

Oct. 24, 1933.

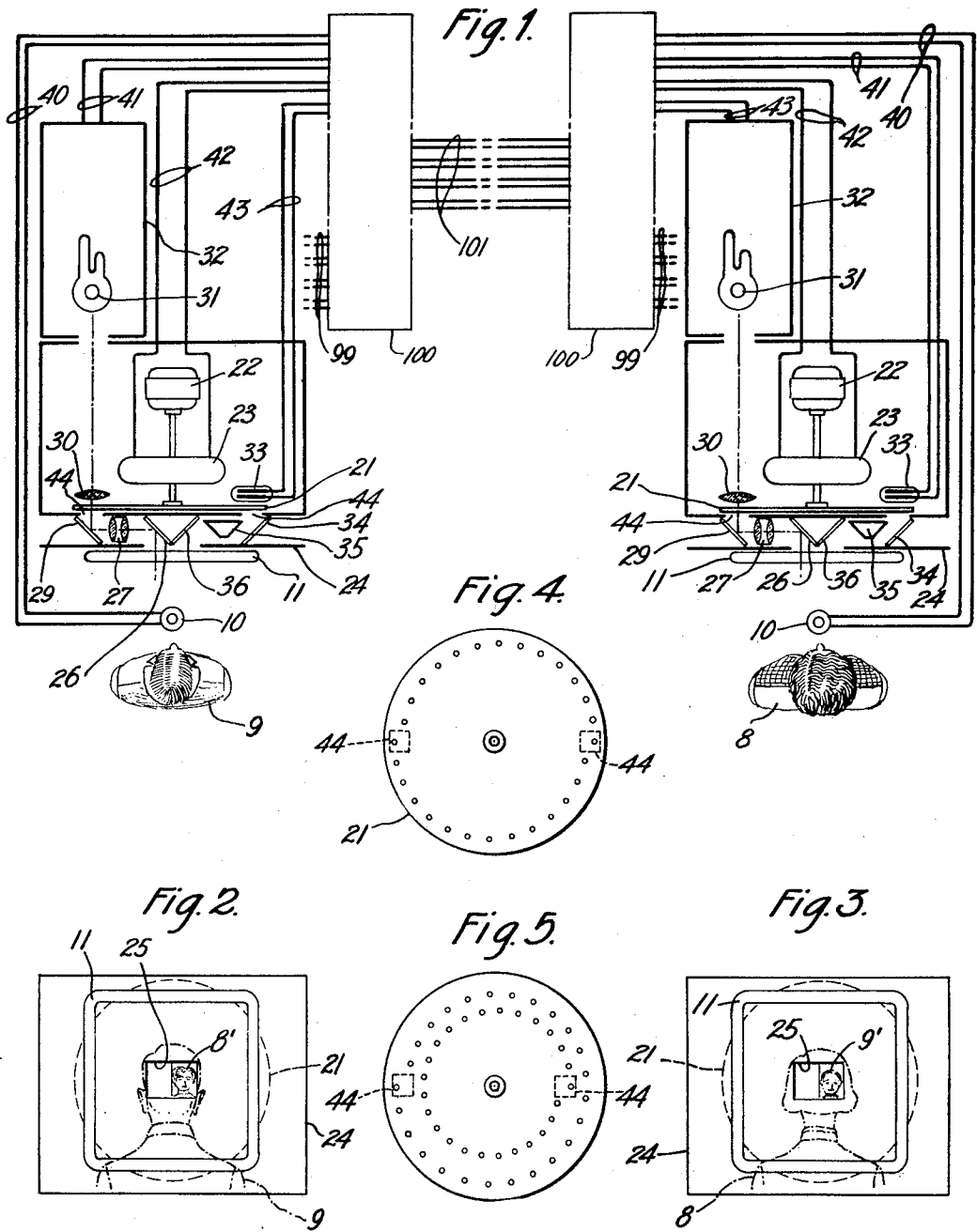
H. E. IVES

1,932,253

TELEVISION SYSTEM

Filed Oct. 1, 1926

2 Sheets-Sheet 1



Inventor:
Herbert E. Ives
by *Jul L. Palmer* Att'y.

Oct. 24, 1933.

