Sept. 29, 1936. H. R. LUBCKE 2,055,748

TELEVISION SYSTEM

Filed July 29, 1932 2 Sheets-Sheet 1

Fig. 1.

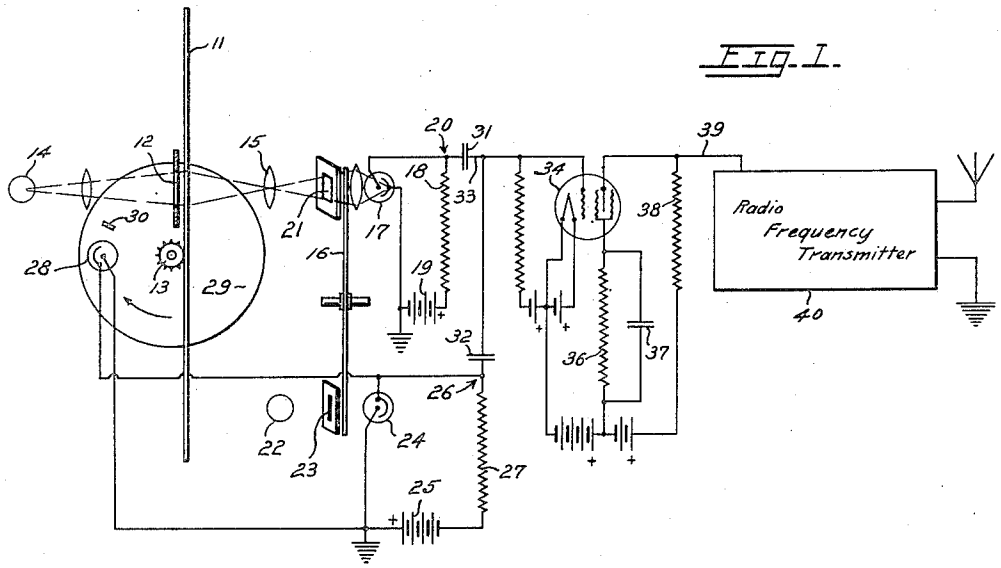
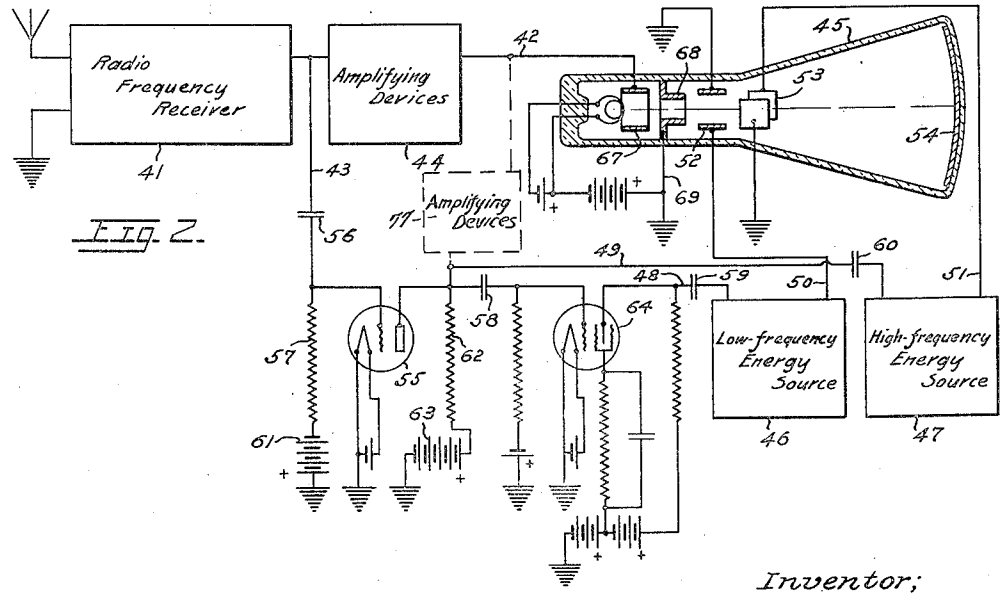


Fig. 2.



