April 21, 1936. P. T. FARNSWORTH 2,037,711

METHOD AND APPARATUS FOR TELEVISION

Original Filed Nov. 26, 1928 2 Sheets-Sheet 1

Fig. 1

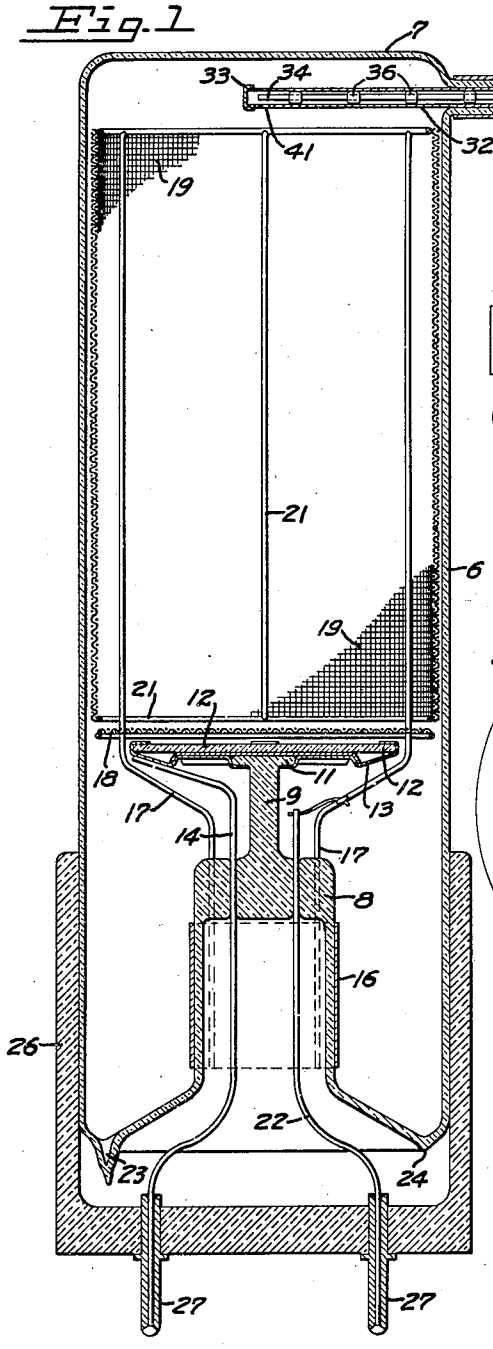

Fig. 4

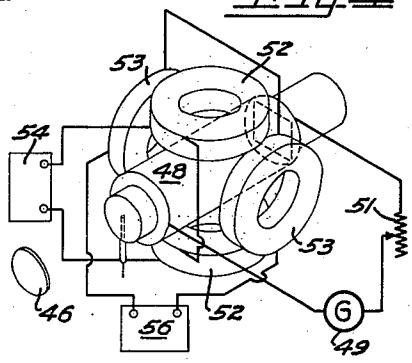

Fig. 2

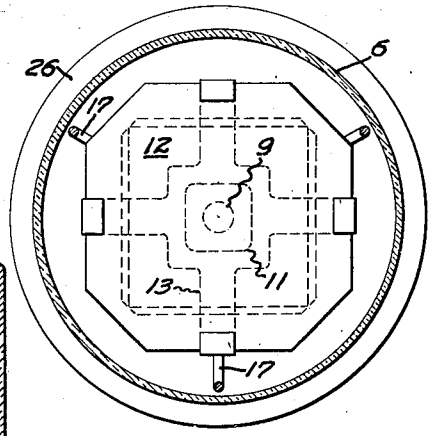

Fig. 3

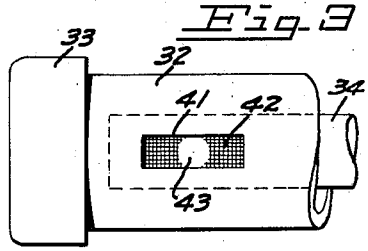

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Fig-6

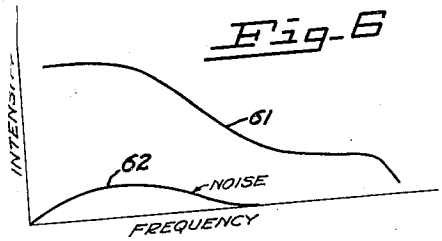


Fig-7

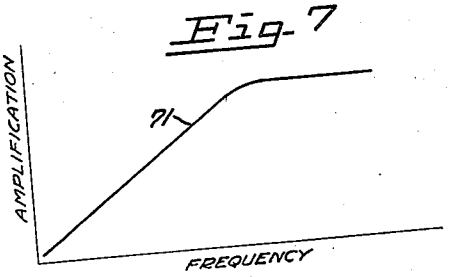


Fig-8

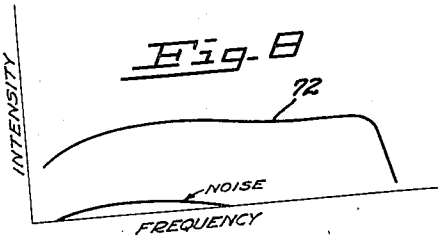
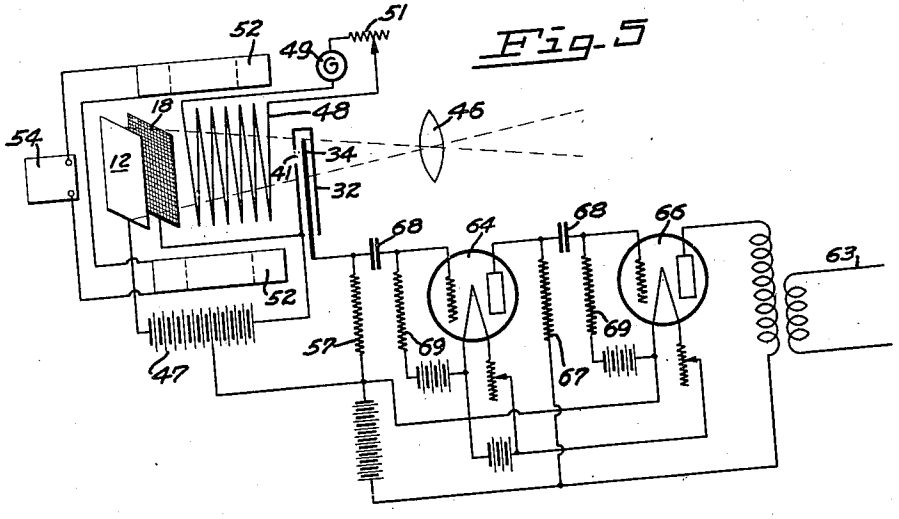


Fig-5



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Patented Apr. 21, 1936 2,037,711

UNITED STATES PATENT OFFICE

2,037,711

METHOD AND APPARATUS FOR TELEVISION

Philo T. Farnsworth, San Francisco, Calif., assignor, by mesne assignments, to Television Laboratories, Inc., San Francisco, Calif., a corporation of California

Application November 26, 1928, Serial No. 321,305
Renewed September 21, 1931

27 Claims. (Cl. 178—6)

My invention relates to the transmission of electrical impulses to form pictures. While it is particularly applicable to television,—i. e., the transmission of successive images, each within the optical period, giving the appearance of motion to the object pictured,—it also has a general applicability to electrical picture transmission systems.

An object of my invention is to provide a means of increasing the sensitivity of a television transmitter.

Another object of my invention is to provide a means of increasing the detail of the transmitted picture.

