June 2, 1942. A. V. BEDFORD 2,284,714

TELEVISION SYSTEM

Filed Dec. 18, 1937 7 Sheets-Sheet 1

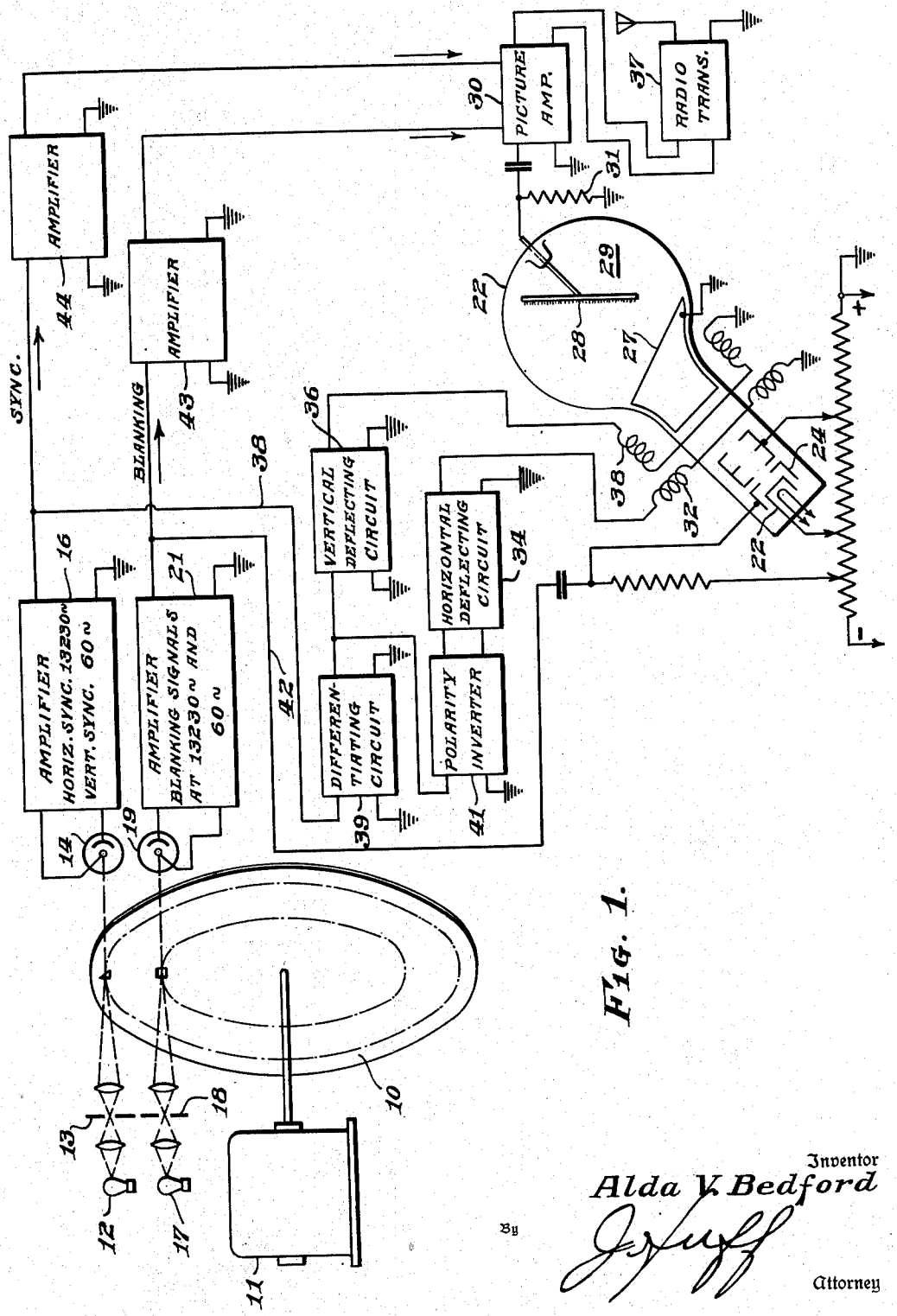


FIG. 1.

Inventor
Alda V. Bedford

By

Attorney

June 2, 1942. A. V. BEDFORD 2,284,714

TELEVISION SYSTEM

Filed Dec. 18, 1937 7 Sheets-Sheet 2

FIG. 2.

