, and is deflected by means of the coils 57 and 58. The potential across the impedance 36 acting on the grid varies the intensity of the ray in accordance with the variations in transmitted current to produce a picture on the fluorescent screen when the ray is deflected at the scanning frequencies of 15 and 1500 cycles.

Means are provided for selecting and utilizing the components of these frequencies from the transmitted current. Bridged across the impedance is a detector-amplifier system comprising the vacuum tubes 62 and 63 with suitable coupling and biasing impedances 64 and 66. The detector-amplifier demodulates the transmitted wave and feeds into its output

impedance 67 components *c* and *d* of the transmitted wave.

Coupled with the impedance 67 is a sharply selective network, passing the fundamental scanning frequency *c* and rejecting the distorting components. This network may comprise either a recurrent filter type of network as shown, including resonant series elements 68 and anti-resonant shunt elements 69, or it may comprise coupled oscillating circuits tuned to the fundamental scanning frequency. The fundamental frequency is impressed on an impedance 71 across which is connected the grid-filament circuit of an amplifying tube 72, whose plate circuit supplies the low frequency deflecting coils 57.

Also bridged across the impedance 36 is the circuit supplying the high frequency deflecting coils, comprising a small blocking condenser 73 in each side of the circuit and in series with a resistor 74. The resistor is also connected in shunt with the deflecting coils 57 across the output of the coils 72. The condensers 73 are of such size as to offer a large reactance to the low scanning frequency but low reactance to the high scanning frequency. A negligible amount of the low frequency is therefore fed back to the line thru these condensers from the tube 72, but practically the full value of the high frequency is impressed from the line across the resistor 74, together with the low frequency component from the tube 72.

A pair of amplifying tubes 81 is connected in "push-pull" relationship across the resistor 74, and a battery 82 is connected from a center tap on the resistor to the filament circuit of the tubes 81 to maintain their grids at a negative potential such that current flow in their plate circuits is substantially blocked.

This condition is not upset by the high frequency scanning and picture components of the potential across the resistor 74. At the limits of the swing of the low frequency scanning potential, however, the negative potential on the grid of one or the other of the tubes is sufficiently reduced to allow the tube to operate as an amplifier, and since the high scanning frequency is being received when this condition obtains; the output of these tubes is a succession of oscillation trains of the high frequency, which are delivered to a transformer whose primary winding 83 is connected between the plates of the tubes 81. Plate potential is supplied to the tubes from a battery 84 connected to a center tap 86 on the primary winding.

The secondary winding 87 is connected to feed into a very slightly damped oscillating system. This may be either an electrical or a mechanical system, but I have found an electrically driven tuning-fork to be very satisfactory. Such a device may comprise the fork 91, one arm of which is magnetized by a coil 92 excited by a battery 93. In paral-

lel with the coil 92 is a circuit comprising a microphone button 94 connected to and operated by one arm of the fork, in series with the transformer primary 96. The secondary 97 of this transformer is connected to a driving magnet 98, reacting with the magnetized fork to keep it in oscillation. So connected these forks are familiar laboratory equipment. For this use, however, the usual arrangement is modified by including in series with the coil 97 and the driving magnet a second transformer primary 99, a condenser 101, and a rheostat 102. The elements so associated form a resonant circuit tuned to the high scanning frequency, which is also the natural frequency of the fork. By adjusting the rheostat 102 the damping in this circuit is so adjusted that the fork will not maintain itself in oscillation, but will gradually come to rest if oscillations are induced in it. The time required for an oscillation to die away may be adjusted at ten seconds or even longer.

The output of the transformer 87 is connected across the driving coil 98. The recurrent trains of oscillations of the scanning frequency fed from the transformer supply the energy lost by the fork, and not only keep it in vibration but hold its phase constant with respect to the scanning, at the transmitter, of the object to be pictured.

A secondary 103 coupled with the primary coil 99 feeds into a circuit comprising a resistor 104 and an inductor 106. Each of these elements has a variable tap 107 and 108, and across these taps the grid-filament circuit of an amplifier 109 is connected. The plate circuit of the amplifier supplies the high frequency scanning coils 58, the phase and amplitude of the scanning being adjustable by moving the taps 107 and 108.

It will thus be seen that the transmitted current divides into three paths, actuating the two scanning circuits and the picture circuit respectively. The picture is reproduced on the screen of the receiving tube with its shaded border, but the transmission channel is not carrying picture and scanning frequencies simultaneously, and distortion is thereby reduced.

I claim:

1. In a system for the transmission of electrical impulses to produce pictures, an area or varying light reactive value arranged in effective position to be scanned with the object to be pictured, and means for scanning said area coordinately with said object, for producing electrical impulses of scanning frequency.

2. In a system for the transmission of electrical impulses to produce pictures, an area arranged in effective position to be scanned with the object to be pictured, and means for scanning said area coordinately with said object for producing electrical impulses of

scanning frequency, the elementary units of said area having a light reactive value which is a function of their position in said area.

