March 29, 1949. D. D. GRIEG 2,465,371

COLOR TELEVISION

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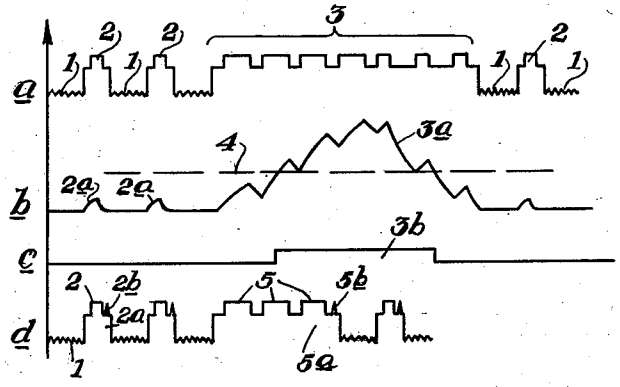
Fig. 1.



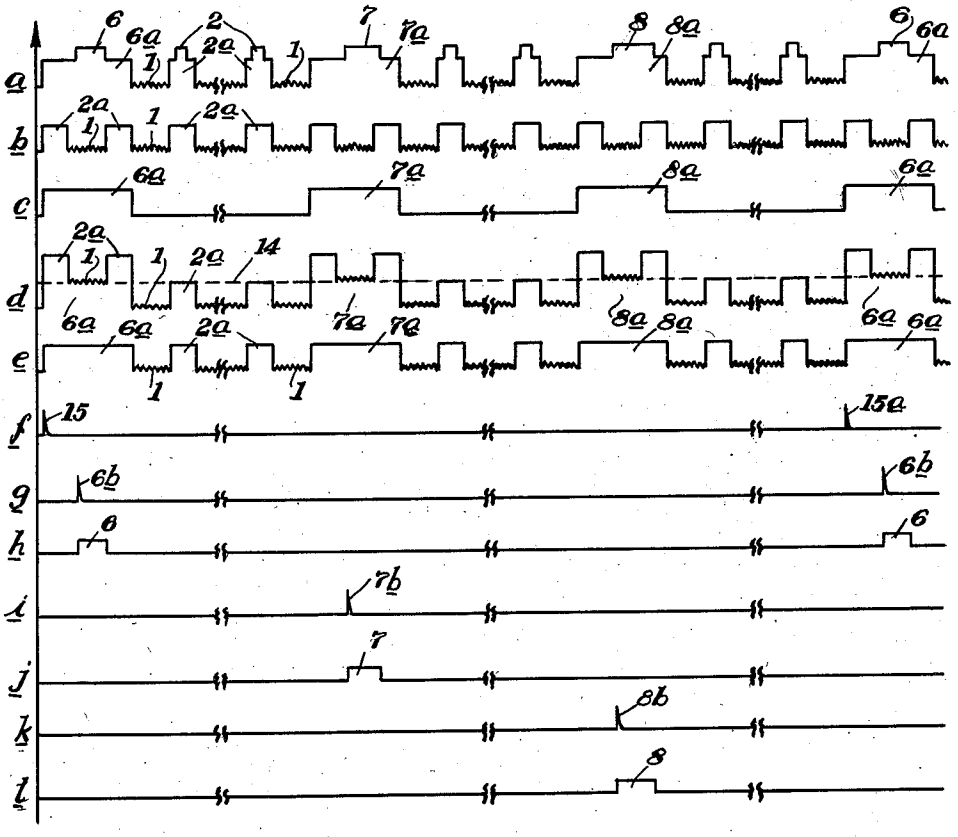


Fig. 2.

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Fig. 2a.

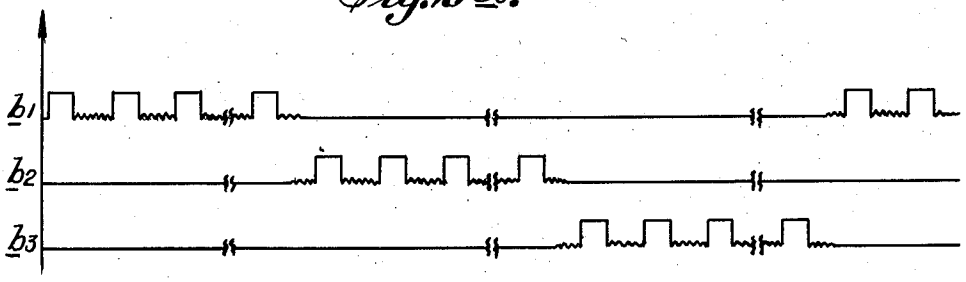
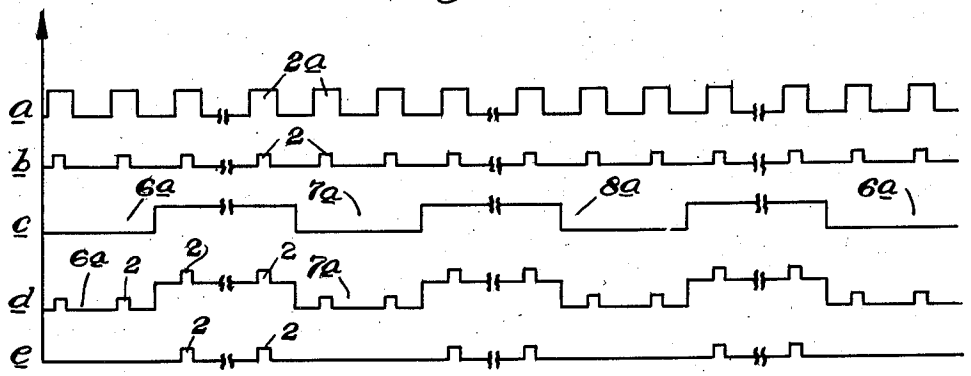