Still another object of my invention is to decrease the effect upon the transmitted picture of "noise", that is, of stray impulses generated by mechanical shocks to the transmission apparatus, or by induction from adjacent apparatus or lines.

My invention has 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:—

Figure 1 is an axial sectional view of a transmitting photo-electric cell embodying my invention.

Figure 2 is a transverse sectional view of the same cell, the plane of section being indicated by the line 2—2 of Fig. 1.

Figure 3 is a detail view on a greatly enlarged scale of the target of the cell with its shield, showing the scanning apertures.

Figure 4 is a schematic diagram of the transmitting apparatus.

Figure 5 is a diagram of the transmitting circuits.

Figures 6, 7 and 8 are frequency response curves of the various parts of the apparatus.

All methods of electrical picture transmission which have thus far been proposed involve the systematic passage of a scanning element over the pictured area to dissect or analyze it into elementary areas, the picture current being proportional at each instant to the mean light intensity from the elementary area covered at that instant by the scanning element or, in indirect processes, to an equivalent quantity. Scanning elements of various types have been devised, such as light beams, conductive feelers, cathode ray pencils, and moving apertures, but since the end product of the process is a picture, it has been found convenient to adopt optical terms in referring to the process, and therefore the scanning element, whatever its nature, is termed an "aperture", and its conductivity, permeability to the electron stream, or other equivalent quality is referred to as its "transparency".