3. In a system for the transmission of electrical impulses to produce pictures, an area arranged in effective position to be scanned with the object to be pictured, and means for scanning said area coordinately with said object for producing electrical impulses of scanning frequency, the elementary units of said area having a light reactive value which is a function of the effective position of said area with respect to said object.

4. In a system for the transmission of electrical impulses to produce pictures, an area arranged in effective position to be scanned with the object to be pictured, and means for scanning said area coordinately with said object for producing electrical impulses of scanning frequency, said area having a light reactive value varying in accordance with a system different from the picture.

5. In a system for the transmission of electrical impulses to produce pictures, a shaded border arranged to be effective as if bounding the object to be pictured, and means for scanning said border coordinately with said object for producing electrical impulses of scanning frequency.

6. In a system for the transmission of electrical impulses to produce pictures, a shaded border arranged to be effective as if bounding the object to be pictured on opposite sides, and means for scanning said border coordinately with said object for producing electrical impulses of scanning frequency.

7. In a system for the transmission of electrical impulses to produce pictures, a border shaded with a contrast increasing longitudinally and transversely thereof and arranged as if bounding the object to be pictured, and means for scanning said border coordinately with said object for producing a current having a plurality of scanning frequency components.

8. The step in the method of synchronizing a transmitter and receiver of electric impulses for the production of pictures which comprises scanning an area of varying light reactive value coordinately with the object to be pictured.

9. The method of producing a scanning component in a current for the production of pictures which comprises bounding the object to be pictured with a shaded border and traversing said border and object by a scanning means associated with a transmitting means.

10. The method of producing a scanning component in a current for the production of pictures which comprises bounding the object to be pictured with an area whose luminosity increases thereacross and traversing said border and object by a scanning means associated with a transmitting means.

11. The method of producing a scanning component in a current for the production of pictures which comprises bounding the object to be pictured with an area whose luminosity varies thereacross in accordance with a two dimensional system and traversing said border and object by a scanning means associated with a transmitting means.

12. The method of synchronizing a transmitter and a receiver of electrical impulses for the production of pictures which comprises bounding the object to be pictured with a shaded border, producing a current corresponding to the illumination from successive elementary units of said object and border, and utilizing the current corresponding to said border to control the frequency of a receiving scanning system.

13. The method of synchronizing a transmitter and a receiver of electrical impulses for the production of pictures which comprises bounding opposite edges of the object to be pictured with areas whose luminosity varies thereacross in two dimensions, producing a current corresponding to the illumination from successive elementary units of said object and said areas, and using the current corresponding to said areas to control the frequency of a receiving scanning system.

14. The method of synchronizing a transmitter and a receiver of electrical impulses for the production of pictures which comprises bounding opposite edges of the object to be pictured with a border shaded from light to dark in one dimension and with increasing contrast in another dimension, scanning said picture and border in a direction parallel to said edges at a high frequency and transverse to said edges at a low frequency, producing a current corresponding to the illumination from successive elementary areas of said object and said border, and utilizing the components of said current and said border to actuate a receiving scanning means.

15. The method of synchronizing a transmitter and a receiver of electrical impulses for the production of pictures which comprises bounding opposite edges of the object to be pictured with a border shaded from light to dark in one dimension and with increasing contrast in another dimension, scanning said picture and border in a direction parallel to said edges at a high frequency and transverse to said edges at a low frequency, producing a current corresponding to the illumination from successive elementary areas of said object and said border, rectifying a portion of said current, and utilizing a component of the rectified current to actuate a receiving scanning means.

16. The method of synchronizing a transmitter and a receiver of electrical impulses for the production of pictures which comprises bounding opposite edges of the object

to be pictured with a border shaded from light to dark in one dimension and with increasing contrast in another dimension, scanning said picture and border in a direction parallel to said edges at a high frequency and transverse to said edges at a low frequency, producing a current corresponding to the illumination from successive elementary areas of said object and said border, and utilizing a component of said current to control the frequency of a high frequency receiving scanning means.

17. The method of synchronizing a transmitter and a receiver of electrical impulses for the production of pictures which comprises bounding opposite edges of the object to be pictured with a border shaded from light to dark in one dimension and with increasing contrast in another dimension, scanning said picture and border in a direction parallel to said edges at a high frequency and transverse to said edges at a low frequency, producing a current corresponding to the illumination from successive elementary areas of said object and said border, utilizing a component of said current to control the frequency of a high frequency receiving scanning means, rectifying a portion of said current, and utilizing a component of the rectified current to actuate a low frequency receiving scanning means.

18. In a system for the transmission of electrical impulses to produce pictures, a shaded border arranged as if bounding the object to be transmitted, means for scanning said object and said border to produce a current varying with the illumination from successive elementary units of said object and border, means for transmitting said current to a receiving apparatus, and means in said receiving apparatus for utilizing the part of said current corresponding with the border to synchronize a receiving scanning means.

