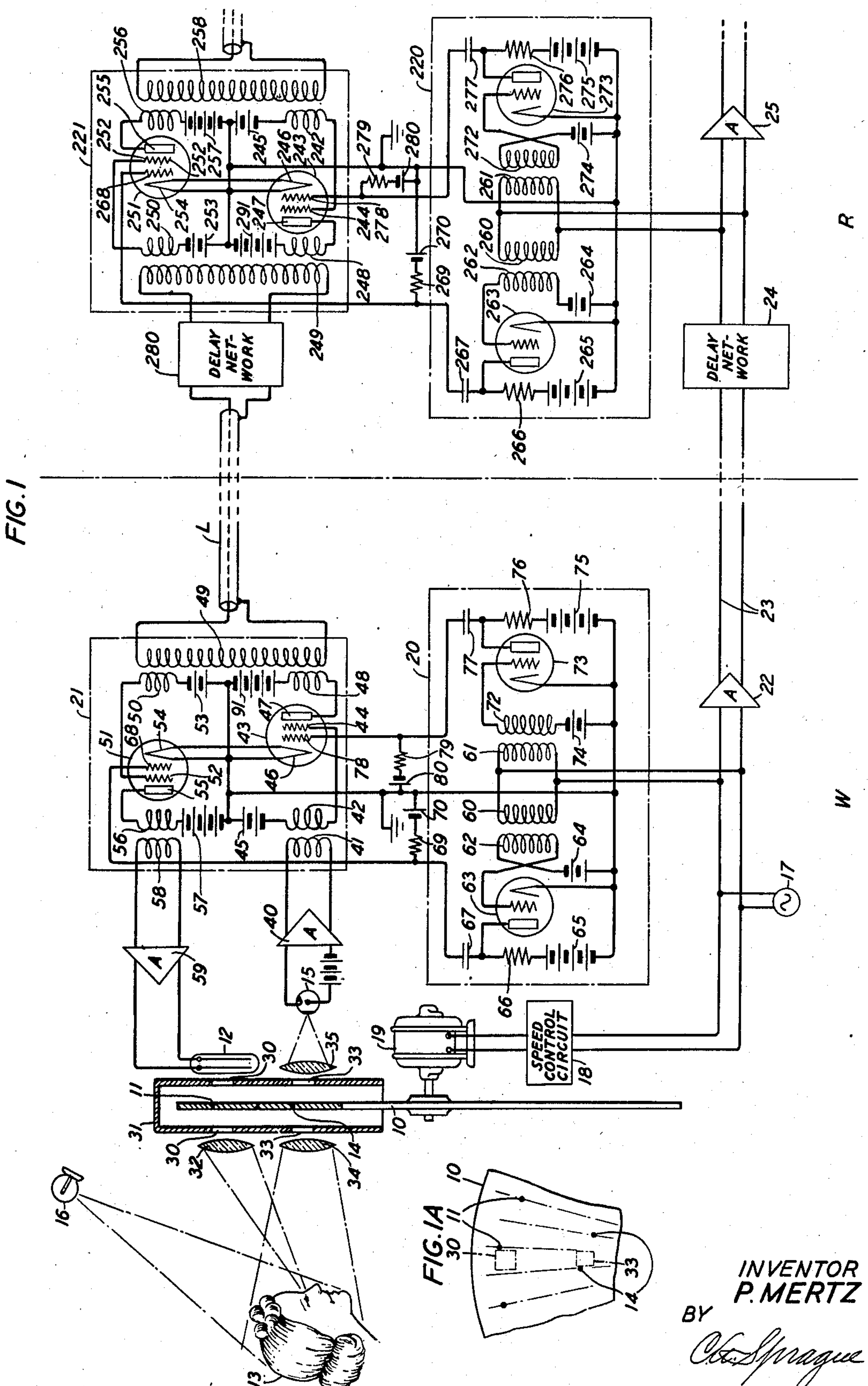
Jan. 12, 1943. P. MERTZ 2,308,381

TWO-WAY TELEVISION TRANSMISSION

Filed Dec. 29, 1939 4 Sheets-Sheet 1



INVENTOR
P. MERTZ
BY
O. A. Sprague
ATTORNEY

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TWO-WAY TELEVISION TRANSMISSION