Inventor;
Harry R. Lubcke,
per Arthur J. Farnsworth.
Attorney.

Sept. 29, 1936. H. R. LUBCKE 2,055,748

TELEVISION SYSTEM

Filed July 29, 1932 2 Sheets-Sheet 2

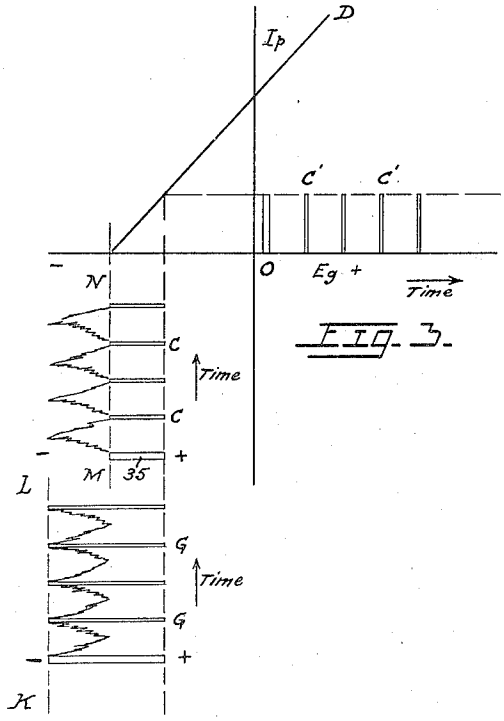
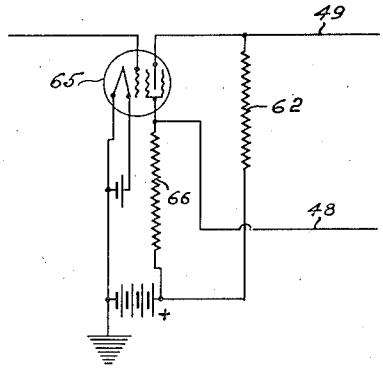


Fig. 3.

Fig. 6.



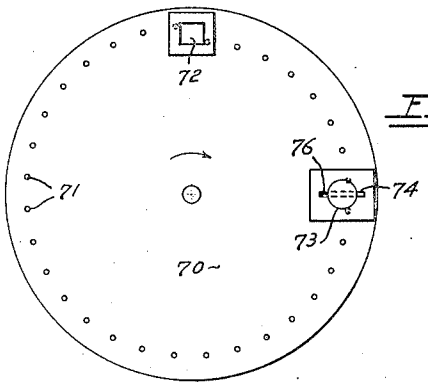
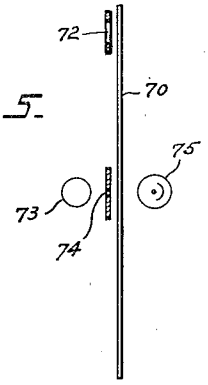


Fig. 4.

Fig. 5.



Inventor;
Harry R. Lubcke,
per Arthur J. Farnsworth.
Attorney.

Patented Sept. 29, 1936 2,055,748

UNITED STATES PATENT OFFICE

2,055,748

TELEVISION SYSTEM

Harry R. Lubcke, Los Angeles, Calif.

Application July 29, 1932, Serial No. 625,620

6 Claims. (Cl. 178—6)

My invention relates to television systems, and more specifically to those wherein both image transmission and synchronization are accomplished over a single channel of communication from transmitter to receiver.

In the practice of television, it is necessary to have the scanning devices at the receiver and the transmitter operate exactly in step, so that the specific light intensity of a given spot in the field of view at the transmitter will be reproduced in the same relative position at the receiver. This requires a coaction between the transmitter and receiver, in addition to a proper response to the degree of light or darkness of the elementary areas of the picture. This specific coaction is often obtained by utilizing a second channel of communication from transmitter to receiver, for the transmission of synchronizing pulses or frequencies; or it is accomplished by operating the scanning devices on an alternating power supply that is common to both the transmitter and receiver. Both of these methods have apparent disadvantages in comparison to one which transmits all the necessary impulses over a single channel of communication. To provide improved means for the accomplishment of this latter method, is one of the objects of this invention.

