Nov. 26, 1935. V. K. ZWORYKIN 2,022,450

TELEVISION SYSTEM

Original Filed Dec. 29, 1923 3 Sheets-Sheet 1

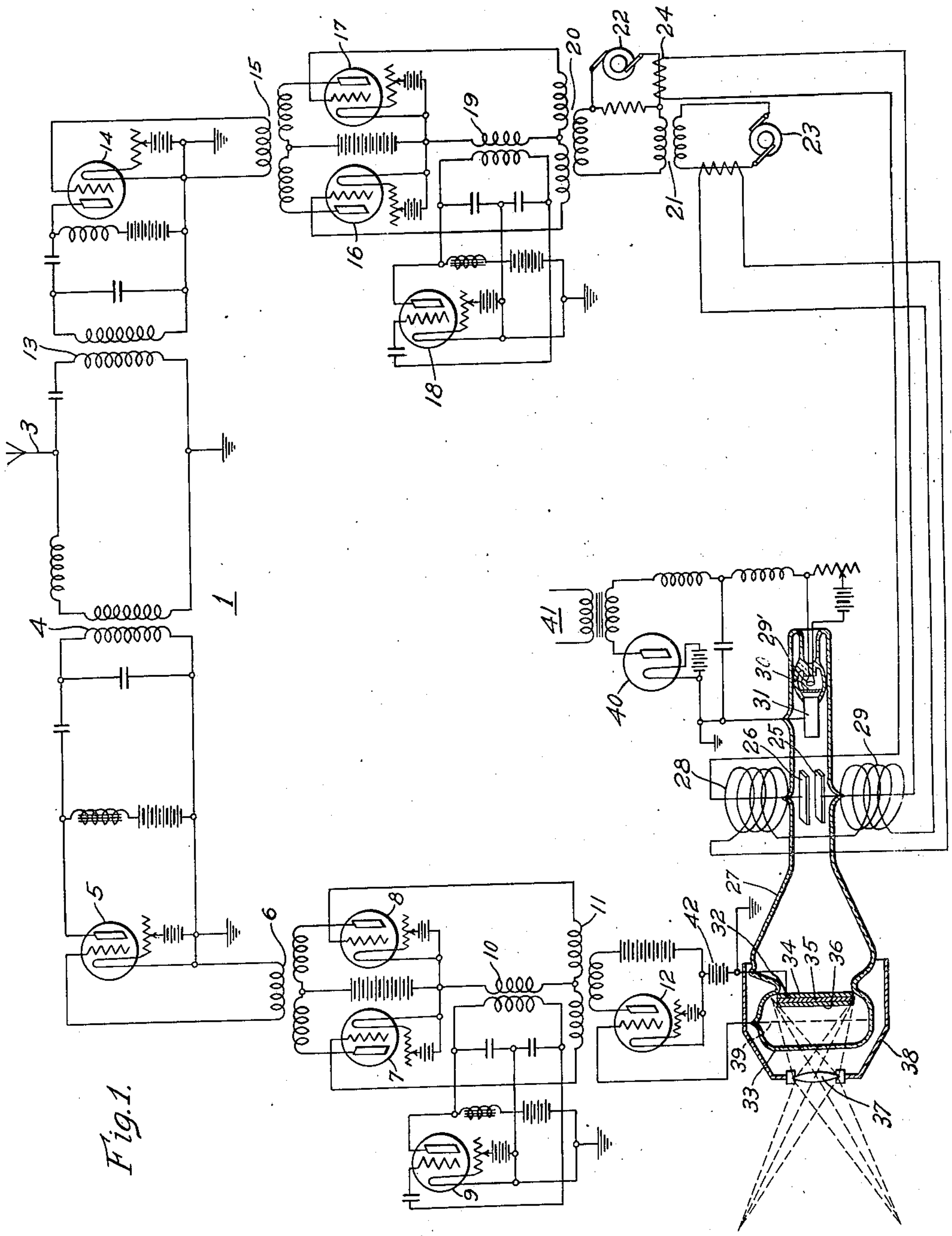

Fig. 1.