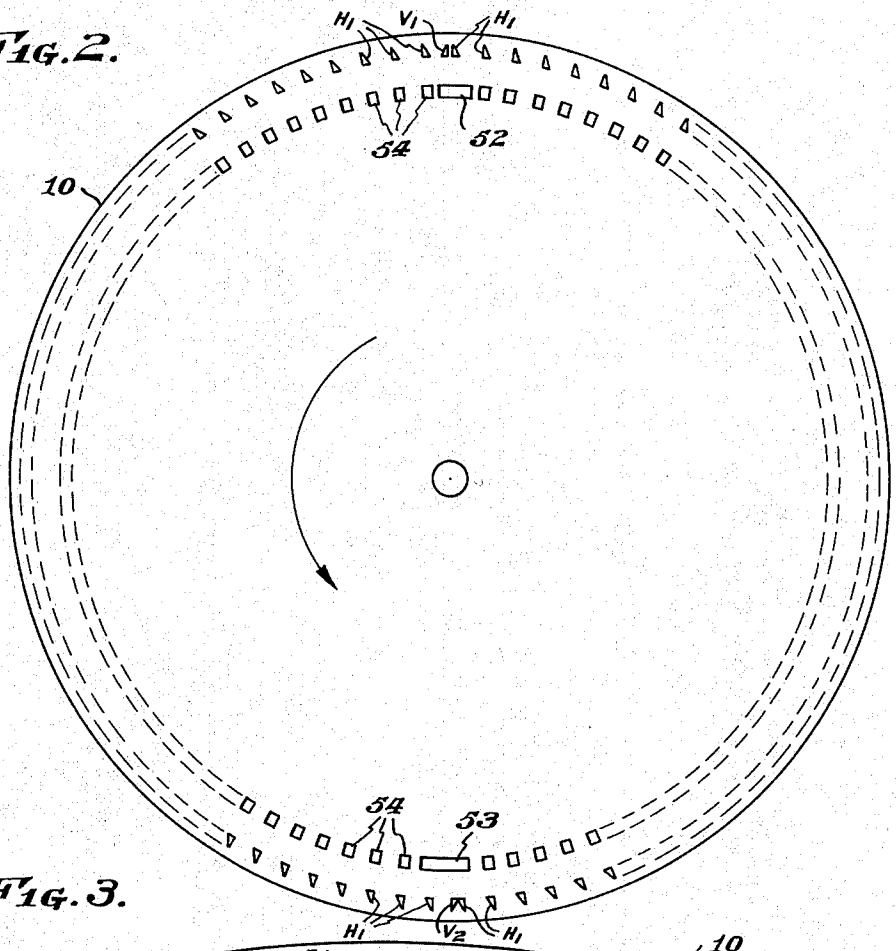
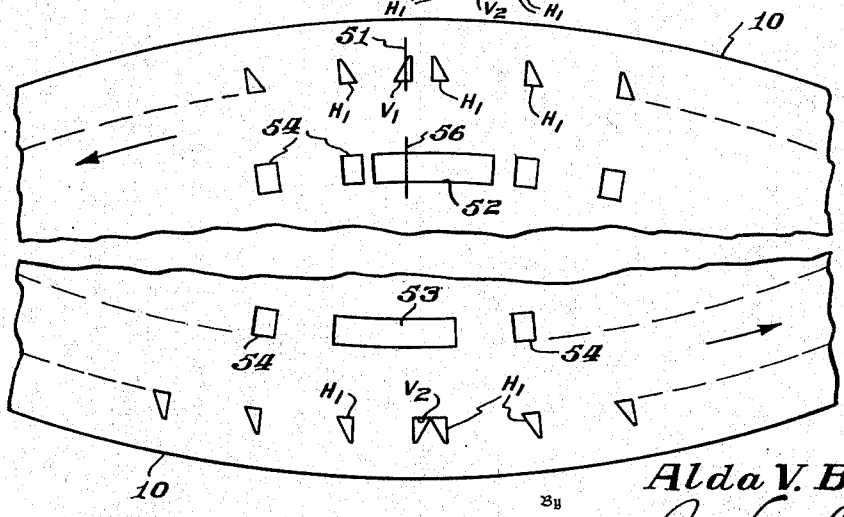


FIG. 3.



Inventor

Alda V. Bedford

By

Attorney

June 2, 1942. A. V. BEDFORD 2,284,714

TELEVISION SYSTEM

Filed Dec. 18, 1937 7 Sheets-Sheet 3

FIG. 4.

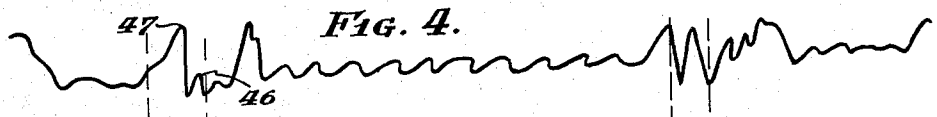


FIG. 5.

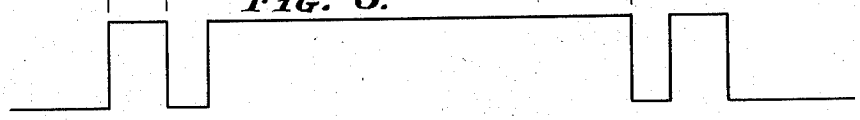


FIG. 6.

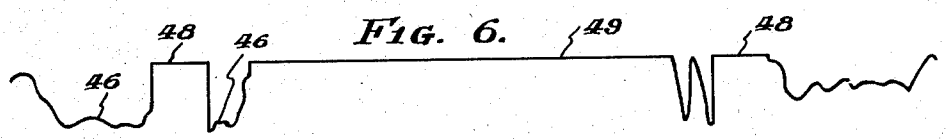


FIG. 7.

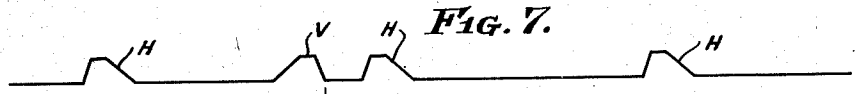


FIG. 8.

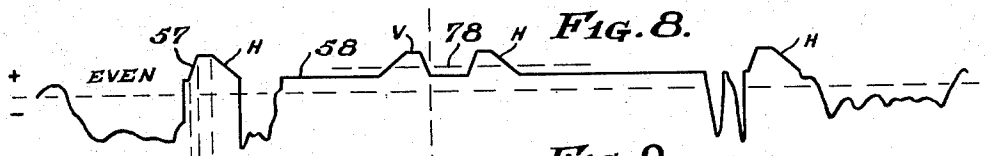


FIG. 9

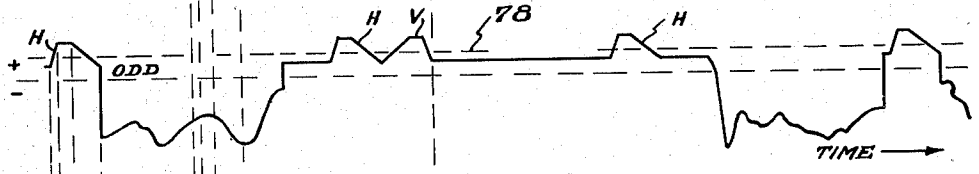


FIG. 10.

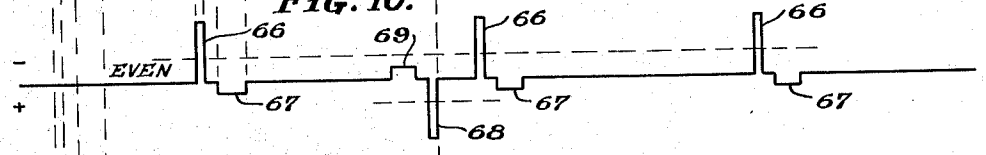
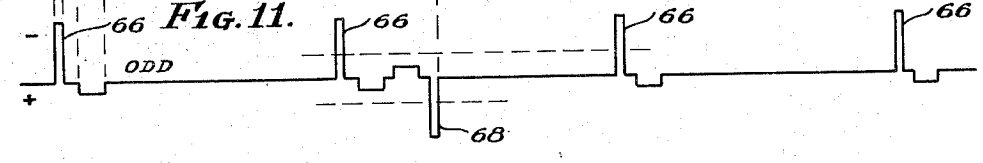


FIG. 11.