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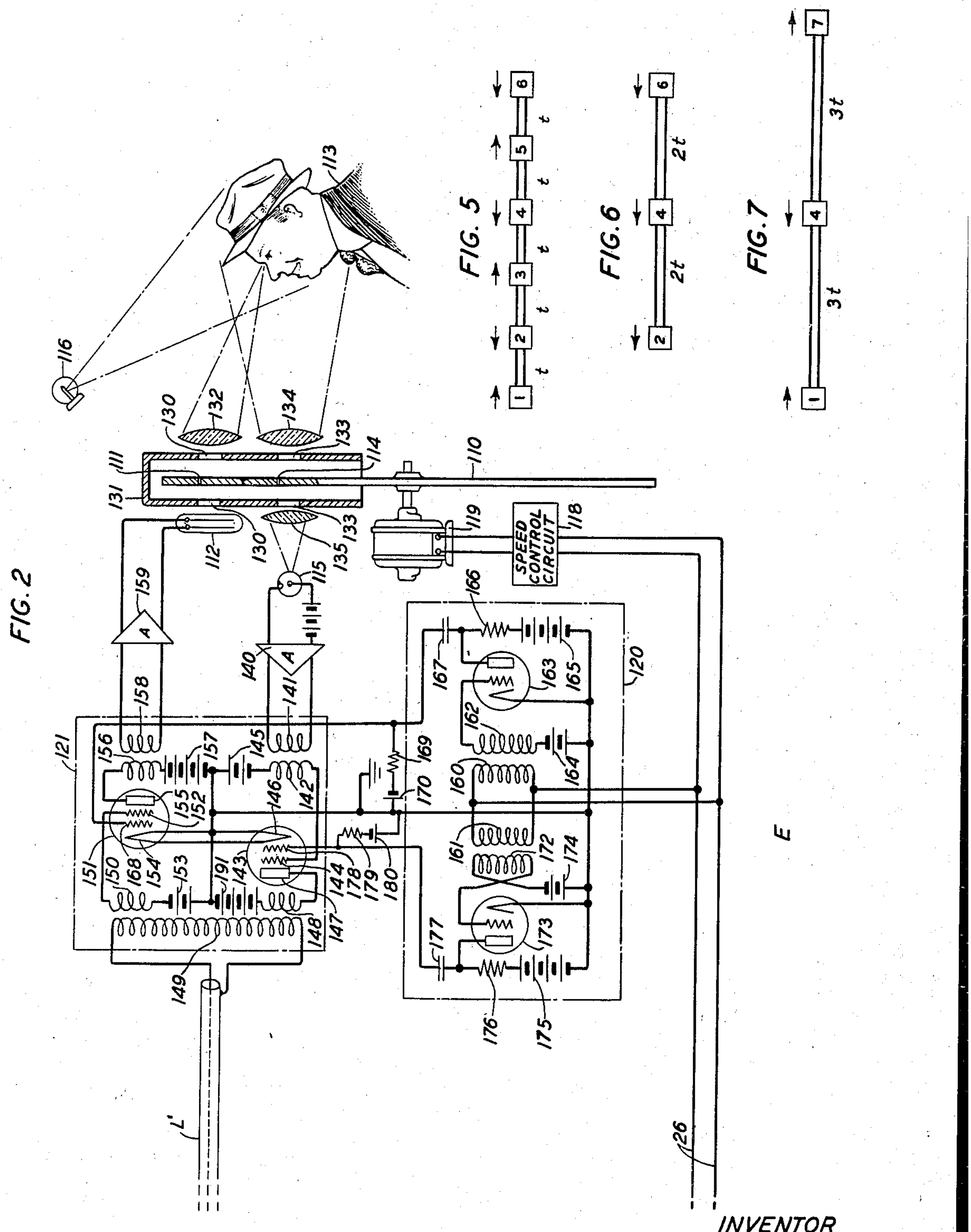

FIG. 2

FIG. 5

FIG. 6

FIG. 7

INVENTOR
P. MERTZ
BY
C. A. Sprague
ATTORNEY

TWO-WAY TELEVISION TRANSMISSION

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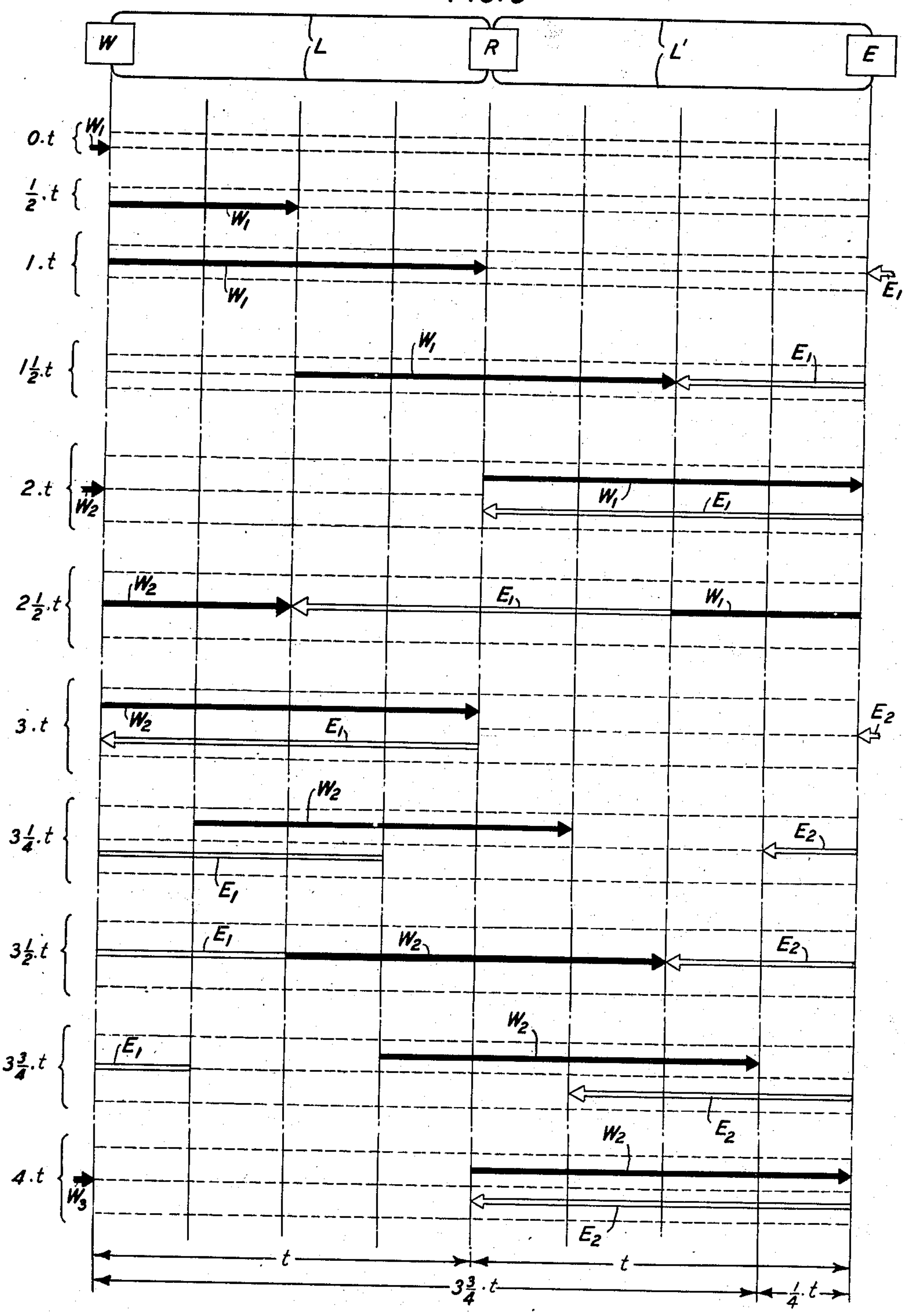
FIG. 3



