

June 1, 1937.

H. E. IVES

2,082,339

TELEVISION SYSTEM

Filed March 2, 1927

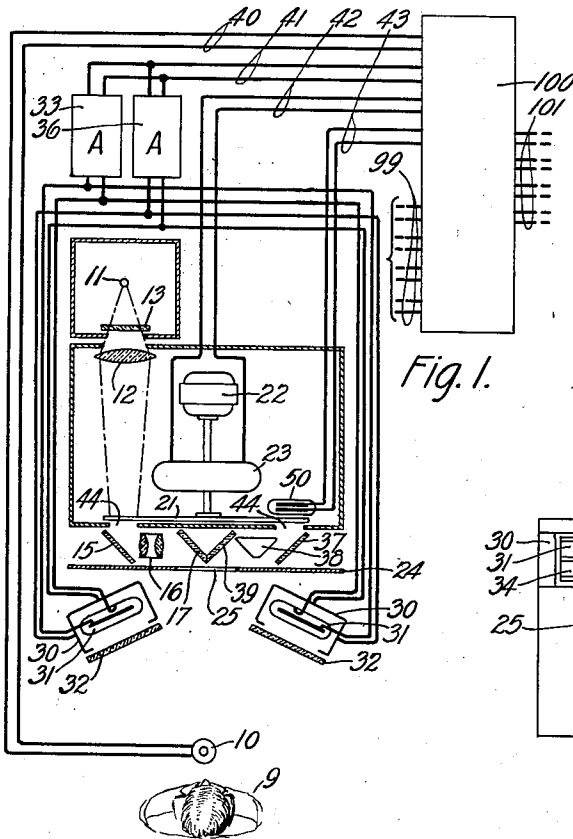


Fig. 1.

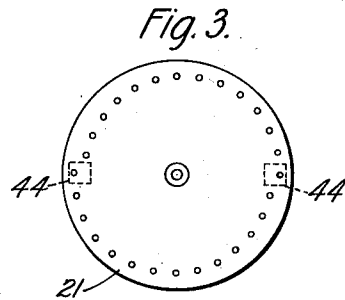


Fig. 3.

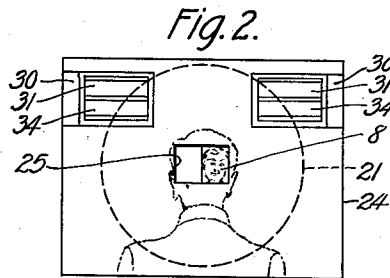


Fig. 2.

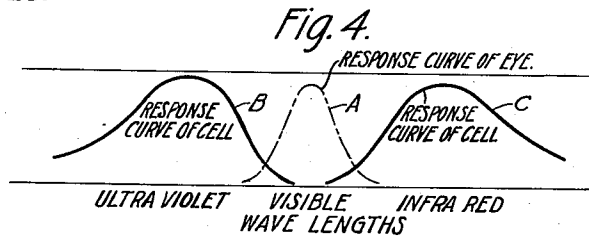


Fig. 4.

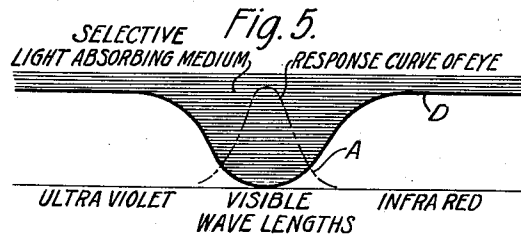


Fig. 5.

Inventor:
Herbert E. Ives
by Joel C. Palmer
Attorney

UNITED STATES PATENT OFFICE

2,082,339

TELEVISION SYSTEM

Herbert E. Ives, Montclair, N. J., assignor to
Bell Telephone Laboratories, Incorporated,
New York, N. Y., a corporation of New York

Application March 2, 1927, Serial No. 171,962

20 Claims. (Cl. 178—6)

This invention relates to electro-optical transmission and more particularly to selective illumination and selective translation of light effects into electric current for two-way television systems.