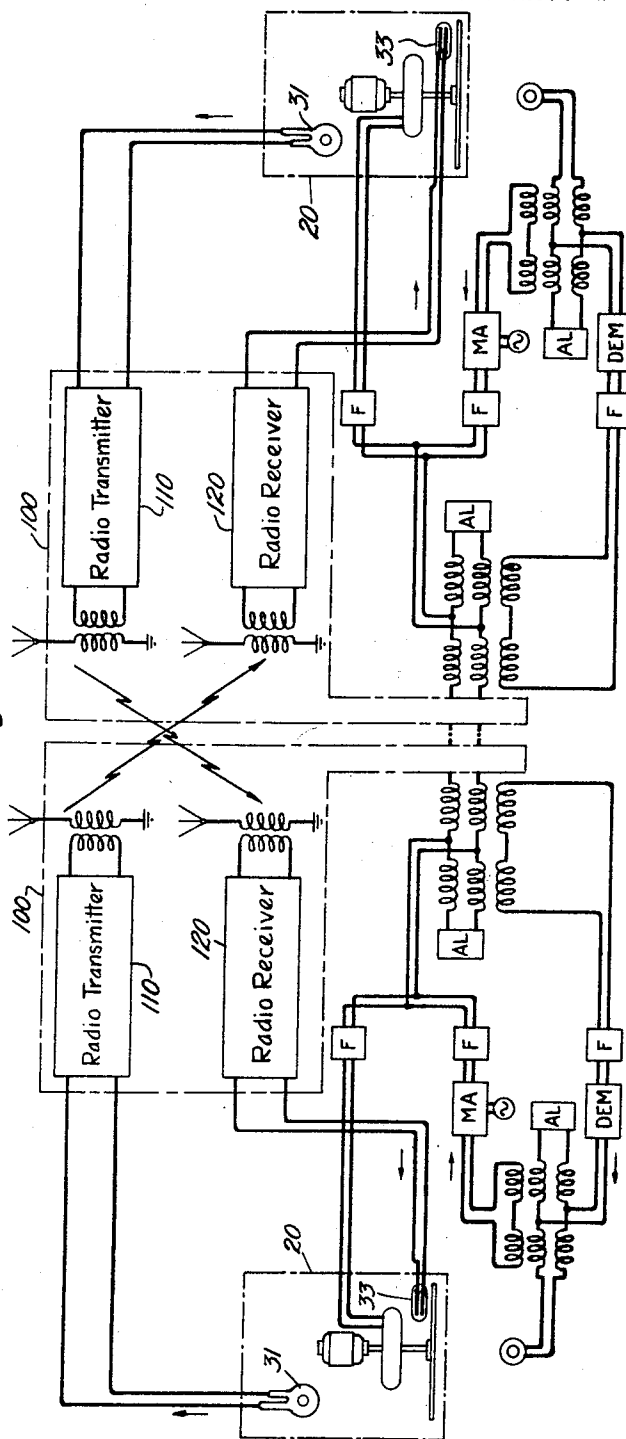
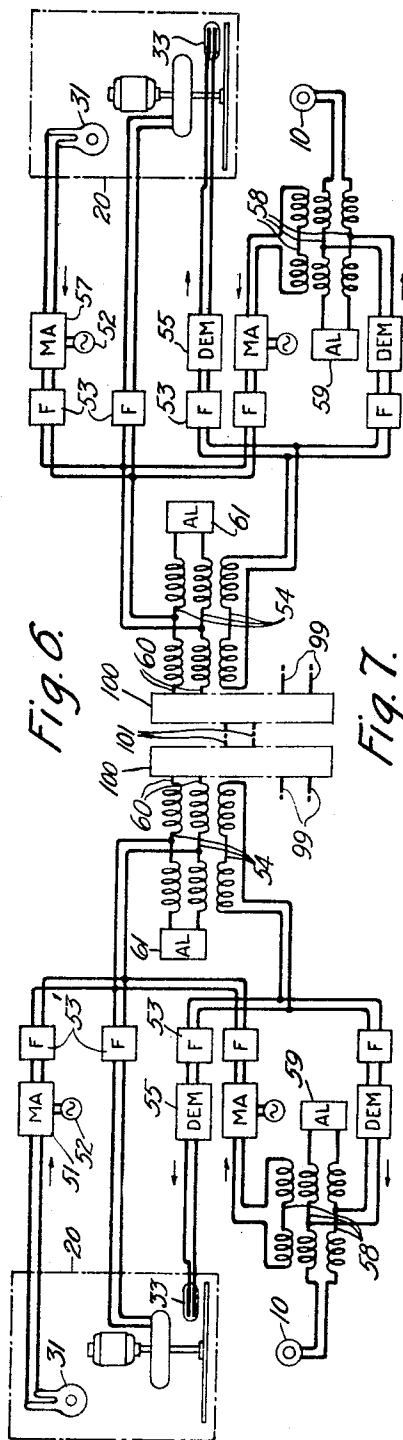
H. E. IVES