Inventor

Alda V. Bedford

By

Attorney

June 2, 1942. A. V. BEDFORD 2,284,714

TELEVISION SYSTEM

Filed Dec. 18, 1937 7 Sheets-Sheet 4

FIG. 12.

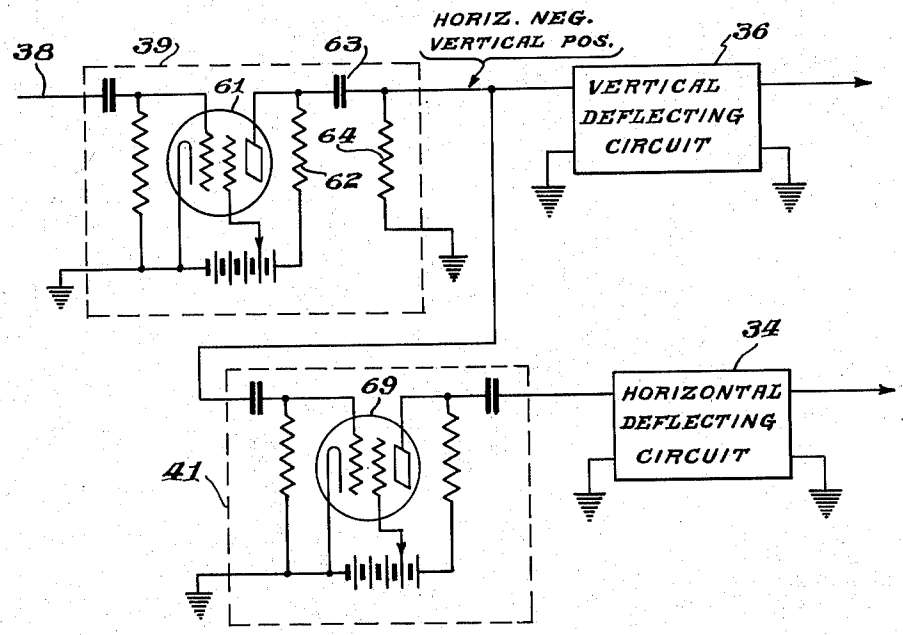
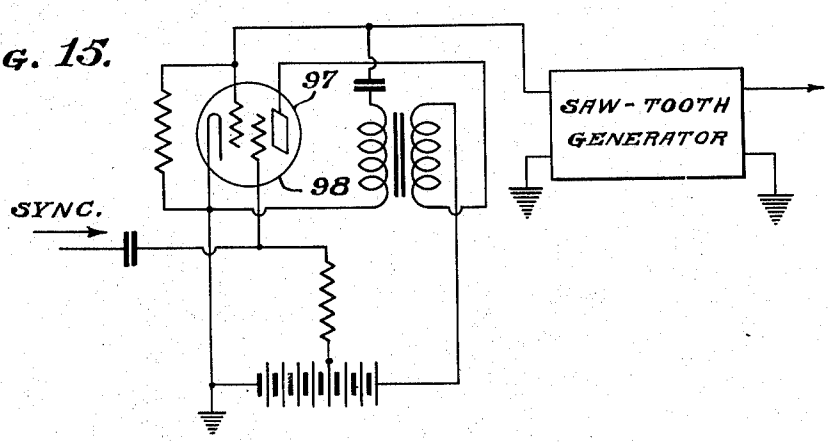


FIG. 15.



Inventor
Alda V. Bedford

By

Attorney

June 2, 1942. A. V. BEDFORD 2,284,714

TELEVISION SYSTEM

Filed Dec. 18, 1937 7 Sheets-Sheet 5

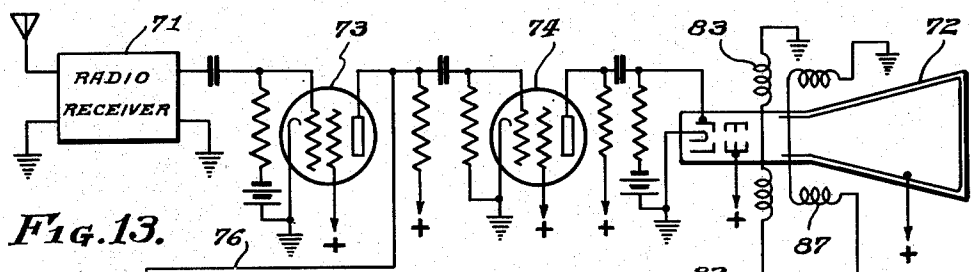
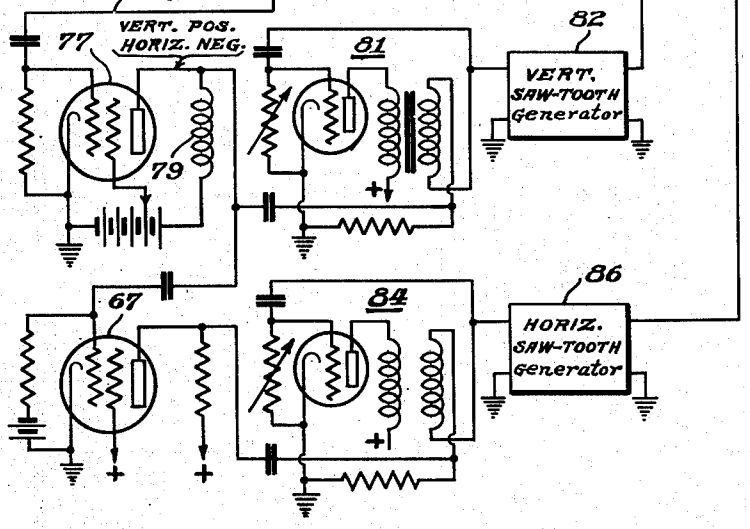


FIG. 13.