19. In a system for the transmission of electrical impulses to produce pictures, a shaded border arranged as if bounding opposite edges of the object to be transmitted, means for scanning said object and said border to produce a current varying with the illumination from successive elementary units of said object and border, means for transmitting said current to a receiving apparatus, and means in said receiving apparatus for utilizing the part of said current corresponding with the border to synchronize a receiving scanning means.

20. The method of synchronizing a transmitter and receiver of electrical impulses to produce pictures which comprises the alternate transmission of a series of scanning frequency impulses and a series of picture frequency impulses.

21. In a receiver for use with a transmitter of impulses alternately of picture and scanning frequencies, means for detecting a

low frequency component of the transmitted impulses, means for filtering out substantially all but the fundamental frequency of said component, and means for utilizing said fundamental frequency to actuate a receiving scanning means.

22. In a receiver for use with a transmitter of impulses alternately of picture and scanning frequencies, a damped oscillating system responsive to a scanning frequency and capable of sustaining oscillation during the transmission of said picture frequency impulses, means for utilizing a component of the transmitted impulses to maintain said system in oscillation, and means for utilizing the oscillations of said system to actuate a receiving scanning means.

23. In a receiver for use with a transmitter of impulses alternately of picture and scanning frequencies, a damped oscillating system responsive to a scanning frequency and capable of sustaining oscillation during the transmission of said picture frequency impulses, means for utilizing a component of the transmitted impulses to maintain said system in oscillation, means for utilizing the oscillations of said system to actuate a receiving scanning means, and means for adjusting the damping of said system.

24. In a system for the transmission of electrical impulses to produce pictures, a border arranged as if bounding the object to be pictured comprising an area of low contrast light reactive value on one side of said object and an area of high contrast on the opposite side of said object, the light reactive values of said areas varying systematically in a direction perpendicular to the direction of the variation in contrast.

25. In a system for the transmission of electrical impulses to produce pictures, an area arranged as if bounding the object to be pictured and having a light reactive value varying in mean intensity in one dimension and in contrast in the other dimension.

26. The method of synchronizing a transmitter and receiver of electrical impulses to produce pictures which comprises transmitting a group of impulses of scanning frequency, discontinuing said impulses for an interval longer than a single scanning frequency cycle, and transmitting picture frequencies during said interval.

27. The method of synchronizing a transmitter and receiver of electrical impulses to produce pictures which comprises transmitting a group of impulses of high scanning frequency, discontinuing said impulses for the interval required for a low scanning frequency to traverse the picture area, and transmitting picture frequencies only during said interval.

28. In a system for the transmission of electrical impulses to produce pictures and including a circuit for carrying the picture

impulses, means for scanning a pictured object to produce said impulses, and means for producing series of scanning frequency impulses in said circuit alternately with said picture impulses.

29. In a system for the transmission of electrical impulses to produce pictures and including a circuit for carrying the picture impulses, means for scanning a pictured object to produce said impulses, and means for producing series of scanning frequency impulses of systematically varying amplitude in said circuit alternately with said picture impulses.

30. In a system for the transmission of electrical impulses to produce pictures and including a circuit for carrying the picture impulses, means for scanning a pictured object to produce said impulses, and means for producing series of scanning frequency impulses modulated with a lower scanning frequency in said circuit alternately with said picture impulses.

In testimony whereof, I have hereunto set my hand.

PHILO T. FARNSWORTH.

impulses, means for scanning a pictured object to produce said impulses, and means for producing series of scanning frequency impulses in said circuit alternately with said picture impulses.

29. In a system for the transmission of electrical impulses to produce pictures and including a circuit for carrying the picture impulses, means for scanning a pictured object to produce said impulses, and means for producing series of scanning frequency impulses of systematically varying amplitude in said circuit alternately with said picture impulses.
30. In a system for the transmission of electrical impulses to produce pictures and including a circuit for carrying the picture impulses, means for scanning a pictured object to produce said impulses, and means for producing series of scanning frequency impulses modulated with a lower scanning frequency in said circuit alternately with said picture impulses.

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DISCLAIMER

1,844,949.—*Philo T. Farnsworth*, Berkeley, Calif. SYNCHRONIZING SYSTEM. Patent dated February 16, 1932. Disclaimer filed July 7, 1934, by the patentee.

Hereby enters the following disclaimer:

1. From the scope of claims 1, 2, 3, and 4 he disclaims any interpretation of the "area arranged in effective position to be scanned with the object to be pictured", wherein said area must be interpreted as including said pictured object to meet the definition thereof given in said claims.

2. From the scope of claims 5, 9, 12, and 18 he disclaims any interpretation of a "shaded border" except that wherein the term "shaded" is defined as "showing gradations of light or color".

3. From the scope of claim 8 he disclaims any interpretation of "an area of varying light-reactive value" wherein said area must be interpreted as including within its borders the object to be pictured.

4. From the scope of claim 21 he disclaims any interpretation except that wherein the low frequency component of the transmitted impulses is modulated upon a higher scanning frequency.

[*Official Gazette August 7, 1934.*]

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