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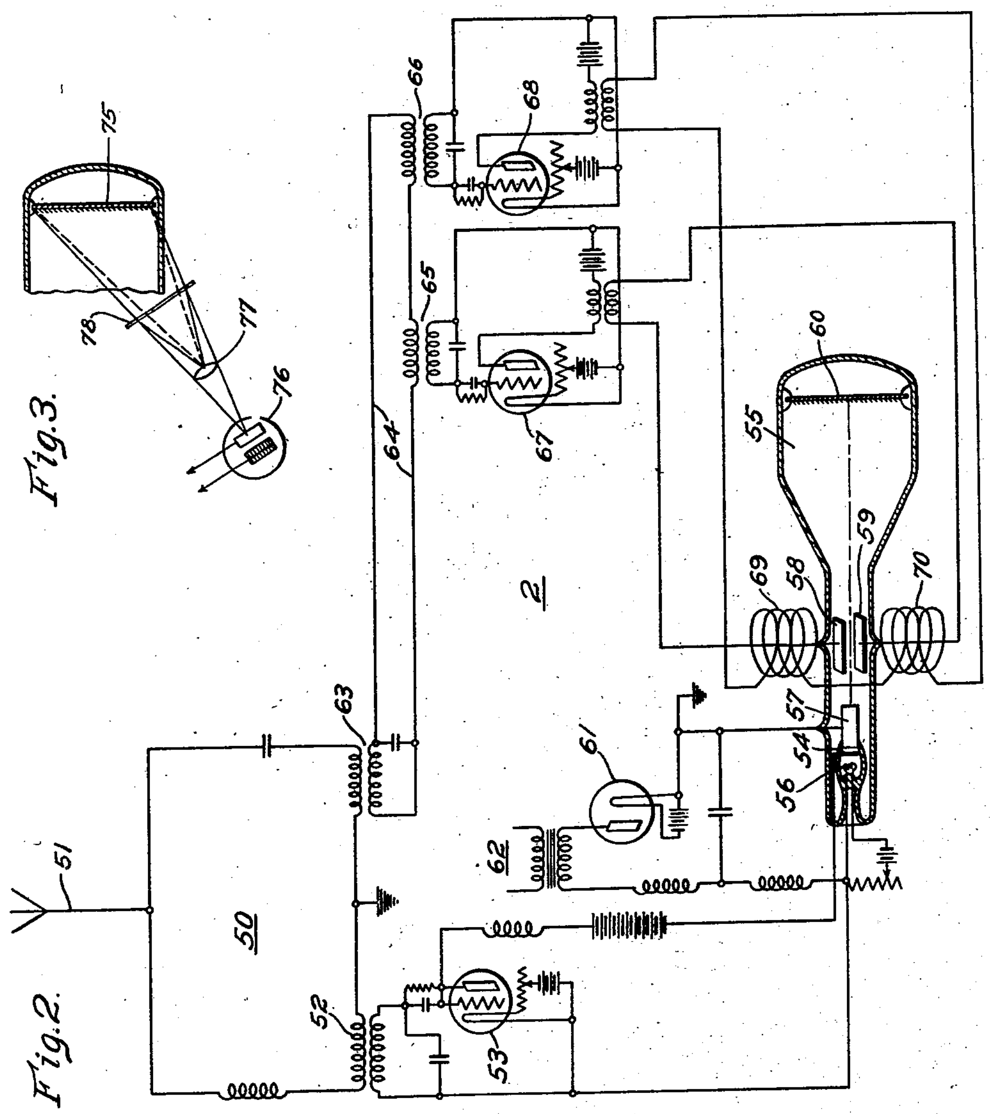
3 Sheets-Sheet 2