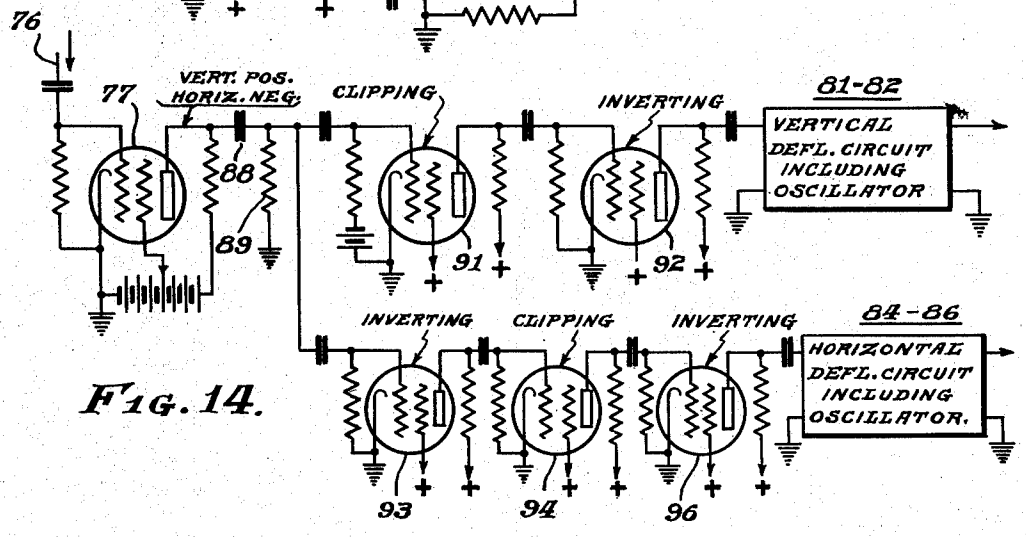


FIG. 14.

Inventor
Alda V. Bedford

By

Attorney

June 2, 1942. A. V. BEDFORD 2,284,714

TELEVISION SYSTEM

Filed Dec. 18, 1937 7 Sheets-Sheet 6

FIG. 16.

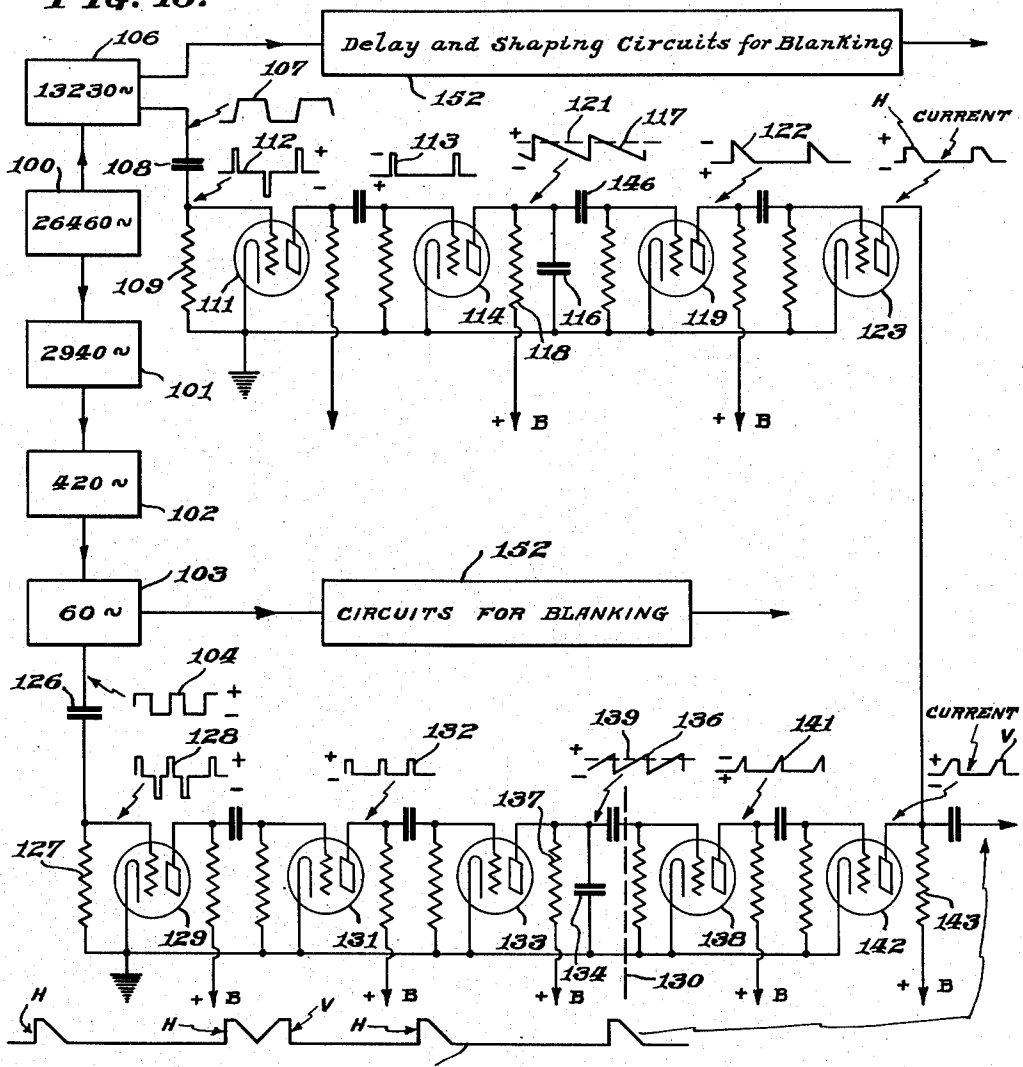


FIG. 17.

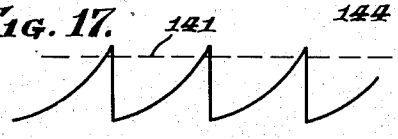


FIG. 18.

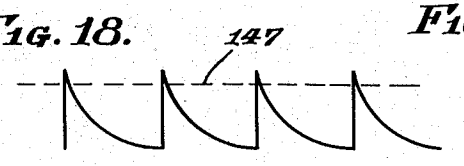
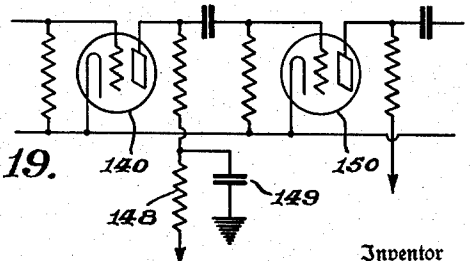


FIG. 19.