One of the problems in television is the securing of sufficient illumination of the object whose image is to be transmitted and is particularly difficult where it is desired to transmit images of human beings. In systems subjecting the object to a flood of illumination, the light may be insufferably bright, and in two-way television systems where a person is simultaneously both the object and the observer the illumination must not interfere with the observer seeing the incoming image.

According to this invention the above mentioned difficulty of illumination is largely overcome by selectively illuminating the individual by a light of proper intensity and color or wave lengths to which the eye is not particularly sensitive and by using light sensitive devices particularly sensitive to the light used. The term light, as herein used, includes the radiation of the entire known spectrum.

The red and infra-red, and the blue, violet, and ultra-violet radiations all have a low luminous value and consequently cause, when their intensity is properly controlled, little personal annoyance and interfere but slightly, if at all, with human vision. Infra-red and ultra-violet light or radiant energy are particularly effective in exciting certain kinds of light sensitive cells. For example, the thalo-sulphide cell is most responsive to infra-red illumination, while other types of light sensitive elements such as the potassium hydride photoelectric cell are most sensitive to rays in the short wave region of the visible spectrum and just beyond in the ultra-violet.

This invention makes possible the selection of illumination which is unobjectionable to an observer who is being subjected to it and at the same time permits using the most effective wave lengths for the light sensitive elements employed, thereby obtaining the highest photoelectric response from the exciting illumination. The relative intensities of the various selective radiations may be controlled, either directly by varying the intensity of the light source or the transparency of a medium which the light traverses, or indirectly by varying the flow of the generated photoelectric current to produce the proper tone values in a reproduced picture.

Selective illumination may be secured either

by employing light sources which in themselves are confined to a limited range within the desired range of wave lengths; or by employing a source of illumination which may extend through and to a considerable range both below and above the undesired range and interposing a light absorbing medium or filter between the source of light and the object, which substantially eliminates the rays within the undesired range.

A more detailed description of the invention follows and is illustrated in the accompanying drawing in which

Fig. 1 is a schematic arrangement of the terminal apparatus of a two-way television system selected for illustrating this invention;

Fig. 2 is a front view of Fig. 1;

Fig. 3 is a side view of a television scanning disc;

Fig. 4 is a set of typical curves showing the response of the human eye and the response of typical light sensitive cells to infra-red and ultra-violet rays; and

Fig. 5 is a set of curves showing the response of the human eye, and the range of illumination filtered out by a light absorbing medium placed in front of a light source having a range extending from the infra-red to the ultra-violet.

The apparatus for one interconnecting subscribers station adapted for simultaneous two-way television and telephone transmission and the exchange leads and central office switching equipment for connecting to other stations are diagrammatically shown in Fig. 1. The apparatus for each subscriber's station is substantially identical and is preferably interconnected by suitable circuits leading to and from the central office. The station operator or user is positioned in front of the television and telephone apparatus in such relation that he may observe the image being received from another station and can at the same time be scanned by his local television set. The subscribers telephone station apparatus 10 connects with the telephone central office by the line 40.

The television apparatus has for its principal moving element a scanning disc 21 operated by a motor 22 and a synchronizing controlling device 23. The scanning disc contains two series of small apertures which may be arranged as shown in Fig. 3 for simultaneously sending and receiving, respectively. The area which may be scanned by such a disc at its plane is determined by the radial width of the spiral and the pitch of the apertures. Each of the two viewing openings