1,932,253

TELEVISION SYSTEM

Filed Oct. 1, 1926

2 Sheets-Sheet 2



Inventor:
Herbert E. Ives
by *Jul. W. Palmer* Att'y.

UNITED STATES PATENT OFFICE

1,932,253

TELEVISION SYSTEM

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

Application October 1, 1926. Serial No. 138,845

5 Claims. (Cl. 173—6)

This invention relates to a simultaneous two-way television system and more particularly to such a system which is especially suited for use in conjunction with existing telephone or other communicating systems.

An object of this invention is the provision of an improved two television system in which parties at the two terminal stations respectively may simultaneously see each other.

Another object is the provision of a practical television system having three or more interconnectible stations provided with duplicate television apparatus which will enable a party at any station to see a party at a connected station while he himself is being seen by the other party.

In a specific arrangement herein chosen as illustrative of the invention and described in detail below the scanning and reproducing at each station is effected by the use of a single scanning disc having two sets of spirally arranged apertures, the corresponding apertures of each set being located on opposite sides of the disc. One set of apertures scans the transmitting field and the other the receiving field. This exemplifies a feature of the invention which may be characterized as a scanning means of the type in which the transmitting and receiving fields are scanned by the successive sweep of apertures or their equivalent across the fields in parallel lines, the order in which the lines are scanned for each field being such as to permit more than two stations to be interconnectible, two at a time, without in version of portions of one of the images, as would occur if a single spiral of apertures were employed. A system including mirrors and lens directs the scanning rays to a photo-electric cell for the production of picture currents, while another system directs the reproducing rays from the reproducing lamp to the eye of the observer. A number of these terminal equipments may be indiscriminately interconnected with each other in a manner similar to that employed in telephony or in broadcasting. Such interconnection may be made over local lines, toll lines, or radio channels.

This television equipment is adapted for use with an ordinary telephone instrument, which can be used by the observer without interfering with the television equipment. It may be utilized in a comprehensive television system comprising either a small or a large number of interconnectible stations, a part or all of which may be associated with and used in conjunction with a telephone system. In a combined television and telephone system the user at each station is able both to see and talk with the user at any other

station. Images of not only the user but of various other objects such as signatures, checks, letters, legal papers, pages of books, pictures and also three dimension objects both stationary and moving may be transmitted and received. This system in association with a telephone system can be employed for the reproduction of talking moving pictures transmitted simultaneously from a distance to one or a plurality of stations.

An important characteristic of this invention, in addition to the accomplishment of continuous and contemporaneous two-way transmission of images, is the universal and indiscriminate interconnectibility of the apparatus used at each station with any and all other stations.

The photo-electric cells, glow lamps, amplifiers and transmission channels in the television circuits are all substantially instantaneously responsive to minute current variations and operate with substantially no distortion. The transmission of the vision, voice and control currents may be made over either a plurality of conductors or one pair of conductors or a common medium.

In one embodiment, the television, the voice and the control or synchronizing currents are transmitted over respective pairs of conductors while in another embodiment the different currents are utilized to modulate respective carrier currents which are transmitted over a single pair of conductors or by radio channels or a combination of both radio and wire directed channels.

Some of the general features of this invention have been outlined above. Further objects and features will appear and a better understanding of the invention will be had from the following detailed description and accompanying drawings.

Fig. 1 is a general schematic representation of a simultaneous two-way television transmission system and a two-way telephone system employing physical circuits.

Figs. 2 and 3 are front elevation views of the television apparatus showing the position of the user and the received image.

Figs. 4 and 5 are elevation views of television scanning discs.

Fig. 6 is a general schematic representation of a simultaneous two-way television transmission system and a two-way telephone system employing carrier current transmission channels.