Inventor

Alda V. Bedford

By

Attorney

June 2, 1942. A. V. BEDFORD 2,284,714

TELEVISION SYSTEM

Filed Dec. 18, 1937 7 Sheets-Sheet 7

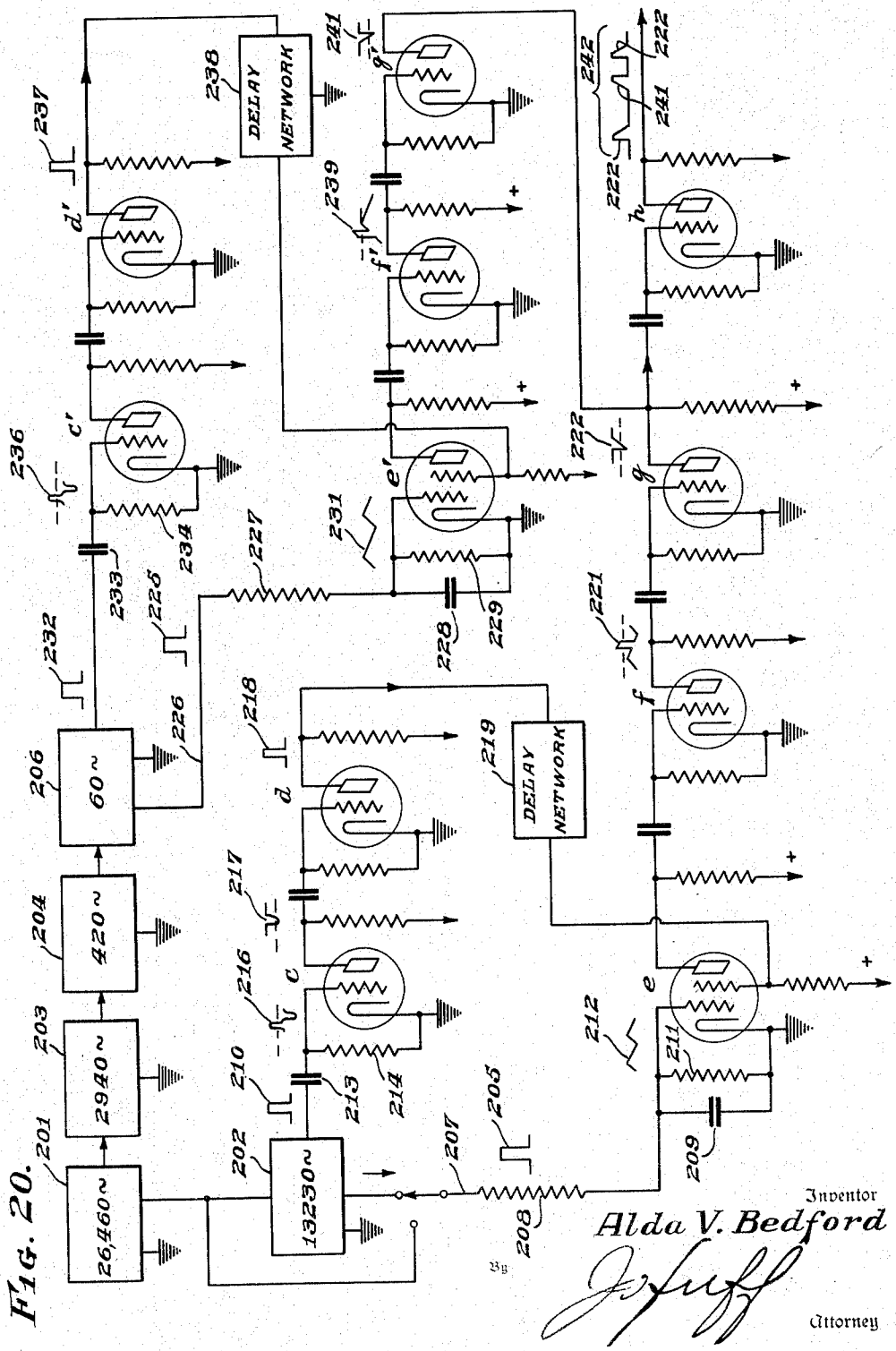


FIG. 20.

Inventor
Alda V. Bedford
By
Attorney

Patented June 2, 1942 2,284,714

UNITED STATES PATENT OFFICE

2,284,714

TELEVISION SYSTEM

Alda V. Bedford, Collingswood, N. J., assignor to Radio Corporation of America, a corporation of Delaware

Application December 18, 1937, Serial No. 180,493

8 Claims. (Cl. 178—6.8)

My invention relates to television systems and particularly to the feature of providing synchronism between the scanning at the television transmitter and the scanning at the television receiver.

In television systems it is the usual practice to maintain synchronism between the transmitter and the receiver by transmitting horizontal synchronizing impulses at the end of each scanning line and vertical synchronizing impulses at the end of each picture frame, all the synchronizing impulses being combined with the picture signals and transmitted as a composite signal.

In order that the synchronizing signals may be separated from the picture signals at the receiver, the synchronizing impulses are made of greater amplitude than picture signals of like polarity. Thus amplitude separation may be employed by means of a separating or "clipping" tube.

After the picture signals have been removed it is the usual practice to separate the horizontal synchronizing impulses from the vertical synchronizing impulses either by amplitude selection or by frequency selection.

When amplitude selection is employed it has been customary to transmit the vertical synchronizing impulses with a greater amplitude than the horizontal synchronizing impulses or vice versa. While this method gives very exact synchronizing, it is undesirable because it is uneconomical of the transmitter power, too much power being utilized for synchronizing signals and not enough for picture signals.

Frequency separation of horizontal synchronizing impulses and vertical synchronizing impulses is satisfactory from the transmitter power standpoint but it has been found that it does not give as exact synchronization as is desired, especially when the picture is being interlaced. This is due largely to the fact that, in order to obtain frequency separation, the vertical synchronizing impulses are of much longer duration than the horizontal synchronizing impulses and that the vertical synchronizing impulses are supplied to an integrating circuit at the receiver whereby the desired separation results. One way of improving the operation of a system of this type is described and claimed in my United States Patent No. 2,192,121, issued February 27, 1940, entitled "Television systems and the method of operation thereof," and assigned to the Radio Corporation of America.