Another object is to provide a new and better method for combining synchronizing pulses with the image pulses, to form a composite signal sent over the single channel of communication.

Another object is to provide simplified and efficient means for selecting the synchronizing pulses from the composite signal at the receiver, and for applying them to the scanning devices.

Still another object is to provide means for sharpening the synchronizing or image pulses.

A further object of this invention is to remove from the synchronizing output certain spurious pulses, which may arise from imperfections in the communication channel.

My objects have been attained in the manner illustrated in the accompanying drawings, in which:—

Figure 1 is a diagrammatic representation of a complete television transmitting apparatus for transmitting images on motion picture film, in accordance with the principles of my present invention;

Figure 2 similarly illustrates a complete television receiving apparatus;

Figure 3 is a diagram explanatory of my improved method for selecting the synchronizing pulses from the composite received signal;

Figure 4 is a diagrammatic representation in front elevation, of an alternate arrangement of a portion of the transmitting apparatus, adapted for the scanning of three dimensioned subjects instead of motion picture film;

Figure 5 is a side elevation of the apparatus illustrated in Fig. 4; and

Figure 6 is a diagrammatic representation of an alternate arrangement of selecting amplifier, and its connections to the receiver scanning sources.

Similar reference numerals refer to similar parts throughout the several views.

Referring to Fig. 1, a motion picture film which is to be transmitted by my improved method is indicated at 11. This is caused to move uniformly past an aperture 12 by means of a suitable mechanism, as by the sprocket 13. It is illuminated by light from a source 14.

An image of the film is focused by a lens 15, on a rotary Nipkow disk 16, which is provided with a concentric ring of small holes near its periphery, and allows light from only one elemental area of the image to pass through to a photoelectric device 17 at any instant of time. The combined motion of the film and disk thus accomplishes sequential two-dimensional scanning, and device 17 is thus made to produce electrical pulses corresponding to lighting of the elementary portions of the film. Each bright pulse of light causes a large flow of electrons through the circuit composed of device 17, a resistor 18, and a battery 19, and causes the potential at the top of this resistor at point 20, to become more negative than normal. Let us define these pulses for the purpose of this discussion, as image pulses.

The high frequency synchronizing pulse apparatus, which functions to produce a pulse for each scan of a hole in disk 16 past an image aperture 21, is located at a circumferential point on disk 16, other than that opposite aperture 21. A source of light 22 illuminates a portion of the ring of holes in the disk, directly opposite an aperture 23 and a photoelectric device 24. It will be seen that as each of the holes in disk 16 pass aperture 23, a flash of light will impinge upon photoelectric device 24, and give rise to an electron surge as before; but because of the reversed connection of device 24 and battery 25, these surges occur in the opposite direction. Thus the last mentioned flash of light causes the potential at point 26 on a resistor 27, connected as indicated in Fig. 1, to become more positive than normal.

To provide the necessary low frequency synchronizing pulses, preferably occurring once for each passage of a frame line of film 11 past aperture 21, a photoelectric device 28 is connected in parallel to photoelectric device 24. It is placed adjacent to an opaque disk 29, that is mechanically connected to, and driven at the proper speed of rotation by, the same mechanism that drives the film sprocket 13, by any suitable means, which it has not been considered necessary to illustrate. This disk has an aperture 30 therethrough, to allow a pulse of light to pass from a light source (not shown) on the opposite side of the disk to photoelectric device 28, and thus also produces an abnormally positive potential at 26 on resistor 27.

Aperture 21, through which light transmitted through the film image passes, is made slightly narrower than the circumferential distance between adjacent holes on scanning disk 16. Thus, from the time one hole leaves the image field until the next one enters, there exists a short interval during which no light can reach the photoelectric device 17, and hence its response at this time corresponds to that of black in the scale of image light intensities.

Aperture 23 is made of a width, which, circumferentially measured, may conveniently be made equal to that of one or two elementary scanning areas; that is, say, one or two eightieths of the distance between adjacent disk holes, for a scanning disk containing a ring of eighty holes. This aperture is positioned so that light is admitted to its associated photoelectric device 24 during the interval between the passage of the disk holes past the image aperture 21. There are nearly eighty such positions possible around an eighty hole disk.