44 in the member in front of the disc at the sending and the reproducing positions has a vertical width substantially equal to the pitch of the apertures. A suitable optical system is used in association with the scanning disc. For transmitting, the object is illuminated and scanned in a series of parallel lines by a light beam passing through the successive apertures in the disc. For receiving the image is produced by variable intensity luminous light beams passing through the successive apertures of the scanning disc as they trace a similar series of parallel rows of elemental areas. As here shown, the scanning arrangement is similar to that disclosed in the copending application of H. E. Ives, Serial No. 138,845, filed October 1, 1926 and the illumination of the object is effected in the manner disclosed in the copending application of Frank Gray, Serial No. 111,731, filed May 26, 1926. The light source 11 used for transmitting has a spectrum including infra-red or ultra-violet wave lengths or both and the light from this source after having the visible rays which interfere most with the incoming image substantially eliminated by the light absorbing medium or filter 13, is concentrated on the scanning disc 21 by means of the lens 12 upon an area slightly larger than the aperture 44 at the left side of the scanning disc. A small beam of light passes through only one aperture of the scanning disc and the aperture 44 at a time and this beam of light is reflected by means of the mirror 15 through the lenses 16 to the mirror 17 where it is again reflected upon the object. As a result of this arrangement, small elemental areas of the object are successively illuminated and scanned in a series of parallel lines by a spot of intense invisible light. The light reflected from the object falls on wide aperture light sensitive cells shown in the housing 30. The light sensitive cells may be of any suitable number, type and arrangement and preferably two cells 31 and 34 are placed adjoining each other in each position, one being sensitive to infra-red rays and the other sensitive to ultra-violet rays. The photo-electric current generated in these cells is amplified by distortionless adjustable amplifiers. One-half of the light sensitive cells are particularly sensitive to infra-red rays and are connected to one amplifier 33 and the other half are particularly sensitive to ultra-violet rays and are connected to another amplifier 36. One of the reasons for connecting the two types of cells to different amplifiers is to permit an adjustment of the tone value of the reproduced picture by amplifying the photo-electric current from the infra-red cells or from the ultra-violet cells to a greater or lesser degree. These amplifiers connect to the circuit 41 which leads to the central office exchange. The light sensitive cells may be substantially totally shielded by the housing 30 to prevent light reaching them from other directions than the object, and they may be selectively shielded by means of the color screens or filters 32 positioned between the object and the photo-electric cells which may be designed to assist in controlling the character or tone value of the received picture. However, these screens may or may not be used.

The picture current received from a distant station may be translated into light by means of any suitable device such as a neon glow lamp 50 capable of responding to the very rapid variation of the photo-electric current. The light from this lamp is viewed through the television scanning disc. Upon passing through successive aper-

tures of the scanning disc 21 the light is reflected by the mirror 37 to the left and right transposing prism 38 through which it is transmitted to mirror 39 from which it is again reflected through the right half of the viewing aperture 25 towards the observer.

The synchronizing apparatus may be of any suitable type capable of maintaining interconnected television stations in synchronism and in exact phase relationship with each other. Various arrangements of this character have been developed in connection with telegraphic systems, picture transmission systems and for other purposes. The arrangement diagrammatically shown here is based upon driving the television disc by means of a substantially constant speed motor 22 having sufficient power to rotate the television disc at the proper speed, and upon maintaining exact synchronism by an alternating current generator 23. The source of power for operating the motor 22 may be furnished locally or from a central point. When, for example, television stations are interconnected, each is brought up to required synchronous speed by its driving motor 22 and then locked and held in synchronism and phase by the alternating current generator 23 in a manner similar to that disclosed in the Ives application referred to above.

Where television stations are employed in an intercommunicating system, the desired switching connections are made through a central office exchange similar to that used for interconnecting subscribers' telephone stations. Such interconnecting central office apparatus is indicated at 100. Any practical number of stations may be connected by a plurality of circuits 99 with a central office and several central offices interconnected by the necessary trunks or toll lines 101 as indicated in the drawing.

A front view of the apparatus and an indication of the position of the user is shown in Fig. 2. The user in general sees a rectangular viewing opening 25 through the screen 24, one-half showing the image of the object within the field of view such as that of the person with whom he is talking and the other half appearing blank as through this half he is being scanned. An image of the incoming picture shows at 8 in the right half of the opening 25.