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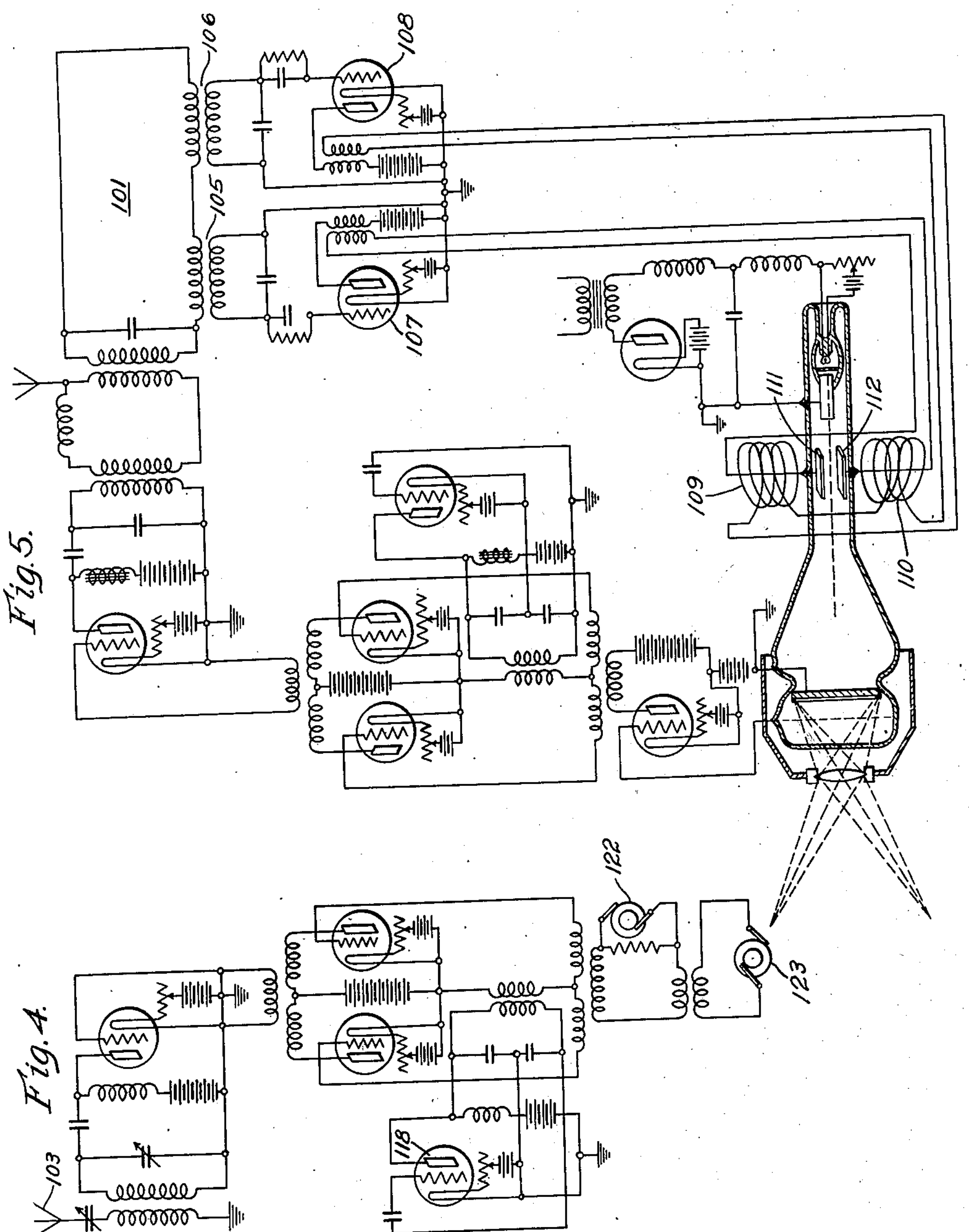

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UNITED STATES PATENT OFFICE

2,022,450

TELEVISION SYSTEM

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Original application December 29, 1923, Serial No. 683,337. Divided and this application November 21, 1931, Serial No. 576,485

5 Claims. (Cl. 178—6)

My invention relates, in general, to television systems, and comprises a division of the invention embodied in an application on television systems, Serial No. 683,337, filed by me on December 29, 1923 and relates particularly to the modification disclosed in Figure 3 of the above-noted application.