It was mentioned above, in considering the image pulse producing apparatus, that a bright pulse of light caused the potential at 20 on resistor 18, to become more negative than normal. Thus an absence of light or blackness, occurring between each scan of a hole across the image, because of the narrowed aperture 21, will cause this potential to have its maximum positive value. It was further mentioned, in considering the synchronizing apparatus, that the bright flash of light causes a maximum positive potential to appear at 26 on resistor 27. Points 20 and 26 are connected together through condensers 31 and 32, of negligible reactance at the frequencies involved, and to the input wire 33 of an amplifier comprising a thermionic device 34. At any instant the resultant potential at 33 will be the algebraic sum of the potentials of points 20 and 26. Thus for the instant when the image transmitting apparatus is registering black, and the synchronizing apparatus is adding a further positive pulse, it will be seen that the potential at wire 33 corresponds to what may, for the purpose of this discussion, be called "blacker than black".

The form of this composite signal is indicated along the vertical axis MN in Fig. 3. The electrical potential represented by the axis MN corresponds to black in the scanning. The extension of the synchronizing pulses at the right of axis MN, in the positive direction, indicates their "blacker than black" character in the scale of electrically represented light intensity. The first synchronizing pulse 35 is shown wider than the others above it, to indicate that it is a low frequency pulse which occurs once for each completely scanned image. Thus, for an eighty-line image, seventy-nine narrow pulses occur before the wide pulse is repeated. The amplitude of the synchronizing pulses are shown in Fig. 3 as being about equal to that of the image pulses. They can be made larger or smaller as convenient, and are often made of about one-fourth the amplitude of the image pulses.

Since the synchronizing pulses are made to always occur at a time when the narrowed image aperture insures a black image pulse intensity, it will be seen that they will be of constant amplitude. If means are not provided to establish this constant datum, the synchronizing pulses will be of varying height, depending upon the light intensity being scanned at the instant the pulse occurs; and consequently they will be of less value in maintaining reliable synchronization.

Referring again to Fig. 1, the composite signal of wire 33 is amplified by a quartrode 34, and its associated apparatus, in the usual manner except as to the functioning of a resistor 36 and a condenser 37, in the screen grid lead of the device. Elements 36 and 37 constitute a parallel circuit, having less impedance at high frequencies than at low frequencies, as is well known. In the usual application, the size of elements 36 and 37 are proportioned so that the impedance of the combination is negligible for the highest frequency represented in the wave forms to be amplified. For this frequency, then, the quartrode will function as usual, with a constant screen potential. For a low frequency, however, the impedance of the parallel circuit will be considerable. This causes the potential of the screen grid to decrease each time the control grid becomes less negative than usual, since the greater flow of electrons from the filament to the screen, thus occasioned, produces a greater voltage drop in flowing thru the parallel circuit. The current in the anode circuit of the quartrode is directly affected by the potential of the screen, as is well known, being less for a low screen potential than for a high one.

The usual effect of the control grid becoming less negative, is to increase the anode current; but, in this case, since the screen circuit functions to decrease the current, the resultant effect will be the difference between the two. Thus the quartrode will not amplify low frequencies as well as high frequencies.

Fourier's analysis and experiments show that the high frequency components, in proper phase, of a rectangular or other wave of steep wavefront, account for the sharpness of the wavefront. A device which accentuates the high frequency components of a wave, and preserves their proper phase, will thus accentuate its rectangularity, and compensate for imperfections in this regard in other parts of the system.

That the parallel circuit represented by elements 36 and 37 does not introduce an appreciable phase shift with frequency, can be seen by examining its action. For low frequencies, the resistor carries nearly all the current; and the voltage drop across the impedance is in phase with the current, and the potential variation of the screen is in direct opposition to that of the control grid. For high frequencies, although the phase angle may approach 90°, the impedance is negligible. Thus negligible screen voltage variation occurs, and the quartrode 34 amplifies normally.