Fig. 2b.



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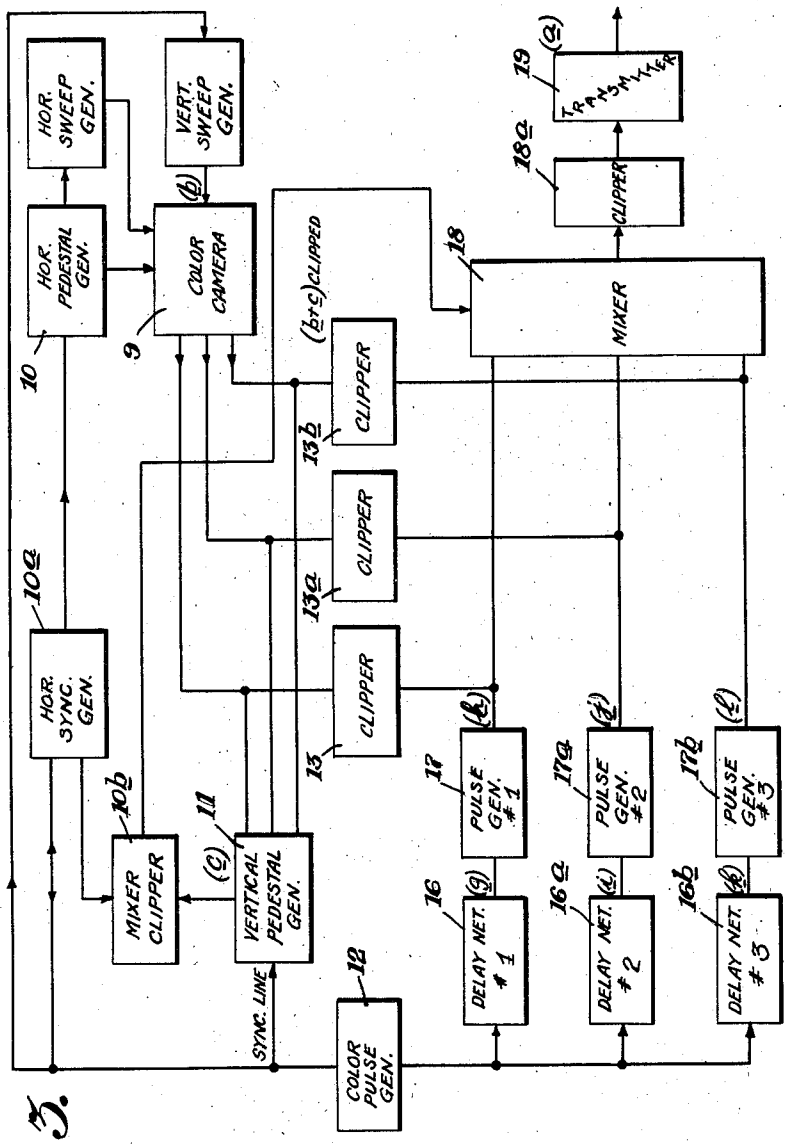

Fig. 3.

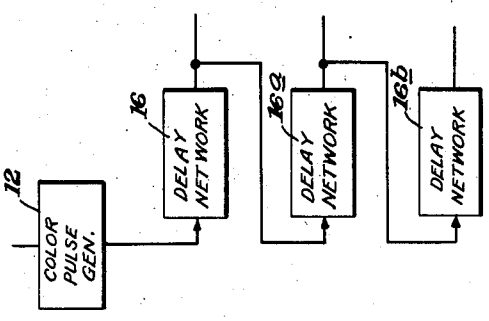

Fig. 3a.

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Fig. 4.