One of the objects of my invention is to provide a system for enabling a person to see distant moving objects or views by radio.

Another object of my invention is to eliminate synchronizing devices heretofore employed in television systems.

Still another object of my invention is to provide a system for broadcasting, from a central point, moving pictures, scenes from plays, or similar entertainments.

The above and other objects of my invention will be explained more fully hereinafter with reference to the accompanying drawings forming a part of this specification.

Referring now to the drawings, Figure 1 is a diagram of a station for broadcasting motion pictures or other visual indications, and may be considered the television transmitter.

Fig. 2 is a diagram of a receiving station for receiving the scenes broadcasted from the transmitting station.

Fig. 3 is a fragmentary view of an alternative arrangement for the transmitting station.

Fig. 4 shows an arrangement whereby the control of the transmitting and the receiving stations may be exercised from a central station; and

Fig. 5 shows the circuits of the transmitting station when a central station is used.

Both of these stations are shown by means of conventional circuit and apparatus diagrams in sufficient detail to enable the invention to be readily explained and understood.

Any visual indications may be broadcasted by the transmitting set 1 consisting of apparatus and circuits and be received by the receiving set 2 consisting of apparatus and circuits.

The apparatus of the transmitting set 1 comprises an antenna system 3 which is so tuned that it may oscillate at two separate and distinct frequencies. The oscillating circuit including the antenna 3 is connected on one side by means of a transformer 4 to the plate circuit of an amplifier triode 5. The grid of the amplifier 5 is connected through a transformer 6 to the plate circuits of modulator triodes 7 and 8. An oscillator triode 9 is connected through a transformer 10 to the grid circuit of the modulator triodes 7 and 8. The above arrangement comprises what is known as an ordinary "push-and-pull" transmitting arrangement.

By means of a transformer 11, the plate circuit of an amplifier 12 is also connected to the grid circuits of the modulator triodes 7 and 8.

The oscillating circuit comprising the antenna 3 is also connected, by means of a transformer 13, to the plate circuit of an amplifier triode 14. The grid circuit of the amplifier 14 is connected, by means of a transformer 15, to the plate circuits of modulator triodes 16 and 17. An oscillator triode 18 is connected, by means of a transformer 19, to the grid circuits of the modulator triodes 16 and 17. By means of transformers 20 and 21, alternating-current generators 22 and 23 are also connected to the grid circuits of the modulator triodes 16 and 17.

The generator 22 is so constructed as to generate high-frequency alternating current of a frequency of about 1000 cycles, while the alternating-current generator 23 is adapted to generate an alternating current of a frequency at about 16 cycles.

It is, of course, obvious that triodes connected in oscillating circuits may be used in place of the alternating-current generators 22 and 23.

The plates 25 and 26 in a cathode-ray tube 27 are connected in the circuit through a series transformer 24. Coils 28 and 29 are associated with the cathode-ray tube 27 in such position that the magnetic field which may be produced by said coils is parallel to the electrostatic field which may be generated by the plates 25 and 26, and these coils are connected in circuit with the alternating-current generator 23.

The cathode-ray tube 27 is similar in some respects to the ordinary cathode-ray oscillograph and has a hot cathode 29', a diaphragm 30 and tubular anode 31. The diaphragm 30 has a small hole so cut therein as to form the cathode ray into a thin beam.

In place of the ordinary fluorescent screen is substituted a composite plate 32 having layers of different material.

A lens 37 or system of lenses is secured in place by means of a frame 38 disposed at the end of the cathode-ray tube. The lens 37 is arranged to focus the image or scene to be observed upon the photoelectric material of the composite plate 32. A grid 39 is placed at some distance in front of the composite plate 32 and is connected to the grid of the amplifier triode 12. A high potential is applied to the anode 31 by a rectifier 40 which is supplied with current from an alternating-current source 41.