While this terminology leads to some apparent absurdities, in that an "aperture" may be a material object, it is adopted here as being the most general thus far proposed. It will be apparent that in this sense the "aperture" is that portion of the system which determines shape of the elementary picture areas and their size as compared with the picture as a whole.

Since the picture current can represent only the mean illumination from the elementary area embraced by the aperture, it follows that no details smaller than this area can be reproduced. It also follows that abrupt transitions from light to shade in the reproduced picture are impossible, the transition occupying an interval corresponding to the aperture width. Considered in electrical terms, it means that picture current components of frequencies higher than a definite cut off value are either attenuated or completely suppressed. This is known as the "aperture effect".

It is obvious that from the standpoint of reproduction of detail, the smaller the aperture used, the better will be the picture. However, a reduction in aperture involves a corresponding reduction in the sensitivity of the device and altho this may in some degree be compensated for by amplification, a point is quickly reached where accidental effects of induction, mechanical vibration of amplifier tubes, and the like, become so great as to mask the picture currents to a greater or less extent, and the quality of the picture is seriously impaired. These masking influences are all grouped under the term "noise", since in genesis and effect they are directly analagous to noise in a telephone system. The intensity level of the picture currents must be materially higher than the noise level if a satisfactory picture is to result. The interferent noise which disturbs picture transmission has been found by experiment to occur chiefly at relatively low frequencies, its maximum intensity usually occurring at less than 1000 cycles.

In general terms, my invention comprises the generation of picture currents having both high and low frequency components, the component

frequencies upon which interference occurs being disproportionately large, and then equalizing or proportionalizing the components after generation. This may be done in a television transmitter by providing a scanning apparatus having a large and a small aperture, with which the picture area is simultaneously scanned, and by passing the combined currents thru a network which attenuates the low frequencies more than the high, or what is equivalent, amplifies the high frequencies more than the low. The small aperture determines the limit of detail in the picture; the large aperture raises the intensity of the frequencies within the interference range well above the noise level, and greatly increases the sensitivity of the apparatus.

In practice, I have embodied my invention in a television transmitter of the type described in my copending applications, Serial No. 159,540, filed January 7, 1927, now Patent 1,773,980, granted Aug. 26, 1930, and Serial No. 270,673, filed April 17, 1928. The transmitter comprises a dissector tube having a cylindrical glass envelope **6**, having at one end a flat window **7** and at the other a stem **8** upon which the elements of the tube are supported, and thru which certain of the leads pass.

The inner end of the stem carries a short glass pillar **9** terminating in a square button **11**. The button supports a glass plate **12** which has a metallized surface on which is deposited a photosensitive film. A metal clip or spider **13** holds the plate in place and makes contact with the photosensitive film, and a lead **14**, secured to the clip, passes out thru the stem **8**.

A band clamp **16** surrounds the stem, and to this are secured wires **17** which carry the anode structure, which comprises a screen **18** of wire mesh, parallel and closely adjacent to the photosensitive cathode surface, and a cylindrical screen **9**, also of wire mesh, which conforms closely to the inner surface of the envelope, extending from the transverse screen **18** to within a short distance of the window **7**. A wire frame **21** stiffens the screens and is secured, preferably by welding, to the support wires **17**. An anode lead **22** is sealed thru the stem and also connects with the support wires.

The tip **23**, thru which the tube is evacuated, is formed at the seal **24** which joins the stem with the cylindrical body of the envelope. The tip is protected by the base **26** which is formed of insulating material and supports the tube when in use. The base carries contact pins **27** which terminate the anode and cathode leads.

Joining the envelope at the other end of the tube, adjacent the window **7**, is a short side tube **30**. This tube carries a tubular metal shield **32** mounted by a cap **33**. A wire target **34**, preferably of nickel or other material which is a good secondary emitter of electrons, extends within the shield and is spaced and insulated from it by the beads **36**. Separate leads **37** and **38** are connected to the shield and target respectively, and are sealed thru the end of the side tube **31**. The side tube is protected and shielded externally by a metal sleeve **39**, to which the shield lead **37** is connected.