It will be appreciated, that any impedance composed to give an inverse variation of magnitude with frequency; and, ideally, having a phase characteristic independent of frequency, can be used in place of elements 36 and 37.

The composite signal, thus amplified, appears across the terminals of a resistor 38; of phase op-

posite that of wire 33, and corresponding to the phase of a "positive" television image, wherein the bright portions of the image correspond to the positive voltage peaks. As shown in Fig. 1, the amplified signal is carried over wire 39 to a radio transmitter 40, which functions to modulate it upon a radio frequency carrier, in a manner well known to the art. Additional stages of amplification, of the type described, or of the usual distortionless form, can be added between resistor 38 and wire 39, if required.

The function of the radio transmitter is to provide means for sending the composite signals to a distant receiving station, and it may be of any suitable type known to the art. It should be noted also that, instead of the transmitter-receiver radio communication channel indicated, a single wire with earth return, or a pair of wires, can be used.

Passing now to a consideration of the receiving apparatus, as shown diagrammatically in Fig. 2, a radio receiver is conventionally shown at 41. This apparatus is capable of; intercepting the emissions of transmitter 40; demodulating (or detecting) them; and amplifying them if necessary, to the end that substantially the same electric pulses will travel in wires 42 and 43, that travel in wire 39 at the transmitter.

The number of stages of amplification between wire 33, at the transmitter, and wire 43 at the receiver, is made such that the phase of the signal in wire 43 corresponds to a "negative" television image; that is, wherein the bright portions of the image correspond to the negative voltage peaks. Rectangle 44 diagrammatically represents a single stage, or any odd number of stages, of amplification, which are provided to change the phase of the image signal to positive, in wire 42, as is necessary for the proper operation of the cathode-ray tube 45; since, in this arrangement of apparatus, positive voltage peaks correspond to maxium brilliancy on the screen. These stages can be of the usual distortionless type, or of the high frequency accentuaing type, described above in connection with the transmitting apparatus.

In Fig. 2, rectangles 46 and 47 represent sources of sawtooth scanning energy, of low and high frequency respectively, provided for the actuation of the cathode-ray image reproducing tube 45. The detailed construction and operation of these generators has been fully explained in my copending application No. 596,711, filed March 4, 1932. Wires 48 and 49 represent proper connections to these low and high frequency sources, for effecting synchronization thereof by the application of the voltage pulses originating in the transmitting apparatus, as fully described in the above cited application. Wires 50 and 51 connect the output of these sources to the deflection plates 52 and 53 of the cathode ray tube 45, respectively, for deflection of the electronic beam over the fluorescent screen 54 for scanning purposes.

Passing now to the means for separating the synchronizing pulses from the image pulses, the thermionic vacuum tube 55 and its associated apparatus, constitute a selecting amplifier, adapted to perform this function. The composite signal of negative television polarity, shown along the vertical axis MN in Fig. 3, is carried by wire 43 of Fig. 2, as previously explained. A stopping condenser 56 is provided, to remove the direct positive potential applied to the anode of the last tube in receiver 41, and to make the separating apparatus unresponsive to low frequencies. Condenser 56 and resistor 57 compose a high-pass filter, adapted to transmit high frequency energy with less attenuation than low frequency energy. It is found in practice that shift of axis, with respect to maximum energy peaks, is a common form of communication-channel distortion. This causes the peaks to be received partly below, as well as above, the axis; although originated at the transmitter entirely above the axis. It is found that these extensions below the axis impair the reliability of synchronization of the receiver equipment, by introducing spurious pulses in the synchronization channel. Since, however, such peaks are generally of considerable duration, with respect to the time of a synchronizing pulse, they can be removed from the synchronization apparatus by making it unresponsive to low frequencies. Thus condenser 56 is made relatively small, as are the similar cooperating condensers 58, 59, and 60 in the other portions of the synchronizing apparatus.