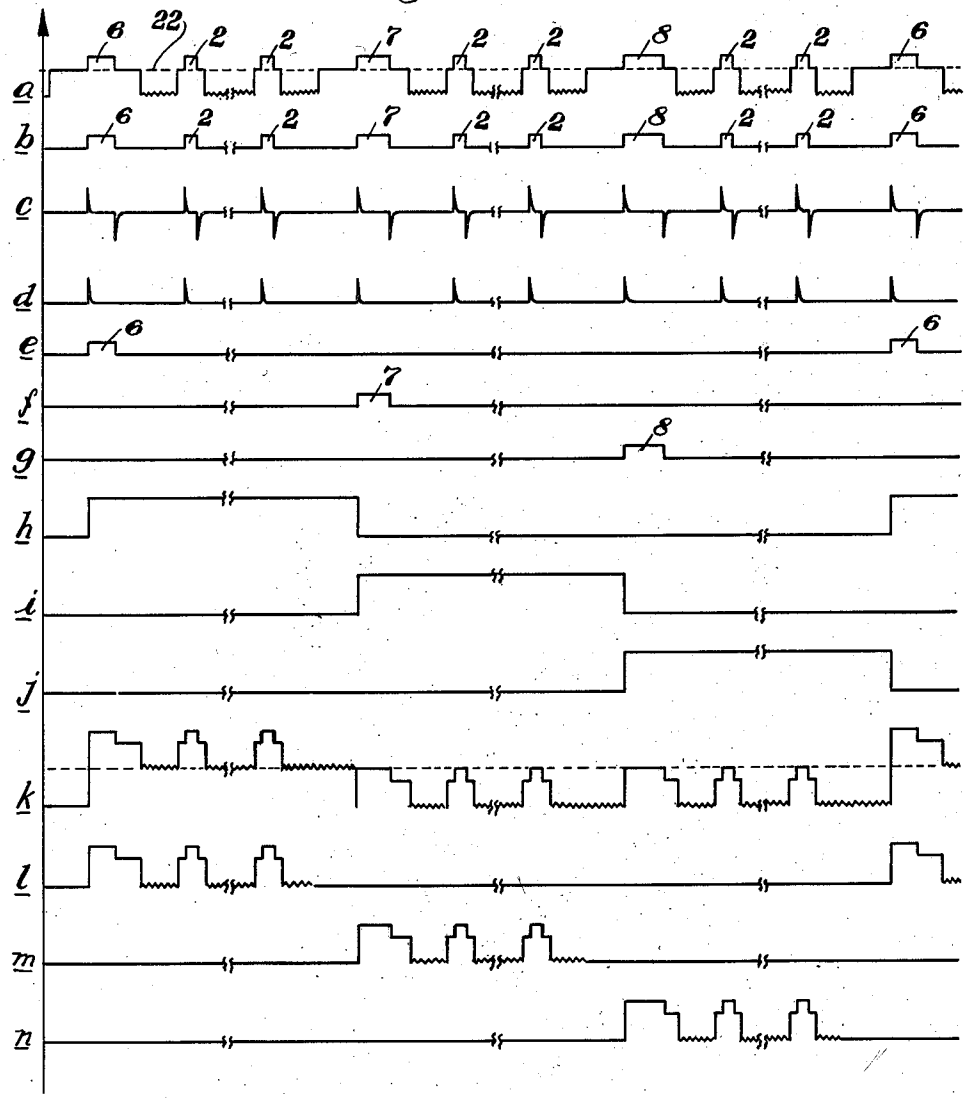

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Fig. 5.