Adjacent the end of the shield **31**, facing the cathode and in the axis of the tube, is an aperture **41**. The aperture is covered by a screen **42** of fine wire mesh, and in the center of this screen is a smaller aperture **43** which is materially larger than the mesh of the screen. The aperture **41** is preferably rectangular, or at least elongated in form, with the central aperture **43** occupying its full width. Both apertures may be square or round if desired, but this results in a lower transmission of detail in one direction than in the other if the scanning frequencies are markedly different, as is usually the case.

Associated with the tube is certain auxiliary apparatus, which is diagrammatically indicated in Figures 4 and 5. An optical system, indicated in the figures by the lens **46**, focuses an image of the object to be pictured thru the window **7** onto the photo-electric cathode. Electrons are liberated from the elementary areas of the surface of the cathode in proportion to their illumination, and these electrons are drawn toward the anode by a potential supplied by the battery **47**, which is connected between the cathode and anode. The major portion of these electrons pass thru the screen **18** into the equipotential space within the screen **19**, and these continue to travel longitudinally of the tube with practically undiminished velocity.

The tube is surrounded by a coil **48**, which is supplied with direct current by a generator **49** to produce a practically uniform magnetic field within the tube and coaxial therewith. This field focuses the electron stream, and is adjusted by means of the rheostat **51** to bring the focus into the plane of the aperture **41**, as is explained in my copending application Serial No. 270,673 above mentioned.

The focused stream of electrons is deflected by coils **52**, **52** and **53**, **53**, which are supplied respectively by the high frequency oscillator **54** and the low frequency oscillator **56**, so that all parts of the electrical image in turn sweep over the compound aperture to accomplish the scanning action. The high frequency scanning takes place in the direction of the longer axis of the aperture, the low frequency movement of the image during each high frequency traverse preferably being equal to the width of the aperture. Those electrons entering the aperture impinge on the target, liberating secondary electrons. The shield **32** is maintained at the anode potential by the battery **47**. The target **34** is connected to a point on the same battery which keeps it somewhat negative with respect to the shield, and the secondary electrons are therefore drawn to the shield, constituting a current which flows from the battery to the shield, and thence to the target and back thru a high resistance **57** to the battery. This refers to the conventional "current flow", and not to the actual electron flow, which is in the reverse direction.

It will be appreciated that some of those electrons falling on the screened portion of the aperture will be stopped by the wires, which thus serve to reduce the transparency of the aperture. All of the electrons falling on the aperture **43**, however, will pass unimpeded to the target, and the central aperture therefore has a higher transparency than the larger aperture which embraces it.

The picture current produced by the tube thus represents two superposed pictures, one having high contrast and small detail, the other smaller contrast and greater detail. Electrically this is represented by Figure 6, in which curve **61** represents the frequency characteristic of the tube, and curve **62** represents the noise level. Pictorially we may think of the resultant picture as one in which the large masses are shown in full contrast, while the details are sketched in lightly.

The fall of potential across the resistor **57** is

amplified and passed on to the line 63, which may be either a transmission line or the input circuit of a radio transmitter. The amplifier shown includes the usual vacuum tubes 64, 66, with coupling networks comprising the plate resistors 67, coupling condensers 68, and grid resistors 69. The condensers 68 are of relatively low capacity and the grid resistors of somewhat lower resistance than would ordinarily be used. This results in the amplifier discriminating against the lower frequencies, its response curve being approximately as shown in curve 71, Figure 7. This curve taken in connection with the curve 61 gives an over-all response curve such as is shown in Figure 8, curve 72. It will be noted that the frequency characteristic is substantially flat up to the cut off point which is determined by the aperture 43. The low frequencies have been reduced to their normal values, or proportionalized, the noise level has been correspondingly reduced, and the details of the pictures resulting from the currents will have their full contrast values. Absolute flatness of the over-all curve is not essential, as the eye has a wide tolerance in this regard. In some cases it has even been found of advantage to over-attenuate the low frequencies, causing the high frequencies to dominate in the resultant characteristic.

It is obvious that it is immaterial at what point in the system the proportionalizing is done. So called "equalizing networks", which attenuate certain component frequencies as compared to others, are well known in telephone practice, and the particular type used in this instance is purely a matter of choice. While I have here shown an amplifier in which the attenuation of the low frequencies occurs between successive amplifier tubes at the transmitter, it may be advisable to give the transmitting amplifier a flat characteristic, and to place the equalizer at the receiving end of the system, either as a part of an amplifier or as a separate network.