Fig. 7 is a general schematic representation of a simultaneous two-way television transmission system and a two-way telephone system in which the telephone and synchronizing transmission circuits are wire directed channels and the picture transmission circuits are radio channels.

Where similar reference characters appear they designate similar parts in the different drawings.

Two inter-connecting stations adapted for simultaneous two-way television and two-way telephone transmission and the exchange leads for other stations are diagrammatically shown in Fig. 1. The apparatus at the stations is substantially identical and is inter-connected by separate circuits for each channel. Four channels are employed, one for two-way telephone transmission, two for vision or picture transmission, one in each direction, and one for maintaining synchronism between the apparatus of the television stations. The station operators or users 8 and 9 are positioned at their respective stations in front of the television and telephone apparatus in such relation that they may observe the transmitted image of each other and be scanned by their respective television sets. The subscriber's telephone station apparatus 10 connects with the telephone line 40. The subscriber is illuminated by a light source 11 which may be a mercury vapor lamp of rectangular shape or other suitable light source. The television apparatus has for its principal moving elements a scanning disc 21 operated by electric motor 22 and a synchronizing controlling device 23. A single scanning disc containing two series of small apertures arranged in spiral form as shown in ether Figs. 4 or 5, is used at each station for both sending and receiving. 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, and each of the openings 44 in the member in front of the disc at the scanning and reproducing positions has a width equal to the pitch of the disc apertures. See Figs. 4 and 5. A suitable optical system is used in association with the scanning disc which focuses an image of the object of the proper size at the plane of the disc. The scanning of the object is by reflected light from a series of parallel rows of elemental areas. The reconstruction of the image is by variable intensity light beams passing through the apertures of the scanning disc as they trace a similar series of parallel rows of elemental areas. A screen 24 having an aperture 25 of suitable size through which the transmitted image may be viewed and the user scanned is positioned in front of the apparatus. In sending, reflected light rays from the user pass through one half of the aperture 25 to the mirror 26, positioned at an angle of 45° to the axis of the disc, from which they are reflected and passed through the compound photographic lens 27 to the mirror 29, also positioned at an angle of 45° to the axis of the disc, where they are again reflected to form an image of the user at the plane of the disc. The rays which pass through the apertures of the disc are concentrated by the lens 30 upon a photoelectric cell 31 where they generate photoelectric currents which are amplified by a substantially distortionless amplifier 32 and passed to the transmission line.

The photoelectric currents after being amplified are transmitted over any suitable channels such as the circuits 41 and 43 to the receiving lamps 33 of the inter-connected stations. The receiving lamp may be a neon lamp or any other suitable light source capable of responding to the very rapid variations of the photoelectric current. Light from the receiving lamp 33 passes to the mirror 34 and is reflected to the left and right transposing prism 35 through which it is transmitted to the mirror 36 from which it is again reflected through the aperture 25 towards

the observer. If left and right transpositions are unobjectionable, as might be the case in transmitting pictures, the prism 35 may be omitted.

The synchronizing apparatus may be of any suitable type capable of maintaining inter-connected television stations in synchronous and in exact phase relationship with each other. Various arrangements of this character have been developed in connection with telegraph systems, other 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 proper speed and upon maintaining exact synchronism by an alternating current synchronous 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 inter-connected, each is brought up to required synchronous speed by its driving motor 22 and then locked in phase and so held by the alternating current synchronous generators 23. The synchronous generators are primarily for the purpose of maintaining the locking of the television discs of the stations in synchronism and in exact phase rather than for supplying the driving power. When so inter-locked, a small variation in speed may occur since all inter-connected stations operate exactly alike. If one station tends to lead, its synchronous generator transmits power and thereby causes a lagging synchronous generator to accelerate slightly, while the latter taking power from the former also causes it to slow down slightly thus each compensates for any tendency of the other to either lead or lag. In two such stations having inter-connected synchronous generators one or the other would tend at any instant to act as a generator and the other as a motor and consequently react on each other. The tendency of the synchronous generators to lead or lag is reduced to a minimum by proper design and suitable circuit inter-connection.

Where television stations are employed in an inter-communicating system, the desired switching inter-connections are made through a central office exchange similar to that used for inter-connected subscribers' telephone stations. Such inter-connecting 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 the central offices inter-connected by the necessary trunks or toll lines 101 as indicated in the drawings. In accordance with the practice followed in inter-communicating systems of locating the power supply and other control equipment at a central station, the exchange preferably would be equipped with a master alternating current generator for locking and holding the synchronizing device of each television set in synchronism and in phase, and also supplying such other facilities and power as would be appropriate and as are well known to the art.