INVENTOR
P. MERTZ
BY
C. A. Sprague
ATTORNEY

TWO-WAY TELEVISION TRANSMISSION

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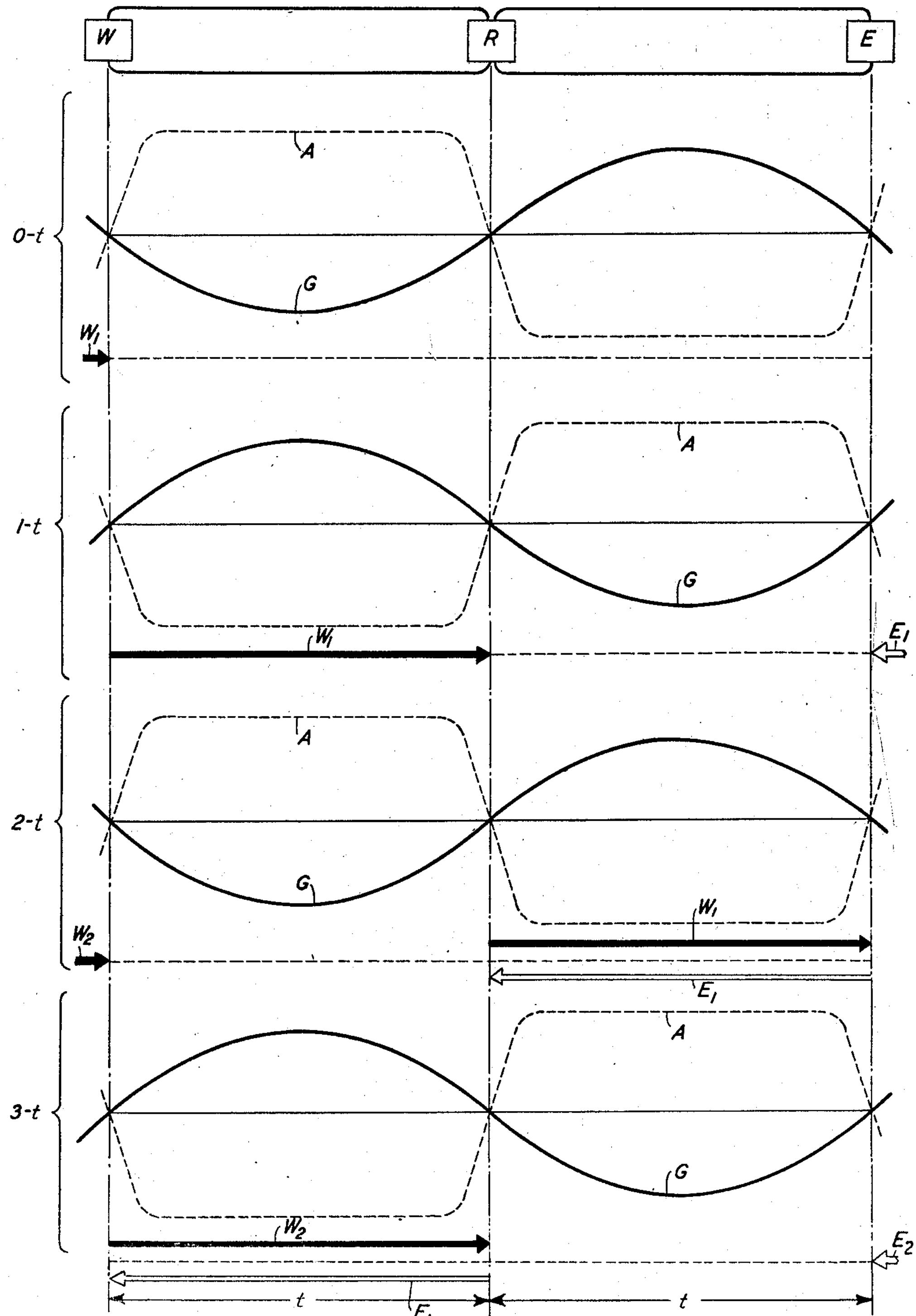
FIG. 4



INVENTOR
P. MERTZ
BY
O. C. Sprague
ATTORNEY

Patented Jan. 12, 1943

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UNITED STATES PATENT OFFICE

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TWO-WAY TELEVISION TRANSMISSION

Pierre Mertz, Bellerose, N. Y., assignor to Bell Telephone Laboratories, Incorporated, New York, N. Y., a corporation of New York

Application December 29, 1939, Serial No. 311,490

6 Claims. (Cl. 178—6)

This invention relates to signaling systems and method and particularly to a system for two-way transmission of television signals over a single transmission channel including one or more repeaters remote from the terminal stations.

An object of the invention is to provide a novel form of signaling system in which the transmission is alternately in opposite directions.

Another object is to provide novel means for conditioning a repeater in a signaling system to cause the direction of transmission through the repeater to be reversed.