The potential of the battery 61 is such as to bias the grid of tube 55 to cut-off; that is, to reduce its anode current substantially to zero. This action is shown diagrammatically in Fig. 3, where the line ND represents the grid-voltage plate-current characteristic of the tube. The alternating potential of the composite signal MN is, of course, superimposed on the direct potential of battery 61. The positive synchronizing pulses indicated at C in Fig. 3, cause the grid of tube 55 to become less negative, and to allow pulses of anode current indicated at C' to flow from the filament to the anode, and through a resistor 62 and a battery 63. The image pulses, causing the grid to become more negative than the value which causes the anode current to cease, are thus not reproduced in the anode circuit. In this way the synchronizing pulses are selected from the composite signal.

The synchronizing current pulses C' cause negative voltage pulses to appear at the top of resistor 62. These are applied through the wire 49, and the stopping condenser 60, to the high frequency scanning source 47 for the synchronization thereof. This output is further amplified by a quartrode 64, which is of the high frequency accentuating type described above in considering the transmitting station; and then is applied to the low frequency source 46 through wire 48 and stopping condenser 59, for the synchronization thereof.

When thus synchronized, the low and high frequency generators coact to constantly position the fluorescent spot on the cathode ray tube screen, in the same relative position as that occupied by the scanning disk hole in relation to the motion picture film frame being scanned at the transmitter.

It is not necessary to separate the low and nigh frequency synchronizing pulses, so as to apply each to its proper receiver source. The natural periods of the receiver sources cause them to respond, like pendulums in a mechanical system being subjected to mechanical pulses. Only the pulses of periodicity near that of the source, are effective in synchronizing it. It is necessary, however, to provide some sort of high impedance or unilaterally conductive element, between wires 48 and 49, so that the scanning generators shall not be closely coupled, nor be liable to react upon each other. The addition of the quartrode 64 accomplishes this purpose, and, incidentally, also sharpens the pulse applied to generator 46.

It will be appreciated that sharp pulses are desirable in synchronizing television scanning

apparatus, rather than gradual pulses, or energy variations approaching the sinusoidal; in that a rapid change of energy acts to cause local action at that instant, regardless of local conditions, whereas a gradual change of energy acts to cause local action at one instant for a given local condition, and at a later instant when local conditions are less favorable for initiating the action. It will be understood that thermionic tube 55 can also be a high frequency accentuating quartrode; or that both of the thermionic tubes can be distortionless amplifiers, and still function as selecting amplifier and isolating amplifier respectively. It will be further understood that the rectangularity of the pulses delivered by the herein disclosed separating means, exceeds that of devices employing wave filters, or other frequency discriminating devices. Such devices often deliver quasi-sinusoidal energy for the pulse inputs.

An alternate arrangement of connections from the selecting amplifier 55 to the scanning generators 46 and 47, may consist in inserting impedances, that are relatively high at the operating frequencies of these sources, in one or both of the wires 48 and 49. It is possible to achieve proper synchronization of, and absence of interaction between, the scanning source, by placing resistors in wires 48 and/or 49. These function to reduce the amplitude of the synchronizing pulses, as well as to isolate the sources; but to a less amount than the isolation gained, if resistors be located in both wires. The reduced pulse amplitude is compensated for by increasing the pulse amplitude at the transmitter, increasing the amplification of device 55, or in other ways that will be apparent to those skilled in the art.

Another alternate arrangement of connections, lies in inserting diodes in one or each of the wires 48 and 49, with the cathodes connected to the top of resistor 62 and anodes toward the scanning generators. The synchronizing voltage pulses at resistor 62 are negative, and thus lower the potential of the diode cathode with respect to its anode, allowing an electron flow between the two. In the reverse direction, however, negative voltage pulses, arising from the operation of the scanning generators, and attenuated by the small stopping condensers 59 and/or 60, are incapable of flowing through the diode, since they act to make the anode potential more negative than that of the cathode. It is evident that other unilaterally conductive devices can be used in place of this diode.

A further alternative arrangement of the output circuits is illustrated in Fig. 6. Here a quartrode, 65, is adapted to give two independent output circuits by providing a resistor 66, in the screen circuit. The synchronizing output for one source appears at the top of resistor 62 and is led off through wire 49, as before, while wire 48, connecting with the other generating source, is connected to the top of resistor 66. It will be appreciated that as many output circuits as desired can be secured, by placing the proper number of output electrodes in the thermionic device 65.