The television stations for simultaneous transmission in both directions must, in order for a plurality of stations to be indiscriminately inter-connected in various ways, use the same side of the scanning disc for similar purposes and all discs must rotate in the same direction or otherwise harmonize with each other. For example, the right side of the disc may be used for receiving and the left side for transmitting at each station. The use of one side of the disc for sending and the

other for receiving produces a complete inversion of the image in the arrangement shown in the drawings. While the compound photographic lens 27 produces a completely inverted image of the object at the plane of the scanning disc, when viewed from the photoelectric cell; it causes only vertical inversion of the image at the disc when viewed in the opposite direction and it is the latter image that is electrically transmitted. The disc at the receiving end then makes a complete inversion of the image which results in its being right side up but reversed as to right and left. This last mentioned transposition is compensated for by the prism 35. In other words, the optical system as well as the circuit connections are arranged to produce a true image of the actual object. If a single spiral of apertures were used for scanning both the transmitting and receiving fields, one of the fields would be scanned from an outside edge toward the center while the other was being scanned from the center toward an outside edge. Two stations could be so designed as to operate properly with this arrangement, the transmitting field at one station being matched with the receiving field at the other with respect to the order of scanning. If, however, a third station were to be provided with a similar disc the receiving field thereat could be matched to only one of the other transmitting fields, with the result that the image produced by current from the unmatched transmitter would be split and the two halves interchanged. The improved system herein described, therefore has the necessary characteristics for multiple customer use between two or more stations or a plurality of intercommunicating stations.

Front views of the apparatus and an indication of the position of the user are shown in Figs. 2 and 3. The user in general sees a rectangular opening 25 through the screen 24; one half of the opening showing the image of the object within the field of view such as that of the person with whom he is communicating and the other half being blank. The light source 11 shining in the eyes of the user may interfere with his observation of the transmitted image but this may be overcome by the proper choice of color of the illuminating light source so that the ratio of photoelectric to visual efficiency is a maximum. In Fig. 2 the picture of the user 8 of Fig. 3 appears as image 8' and in Fig. 3 the picture of the user 9 of Fig. 2 appears as image 9'. However, the picture of any other object within view would have its image transmitted and similarly reproduced.

Elevational views of two designs of the television scanning disc referred to in the description of Fig. 1 are shown in Figs. 4 and 5. The disc 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. In Fig. 4 each set of apertures occupies 180° , while those of Fig. 5 each occupy 360° , and in each case the sets of apertures are displaced by 180° . The scanning and the receiving positions, with reference to the disc, are correspondingly located at opposite sides or 180° apart. However, the angular displacement of the two sets of apertures can be different than 180° and the scanning and receiving positions correspondingly positioned. Other arrangements of the apertures and of the scanning and receiving positions are obvious from the foregoing descriptions, the essential require-

ment being symmetry and phasing of the action of the scanning discs between interconnected operating stations. The number, size and spacing of the apertures are dependent upon the amount of detail required in the reproduction.

A general schematic representation of a simultaneous two-way television transmission system and a two-way telephone system in which the television and the telephone transmission channels are of the carrier current type and the synchronizing channel direct transmission and all channels transmitted over one pair of wires is shown in Fig. 6. The synchronizing channel could be a carrier current channel. The principal television apparatus is shown within the rectangle 20 and the telephone station apparatus 10 is also diagrammatically shown. The two-way simultaneous television system requires two one-way transmission channels, the synchronizing circuit one channel, and the telephone requires one two-way transmission channel. The carrier current circuits are standard carrier current transmission channels designed to transmit the required frequencies. The photoelectric cell 31 is connected with an amplifier and modulator 51 associated with an oscillator 52 for generating a suitable carrier current which in turn is connected with the filter 53 and then to the outgoing side of the hybrid coil 54 connecting with the carrier transmission circuit 60 and 101. A balancing network or artificial line 61 is associated with the hybrid coil. Similar carrier current transmitting apparatus but having carrier currents of different frequencies is connected with the other outgoing carrier current channel 99. The television receiving light source 33 receives the transmitted photoelectric current from the transmission line through the incoming side of the hybrid coil 54, a filter 53 and a demodulator and amplifier 55. The telephone subscriber's apparatus 10 is connected for two-way operation to the carrier current transmission system through hybrid coil 58 associated with balancing network or artificial line 59. The telephone transmitting and receiving carrier current channels are similar to those employed for the television circuits and are connected to the carrier current transmission line in the usual manner through the hybrid coil 54. While the telephone system is here shown as of the carrier current type, voice frequency could be used simultaneously with the carrier channels over the same transmission line as is common practice in telephony. The synchronizing channel is shown without carrier apparatus in the subscriber's circuit and only filtering apparatus 53' is shown, since the master alternating current is preferably generated at the central office exchange 100. The central offices or exchanges 100 are inter-connected by trunks or toll lines 101.