In accordance with a specific embodiment of the invention herein shown and described for the purpose of illustration, there are provided a plurality of terminal stations, each including television transmitting and receiving apparatus, connected by a television transmission line including one or more repeaters. The television transmitting apparatus at each station generates a television signal which is impressed upon a television transmission line during intermittent periods of substantially equal duration, alternate line scanning periods for example, and these transmission periods are separated by substantially equal periods during which the signal transmission is interrupted and a television image produced under control of a television signal received over the television transmission line. The transmission periods at the different terminal stations may or may not be concurrent, that is, the signal transmission from the different terminal stations may occur simultaneously or the signals may be transmitted from one station while signals are being received at another station. One or more repeaters are provided on the television transmission line at a location or locations where the television signals arriving from the different terminals, respectively, are non-overlapping, that is, the position of each repeater on the line is such that the signal propagation time from either terminal to the repeater is substantially equal to the signal transmission period or to an integral multiple thereof.

Each repeater on the transmission line (the terminal repeaters included) is conditioned to transmit the image currents arriving at the repeater first in one direction and then in the opposite direction under control of a source of alternating electromotive force, having a period substantially equal to twice the signal transmission period, which is transmitted over a separate narrow frequency band transmission line, this control electromotive force being synchronized with the image scanning at the terminal stations. When there are six repeaters, numbered 1 to 6, inclusive, on the line, for example, so spaced that the transmission time between repeaters is equal to the duration of each signal transmission period, the odd numbered repeaters 1, 3 and 5 will be transmitting in one direction at the same time that the even numbered repeaters 2, 4 and 6 will be transmitting in the opposite direction. However, the repeaters may be spaced an integral multiple of the distance just assumed, that is, by a distance such that the signal transmission time between adjacent repeaters will be an integral multiple of the signal transmission period. If, for example, the odd numbered repeaters 1, 3 and 5 are omitted the even numbered repeaters 2, 4 and 6 will transmit in one direction during the same time interval and in the opposite direction during the next time interval. If repeaters numbered 1, 2, 4 and 5 are omitted, the remaining repeaters 3 and 6 will transmit in opposite directions during a certain time interval.

In order that each terminal station may transmit or receive at all times so that there will not occur any loss in signaling time, the transmission time between stations must be equal to the signaling period (or to the substantially equal spacing period), or to an odd multiple thereof if the terminal stations transmit simultaneously and receive simultaneously. If one station transmits while the other receives, the terminal stations should be spaced so that the transmission time between stations is equal to an even multiple of the signaling period (or of the substantially equal spacing period).

The signal transmission time between adjacent repeaters must be made substantially equal to the signal transmission period (line scanning period, for example) or to an integral multiple thereof in order that the television signals from opposite directions may arrive at a repeater during non-overlapping time intervals. If, however, on account of geographical considerations, for example, the repeaters cannot be so spaced that the signal transmission time between adjacent repeaters is equal to the signal transmission period or to an integral multiple thereof, the distance may be made smaller than required and the transmission time increased to the correct value by means of a suitable delay network incorporated in the repeater. In this event it may also be necessary to place a delay network in the line for transmitting the alternating current for controlling the conditioning of the repeater, since the transmission time of the control current should be the same as that of the signaling current.

The invention will now be described in connection with the accompanying drawings in which:

Figs. 1 and 2 when placed side by side with Fig. 1 at the left constitute a diagrammatic view of the two-way television system in accordance with the present invention;

Fig. 1A is a fragment of a front elevation of the scanning disc used at the terminal stations of the television system shown in Figs. 1 and 2;

Figs. 3 and 4 are diagrams to which reference will be made in explaining the operation of the system; and

Figs. 5, 6 and 7 are diagrammatic views of a transmission line including a plurality of intermediate repeaters which may be employed in the television system shown in Figs. 1 and 2.

Referring now to Figs. 1 and 2, there is disclosed a two-way television system comprising two terminal stations W and E connected by a transmission line L, L', a coaxial conductor line, for example, including one or more intermediate repeaters R, only one intermediate repeater being shown for simplicity.

At station W there is provided a scanning disc **10** having two sets of spirally arranged apertures, the one set including the apertures **11** being employed to direct light from neon lamp **12** to the eye of observer **13** for the production of television images under control of received image current and the other set including the apertures **14** being used to transmit light reflected from the face of the observer **13** to a photoelectric cell **15** for generating an image current for transmission. In Fig. 1 the scanning disc is shown as a side elevation partly in section while Fig. 1A shows a fragment of a front elevation of the disc. As shown in the drawings, the face of the observer is illuminated by light from a source **16** but, if desired, light could be directed upon the face of the observer through the apertures of the scanning disc to illuminate the elemental areas thereof one at a time in succession and the reflected light received by a photoelectric cell or other light sensitive electric device. Moreover, if desired, suitable cathode ray apparatus may be employed for scanning the subject and thereby setting up an image current and for producing television images under control of a received image current.

Alternating current from an oscillator **17** is supplied to a motor speed control circuit **18** which controls the speed of the driving motor **19** for scanning disc **10**, as disclosed in U. S. Patent 1,999,376, granted to H. M. Stoller, April 30, 1935, for example. Current from alternating current source **17** is also supplied to the control circuit **20** at station W for periodically reversing the direction of transmission of amplifier **21** and current from this source is also transmitted through amplifier **22** and over line **23** to the repeater station R where it is transmitted through the delay network **24** and amplifier **25** and thence over line **26** to the terminal station E where it is supplied to speed control apparatus **118**, like the apparatus **18** at station W for controlling the speed of the scanning disc driving motor at that station. At the repeater station R the current from source **17** is supplied to a control circuit **220** for periodically reversing the direction of transmission of amplifier **221** and at the terminal station E current from source **17** is also supplied to a control circuit **120**, like the control circuit **20**, for periodically reversing the direction of transmission of an amplifier **121** like the amplifier **21** at station W.