In the receiving device 2, an oscillating circuit 50, including an antenna 51, is adapted to be resonant to current of two distinct frequencies, these frequencies being the frequencies generated by the oscillating circuits that include the triodes 9 and 18 of the transmitting set. An amplifier triode 53 is connected to the oscillating circuit 50. The plate circuit of the amplifier triode 53 is connected to a grid 54 in a cathode-ray tube 55.

The cathode-ray tube 55 is constructed in a manner similar to the ordinary cathode-ray oscillograph and comprises a hot cathode 56, the grid 54, a tubular anode 57, plates 58 and 59 that are used to set up an electrostatic field and a fluorescent screen 60. The anode 57 of the cathode-ray tube 55 is supplied with high voltage by the operation of a rectifier 61, that rectifies the alternating current supplied by a source of alternating current 62.

The oscillating circuit 50 is also connected by means of a transformer 63 with a circuit 64. The circuit 64 is, in turn, connected by means of transformers 65 and 66 with the grid circuit of the amplifier triodes 67 and 68. The plate circuit of the amplifier triode 67 is connected with the plates 58 and 59 of the cathode-ray tube 55, while the circuit of the amplifier triode 68 is connected to the coils 69 and 70 that are associated with the cathode-ray tube 55 and so disposed with respect thereto that the magnetic fields generated by the coils are parallel to the electrostatic field generated by the plates 58 and 59.

The transformer 65 is so constructed that it acts as a wave trap for the particular high frequency that is generated by the generator 22 at the transmitting station so as to eliminate this frequency from the circuit 64. In a like manner, the transformer 66 acts as a wave trap for the particular frequency generated by the generator 23 by the transmitting station.

The alternative arrangement of the apparatus in the transmitting station, shown in Fig. 3, is adapted to transmit pictures. This system differs from the one shown in Fig. 1 in that an ordinary cathode-ray oscillograph is employed. One end only of the oscillograph has been shown. This oscillograph has the usual fluorescent screen 75. There is a photoelectric cell 76 situated close to the oscillograph. A lens 77 is disposed between the photoelectric cell and the cathode-ray tube arranged to focus the light from the fluorescent screen on the cell. A diapositive or ordinary photographic negative 78, that has the image on it that it is desired to transmit, is placed between the lens and the cathode-ray tube. The circuit connections of this arrangement are similar to those shown in Fig. 1.

The apparatus shown in Fig. 4 is practically identical with the apparatus shown at the right in Fig. 1, with the exception that there is provided a separate antenna 103 and includes means whereby the synchronizing frequencies generated by the generators 122 and 123 may be radiated from a central station.

Fig. 5 is very similar to Fig. 1, with the exception that the coils 109 and 110 for creating the electromagnetic field for controlling the cathode beam and the plates 111 and 112 for creating the electrostatic field are controlled by detector triodes 107 and 108 which are connected to the receiving antenna through the oscillatory circuit 101.

Having briefly described the apparatus shown in the drawings, I will now explain its detailed operation. For this purpose, it will be assumed that it is desired to broadcast the image of some object which is in front of the lens 37 associated with the transmitting cathode-ray tube 27.

Ordinarily, the oscillations generated by the oscillator 9 are not radiated by the antenna 3. This is because of the fact that these oscillations are neutralized by the action of the modulator triodes 7 and 8, and, consequently, there is no transfer of energy into the secondary of transformer 6. The only manner in which the antenna can be set in oscillation by the operation of the triode 9 is by a change in condition in the primary of the transformer 11 which is connected to the grid 39 and to the aluminum foil 34 of the composite plate 32.