The scanning disc shown in Fig. 3 is identical with that of the Ives case hereinbefore mentioned and contains two substantially similar series of spiral apertures, one series is used for analyzing the object whose image is being transmitted, while the other is simultaneously integrating the image of the object whose picture is being received. The two sets of spiral apertures as here shown are displaced by and occupy 180°. The transmitting and receiving positions with respect to the disc are correspondingly located at opposite sides or 180° apart. Other arrangements of the apertures and corresponding locations of the sending and receiving positions are obvious.

A number of typical curves showing the response of the human eye and the response of light sensitive cells is shown in Fig. 4. These curves are drawn with the ordinates representing response and the abscissae representing wave length. The response of the human eye to a light source of approximately uniform intensity for all wave lengths varies greatly with wave length as shown by curve A extending over the visible range. The maximum sensitivity or response is obtained from yellow-green light,

while a response of about half the maximum obtains for blue-green and red light, and substantially no response obtains for ultra-violet and infra-red light. A typical response curve of an ordinary photoelectric cell is shown by curve B. Such a cell is most sensitive to blue and violet rays and practically insensitive to yellow, orange and red rays. A typical response curve of a thalo-sulphide cell is shown by curve C. Such a cell is particularly sensitive to red and infra-red rays. Light sensitive cells having response characteristics similar to those shown by curves B and C are particularly suitable for excitation from light rays which are invisible to the human eye. The arrangement herein disclosed is not only adapted for using one or more types of light sensitive cells, but for using different types simultaneously and for adjusting the relative response of different cells so as to obtain tone characteristics in a reproduced picture which are substantially similar to the visible light effects of the object whose image is being produced. By suitable blending of the output energies of a plurality of light sensitive cells having different response characteristics, invisible rays may be used for illuminating the object at such intensities as to avoid annoyance to the observer and at the same time secure high response from the light sensitive cells and also a faithful tone reproduction of the object being viewed.

The action of a light absorbing medium or filter placed in front of a source of light having a wide range or band of wave lengths is shown in Fig. 5, the absorbing medium or filter being one which cuts off substantially all rays within the visible wave length range and passes a very large part of the ultra-violet and infra-red rays. The curve A shows the light response of the human eye. A light source having rays extending from within the infra-red to within the ultra-violet zones may be used by using a light absorbing medium or filter having a cut-off characteristic such as that shown by curve D in Fig. 5. Such a light absorbing medium or filter does not cut off all of the visible rays, but effectively cuts off the whole intermediate portion of the light within the visible spectrum and especially the yellow and green, which cause greatest annoyance, as shown from the eye response curve A, and most seriously interfere with the observing of the incoming image. Also invisible light sources rich in either ultra-violet or infra-red radiations may be used without a light filter. However, a filter cutting off the objectionable visible rays would be used with such sources of illumination if their range extended to any appreciable extent into the visible range.

In the arrangement selected and described for illustrating this invention, small elemental areas of the object are successively illuminated and scanned by a spot of intense light of the kind above described. However, in accordance with the invention in a broad aspect, the object may be illuminated as a whole by a flood of invisible rays and small elemental areas of the object successively scanned by an arrangement similar to that shown in the Ives application referred to hereinbefore.

Selective illumination and light sensitive cells particularly responsive to the selected wave lengths may be expected to increase the response of the light sensitive elements in the order of approximately ten times that of an ordinary non-selective general flood lighting arrangement.

The term "light" as used herein is intended to

include electro-magnetic waves above and below, as well as within, the so-called visible spectrum. The term "television" is intended to cover recording as well as directly viewing an image built up at such speed that direct viewing is possible.

What is claimed is:

1. In an electro-optical television system, a source of light in which infra-red and ultra-violet rays predominate for illuminating an object whose image is to be transmitted, and light sensitive elements particularly responsive to infra-red and ultra-violet rays, respectively, for translating the said rays into electric current at the transmitting station, and a source of light in which luminous rays predominate, the intensity of which is controlled by said current for producing an image of the said object at the receiving station.