The field which is scanned by apertures **11** of the scanning disc for producing a television image is defined by apertures **30** in housing **31**, the light from lamp **12** passing through the apertures **30**, the scanning disc apertures **11** and the lens **32**. The field to be scanned for setting up an image current is defined by apertures **33** in housing **31**, the light reflected from the face of the observer **13** passing through the lenses **34** and **35**, the apertures **33** and the scanning disc apertures **14**. The spirally arranged apertures **14** are equally spaced by substantially twice the usual distance with respect to the width of the apertures **33** defining the field to be scanned so that the scanning of the field of view is interrupted for a period equal to the line scanning period between the scanning of successive lines. The centers of the apertures **11** and **14** are on different radii of the disc **10**, respectively, such that the angle formed by the radii going through the centers of two adjacent apertures **11** is bisected by the radius going through the center of an aperture **14**. Thus the scanning of a field of view for television transmission and the scanning of the image field for television image production take place alternately. If the line scanning period is t, the subject **13** will be scanned during a period t for generating an image current in the circuit of photoelectric cell **15** and, during the following line scanning period t, the lamp **12** will be scanned for setting up an image under control of the image current generated at station E and transmitted over line L.

The image current generated in the circuit of photoelectric cell **15** is amplified by the amplifier **40**, the output of which is connected to the primary winding **41** of a transformer, the secondary winding **42** of which is connected to the grid-cathode circuit of a four-element vacuum tube **43**, one terminal of winding **42** being connected directly to the control electrode **44** and the other terminal of winding **42** being connected to the negative terminal of a grid biasing battery **45**. The positive terminal of battery **45** and the cathode **46** are grounded. The anode-cathode circuit of tube **43** may be traced from the anode **47**, winding **48** of a transformer having two other windings **49** and **50**, anode battery **91** to the grounded cathode **46**, the winding **49** being connected to the line L over which the amplified image current generated by photoelectric cell **15** is transmitted to the repeating station R.

The image current received over line L from the repeater station R is transmitted through transformer windings **49**, **50** to the control circuit of amplifier tube **51** which circuit may be traced from grid **52**, transformer winding **50**, grid biasing battery **53** to the grounded cathode **54**. The anode-cathode circuit of tube **51** may be traced from the anode **55** through the primary winding **56** of a transformer and anode battery **57** to the grounded cathode **54**, the secondary transformer winding **58** being connected to the input of amplifier **59**. The received image current is thus amplified by the amplifier tube **51** and by the amplifier **59** and then impressed upon the image producing lamp **12** which is connected to the output of amplifier **59**.

The system is designated so that the image signals from amplifier **40** which are to be transmitted over L, L' to station E and the image signals transmitted over line L, L' from station E to station W are alternately impressed upon the amplifier **21**. The control circuit **20** is provided for reversing the direction of transmission of amplifier **21** in synchronism with the transmission and reception of the signaling impulses at station W. If t is the time required for scanning a single line of the field of view, then signals will be transmitted from station W through a circuit including amplifier tube 43 for a period t and for the next period t signals will be received over line L from station E, these signals being amplified by the vacuum tube 51. The period of the sine wave from source 17 will then be $2 \cdot t$ (or the frequency will be $1/2 \cdot t$) so that the amplifier tube 43 will be conditioned for amplifying the outgoing signal during one-half cycle of the wave from oscillator 17 and the amplifier 51 will be conditioned for amplifying the incoming signal during the preceding and following half cycles of the wave from oscillator 17.

The sine wave from oscillator 17 is impressed upon the primary transformer windings 60 and 61 in parallel. The transformer having the primary winding 60 has a secondary winding 62 connected to the control grid-cathode circuit of vacuum tube 63 in series with a grid biasing battery 64, the cathode of this vacuum tube being grounded. The anode circuit of vacuum tube 63 comprises an anode battery 65 and an anode resistor 66, and the anode is connected through a condenser 67 to the grid 68 of vacuum tube 51. The average potential of the conductor between condenser 67 and grind 68 is fixed by means of a grid leak or high resistance 69 and a grid biasing battery 70. Similarly, the transformer having the primary winding 61 has a secondary winding 72 connected to the control grid-cathode circuit of vacuum tube 73 in series with a grid biasing battery 74, the cathode of this vacuum tube being grounded. The anode circuit of vacuum tube 73 comprises anode battery 75 and an anode resistor 76, and the anode is connected through a condenser 77 to the grid 78 of vacuum tube 43. The conductor between condenser 77 and grid 78 is connected to ground through the high resistance 79 and the grid biasing battery 80. The windings 62 and 72 are so connected to the grid-cathode circuits of tubes 63 and 73 that the sine wave voltage from oscillator 17 impressed upon the grid of tube 63, with respect to ground, is 180 degrees out of phase with respect to that impressed upon the grid of tube 73. For proper operation, moreover, it is desirable that each of tubes 63 and 73 should be considerably overloaded by the electromotive force from oscillator 17 in order that the anode of the tube will quickly reach a maximum positive value when the polarity of the electromotive force impressed upon the grid of the tube is reversed from positive to negative.