While the system has been shown as adapted to an electrical system of scanning, it is obvious that the method is perfectly general, and that double or multiple aperture scanning, either with concentric or with separately positioned apertures, may be practiced with any scanning system yet proposed.

Other modifications are the use of intermediate apertures, or, carrying this idea to the limit, an aperture which shades by continuous graduations from full transparency at the center to full opacity at the edge, comprising in reality an indefinitely large number of superposed apertures. This arrangement will give a continuously falling frequency characteristic, instead of the stepped characteristic of the double aperture device. "Effective transparency" refers to "transparency" as it affects the intensity of the resultant signal, regardless of apparent transparency as determined by eye.

I claim:

1. A scanning apparatus having an aperture of relatively large dimension in the direction of its traversal of the picture field, and a second aperture of relatively small dimension in said direction, each of said areas effectively defining a proportionate area of said field for transmission, and means for effecting the simultaneous scanning of an object with said apertures.

2. A scanning apparatus having a large aperture of relatively low effective transparency and a smaller aperture of higher effective transparency, and means for effecting the simultaneous scanning of an object with said apertures, each of said apertures effectively defining a proportionate elementary area for transmission.

3. A scanning apparatus having a large aperture of relatively low effective transparency and a smaller aperture of higher effective transparency centrally positioned with respect thereto, and means for effecting the simultaneous scanning of an object with said apertures, each of said apertures effectively defining a proportionate elementary area for transmission.

4. A system for the transmission of electrical impulses to produce pictures comprising means for producing a picture current comprising low frequency alternating components only, additional means for producing a picture current comprising both low and high frequency components, and means for simultaneously transmitting said picture currents.

5. A system for the transmission of electrical impulses to produce pictures comprising means for producing a picture current comprising low frequency alternating components only, additional means for producing a picture current comprising both low and high frequency components, means for simultaneously transmitting said picture currents, and means for proportionalizing the high and low frequency components in the combined currents.

6. A transmitter for producing electrical impulses to form pictures comprising means for analyzing the object to be pictured into elements of relatively large area, synchronously operated means for analyzing the object into elements of smaller area, and means for supplying electrical currents corresponding to the illumination of each of said elementary areas.

7. A transmitter for producing electrical impulses to form pictures comprising means for analyzing the object to be pictured into elements of relatively large area, synchronously operated means for analyzing the object into elements of smaller area, means for supplying electrical currents corresponding to the illumination of each of said elementary areas, and means for proportionalizing the high and low frequency components in said currents.

8. In a system for transmitting electrical impulses for the formation of pictures, means for forming an image of the object to be pictured, means for analyzing said image into relatively large elementary areas, means for analyzing said image into smaller elementary areas, a source of electric current, and means for modulating said current in accordance with the intensity of each of said image areas.

9. In a system for transmitting electrical impulses for the formation of pictures, means for forming an image of the object to be pictured, means for analyzing said image into relatively large elementary areas, means for analyzing said image into smaller elementary areas, a source of electric current, means for modulating said current in accordance with the intensity of each of said image areas, and an equalizer for attenuating the low frequency components in said modulated current as compared to the high frequency components.

10. A transmitter of electrical impulses for the formation of pictures comprising means for forming an electrical image of the object to be pictured, means for deflecting said image in accordance with a predetermined time schedule, a target arranged to receive a portion of the component electrons of said image, a shield for said

target having an aperture therein, and a screen partially transparent to electrons covering said aperture, said screen having a more highly transparent aperture therein.

11. A transmitter of electrical impulses for the formation of pictures comprising means for forming an electrical image of the object to be pictured, means for deflecting said image in accordance with a predetermined time schedule, a target arranged to receive a portion of the component electrons of said image, a shield for said target having an aperture therein, and a screen partially transparent to electrons covering said aperture, said screen having a more highly transparent central aperture therein.

12. A photo-electric apparatus comprising a surface operative to initiate an electrical discharge corresponding to the illumination thereof, an electrode positioned to accelerate said discharge, a target in the path of said discharge, a shield for said target having an aperture therein, and a screen covering said aperture, said screen being partially transparent to the discharge and having a smaller and more transparent aperture therein.

13. A photo-electric apparatus comprising a surface operative to initiate an electrical discharge corresponding to the illumination thereof, an electrode positioned to accelerate said discharge, a target in the path of said discharge, a shield for said target having an aperture therein, and a wire mesh screen covering said aperture, said screen having an aperture therein larger than the screen mesh.