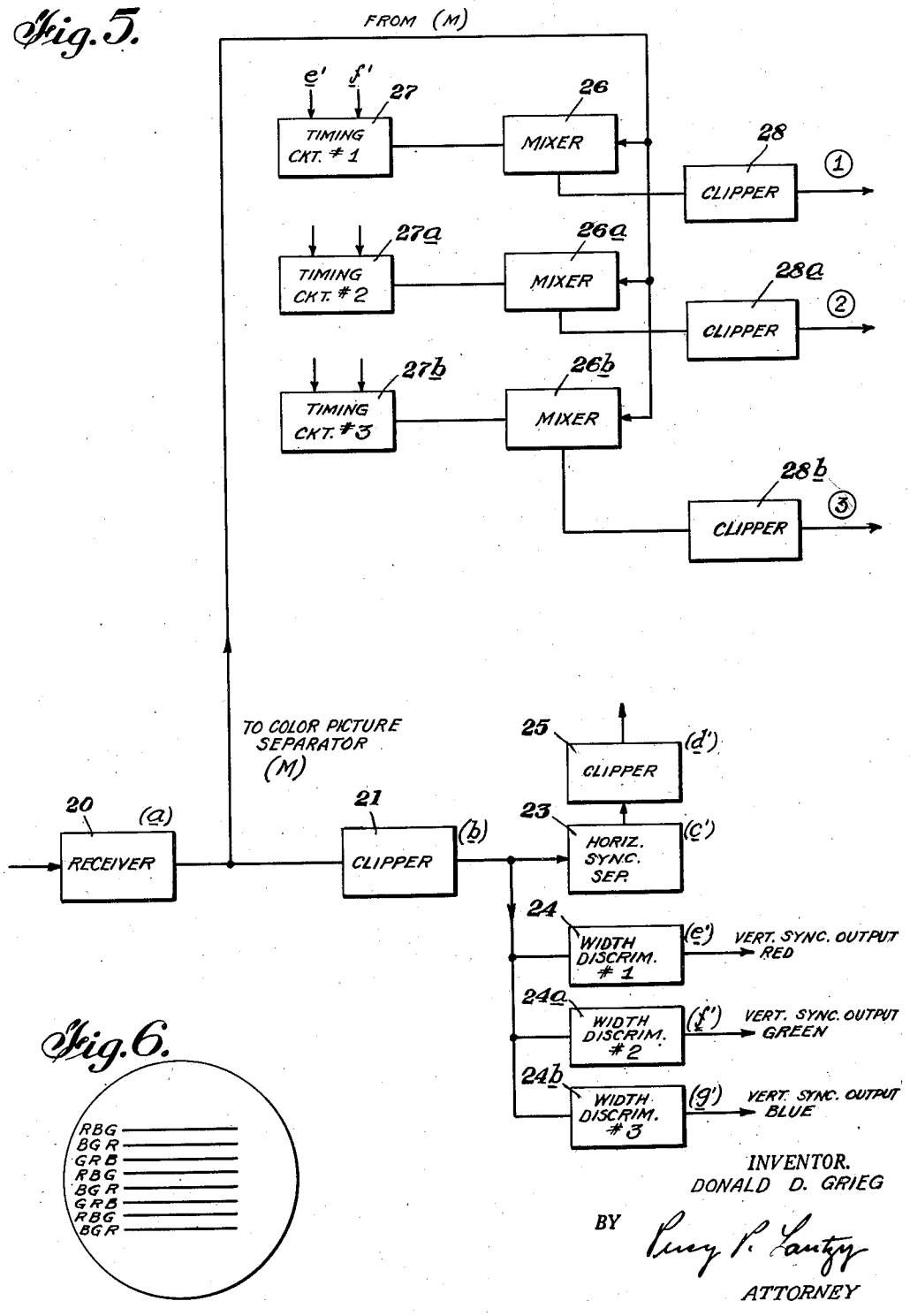

Fig. 6.

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Patented Mar. 29, 1949

2,465,371

UNITED STATES PATENT OFFICE

2,465,371

COLOR TELEVISION

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Application January 13, 1945, Serial No. 572,696

9 Claims. (Cl. 178—5.2)

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This invention relates to new and useful improvements in television systems and more particularly to a novel arrangement for controlling the vertical or frame synchronizing pulses in television transmitting and receiving arrangements.

Heretofore it has been the practice to separate the lines of video pulses by individual horizontal or line synchronizing pulses and to separate frames of such lines by a plurality of pulses which were subsequently integrated into a single synchronizing pulse.

In order to eliminate the inaccuracy that may be introduced by the conversion last referred to, to simplify the wave-forms now customarily required and to allow a flexibility so as to permit future changes in the system, according to the present invention the frame or vertical synchronizing pulse or pulses are distinguished from other pulses merely by their modulation.

In one embodiment of the invention successive frame synchronizing pulses are distinguished from one another by their time or width modulation and thus may be used to control the interlacing of the lines of successive frames, e. g. to produce color effects and for other similar purposes.

These and other features of the invention will more clearly appear from the following detailed description of certain preferred embodiments thereof and the appended claims. The invention will be described with reference to the drawings in which:

Fig. 1 contains a collection of voltage curves of typical television signals arranged in accordance with prior practices and the present invention;

Fig. 2 shows voltage curves representing the signals at various stages of the transmitter;

Fig. 2*a* shows voltage curves of the color signal indicated at *b* in Fig. 2;

Fig. 2*b* illustrates the generation of the horizontal synchronizing pulses;

Fig. 3 is a block diagram of a transmitter embodying the present invention;

Fig. 3*a* is a modification of Fig. 3;

Fig. 4 shows voltage curves of television signals as they appear in various parts of the receiver;

Fig. 5 is a block diagram of a receiver embodying the present invention; and

Fig. 6 represents the end of a cathode ray tube in the receiver showing the interlaced video color lines.