It also is possible to utilize this invention when the polarity of the photoelectric devices 24 and 28, and of battery 25, are reversed. In this case, instead of the outputs of these devices adding to that of the image pulse produced in photoelectric device 17, during the time when it is not receiving light, to give a "blacker than black" composite signal, they subtract from it. Their amplitude is made considerably greater than the amplitude of the maximum pulse produced in the image device, by increasing the intensity of the light sources 22 and that back of aperture 30, for example, thus causing the pulses to be "whiter than white" in the scale of electrically represented light intensities. A composite signal of this nature is shown along vertical axis KL in Fig. 3. The "whiter than white" peaks are shown at G in this figure.

In separating these pulses from the composite signal at the receiver, the number of stages of amplification between wires 33, at the transmitter, and wire 43, at the receiver, is made such that the phase of the signal in wire 43 corresponds to a positive television image. This is as indicated on axis KL in Fig. 3. The potential of battery 61 is increased over its previous value, by an amount sufficient to cause the image pulse variations to occur still more negatively than the cut-off potential, of tube 55. The greater distance of axis KL from the axis of zero grid potential OIp, with respect to that of axis MN, indicates diagrammatically the proper condition. It will be seen that pulses G will only be reproduced in the anode current as pulses C', and that the operation of the remainder of the apparatus will be the same as previously explained.

It is possible to remove the "whiter than white" pulse from the input to the cathode-ray intensity control connection 42 in Fig. 2, by providing two stages of amplification in the device represented by rectangle 44, and two additional stages of amplification represented by dotted rectangle 77 after resistor 62, the output of the last mentioned stages being connected to wire 42. The phase of the synchronizing pulses of voltage being negative at resistor 62, the phase two stages beyond it will also be negative. The phase of the composite signal, in wire 43 being positive, the phase two stages beyond it will also be positive. Thus, when the two outputs are combined in wire 42, it will be seen that the negative synchronizing pulses from the synchronizing channel will tend to cancel the original positive pulses present in the continuation of the composite channel. The relative amplification of the two two-stage amplifiers is adjusted in practice until cancellation is obtained, or it may be made such that a negative pulse predominates, which extinguishes the spot on the cathode-ray tube screen during the sychronizing action. The two amplifiers serve to isolate the connections between channels, and to prevent interaction between input and output of a single stage, as would exist if resistor 62 was connected directly to wire 42.

An alternate arrangement for removing the positive pulse lies in providing the cathode-ray tube with two electrodes capable of modulating the electron beam thereof. Two control elements of the type shown at 67 in Fig. 2 are provided, one being connected to wire 42 as usual, and the other to the output of the synchronizing channel. The two two-stage amplifiers need not be employed in this arrangement. It will be further understood that the anode 68 of the cathode-ray tube, as shown, can have its action modulated by the output of the synchronizing channel, by inserting a resistor in lead 69, and connecting said output to the top thereof, and vice versa, wherein the wire 42 is there connected, and said output is connected to control electrode 67.

An alternate arrangement of the transmitter scanning equipment, adapted to scan three di-

mensional objects, such as living persons, is shown diagrammatically in Figs. 4 and 5. At 70 is represented the conventional Nipkow disk with spirally arranged holes 71. Light from a source (not shown) passes through an aperture 72, narrowed as was aperture 21 in Fig. 1, and is focused on the object to be transmitted. Photoelectric devices (also not shown) are provided as usual, to catch the light reflected from the object, and to initiate the electrical image pulses in the same manner that photoelectric device 17 functions in Fig. 1. A source of light 73, preferably located at a circumferential position other than that occupied by aperture 72 for mechanical convenience, is arranged to permit light to pass through an aperture 74 to disk 70, and thru the scanning holes therein to a photoelectric device 75. Aperture 74 is made long radially, to allow light to pass through any of the spirally arranged holes, and also through the hole 76, spaced from the usual spiral series, and in such a position that it can pass light to the photoelectric device at the completion of an entire scan of the object.