An object of my invention is to provide an improved method of and means for synchronizing the scanning at a picture transmitter with the scanning at the receiver.

A further object of my invention is to provide a method of and means for synchronizing the transmitter and receiver of a television system which combine the advantages of the above-mentioned methods of synchronizing impulse selection or separation without their disadvantages.

A further object of my invention is to provide a method of and means for obtaining very exact synchronizing in a television system without being wasteful of transmitter power.

A further object of my invention is to provide a method of and means for obtaining complete isolation of horizontal synchronizing impulses and vertical synchronizing impulses.

A still further object of my invention is to provide improved interlaced scanning for television systems.

A still further object of my invention is to provide an improved television transmitter.

A still further object of my invention is to provide an improved television receiver.

A still further object of my invention is to provide an improved means for and a method of producing recurring impulses each having a front side of different slope than its back side.

In a preferred embodiment of my invention I produce horizontal synchronizing impulses and vertical synchronizing impulses which differ from each other in that in one group of impulses each impulse has a steep front side and a gradually sloping back side while in the other group of impulses each impulse has a steep back side and a gradually sloping front side. For example, each horizontal synchronizing impulse may have a steep front while each vertical synchronizing impulse has a steep back side. Preferably, the two groups of impulses have the same amplitude whereby transmitter power is conserved just as in the case of frequency separation of synchronizing impulses.

At the receiver, after removal of picture signals in a conventional manner, the horizontal and vertical synchronizing impulses are passed through a differentiating circuit whereby the steep front edge of a horizontal synchronizing impulse produces a sharp positive impulse while the steep back edge of a vertical synchronizing impulse produces a sharp negative impulse, this difference in polarity being due to the fact that a steep front is rising whereas a steep back side is falling.

The positive polarity horizontal synchronizing impulses and the negative polarity vertical syn-

chronizing impulses may then be separated from each other and impressed upon their respective deflecting circuits for maintaining synchronism between transmitter and receiver. Or, as will be more fully explained hereinafter, after differentiation the two groups of synchronizing signals may be impressed upon the deflecting circuit oscillators without separation provided the polarity of the synchronizing signals is reversed for one deflecting circuit. In other words, certain oscillators, such as blocking oscillators, will synchronize only on positive impulses, the presence of negative impulses not being detrimental.

The invention will be better understood from the following description taken in connection with the accompanying drawings, in which

Figure 1 is a block diagram of a television transmitter embodying my invention,

Figure 2 is a view of the synchronizing and blanking impulse generating disc shown in Fig. 1,

Figure 3 is an enlarged view of the upper and lower sections of the disc shown in Fig. 2,

Figures 4 to 11 are curves showing the shapes of the synchronizing impulses and also showing how they are combined with the picture and blanking signals,

Figure 12 is a circuit diagram of a portion of the transmitter shown in Fig. 1,

Figures 13 and 14 are circuit diagrams of two television receivers constructed in accordance with different embodiments of my invention,

Figure 15 is a circuit diagram showing one way of synchronizing a deflecting circuit in a system embodying my invention,

Figure 16 is a circuit diagram of an electronic generator for producing synchronizing signals in accordance with my invention,

Figures 17 and 18 are curves which are referred to in explaining a modification of the invention shown in Fig. 16,

Figure 19 is a circuit diagram showing a modification of a portion of the circuit shown in Fig. 16, and

Figure 20 is a circuit diagram of another electronic generator for producing synchronizing signals in accordance with my invention.

Before describing the transmitter shown in Fig. 1, it will be helpful to refer to Fig. 7 which shows the shape of the horizontal synchronizing impulses indicated at H and of the vertical synchronizing impulses indicated at V. It will be seen that each of the impulses H has a steep front and a gradually sloping back while the impulse V has a gradually sloping front and a steep back. It will be noted that the H and V impulses are of the same amplitude and that an H impulse has substantially the same duration and energy content as a V impulse. Yet, at the receiver the horizontal synchronizing impulses and the vertical synchronizing impulses may be separated if the signals shown in Fig. 7 are passed through a differentiating circuit. This produces signals of the character shown in Fig. 10. It is apparent that here the horizontal synchronizing impulses and the vertical synchronizing impulses are of opposite polarity and may be separated from each other by amplitude selection.

Referring now to Fig. 1, I have shown merely by way of example, a transmitter in which a disc 10 rotated by a motor 11 is employed for producing synchronizing impulses of the desired shape. Near the periphery of the disc 10 there are openings for producing the synchronizing impulses. The other row of openings is for producing blanking impulses. The shapes and spacings of the openings will be described later in connection with Figs. 2 and 3.

To produce the horizontal synchronizing impulses, a source of light 12, a mask 13 having a slit therein, and a suitable optical system form a vertical slit of light on the row of synchronizing openings. As an opening rotates past this slit of light an amount of light dependent upon the shape of the opening passes therethrough and impinges upon a photoelectric cell 14 to produce voltage impulses of the desired shape at the input of an amplifier 16.

Blanking impulses are produced in a similar manner by means of a light source 17, a slotted mask 18 and a suitable optical system which form a vertical slit of light on the row of blanking openings. Thus an amount of light dependent upon the shape of a blanking opening reaches a photoelectric cell 19 whereby voltage impulses of the desired shape and duration are supplied to the input of an amplifier 21.

The device for generating the picture signal is illustrated as a cathode ray transmitter tube of well-known design. It comprises a highly evacuated envelope 22 having therein a cathode 23, a grid 24, a first anode 26 and a second anode 27 for producing an electron beam. Envelope 22 also contains a mosaic 28 of photoelectric elements which are insulated from each other and from a metallic back plate 29.

An optical image of the subject to be transmitted is projected upon the mosaic 28 whereby an electrostatic image is formed thereon. Thus, when the mosaic is scanned by the cathode ray, picture signals are produced which appear across an output resistor 31 connected between the back plate 29 and the second anode 27. These pictures are then amplified by a picture amplifier 30 and supplied to a radio transmitter 37.

The cathode ray may be caused to scan the mosaic 28 by means of horizontal and vertical deflecting coils 32 and 33, respectively, which are supplied with saw-tooth current from their respective deflecting circuits 34 and 36.

The horizontal deflection and the vertical deflection of the cathode ray of the transmitter tube are made to occur in the proper time relation by means of the synchronizing impulses supplied from amplifier 16 over a conductor 38 to a differentiating circuit 39 in the output of which appear signals of the character shown in Fig. 10.