Referring now to Fig. 1 of the drawings, *a* illustrates a typical basic television signal which is sent out by the conventional transmitter. The

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signal consists of a succession of video signals 1, followed by a horizontal synchronizing signal 2, at the end of each line along which the scanning takes place. These video signals with the horizontal synchronizing signal are repeated until a frame is completed. Then follow a succession of frame or vertical synchronizing impulses 3, consisting a plurality of relatively long and short pulses. Equalizing pulses which are generally required with this type of wave-form are not shown in the illustration. By well known means the horizontal synchronizing impulses 2, are removed from the composite wave-form, converted into impulses 2*a* indicated at *b*, and the horizontal synchronizing pulses 3 are integrated into a pulse 3*a*. By clipping the pulse 3*a* along line 4, the frame synchronizing pulse 3*b* of Fig. 1*c* is produced.

It will be clear from an inspection of line *b*, of Fig. 1 that if the line 4 along which the pulse 3*a* is clipped were shifted then the position or the length of pulse 3*b* would be changed. This occurs when the characteristics vary, supply voltages change, signal levels vary, etc., and leads to inaccuracies of timing and distortion, e. g. when the vertical synchronizing pulse is used in an interlaced scanning system to control the interlacing of successive frames. The purpose of the present invention is to avoid such distortion and this as indicated at *d* in Fig. 1 is accomplished by transmitting one or more frame synchronizing pulses similar to 5, distinguished from the horizontal synchronizing pulses, and preferably from other frame synchronizing pulses by time (width) modulation. It is not necessary to integrate and minor shift can occur in the vertical synchronization.

The frame synchronizing pulse or pulses 5, can be used in the conventional manner as frame synchronizing pulse of a black and white picture whether interlaced or not, for controlling stereoscopic or polychromatic systems, or for other similar purposes.

The pedestals 2*a* and 5*a* carrying the synchronizing pulses 2 and 5 may carry also a second pulse indicated at 2*b* and 5*b* whose position is modulated with respect to the leading or trailing edge of the synchronizing pulse to convey some information, e. g. the sound accompaniment of the video signals.

According to one of the features of the present invention the vertical synchronizing pulses having a characteristic time or width modulation are used to control the interlacing of three successive frames of picture signals corresponding

to light of different colors, e. g. red, blue, and green. In the following description an embodiment of this feature will be explained, it being understood that the invention is not limited to such application.

In Fig. 2, *a* illustrates the signal which it is desired to transmit. It consists of vertical synchronizing pulse **6**, of a given width followed by the customary lines of video signals. These lines are interlaced with the lines preceding pulse **6**.

At the end of the first frame, a vertical synchronizing pulse **7** is produced which is of greater width than pulse **6**. The lines of video signals that follow pulse **7** will be interlaced between the lines spaced by pulses **6** and **7**.

At the end of the next frame vertical syncronizing pulse **8** is produced which is wider than **7**. The lines of this frame are interlaced, between the lines of the second mentioned of the second frame and the lines following pulse **8**, i. e. preceding the next pulse **6**. The succession of the three groups or fields of signals as above described may then be repeated in the same sequence or preferably in rotating sequence so that each line receives all three color signals in each frame period in order to prevent "color crawling."

As above stated, the pedestals of the synchronizing signal may carry also pulses modulated with respect to the leading or trailing edges of the synchronizing signals to convey some additional information, e. g. sound.

The video signals between **6** and **7** may represent red, between **7** and **8** blue, and between **8** and **6** green color.

A color camera of suitable type indicated in Fig. 3 at **9** will, as it scans an object, produce under the control of a horizontal pedestal generator **10**, horizontal sweep generator **20**, and vertical sweep generator **21**, video signals similar to those indicated in Fig. 2*a*. In this figure at b_1, are shown the video signals representing red, at b_2, those representing blue and at b_3, the signals representing the green color. In Fig. 2, at *b*, these signals representing the three color components are shown in a single line one after the other and without the intervening frame synchronizing pulses.

The output of the color camera **9**, is connected with the output of a vertical pedestal generator **11**. The generator **11** produces the pedestals **6***a*, **7***a*, and **8***a* (Fig. 2, lines *a* and *c*) for the vertical synchronizing pulses **6**, **7**, and **8**. It is controlled by a color pulse generator **12**, which is adapted to produce the pulses shown at *f* in Fig. 2, marking the start of the color cycle i.e. the leading edge of pulse.

When the output of **11** and **9** are combined, we obtain three groups of pulses one of which is indicated at *d*, in Fig. 2. The three groups of pulses are fed into clippers **13**, **13***a* and **13***b*, respectively, to cut them along line **14** of Fig. 2 line *d*. A composite of the resultant signals is shown at Fig. 2 line *e*. The three vertical synchronizing pulses **6**, **7**, and **8** occur between two successive pulses **15** and **15***a*, produced by generator **12**.