2. In an electro-optical television system, means for scanning an object at the transmitter comprising a source of illumination in which infra-red and ultra-violet rays predominate, and correspondingly selective photoelectric elements actuated by said rays for translating said rays into electric current.

3. In an electro-optical television system, means for scanning an object at the transmitter comprising a source of illumination whose spectrum contains infra-red and ultra-violet rays, a light filter substantially cutting off the rays within the mid portion of the visible frequency band, and light sensitive cells particularly responsive to rays outside of the extremities respectively of the band cut-off by the said filter for translating said rays into electric current.

4. In an electro-optical transmission system, a source of infra-red light rays and a source of ultra-violet light rays, a light sensitive device translating light into electrical energy which is particularly responsive to said infra-red rays, a light sensitive device translating light into electrical energy which is particularly responsive to said ultra-violet rays, an amplifying network associated with each of said light translating devices for producing a predetermined relationship between the energy levels in the output circuits of the amplifiers, and a receiving device for converting electrical energy into visible light energy into which the output energies of the said amplifiers are fed.

5. The method of two-way television which comprises simultaneously illuminating the faces of two observers at separated points by means of light which occupies a position at one end of, and partly within and partly without, the visible spectrum, utilizing light reflected from the observers to set up image currents, and producing an image of each observer where it may be seen by the other while the latter is being illuminated and scanned.

6. A system of two-way television which comprises means for simultaneously illuminating the faces of two observers at the two stations respectively, by means of light which occupies a position at the upper end and partly within and partly without the range of wave lengths of the visible spectrum, means for utilizing light reflected from the observer at each station to set up image currents, and means for transmitting said image currents from each station to the other station and for thereby producing an image of the distant observer where it may be seen by the local observer while the latter is being subjected to said illumination.

7. A system of two-way television which com-

prises means for simultaneously illuminating the faces of two observers at the two stations respectively, by means of light containing the rays near both ends of the visible spectrum and substantially devoid of green and yellow rays, means for utilizing light reflected from the observer at each station to set up image currents, and means for transmitting said image currents from each station to the other station and for thereby producing an image of the distant observer where it may be seen by the local observer while the latter is being subjected to said illumination.

8. A system of two-way television which comprises means for simultaneously illuminating corresponding elemental areas of the faces of two observers at the two stations respectively and for similarly illuminating other corresponding elemental areas in succession, means at each station for illuminating the observer comprising a source of light rich in rays near one end of the visible spectrum and containing also green and yellow rays, light sensitive means for receiving light reflected from each observer over a wide solid angle to set up image currents, a light filter between each observer and the light sensitive means substantially cutting off the yellow and green rays, and means for transmitting said image currents from each station to the other station and for thereby producing an image of the distant observer where it may be seen by the local observer while the latter is being subjected to said illumination.

9. A method of producing simultaneous television transmission and reception, which comprises producing in view of the subject an image to be viewed by said subject, and simultaneously scanning said subject for transmission by a source of radiation radiating energy outside the band of visible light.

10. A method for producing two-way television between two relatively separated points, which comprises producing in view of the subject at each end, an image of the subject at the other end, reconstructed from signals received, and simultaneously scanning the subject at each end for transmission to the other end by a source of radiation radiating energy outside the band of visible light.

11. The method of two-way television which comprises utilizing light from the object for operating light sensitive electric means for forming image currents, in which light certain wave lengths are weak or absent, and simultaneously applying to the object light produced by the incoming image, which light is rich in said rays.

12. A method of producing simultaneous television transmission and reception which comprises producing in view of the subject an image to be viewed by said subject, simultaneously scanning said subject for transmission by illuminating small successive areas of said subject with radiations from a source radiating energy outside the band of visible light, receiving the radiations reflected from said subject upon a plurality of light sensitive electric devices, and controlling the amplitude of currents generated by said devices to maintain a desired relationship therebetween.