The deflecting circuits 34 and 36 may be of any suitable design, each deflecting circuit including an oscillator such as a blocking oscillator. A deflecting circuit of this character is described in Tolson Reissue Patent 20,338.

Since a blocking oscillator is pulled into synchronism by impulses of positive polarity, the output of the differentiating circuit may be impressed directly upon the horizontal deflecting circuit whereby the positive horizontal synchronizing impulses control the horizontal deflection.

By passing the output of circuit 39 through a polarity inverter 41, such as a single amplifier tube, the vertical synchronizing impulses are given a positive polarity whereby they, when impressed directly upon the vertical deflecting circuit, control the vertical deflection.

Suitable differentiating circuits will be described in detail hereinafter.

Blanking signals from the output of amplifier 21 are supplied over a conductor 42 to the grid 24 of the cathode ray transmitter tube for block-

ing the cathode ray during the horizontal return period and during the vertical return period.

Since the synchronizing and blanking signals are to be transmitted together with the picture signals to a receiver, the blanking signals are supplied through an amplifier 43 to a suitable amplifier stage in the picture amplifier 30 for removing undesired transient signals from the picture signals and for producing pedestals upon which the synchronizing impulses are to be located.

The synchronizing impulses are supplied through an amplifier 44 to a later stage in the picture amplifier 30 where they are added to the picture and blanking signals.

The way in which picture, blanking and synchronizing signals are added is illustrated in Figs. 4 to 8. The picture signal appearing across resistor 31 is shown in Fig. 4 at 46. It is mixed with the blanking signals shown in Fig. 5 whereby undesired transients 47 are removed from the region of the picture signals. These transients are next clipped off to produce the signal shown in Fig. 6 consisting of picture signals 46 and pedestals 48 and 49 which, at the receiver, provide horizontal return line and vertical return line blanking, respectively.

The synchronizing signals shown in Fig. 7 are then added to the signal shown in Fig. 6 to produce the complete signal shown in Fig. 8, this complete signal being used to modulate the radio transmitter carrier.

The above-described method of combining picture signals, pedestals and synchronizing impulses is described and claimed in my above-mentioned United States Patent 2,192,121.

Now referring more in detail to the impulse generating disc 10, the shapes of the synchronizing and blanking openings and their relative locations are shown in Fig. 2 and in the fragmentary views in Fig. 3. Referring to Figs. 2 and 3, the two diametrically opposed openings V_1 and V_2 for producing the vertical synchronizing impulses V shown in Figs. 8 and 9 have a steep front side and a gradually sloping back side, it being noted that the disc 10 is rotated in the direction of the arrow. The slit of light which is projected upon the row of synchronizing openings is indicated at 51.

The openings H_1 which produce the horizontal synchronizing impulses H shown in Figs. 8 and 9 have steep front sides and gradually sloping back sides.

The relation between the openings V_1, V_2 and H_1 is such as to produce interlaced scanning in the manner described and claimed in United States Patent No. 2,152,234, issued March 28, 1939, in the name of R. C. Ballard, entitled "Television systems" and assigned to the Radio Corporation of America. In my disc shown in Fig. 2, the steep edge of an opening corresponds to the center of an opening in the disc shown in this Ballard patent.

As taught by Ballard, the interlacing is obtained by having the horizontal synchronizing impulse immediately following the impulse produced by opening V_2 occur one-half line later than the horizontal synchronizing impulse immediately following the impulse produced by opening V_1.

For the specific transmitter being described, the disc 10 is rotated at 30 rotations per second whereby 60 vertical synchronizing impulses per second are transmitted. To produce a 441-line picture, 441 openings H_1 are required, this giving a horizontal synchronizing frequency of 13,230 impulses per second. On the drawings, no attempt has been made to draw the disc openings in the proper scale to include all 441 openings H_1 on a disc of the size shown.

Referring now to the openings for producing the blanking impulses of the character shown in Fig. 5, openings 52 and 53 are opposite openings V_1 and V_2, respectively, and the immediately adjacent openings H_1 for producing the vertical blanking impulses which form the pedestals 49. Opposite the remaining openings H_1 there are the openings 54 for producing the horizontal blanking impulses which form the pedestals 48 (Fig. 6). The slit of light which is projected upon the row of blanking openings is indicated at 56.

Preferably the front edges of the blanking openings are located slightly ahead of the synchronizing openings to produce a "shelf" at the front of the synchronizing impulses, as indicated at 57 and 58 in Fig. 8.

While my invention is being described in connection with an interlaced scanning system and is especially useful in such a system for obtaining exact interlacing, it should be understood that the invention is not limited to scanning of this type.

In Fig. 9 there is shown the complete signal as it occurs 1/60 second after the occurrence of the signal shown in Fig. 8, the steep fronts of the impulses H in Fig. 9 for the odd lines falling half way between the steep fronts of the impulses H in Fig. 8 for the even lines.

I shall now describe how the synchronizing impulses supplied from amplifier 16 in Fig. 1 are utilized for synchronizing purposes. Referring to Figs. 1 and 12, synchronizing impulses of the character shown in Fig. 7 and of positive polarity are supplied to the differentiating circuit 39. In the specific embodiment shown in Fig. 12, circuit 39 comprises a vacuum tube 61 which is biased during operation to function as an amplifier. This bias may be grid leak bias maintained by the periodically recurring horizontal synchronizing impulses which are of positive polarity at the input of tube 61. Or the control grid of tube 61 may be properly biased by means of a biasing battery or other suitable biasing source.

Plate voltage may be supplied to the plate of tube 61 through a plate resistor 62.

The synchronizing impulses appearing across resistor 62, which are as shown in Fig. 7 but amplified and inverted in polarity, are impressed across a differentiating circuit consisting of a condenser 63 of small capacity and a resistor 64 of comparatively low resistance. The resistance of plate resistor 62 should be low compared with the resistance of resistor 64 whereby the current flow through resistor 64 is determined mainly by the impedance of condenser 63. The resistance of 62 may be 1/20 of the resistance of 64, for example. The time constant of the circuit 62—63—64 should be short compared with the duration of each horizontal synchronizing impulse supplied over conductor 38. For example, this time constant may be 1/5 of the duration of such an impulse. It will be understood that the values are not critical and that exact or complete differentiating is not required. Substantial differentiation is all that is required.