In addition to the vertical pedestal generator **11**, the generator **12** controls also three delay networks **16**, **16***a*, and **16***b*. The network **16**, is arranged to produce pulses like **6***b* indicated in Fig. **2** at *g*. These pulses produce the field synchronizing pulses **6**, to be placed on the pedestals **6***a*.

The network **16***a* is arranged to produce the pulses **7***b* indicated in Fig. 2 line *i*, to place the synchronizing pulse **7** on the pedestals **7***a*, and the delay network **16***b* produces the pulses **8***b* of Fig. 2 line *k* which generates the vertical synchronizing pulses **8**. The networks are delayed with respect to one another so as to produce the three pulses **6**, **7**, **8** of varying widths by the relative displacement of the leading edges thereof.

The outputs of delay networks **16**, **16***a*, and **16***b*, are fed into different width pulse generators **17**, **17***a*, and **17***b*, which are trigger circuits or shaper circuits adapted to produce square pulses of certain widths. The outputs of the pulse generators will be the three vertical synchronizing pulses of different widths **6**, **7**, and **8**.

These pulses are indicated in Fig. 2 at lines *h*, *j*, and *l*. The ouputs of pulse generators **17**, **17***a* and **17***b*, and of the clippers **13**, **13***a*, and **13***b*, are fed into a mixer **18**.

While the generation of horizontal synchronizing pulses is well known, I have illustrated in Fig. 2*b* one way of accomplishing this in the present system. In this figure line *a* illustrates the output of the horizontal pedestal generator **10**. This generator is connecetd with a horizontal synchronizing pulse generator **10***a*, which produces the pulses shown on line *b* in Fig. 2*b* and which feeds into a mixer and clipper **10***b* which in turn is controlled by the vertical pedestal generator **11**. On the line *c*, in Fig. 2*b* I have shown the vertical pedestal pulses and on line *d* of Fig. 2*b*, I have shown the horizontal synchronizing pulses of line *b* of Fig. 2*b*, superimposed on the pulses of line *c* of Fig. 2*b*. The horizontal pulses are shown on line *e*, Fig. 2*b*, and is the completed horizontal pulse which is fed into the mixer **18**.

It will be obvious to those skilled in the art that many modifications of the procedure which I have outlined are possible without departing from the spirit of the present invention.

The output of mixer **18** is fed to a transmitter **19** preferably through an intervening clipper **18***a*. The transmitter **19** will then transmit the signal shown on line *a* of Fig. 2.

While I have shown in Fig. 3, the three delay networks **16**, **16***a*, and **16***b*, connected in parallel with the output of the color pulse generator **12**, the first one of these networks may be omitted, and they may also be connected in series with one another and with the generator **12**. Such alternative arrangement is indicated in Fig. 3*a*.

The television signal *a* is transmitted through any suitable medium to actuate a receiver **20**, Fig. 5. The received signal shown in Fig. 4 line *a* corresponds to the signal shown in Fig. 2 line *a*, but dimensioned to bring out more clearly the relationship between the timing of the various pulses. The output of the receiver is supplied to a clipper **21**, where the incoming signal *a* is clipped along line **22**. The resultant is shown at *b* in Fig. 4, consisting of successive cycles of vertical synchronizing pulses **6**, **7**, and **8** separating groups of horizontal synchronizing pulses **2**.

The clipper **21** is connected with a horizontal synchronizing signal separator **23**, and also with three width discriminators **24**, **24***a* and **24***b*. The separator **23** will have in its output, impulses representing the leading and trailing edges of all the synchronizing pulses. These are indicated at *c* in Fig. 4 and when fed through a clipper **25** will produce the horizontal synchronizing pulses indicated at *d* Fig. 4. It should be noted that the dimensions at the television waveform are so chosen as to produce equally spaced horizontal synchronizing pulses. It should also be noted that other means, such as an additional width discriminator may be used to separate the hori-

zontal synchronizing pulses. For the waveform illustrated the time for vertical blanking is approximately one-half line period. If a longer blanking time is desired in the system several times line period may be used, and if desired additional horizontal synchronizing pulses may be included following the color pulses in order to maintain the regularity of the horizontal synchronizing signal.

The width discriminators 24, 24*a* and 24*b* may be of the same type as described in my copending application with Emile Labin, Serial No. 487,072, filed May 15, 1943, issued U. S. Patent No. 2,440,-278, April 27, 1948, and will separate the vertical synchronizing pulses 6, 7, and 8, respectively, indicated at *e*, *f*, and *g*, Fig. 4. These width discriminators include a resonant circuit which is shock-excitable in response to the leading and trailing edges of the pulses and a damping circuit having a vacuum tube connected across the resonant circuit for damping out the oscillatory energy following one or two undulations, as the case may be. The output from the circuit is provided with a threshold clipper stage which is adjustable to pass energy in response to undulations produced from pulses of a width corresponding to the tuning of the resonant circuit. Should the pulses be of a width different from one-half the period of the frequency to which the circuit is tuned, the undulations thereof will be less than that required to produce conduction in the threshold clipper stage. Thus, pulses varying in width from the desired width are blocked, pulse energy being passed by the clipper stage only in response to undulations produced from pulses of the desired width.