14. A photo-electric apparatus comprising a surface operative to initiate an electrical discharge corresponding to the illumination thereof, an electrode positioned to accelerate said discharge, a target in the path of said discharge, a shield for said target having an aperture therein, and a wire mesh screen covering said aperture, said screen having a central aperture therein larger than the screen mesh.

15. A photo-electric apparatus comprising a surface operative to initiate an electrical discharge corresponding to the illumination thereof, an electrode positioned to accelerate said discharge, a target in the path of said discharge, a shield for said target having an aperture therein, a screen covering said aperture, said screen being partially transparent to the discharge and having a smaller and more transparent aperture therein, and means for deflecting said discharge.

16. A photo-electric apparatus comprising a surface operative to initiate an electrical discharge corresponding to the illumination thereof, an electrode positioned to accelerate said discharge, a target in the path of said discharge, a shield for said target having an aperture therein, a screen covering said aperture, said screen being partially transparent to the discharge and having a smaller and more transparent aperture therein, and means for forming an optical image on said surface.

17. A photo-electric apparatus comprising a surface operative to initiate an electrical discharge corresponding to the illumination thereof, an electrode positioned to accelerate said discharge, a target in the path of said discharge, a shield for said target having an aperture therein, a screen covering said aperture, said screen being partially transparent to the discharge and having a smaller and more transparent aperture therein, means for forming an optical image on said surface, and means for focusing the electrical discharge to form an electrical image in the plane of the apertures.

18. A photo-electric apparatus comprising a photo-electric surface forming a cathode, an anode screen parallel to said cathode, a target positioned behind said screen, a shield for said target having an aperture therein, and a screen partially transparent to electronic discharge covering said aperture, said screen having a more transparent aperture therein.

19. A photo-electric apparatus comprising a substantially cylindrical envelope, a photo-electric cathode arranged within the envelope and substantially normal to the axis thereof, an anode screen adjacent and parallel to the cathode, a cylindrical screen extending from the anode screen distally from the cathode, and a target arranged to receive a discharge passing longitudinally of the cylindrical screen from the cathode.

20. A scanning apparatus having an elongated aperture of relatively low transparency and a smaller aperture of higher transparency centrally positioned with respect thereto, and means for effecting the simultaneous scanning of an object with said apertures, said scanning means being operative at a high frequency in the direction of the longer axis of said first aperture and at a lower frequency perpendicular thereto.

21. A transmitter of electrical impulses for the formation of pictures comprising means for forming an electrical image of the object to be pictured, means for deflecting said image in accordance with a predetermined time schedule, a target arranged to receive a portion of the component electrons of said image, a shield for said target having an elongated aperture therein, and a screen partially transparent to electrons covering said aperture, said screen having a more highly transparent aperture therein.

22. A photo-electric apparatus comprising a surface operative to initiate an electrical discharge corresponding to the illumination thereof, an electrode positioned to accelerate said discharge, a target in the path of said discharge, a shield for said target having an elongated aperture therein, and a screen covering said aperture, said screen being partially transparent to the discharge and having a more highly transparent central aperture.

23. The method of electrical picture transmission which comprises the steps of simultaneously dissecting the picture area to be transmitted into superposed elementary areas having different limits, generating picture impulses corresponding to the mean illumination of each of said areas, and transmitting the combined impulses.

24. The method of electrical picture transmission which comprises the steps of simultaneously dissecting the picture area to be transmitted into superposed elementary areas having different limits, generating picture impulses corresponding to the mean illumination of each of said areas and having intensities and frequency limits corresponding thereto, transmitting the combined impulses, and equalizing said impulses to provide proper relative proportions of their component frequencies.

25. The method of electrical picture transmission which comprises the steps of simultaneously dissecting the picture area into a plurality of series of different superposed elementary areas to produce a plurality of trains of picture impulses, and combining said trains of impulses to reproduce the picture.

26. The method of electrical picture transmission which comprises the steps of scanning the picture area simultaneously with a plurality of apertures of differing configuration, generating picture impulses having different frequency components corresponding to said apertures, and utilizing the combined impulses to reproduce the picture.

27. The method of electrical picture transmission which comprises the steps of scanning the picture area simultaneously with a plurality of apertures, transmitting a picture current corresponding to the additive effect of said apertures and utilizing said picture current to reproduce the picture.

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