When the polarity of the electromotive force from source 17 impressed upon the grid of tube 73, for example, changes from positive to negative, the anode current quickly reaches a minimum value zero, for example, and the anode potential with respect to ground reaches its maximum positive value. This maximum positive potential is impressed upon one plate of condenser 77, the other plate of which is connected to the grid 78 of tube 43. This positive impulse impressed upon the grid 78 conditions the tube 43 to amplify the televison electromotive force from the transmitting amplifier 40 and the television signal is thus impressed upon line L for transmission. When subsequently the polarity of the electromotive force from oscillator 17 impressed upon the grid of tube 73 changes from negative to positive, the potential of the anode of tube 73 is quickly reduced to its minimum value and as a result a negative impulse is impressed upon the grid 78 to reduce the anode current of tube 43 to zero or a low value and thus prevent the tube from functioning as an amplifier. At the same time that the polarity of the electromotive force from oscillator 17 impressed upon the grid of tube 73 changes from negative to positive, the polarity of the electromotive force from this source impressed upon the grid of tube 63 changes from positive to negative, thus setting up a positive impulse at the anode of tube 63 which is impressed upon the grid 68 of tube 51 to condition it for amplifying the television signal upon the receiving amplifier 59. It is clear, therefore, that while a line of the field of view comprising the subject 13 is being scanned for a time interval t, the image current generated is repeated by the tube 43 of the terminal repeater 21 and impressed upon the line L. During the next period t, the scanning of the field of view comprising the subject 13 is interrupted and the television signal corresponding to the scanning of a line of the field of view at station E received over line L is repeated by the tube 51 of the terminal repeater 21 and utilized to control the illumination produced by the lamp 12 which is scanned by an aperture 11 to produce a line of the image viewed by the observer 12.

The terminal apparatus at station E is the same as that shown at terminal station W and the corresponding parts of the apparatus on station E are numbered the same as the parts of station W except that, at station E, the first digit 1 is added to the numerals used at station W. The control circuit 220 at the repeater station R is likewise identical with the control circuit 20 at station W and the reversible amplifier 221 at the repeater station R is the same as the amplifier 21 at station W except that there is employed a single transformer winding 258 the terminals of which are connected to line L′ instead of the windings 58 and 41 of separate transformers, the terminals of which are connected to amplifiers 59 and 40, respectively. With this exception the parts of the control circuit and reversible amplifier of the repeater R are the same as the corresponding parts of the apparatus at station W and are designated by numerals which are the same except that, at repeater station R, the first digit 2 is added to the numerals used at station W. There is also associated with the amplifier 221 at repeater station R a delay network 280 which it will be necessary to use to supplement the delay of line L if, because of geographical considerations, the delay introduced by the line L is less than t, the duration of the signal transmission period at one station which occurs between two signal reception periods each of the same duration t. No delay network is shown in line L′, it being assumed in this case that the transmission time of signals transmitted over line L′ is equal to t, the signal transmission period. A delay network 24 is employed in the control line 23 to delay the control signal from source 17 by the same amount as the television signal is delayed by the delay network 280, assuming, of course, that the television signal and the control signal are delayed by the same amounts in transmission over lines L and 23, respectively. If these delays in transmission are not the same then the network 24 will not have the same delay as network 280 but the over-all delay in each circuit will nevertheless be adjusted to be equal to the signal transmission period t. No delay network is shown in control line **26**, it being assumed that the transmission time over this line is equal to that over line L'. If the delay in line **26** should be less than that in line L', however, a network similar to network **24** could be inserted to make the over-all value the same.

If desired, of course, the control signal from source **17** may be transmitted over a carrier channel having a frequency outside of the frequency range employed for television transmission and in this case a single physical transmission line may be used for transmitting both the television signals and the control signal.

In order to explain the operation of the system, it will be assumed that there are two terminal stations W and E connected by a line L, L' having only repeating station R and that the transmitting time from station W to the repeater R, the transmission time from station E to repeater R and the signal transmission period t (the time required for scanning a single line of a field of view, for example) are equal. In this case as will be apparent from the diagram of Fig. 3, signal transmission from terminal stations W and E takes place during alternate periods, that is, the phase relationship of the scanning discs **10** and **110** is such that while an aperture **14** at station W is effective for scanning a line of the field of view comprising the subject **13** to cause an image current to be generated, an aperture **111** at station E is effective for scanning the lamp **112** to produce a line of the image observed by the observer **113**.

As shown in Fig. 3, at zero time $(0 \cdot t)$, the generation of a signal W_1 (indicated by the dark or shaded arrow) is started at station W. The signal W_1 is then transmitted over the line L until, at time $1 \cdot t$, the generation of the signal at station W is interrupted and the initially generated portion of the signal (indicated by the arrow-head) has reached the intermediate repeater R. At this time the polarity of the substantially sine wave electromotive force from source **17** (see Fig. 1) impressed upon the grid of tube **263** at station R changes from positive to negative, thus reducing the anode current of tube **263** and making the anode of tube **263** relatively more positive with respect to ground. The resulting positive potential impressed upon the grid **268** of amplifier tube **251** causes the amplifier **221** to be conditioned for transmission from W to E. The signal W_1 is thus impressed upon line L' and transmitted to station E, the initial portion of the signal W_1 reaching station E at time $2 \cdot t$.