The output of the receiver 20 is fed not only to the clipper 21 but also to three mixers 26, 26*a*, 26*b* in parallel.

The output of width discriminator 24, is connected to a timing circuit 27 and in multiple to a timing circuit 27*b*. The output of the width discriminator 24*a* is connected to timing circuits 27 and 27*a* and the output of width discriminator 24*b* is connected to timing circuits 27*a* and 27*b*. These timing circuits may comprise the well-known flip-flop type circuits and will, respectively, produce pulses shown at Fig. 4*h*, *i* and *j* which correspond to pulses $e+f=h$; $f+g=i$; and $e+g=j$. The outputs of the circuits 27, 27*a* and 27*b*, are fed to the mixers 26, 26*a* and 26*b*, where they are combined with the incoming signals *a*. The resultant is indicated at *k* in Fig. 4. The outputs of the three mixers are clipped in clippers 28, 28*a*, and 28*b*, whose outputs in turn are shown at *l*, *m*, and *n*, Fig. 4, which correspond to the three vision signals b_1, b_2, and b_3, shown in Fig. 2*a*.

The outputs of clippers 25, 28, 28*a* and 28*b* are used to control the reproduction of the picture by interlacing the lines of the three successive colors (red, blue and green). This is illustrated in Fig. 6, which represents the screen of the cathode ray tube of the receiver on which the successive horizontal lines are traced. In this illustration the dimensions of the television waveform are chosen such that each line receives all colors successively for each complete color frame transmitted.

I claim:

1. In a television transmitter, a camera for producing in a plurality of output circuits video signals, a generator of pedestals for frame synchronizing pulses having its output circuit connected with the output circuits of the camera, clippers, one connected with each of the connected circuits, a pulse generator controlling the first mentioned generator, a plurality of delay networks controlled by the pulse generator, each delaying to a different extent the generated pulses, a width discriminator connected with each network and arranged to produce pulses whose width is determined by the pulse produced by the associated network said width being less than the width of said pedestals, a mixer to which the clippers and discriminators are connected, and means for transmitting the output of the mixer.

2. In a polychromatic television transmitter, a camera for producing in three output circuits video signals, each representing a different color, a generator of pedestals for vertical synchronizing pulses having output circuits connected with the output circuits of the camera, three clippers, one connected with each of the connected circuits, a color pulse generator controlling the first mentioned generator, a three delay network controlled by the color pulse generator, each delaying to a different extent the pulses generated by the latter, a width discriminator connected with each network and arranged to produce pulses whose width is determined by the pulse produced by the associated network said widths being less than the width of said pedestals, a mixer in which the outputs of the three clippers and discriminators are fed, and means for transmitting the output of the mixer.

3. A television receiver comprising means for receiving video signals separated by horizontal synchronizing pulses of uniform width and vertical synchronizing pulses of varying widths said pulses being superimposed on pedestal pulses, a clipper and a plurality of mixers connected in multiple with the receiving means, the output of said clipper consisting of said synchronizing pulses devoid of said pedestal pulses, a plurality of pulse width discriminators connected in multiple with the clipper and each arranged to segregate a vertical synchronizing pulse of a particular width, a plurality of flip-flop timing circuits connected with the outputs of the last mentioned width discriminators, a connection from each flip-flop circuit to a different one of the mixers, a clipper to which the output circuit of each mixer is fed, and means for interlacing the outputs of the last mentioned clippers.

4. In a polychromatic television receiver, video signals separated by horizontal synchronizing pulses of uniform width and the frames by vertical synchronizing pulses of varying widths all of said pulses being superimposed on pedestals, a clipper and a plurality of mixers connected with the receiving means, the output of said clipper consisting of said synchronizing pulses devoid of said pedestal pulses, width discriminators connected with the last mentioned clipper and each arranged to segregate a vertical synchronizing pulse of a particular width, said discriminators controlling said mixers, and means for interlacing the outputs of the mixers.