The device comprising aperture 74, hole 76, and photoelectric device 75 can, of course, be connected in either a positive or negative manner, to give either "blacker than black", or "whiter than white" synchronizing pulses. In case the latter pulses are to be produced, the light source 73 can be arranged to shine through the disk to suitable fixed reflecting surfaces, for reflection to image pulse-producing photoelectric devices. In this manner both synchronizing and image pulses may be optically combined, and be impressed upon a single electrical channel.

The illustrated wiring connections, diagrams, and conventional representations of apparatus, not specifically mentioned in the foregoing discussion, but necessary for a complete practical system, will be fully understood by those familiar with the art involved.

Having thus fully disclosed my invention, I claim:

1. In television apparatus, means for removing synchronizing pulses from a communication channel carrying a composite signal, comprising; a thermionic device adapted to separate said pulses from said signal, by having its input circuit biased to a potential near that which would cause its constant output circuit current to become zero; and means for re-inserting the separated pulses in a continuation of the composite signal channel, with a polarity opposite to that of the original pulses.

2. In television apparatus, means for removing the effect of a pulse, present in a composite signal, upon the intensity of an electron stream, comprising; means adapted to separate said pulse from said signal; means for reversing the phase of said pulse; and dual means for influencing the electron stream; one of the last said means being adapted for influencing said stream in accordance with the variations of said signal; the other of the last said means being adapted for influencing said stream in accordance with the reversed phase of said pulse variations.

3. Apparatus for transmitting a motion picture film by television, comprising; means for scanning the film, and for producing image pulses thereby; means for producing, in a single channel of communication between the transmitter and receiver, a signal composed of said image pulses and of synchronizing pulses of substantially rectangular shape and of constant amplitude; means for producing one such synchronizing pulse for each passage of a film frame-line past the scanning aperture, and for each scan of the scanning element across the film; means for transmitting said composite signal from a transmitter to a receiver; means comprising a negatively biased thermionic device for separating said synchronizing pulses from said image pulses; means comprising a separate output electrode in said thermionic device, connected to each source of scanning energy at said receiver for the synchronization thereof; and means for applying said image pulses to an image forming device co-acting with said sources of scanning energy, to reproduce the image.

4. Television synchronizing apparatus comprising; a source of quasi-rectangular synchronizing pulses; a thermionic device adapted to amplify said pulses, and having an input electrode, an output electrode, and a coacting auxiliary electrode; scanning equipment connected in circuit with said output electrode; and an impedance element connected in circuit with said auxiliary electrode, and adapted to change in impedance with changes in frequency of the energy applied to the thermionic device, whereby the rectangularity of the pulses flowing in the output circuit of said thermionic device may be increased.

5. In a television system which includes a plurality of scanning devices at the receiving station, synchronizing means at the receiving station comprising; a thermionic device having an input electrode, and a plurality of output electrodes adapted for supplying identical outputs; the output electrodes being independently connected to the said plurality of scanning devices for synchronization thereof; said scanning devices being adapted for scanning in different directions, and to co-operate to form a single image.

6. A method of television synchronization which comprises; producing a series of substantially rectangular synchronizing pulses of constant amplitude, one for each traverse of the scanning element across the field of view, and occupying a very small fraction of the time of one traverse; producing another series of substantially rectangular synchronizing pulses of constant amplitude, one for each complete traverse of the field of view, having the same amplitude and a duration several times greater than the first mentioned series; the pulses of each of said series being of negative polarity; continuously producing image pulses of positive polarity; combining all said pulses, and transmitting them from the station of origin to a receiving station in a single channel of communication; reversing the phase of all of said pulses at the receiving station, substantially without distortion, by a thermionic amplifying device; applying all of said pulses, in their said reversed phases, to a single non-oscillating thermionic device which has a high negative bias, and which is adapted to amplify and reproduce only the two series of synchronizing pulses, at the same amplitude, in its output circuit; and applying the whole amplitude of said reproduced synchronizing pulses to each of two separate self-oscillating scanning devices at the receiving station for the synchronization thereof; the last said scanning devices being operated at the frequency of repetition of said synchronizing pulses respectively.

HARRY R. LUBCKE.