The light from the image placed before the lens 37 is so varied that, upon the focusing of this light upon the photoelectric globules 36 of the composite plate 32, electron emission of varying intensity by these particles takes place in accordance with the light from the object placed before the lens 37. This electron emission may be considered a species of conduction between the photoelectric globules 36 and the grid 39. This phenomena is intensified by the argon vapor that fills the container 33 as a result of the ionization of the vapor.

In view of the fact that the aluminum oxide plate 35 is an insulator, there is no connection existing between the grid 39 and the aluminum plate 34, even though the photoelectric globules emit electrons. When the cathode beam strikes a particular point upon the aluminum foil, it is of sufficient intensity to penetrate it, as well as the aluminum oxide. The action of the cathode ray on the aluminum oxide in its path, particularly in the presence of the gas, is to produce a conductive connection between the aluminum plate 34 and the particular globule or globules of potassium hydride in the path of the cathode ray. The electrons emitted by these globules are therefore subjected to the field produced by the battery 42 acting across the conductive part of the aluminum oxide. The amount of the emission will depend upon the degree of illumination of these globules. The current flowing in the circuit is dependent upon the electron emission from the globule or globules covered by the cathode beam. This current is amplified by means of the amplifier triode 12. The current from the grid 39 to the grid of the tube 12 is so small that no grid leak is necessary for the tube 12 although one may be supplied if desired. The output of the amplifier 12 now causes the modulator triodes 7 and 8 to transmit, through the transformer 6, the high-frequency oscillations, generated by the oscillator triode 9, modulated in accordance with the current in the amplifier triode 12 which, in turn, is governed by the intensity of the light focused upon the particular spot at which the cathode ray is located. The intensity of this electron stream is, of course, governed by the intensity of the light from the object.

As previously mentioned, the alternating-current generators 22 and 23 are producing alternating current of a high and low frequency, respectively. By the operation of the modulator triodes 16 and 17, the oscillations produced by the oscillator triode 18 are modulated in accordance with both the frequency of the alternating-current generated by the generator 22 and the alternating current generated by the generator 23. This modulated high frequency current is amplified by the amplifier triode 14 and radiated by the antenna 3.

As the output of the alternating-current generator 22 is also connected to the plates 25 and 26 in the cathode-ray tube 27, an electrostatic field is set up by these plates which varies in accordance with the frequency of the current generated by the generator 22. As this electrostatic field varies, the electrostatic action upon the electrode beam causes it to be swung from one edge of the composite plate 32 to the other.

A portion of the alternating current generated by the generator 23 also traverses the coils 28 and 29 which, as before mentioned, are so positioned with respect to the cathode tube 27 that the magnetic field generated by these coils is parallel to the electrostatic field generated by plates 25 and 26. The varying magnetic field set up by these coils tends to cause the cathode-ray beam to traverse the plate 35 in a direction at right angles to that before described.

The resultant action between the magnetic fields and the electrostatic fields upon the cathode beam is such that the beam covers every point in the whole area of the composite plate 32 in $\frac{1}{32}$ of a second, that is, in ½ cycle of the frequency generated by the alternating-current generator 23. Thus, in $\frac{1}{16}$ of a second, the cathode beam traverses the surface of the composite plate twice.

As the cathode beam traverses the surface of the composite plate 32 point by point in a definite sequence, there is a current flowing from the grid 39 and the aluminum foil 34 at each particular point, and this current is directly proportional to the intensity of light from the object to be observed. Thus, the oscillatory current generated by the oscillator triode 9 is modulated in accordance with the light from each portion of the image.

At the receiving station, the modulated oscillatory currents generated by the oscillator 9 of the transmitter are received by the antenna 51 and transferred to the detector triode 53 through the transformer 52. The detector triode 53 then operates to detect the modulations and then these are transferred through its plate circuit to the grid 54 of the cathode-ray tube 55.

By means of the transformer 63, associated with the oscillating circuit 50, the modulated radio-frequency current generated by oscillator 18 is received and transferred by transformers 65 and 66 in the detector triodes 67 and 68. By the operation of the transformer 65, only the radio frequency that is modulated by the generator 22 is detected. In a like manner, by the operation of the transformer 66, only the radio frequency modulated by the generator 23 is received by the detector triode 68.