The frequency band for picture transmission extends over a number of thousand cycles per second and the transmission channels must be capable of faithfully transmitting such frequencies.

A general schematic representation of a simultaneous two-way television transmission system and a two-way telephone system in which the television currents are transmitted by radio and the synchronizing and voice currents are transmitted over a wire circuit is shown in Fig. 7. In this arrangement the synchronizing and the voice currents are transmitted over channels similar to those shown in Fig. 6 and the description there given is applicable here, although any other suit-

able arrangement could be adopted for their transmission such as voice frequencies for voice transmission and higher frequencies for synchronizing. The photoelectric cell 31 is connected to suitable radio transmitting apparatus 110. The television receiving light source 33 is connected with suitable radio receiving apparatus 120. The necessary switching and inter-connecting between a plurality of stations would normally be done through a central office exchange 100 which would include the radio equipment. An advantage obtained by this arrangement in which the television currents are transmitted by radio, is that channels capable of transmitting a wide band of frequencies may readily be obtained.

While the scanning arrangement described in detail herein is such that the user is subjected to strong general illumination and at any instant only the light reflected from a small elemental area of the subject passes through the scanning disc and is utilized to affect the photoelectric cell, spot is equally applicable. When the latter method is used, the position of the photoelectric cell and the source of illumination are interchanged with respect to their positions in the accompanying drawings. The user is subjected to a transient illumination by a rapidly moving beam or spot of intense light and only one small elemental area is intensely illuminated at any instant, which, in turn, reflects light to the photoelectric cell or cells. This method of illuminating and scanning has the decided advantage of not subjecting the user to a flood of intense and disagreeable light. It also facilitates observation of the transmitted image.

The invention disclosed herein is obviously susceptible to various modifications and adaptations without departing from the scope of the invention, and it is not intended to limit the invention to the specific construction herein shown and described except as defined by the scope of the appended claims.

What is claimed is:

1. A two-way television system comprising transmitting and receiving apparatus, an optical system for said transmitting apparatus and an optical system for said receiving apparatus, a mirror in said transmitting optical system so mounted as to be capable of reflecting light directly from an

observer, a second mirror in said receiving optical system in which the observer sees the transmitted image, and means for mounting said mirrors side by side with respect to the observer.

2. A two-way television system comprising transmitting and receiving apparatus, an optical system for said transmitting apparatus, a plane mirror in said transmitting optical system so mounted as to be capable of reflecting light directly from an observer, a second plane mirror in said receiving optical system in which the observer sees the transmitted image, and means for mounting said plane mirrors side by side with respect to the observer.

3. In a television system, a scanning disc employed in simultaneously analyzing and integrating separate images at positions substantially 180° apart on said disc, and an optical system inverting one of said images, thereby compensating for inversion caused by the action of said disc used for analyzing and integrating.

4. In a television system including a plurality of indiscriminating interconnectible stations each having a scanning disc for simultaneously analyzing and integrating transmitted and received pictures, respectively, at positions substantially 180° apart on said discs, and an optical system including a lens and prism arrangement, and means cooperating with said optical system and said scanning disc for neutralizing optical inversions and reversals of each other.

5. A two-way television system comprising two stations each including means for scanning the face of an observer thereat, and means at each station for forming for observation by the local observer while he is being scanned an upright image of the face of the distant observer in a plane substantially perpendicular to the former's line of sight, said last mentioned means including a source of light controlled by image current from the other station, and means including multiple light deflecting means for effecting successive substantial changes in direction of the image forming bundle of rays between said light source and the local observer.

HERBERT E. IVES.