13. A method of producing two-way television between two relatively separated points, which comprises producing in view of the subject at each end, an image of the subject at the other end, reconstructed from signals received, simultaneously scanning at each end for transmission to the other by illuminating small successive areas of said subject at each end with radiations from a source radiating energy outside the band of visible

light, receiving radiations reflected from the subject upon a plurality of light sensitive electric devices, and controlling the amplitude of currents generated by said devices to maintain a desired relationship therebetween.

14. A television system comprising means for directing toward the face of a human subject to be televised light which contains rays in the mid portion of the visible spectrum and also rays near to and in part at least within both ends thereof, light sensitive electric means having greater sensitivity for rays near both ends of the visible spectrum than for rays in the mid portion thereof of the visible spectrum positioned to receive light reflected from said subject for setting up image currents varying in accordance with the reflective power of said subject for light to which said means is most sensitive, and means for filtering from said light before it reaches said subject at least a large part of the rays in the mid portion of the visible spectrum, to which the eye is most sensitive.

15. A method of television which comprises directing toward the face of a human subject to be televised intense light containing strong rays near both ends of the visible spectrum and only weak rays in the mid portion of the spectrum to which the eye is most sensitive, and utilizing light reflected from said subject to actuate light sensitive electric means having maximum sensitivity to light near the two ends of the visible spectrum to set up image currents varying in accordance with the reflective power of the subject for light to which said means is sensitive, whereby the intensity of the illumination can be very great and the image currents large without subjecting the subject to glare.

16. A method of television which comprises directing toward the face of a human subject to be televised light which contains strong rays near both ends of the visible spectrum and also in the mid portion thereof, utilizing light reflected from said subject to actuate light sensitive electric means having greater sensitivity for light near both ends of the spectrum than in the mid portion thereof to set up image currents varying in accordance with the reflective power of said subject for light to which said means is sensitive, and filtering from said light before it reaches said subject a large part of the rays in the mid portion of the spectrum, whereby the intensity of the illumination can be very great and the image currents large without subjecting the subject to glare.

17. Television scanning system, comprising means for scanning a subject for transmission by illuminating small areas of said subject in succession with light which is strong in wave-lengths near both ends of the visible spectrum and weak in wave-lengths in the yellow and green portions thereof, and light sensitive electric means for receiving light reflected from the subject to set up image currents in accordance with the reflective power of the subject, said means being most sensitive to wave-lengths near the two ends of the spectrum, whereby when a human subject is being scanned the intensity of the illumination thereon can be very great and the image currents large without subjecting the subject to glare.

18. A television scanning system, comprising means for directing toward the face of a human subject to be televised light which contains rays near to and at least partly within both ends of the visible spectrum, in which light certain other rays within the visible spectrum to which the

human eye is highly sensitive are weak or absent, and means highly sensitive to light near both ends of the spectrum for receiving light reflected from the subject to set up image currents in accordance with the reflective power of the subject.

19. A system of two-way television which comprises means for simultaneously illuminating the faces of two observers at the two stations respectively, by means of light containing rays near to and at least partly within both ends of the visible spectrum, in which light certain wavelengths within the visible spectrum to which the human eye is highly sensitive are weak or absent, means for utilizing light reflected from the observer at each station to set up image currents, and means for transmitting said image currents from each station to the other station and for thereby producing an image of the distant observer where it may be seen by the local observer while the latter is being subjected to said illumination.

20. A television scanning system comprising means for directing toward the face of a human subject to be televised light which contains rays near to and at least partly within both ends of the visible spectrum, in which light certain other rays of the visible spectrum to which the human eye is highly sensitive are weak or absent, means highly sensitive to light near both ends of the spectrum for receiving light reflected from the subject to set up image currents in accordance with the reflective power of the subject, said last mentioned means comprising means most sensitive to light near the upper end of the visible spectrum and separate means most sensitive to light near the lower end thereof, and amplifying networks individual to said two last mentioned means respectively for amplifying the image currents supplied by one of said light sensitive means to a greater degree than that supplied by the other of said means.

HERBERT E. IVES.