As the plate circuit of the detector triode 67 is connected to the plates 58 and 59 in the cathode-ray oscillograph 55, an electrostatic field is set up by these plates which varies in identically the same manner as the electrostatic field generated by the plates 25 and 26 in the transmitting cathode-ray tube. Likewise, the plate circuit of the triode 68 is connected to the coils 69 and 70 which generate a magnetic field parallel to the electrostatic field generated by the plates 58 and 59 and that varies in exactly the same manner as the magnetic field set up by the coils 28 and 29 at the transmitting station. Thus, when the cathode-ray beam passes through the grid 54 and the anode 57 to the fluorescent screen 60, it is caused to traverse a path in accordance with the resultant magnetic and electrostatic fields set up. Therefore, the cathode-ray beam traverses the whole area of the fluorescent screen once in $\frac{1}{32}$ of a second, or twice in $\frac{1}{16}$ of a second, in the same manner as the cathode beam in the cathode-ray tube 27 at the transmitting station.

When the cathode beam in the cathode-ray tube of the transmitter is in a certain particular position, the oscillatory current generated by the oscillator 9 is modulated in accordance with the intensity of the light falling upon that particular point. This modulated current is radiated by the antenna 3 and received by the antenna 51 at the receiving station. At this particular point, the cathode beam in the cathode-ray tube 55 will be in the same relative position as the cathode beam at the sending station. By the action of the grid 54, the intensity of the cathode ray reaching the fluorescent screen at this particular point is varied in accordance with the light from the image at the transmitting station.

Thus, for every particular point on the image, the carrier current radiated by the antenna 3 is modulated whereby the potential on the grid 54 of the receiving cathode-ray tube 55 is varied, as is, also, the intensity of fluorescence of the particular point upon the fluorescent screen 60.

As the whole area of the composite plate 32 at the transmitting station and the fluorescent screen 60 at the receiving station is covered by the cathode beams in $\frac{1}{32}$ of a second, the image of the object will be displayed on the screen 60 during $\frac{1}{32}$ of a second. However, as the frequency of the oscillation of the generator 23 is 16 cycles per second, the picture will be transmitted twice and will remain on the screen 60 during $\frac{1}{16}$ of a second. Thus, due to the persistency of vision phenomena, any movement of the object before the lens 37 will be properly transmitted and recorded upon the fluorescent screen 60 and will appear thereupon as a moving image.

Of course, in place of transmitting the image of actual objects, it is entirely possible to send moving pictures, as all that is necessary is to pass the pictures before the lens 37 at the required rate and a replica of them will appear on the screen 60. In order to place these pictures before a large audience, it is, of course, possible to intensify and focus them upon an ordinary screen by means of any well known optical system.

The operation of the system when the apparatus used in Fig. 3 is employed at the transmitting station is very similar to that already described. The cathode beam covers the area of the fluorescent screen 75 under the influence of the magnetic and electrostatic fields. When the beam is at one particular point, the light from that spot will traverse the film 78, lens 77 and photoelectric cell 76.

The variation of current of the photoelectric cell 76 causes the carrier frequency to be modulated in accordance with the current flow which is directly proportional to the intensity of light from the fluorescent spot that reaches the photoelectric cell. As this condition occurs for each particular point on the picture, the whole picture will be transmitted in the manner described. The method of reproduction is the same as has been explained in conjunction with Figs. 1 and 2.