At time $1 \cdot t$ the generation of signal E_1 (indicated by the light or unshaded arrow) is started at station E. This signal is similarly transmitted over line L' until, at time $2 \cdot t$, the generation of the signal at station E is interrupted and the initially generated portion of the signal (indicated by arrow-head) has reached the intermediate repeater R. At this time the polarity of the substantially sine wave electromotive force from source **17** impressed upon the grid of tube **273** at station R changes from positive to negative, thus making the anode of tube **273** relatively more positive with respect to ground. The resulting positive potential impressed upon the grid **278** of amplifier tube **243** causes the amplifier **221** to be conditioned for transmission from E to W, thus causing the signal E_1 to be impressed upon line L and transmitted to station W. At time $2 \cdot t$, when the repeater R is conditioned for transmission from E to W, the terminal repeater **121** at station E is conditioned for transmission in the W to E direction. In other words, at time $2 \cdot t$ the polarity of the control electromotive force transmitted over line **23**, **26** and impressed upon the grid of tube **163** changes from positive to negative to cause a positive potential to be impressed upon the grid **168** of tube **151** to cause the received signal W_1 to be transmitted to receiving amplifier **159** and to be impressed upon the lamp **112**. At the time $2 \cdot t$, also, the polarity of the control electromotive force from source **17** impressed upon the grid of tube **73** at station W changes from positive to negative to cause a positive potential to be impressed upon the grid **78** of tube **43** to cause the signal W_2 generated by photoelectric cell **15** and corresponding to the scanning of the second line of the field of view to be transmitted through amplifier **21** and to be impressed upon the line L. At time $2\frac{1}{2} \cdot t$, the signal W_1 is being received at station E, the signal E_1 is being transmitted from E to W through repeater R and signal W_2 is being transmitted from station W. At time $3 \cdot t$, the transmission of signal E_2 corresponding to the scanning of the second line of the field of view at station E is started and at the same time the initial portion of signal W_2 reaches repeater station R and the initial portion of signal E_1 reaches terminal station W. At time $3\frac{1}{2} \cdot t$ signal E_1 is being received at station W, signal E_2 is being transmitted from station E and signal W_2 is being transmitted from W to E through the repeater at station R. At time $4 \cdot t$ the transmission of signal W_3 from station W is being initiated while the initial portion of signal W_2 has just reached station E and the initial portion of signal E_2 has just reached the repeater R.

Fig. 4 is intended to illustrate the method of controlling the direction of transmission of the amplifiers at the terminal and repeater stations. The curve G represents the sine wave from the control source **17** which is impressed upon the grids of the control tubes **63**, **73**, **263**, **273**, **163** and **173**. It is apparent from the diagram that the period of the sine wave is $2 \cdot t$ where t is the signal transmission time between stations, for example the transmission time from station W to station R, and where t is also the transmission time of each signaling impulse as represented by W_1, W_2 or E_1.

At zero time $(0 \cdot t)$ the electromotive force G impressed upon the grid of tube **73** at station W is changed from positive to negative with the result that the anode potential of tube **73** increases rapidly to its maximum value as indicated by curve A (the tube **73** being greatly overloaded by the electromotive force G). The amplifier **43** is thus conditioned for transmitting the signal W_1 set up in the circuit of the photoelectric cell **15** at station W. At time $1 \cdot t$ the electromotive force G impressed upon the grid of tube **263** is changing from positive to negative and the potential at the anode of tube **263** increases rapidly to its maximum value as shown by curve A. The amplifier **251** is thus conditioned for transmitting signal W_1 in a W to E direction. At the same time $1 \cdot t$ the potential applied to the grid of tube **163** is changing from negative to positive (curve G) and therefore the potential applied to the grid of tube **173** is changed from positive to negative. The potential at anode of tube **173** is therefore increased and as a result the amplifier tube **143** is conditioned for transmitting the television signal E_1 generated at station E in the circuit of photoelectric cell **115**.

Similarly at time $2\cdot t$ the potential applied to the grid of tube 73 changes from positive to negative to cause the amplifier tube 43 to be conditioned for transmitting the television signal W_2 generated at station W. At the same time $2\cdot t$ the potential applied to the grid of tube 263 is changing from negative to positive and therefore the potential applied to the grid of tube 273 is changing from positive to negative thereby conditioning the amplifier 243 for transmitting television signal E_1 in the E to W direction. Also at time $2\cdot t$ the potential applied to the grid of tube 163 is changing from positive to negative to cause amplifier tube 151 to be conditioned for transmitting television signal W_1 to the circuit including amplifier 159 and lamp 112.

In the same manner at time $3\cdot t$ the potential applied to the grid of tube 73 is changing from negative to positive and therefore the potential applied to the grid of tube 63 is changing from positive to negative. Positive potential is therefore applied to the grid 68 of amplifier tube 51 to cause the television signal E_1 to be transmitted to the circuit including amplifier 59 and lamp 12. At the repeater station R the potential applied to the grid of tube 263 is simultaneously changing from positive to negative to cause transmission of television signal W_2 through amplifier tube 251. Also at time $3\cdot t$ the potential applied to the grid of tube 163 is changing from negative to positive and therefore the potential applied to the grid of tube 173 is changing from positive to negative with the result that the amplifier tube 143 is conditioned for transmitting the television signal E_2 generated in the circuit of photoelectric cell 115.

It will be observed from Figs. 3 and 4 that while the signals generated at station W and the signals generated at station E overlap on a line L, L′ connecting stations W and E, the signals do not overlap at the repeaters on the line so that the repeaters may be switched to transmit in opposite directions alternately for transmitting the signals in both directions over the line.

Any suitable number of intermediate repeaters may, of course, be employed on the line between the terminal repeaters. In Fig. 5, for example, there are shown six repeater stations numbered 1 to 6, inclusive, repeaters 1 and 6 being the terminal repeaters. These repeaters are spaced so that the transmission time t for transmitting television signals from one repeater to the next repeater is equal to the signal transmission period from each station, which period is preceded and followed by an equal non-transmission period during which signals are received. The direction of transmission through the repeaters at a certain time is indicated by the arrows. It will be observed from Fig. 5 that repeaters which are spaced so that the transmission time of television signals between them is equal to the signal transmission period t or to an odd integral multiple thereof, are conditioned for transmission in opposite directions simultaneously while, on the other hand, repeaters which are spaced so that the transmission time of signals between them is equal to an even integral multiple of the signal transmission period t are conditioned for transmission in the same direction simultaneously. Since the transmission time between the two terminal repeaters 1 and 6 is equal to $5\cdot t$, these repeaters must be conditioned for transmission in opposite directions simultaneously and therefore signal transmission must take place from both terminal stations at the same time.