5. In a polychromatic television receiver, means for receiving video signals separated by horizontal synchronizing pulses of uniform width and vertical synchronizing pulses all of said pulses being superimposed on pedestal pulses of varying widths, a clipper and three mixers connected in multiple with the receiving means, the output of said clipper consisting of said synchronizing pulses devoid of said pedestal pulses, three width discriminators connected in multiple with the last mentioned clipper and each arranged to segregate

a vertical synchronizing pulse of a particular width, three flip-flop circuits connected with the outputs of the last mentioned width discriminators, the first circuit with the first and second, the second with the second and third, and the third with the third discriminator, a connection from each flip-flop circuit to a different one of the mixers, a clipper to which the output circuit of each mixer is fed, and means for interlacing the outputs of the last mentioned clippers.

6. A television system comprising in the transmitter, a camera for producing in a plurality of output circuits video signals, a generator of pedestals for vertical synchronizing pulses having its output circuit connected with the output circuits of the camera, clippers, one connected with each of the connected circuits, a pulse generator controlling the first mentioned generator, a plurality of passive delay networks controlled by the pulse generator, each delaying to a different extent the generated pulses, a width discriminator connected with each network and arranged to produce pulses whose width is determined by the pulse produced by the associated network, a mixer to which the clippers and discriminators are connected, and means for transmitting the output of the mixer; and in the receiver, means for receiving the transmitted signals, a clipper and a plurality of mixers connected in multiple with the receiving means, the output of said clipper corresponding to the combined outputs of the width discriminators at the transmitter but devoid of said pedestals, a plurality of pulse width discriminators connected in multiple with the last mentioned clipper and each arranged to segregate a pulse of a particular width, a plurality of timing circuits connected with the outputs of the last mentioned width discriminators, a connection from each timing circuit to a different one of the mixers in the receiver, a clipper to which the output circuit of each mixer is fed, and means for interlacing the outputs of the last mentioned clippers.

7. A polychromatic television system comprising in the transmitter, a camera for producing lines of video signals, in each circuit representing different colors, means for producing frame synchronizing pulses superimposed on pedestal pulses, means for modulating the width of said synchronizing pulses to differentiate between successive frames of different color, a mixer for said signals and pulses, and means for transmitting the output of the mixer, and in the receiver, means for receiving the transmitted signals, means for discriminating said pulses, means for eliminating said pedestal pulses and means for interlacing lines of successive frames under the control of said pulse.

8. A polychromatic television system comprising in the transmitter, a camera for producing in a plurality of output circuits video signals, each representing a different color, a generator of pedestals for vertical synchronizing pulses having its output circuits connected with the output circuits of the camera, clippers, one connected with each of the connected circuits, a pulse generator controlling the first mentioned generator, means controlled by the pulse generator to produce pulses of a plurality of different widths, a mixer in which the last mentioned pulses are combined with the outputs of said clippers, and means for transmitting the output of the mixer; and in the receiver, means for receiving the transmitted signals, a clipper and a plurality of mixers connected with the receiving means, the output of said clipper corresponding to the last mentioned pulses of different widths devoid of said pedestal pulses, width discriminators connected with the last mentioned clipper and each arranged to segregate a pulse of a particular width, said discriminators controlling said last mentioned mixers, and means for interlacing the outputs of the last mentioned mixers.

9. A polychromatic television system comprising in the transmitter, a camera for producing in three output circuits video signals, each representing a different color, a generator of pedestals for vertical synchronizing pulses having output circuits connected with the output circuits of the camera, three clippers, one connected with each of the connected circuits, a color pulse generator controlling the first mentioned generator, three passive delay networks controlled by the color pulse generator, each adapted to delay to a different extent the pulses generated by the latter, a width discriminator connected with each network and arranged to produce pulses whose width is determined by the pulse produced by the associated network, a mixer in which the three clippers and discriminators are connected, and means for transmitting the output of the mixer; and in the receiver, means for receiving the transmitted signals, a clipper and three mixers connected in multiple with the receiving means, the output of said clipper corresponding to the combined outputs of the three width discriminators at the transmitter devoid of said pedestals, three width discriminators connected in multiple with the last mentioned clipper and each arranged to segregate a pulse of a particular width, three flip-flop circuits connected with the outputs of the last mentioned width discriminators, the first circuit with the first and second, the second with the second and third, and the third with the third discriminator, a connection from each flip-flop circuit to a different one of the mixers in the receiver, a clipper to which the output circuit of each mixer is fed, and means for interlacing the outputs of the last mentioned clippers.

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REFERENCES CITED

The following references are of record in the file of this patent:

UNITED STATES PATENTS

Number	Name	Date
2,109,540	Leishman	Mar. 1, 1938
2,261,762	Hazeltine	Nov. 4, 1941
2,295,023	Beatty	Sept. 8, 1942
2,301,521	Cawein	Nov. 10, 1942
2,306,386	Hollywood	Dec. 29, 1942
2,309,506	Herbst	Jan. 26, 1943
2,319,789	Chambers	May 25, 1943
2,406,760	Goldmark	Sept. 3, 1946