Inasmuch as a particular portion of the image is transmitted by means of a modulated alternating current, the potential upon the grid 54 of the receiving cathode-ray tube 55 will be varied to some extent in accordance with the carrier frequency. The grid 54 will thus influence the cathode beam. The cathode beam falling at a particular point on the fluorescent screen will vary in intensity, thus producing a phenomenon somewhat similar to that occasioned were the cathode beam to be fully cut off. This impulsing action of the cathode beams in the cathode-ray tubes at both the transmitting and receiving stations is intensified, by reason of the fact that the potential applied between the cathode and the anode in each case is fluctuating, being supplied from a direct current derived from a rectified alternating current. By reason of these actions, the tendency of the fluorescent spot on the screen 60 to spread is minimized. The intensity of the cathode beam may be regulated by regulating the voltage of the alternating-current sources 41 or 62 in a well known manner.

Attention is drawn to the fact that any change in the frequency of operation of the alternating-current generators 22 and 23 at the transmitting station causes a corresponding change in the frequency of oscillations in the current effecting the cathode ray at the receiving station, and, consequently, the cathode-ray beams will remain in synchronism at both the transmitting and receiving stations and there will be no distortion in the picture transmitted.

It is obvious that it is entirely possible to have the alternators 22 and 23 generate a synchronizing frequency at a station separate from the transmitting station. In this case, the central synchronizing station would be arranged in the manner shown in Fig. 4. The alternators 122 and 123 correspond to the alternators 22 and 23. These alternators serve to modulate a frequency generated by the oscillating circuit including the oscillator triode 118, and this modulated frequency is radiated from the antenna 103 in the usual manner.

At the transmitting station in Fig. 5, the operation is the same as has been before described, with the exception that the oscillatory circuit 101 is resonant to the synchronizing carrier frequency, and this frequency is transferred to the transformers 105 and 106 of the detector triodes 107 and 108. By the operation of these detectors, the synchronizing frequencies are applied to the coils 109 and 110 and to the plates 111 and 112. The further operation of the system takes place in the same manner as has been described before.

It will be seen that this arrangement permits a number of transmitting stations to transmit pictures or visual indications with only one central station for generating the synchronizing frequency.

It is, of course, apparent, that any number of receiving stations may receive the image broadcasted in a manner similar to that described.

My invention is not limited to the particular arrangement of apparatus illustrated but may be variously modified without departing from the spirit and scope thereof, as set forth in the appended claims.

I claim as my invention:

1. Scanning means for television systems or the like comprising a screen, a scanning medium directed against said screen, means for moving the scanning medium so as to subject each elemental area of the screen to the scanning medium to cause a source of light to be developed at each elemental area of contact of said scanning medium and said screen, means employing a reflection of said source of light to scan an element of a subject to be scanned, and means for translating the various light values on each elemental area of the scanned subject into electric current impulses.

2. Scanning means for television systems or the like comprising a screen, a scanning medium, means for causing said scanning medium to traverse said screen in a predetermined manner, means for causing a point source of light to develop at successive elemental areas of contact of said scanning medium and said screen, means for causing said point sources of light to scan coordinated elemental areas of a subject to be scanned, and means to convert the varying light values determined by each elemental area illuminated into proportionately varied electric current impulses.

3. Scanning means for television systems or the like comprising a cathode ray, a screen adapted to fluoresce under the action of a cathode ray, means for causing said ray to traverse predetermined paths on said screen to produce a series of successive point sources of light, a subject to be scanned, means for causing the successive point sources of light to scan corresponding successive elemental areas of said subject, and light translating means for converting the light values represented by each elemental area illuminated into proportionately varied electric current impulses.

4. Scanning means for television systems or the like comprising means for continuously developing a series of sequentially produced sources of light according to pre-established patterns over successive elemental sections of a predetermined area, a subject to be scanned and means for causing the successive point sources of light to scan corresponding successive elementary areas of said subject.

5. Means for producing an electric current modulated to adapt it for image reproduction comprising a fluorescent screen, means for producing an electron stream focusing upon said fluorescent screen, means for causing said electron stream to traverse said fluorescent screen point by point, a light-responsive electrical circuit element positioned to intercept a portion only of the radiant energy generated at the focus of said electron stream on said screen, and means for interposing the image to be reproduced between said fluorescent screen and said light-responsive electrical circuit element.

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