If desired, the odd numbered repeaters of Fig. 5 may be omitted, thus leaving the even numbered repeaters 2, 4 and 6 as shown in Fig. 6, repeaters 2 and 6 now being the terminal repeaters. As indicated these repeaters are separated to give a transmission time between repeaters equal to $2\cdot t$. In this case, it will be observed that the terminal stations 2 and 4 are separated by a transmission time $4\cdot t$ while the transmission time between each terminal repeater and the intermediate repeater 4 is $2\cdot t$. Therefore all repeaters must transmit in the same direction simultaneously and therefore signal transmission will take place at the one terminal station at the same time that signal reception takes place at the other terminal station.

In Fig. 7 is shown a line employing only three repeaters 1, 4 and 7, repeaters 1 and 7 being the terminal repeaters which are each separated from intermediate repeater 4 to give a transmission time between repeaters equal to $3\cdot t$. Since the terminal repeaters 1 and 7 are separated by transmission time $6\cdot t$ these repeaters must transmit in the same direction simultaneously.

While the invention is applicable to a transmission system employed for signaling other than television and to systems employing various types of transmission lines, it is particularly applicable to the transmission of television signals over transmission lines such as coaxial conductor transmission lines which are capable of transmitting the wide band of frequencies which are required for television transmission. It would not be practicable to employ two-way repeaters using hybrid coils and balancing networks (such as are employed in telephone transmission) on a television transmission line, such as a coaxial conductor line, because of the high line attenuation necessitating a large amplitude output at the repeaters and because the wide frequency range involved would make it difficult to maintain a balance at the hybrid coils.

In the above description it has been assumed that no time is required for switching the repeaters, while actually there may be a little time lost in reversing the direction of transmission of a repeater. To take care of the slight time which may be lost in switching, the width of the apertures 30 and 33 may be made slightly less than twice the spacing between the successive scanning apertures. This will result in the duration of the signal W_1, for example, Fig. 4, being slightly less than the period of a half cycle of the control wave G.

What is claimed is:

1. A two-way television system comprising two terminal stations each having television transmitting means for scanning a field of view along successive substantially parallel lines to produce an image current, and television receiving means for building up an image along successive substantially parallel lines under control of a received television image current, the lines of the field of view of the television transmitter and the lines of the image field of the television receiver at one station being scanned during alternate line scanning periods, a transmission line including a plurality of repeaters for transmitting the television current from each terminal station to the other terminal station, the transmission time between repeaters being equal to a line scanning period or to an integral multiple thereof, and means for conditioning each repeater for transmission in one direction only at a given time and

in opposite directions during alternate line scanning periods, repeaters between which the transmission time is equal to a line scanning period or to an odd integral multiple thereof being conditioned for transmission in opposite directions simultaneously and repeaters between which the transmission time is equal to an even integral multiple of a line scanning period being conditioned for transmission in the same direction simultaneously.

2. A two-way television system in accordance with claim 1 in which means are provided for synchronizing the television transmitter scanning means at the two stations in proper phase such that the image current generated at one terminal station will be received at the other terminal station during a period in which the image field of the television receiver at said other station is being scanned.

3. A two-way television system in accordance with claim 1 in which there are provided at one of the terminal stations a source of alternating current having a period equal to twice the line scanning period and means for transmitting alternating current from said source to the other terminal station for maintaining the terminal scanning apparatus in such phase relationship that the transmitting scanning apparatus is effective for scanning the field of view at both stations simultaneously when the signal transmission time between terminal stations is an odd integral multiple of the line scanning period and that the transmitting scanning apparatus at one station is effective for scanning the field of view at the same time that the receiving scanning apparatus at the other station is effective for scanning the image field when the signal transmission time between terminal stations is an even integral multiple of the line scanning period.

4. A two-way television system comprising two terminal stations, a transmission line connecting said terminal stations and including a plurality of repeaters, transmitting and receiving scanning apparatus at each terminal station for scanning a portion of a field of view and scanning a portion of an image field for producing a television image under control of received image current alternately, control means associated with each repeater for conditioning the repeater for transmission in opposite directions alternately, a source of alternating current, means under control of alternating current from said source for maintaining the transmitting and receiving scanning at the terminal stations in synchronism and in proper phase relationship, and means under control of alternating current from said source for controlling said repeater control means for causing the reversal of the direction of transmission of each repeater in synchronism with the alternate scanning of the field of view for television transmission and of the image field for television reception at one of said stations.

5. A two-way signaling system comprising means for intermittently transmitting signals at each of a plurality of terminal stations of said system, a signal transmission channel including a repeater, said channel having an inherent delay characteristic such that signals transmitted from different stations, respectively, would overlap at said repeater if no means were provided to prevent said overlap, a source of control current for controlling the direction of transmission of said signals over said channel, a second channel for transmitting said control current, and delay networks in said channels respectively for supplementing the inherent delay thereof, thereby preventing overlap at said repeater of signals transmitted from different stations, respectively.

6. A two-way television system comprising two terminal stations each having television transmitting means for scanning a field of view to produce an image current and television receiving means for scanning an image field for building up an image under control of a received image current, the field of view of the television transmitter and the image field of the television receiver at one station being scanned during alternate substantially equal time periods, each time period being at least as long as a line scanning period, a transmission line including a plurality of repeaters for transmitting the television current from each terminal station to the other terminal station, the transmission time between repeaters being equal to said time period or to an integral multiple thereof, and means for conditioning each repeater for transmitting in one direction only for said time period and in opposite directions alternately for equal time periods, repeaters between which the transmission time is equal to said time period or to an odd integral multiple thereof being conditioned for transmission in opposite directions simultaneously and repeaters between which the transmission time is equal to an even integral multiple of said time period being conditioned for transmission in the same direction simultaneously.

PIERRE MERTZ.