The resulting signal appearing across the resistor 64 is as shown in Fig. 10. The action of the differentiating circuit will be seen by comparing Figs. 7 and 10 which are in the same time

relation where Fig. 7 shows the signal which is being impressed upon the input circuit of a tube having a differentiating circuit in its output circuit. It will be seen that the steep front of impulse H causes a negative impulse **66** of substantial amplitude while the gradually sloping back of impulse H causes a positive impulse **67** of small amplitude.

On the other hand, the steep back of impulse V causes a positive impulse **68** of substantial amplitude while the gradually sloping front of impulse V causes a negative impulse **69** of small amplitude.

Where interlacing is employed, the impulses occurring 1/60 second later are in the time relation shown in Fig. 9 and these impulses produce across resistor **64** the impulses shown in Fig. 11.

Since, as indicated by the legend in Fig. 12, the vertical impulses **68** have been made to appear with a positive polarity at the high potential end of resistor **64**, they may be applied directly to the blocking oscillator (not shown) in the deflecting circuit **36**, the negative horizontal impulses having no effect on the oscillator.

As indicated at **41**, an amplifier tube **69** reverses the polarity of the differentiated signals whereby the horizontal impulses **66** are applied with a positive polarity to the blocking oscillator (not shown) in the deflecting circuit **34**, the negative vertical impulses having no effect upon the oscillator.

In Fig. 13 there is shown a receiver designed for the reception of the signals radiated by the transmitter shown in Fig. 1. It comprises a suitable radio receiver **71** which demodulates the received carrier wave and supplies the composite signal shown in Figs. 8 and 9 to a cathode ray receiver tube **72** through amplifier tubes **73** and **74**.

From the output circuit of tube **73**, where the synchronizing impulses are of positive polarity, the composite signal is fed over a conductor **76** to a separating tube **77** which clips the signal at the level indicated by the dotted line **78** in Figs. 8 and 9 to pass only the synchronizing impulses.

Separating tube **77** preferably is grid leak biased as described and claimed in United States Patent No. 2,207,839, issued July 16, 1940, in the name of W. A. Tolson, and assigned to the Radio Corporation of America.

In this embodiment of the invention the plate circuit of tube **77** includes an inductance coil **79** which, at the highest frequency components of the synchronizing impulses, has an impedance which is low compared with the plate impedance of tube **77**. With this impedance relation of coil **79** and tubes **77**, the current flow through coil **79** is substantially independent of the coil impedance whereby the current impulses through coil **79** have the same wave shape as the voltage synchronizing impulses on the control grid of tube **77**.

Since the voltage appearing across coil **79** is equal to

$$L\frac{di}{dt}$$

where L is the coil inductance and where i is the current flowing through the coil, it is apparent that the voltage across coil **79** is the derivative of the voltage impressed upon the control grid of tube **77**.

Thus, impulses like those shown in Figs. 10 and 11 are supplied to the deflecting circuits. In the vertical deflecting circuit the positive vertical impulses **68** (Figs. 10 and 11) are impressed directly upon the grid circuit of a blocking oscillator **81** which is part of the vertical deflecting circuit.

The oscillator **81**, which is adjusted to oscillate uncontrolled at a slightly lower frequency than the rate at which impulses **68** occur, is pulled in step by impulses **68** whereby sharp negative impulses of large amplitude are supplied to a suitable saw-tooth current generator **82** which makes up the remainder of the vertical deflecting circuit for causing a flow of saw-tooth curernt through vertical deflecting coils **83**.

The negative synchronizing impulses **66** (Figs. 10 and 11) are reversed in polarity by amplifier tube **67** whereby positive horizontal synchronizing impulses are supplied to the blocking oscillator **84** of the horizontal deflecting circuit. Oscillator **84** impresses sharp negative impulses upon the saw-tooth current generator **86** to cause a flow of saw-tooth current through the horizontal deflecting coils **87**.

The above-described vertical and horizontal deflecting circuits may be designed in accordance with the teachings of Tolson Reissue Patent 20,338 and/or United States Patent No. 2,101,520, issued December 7, 1937, as a joint invention of W. A. Tolson and J. R. Duncan, and assigned to the Radio Corporation of America.

It will be understood that my invention is not limited to any particular type of deflecting circuit. For example, a multivibrator or a gas tube oscillator may replace the blocking oscillator, or the synchronizing impulses may be amplified sufficiently to be impressed directly upon the saw-tooth generator without the use of an oscillator. Obviously electrostatic deflection may be utilized in place of electromagnetic deflection.

In some cases it may be desirable to isolate the horizontal synchronizing impulses **66** and the vertical synchronizing impulses **68** from each other before they are supplied to their respective deflecting circuits. This may be done as shown in Fig. 14, where parts corresponding to those in Fig. 13 are indicated by the same reference numerals.

In this circuit the separating tube operates the same as the separating tubes shown in Figs. 12 and 13 while the differentiating circuit is the same as shown in Fig. 12, comprising the small capacity condenser **88** and the resistor **89**.

The differentiated signals, having the polarity indicated by the legend, are supplied to a negatively biased clipping tube **91** in the vertical deflecting channel whereby only the positive vertical synchronizing impulses appear in the clipping tube output circuit. These impulses are then reversed in polarity or inverted by a tube **92** whereby they are supplied with a positive polarity to the deflecting circuit **81—82**.

In the horizontal deflecting circuit, the differentiated signals are inverted by a tube **93** whereby positive horizontal synchronizating impulses are supplied to a clipping tube **94**. Only horizontal synchronizing impulses appear in the output of tube **94**. As they are of negative polarity, they are inverted by a tube **96** before being impressed upon the deflecting circuit **84—86**.

It will be understood that the differentiated synchronizing impulses may be applied in various ways to an oscillator for pulling it into synchronism. For example, as shown in Fig. 15, a blocking oscillator of the type described in the above-mentioned Tolson patent may comprise a screen grid tube **97** having its cathode con-

trol grid and plate connected in the usual way to form a blocking oscillator. The screen grid 98 is utilized for synchronizing purposes, the differentiated synchronizing impulses being impressed upon the screen grid as indicated.

In Figure 16 there is illustrated an electronic generator which may be utilized in place of the rotatable disc and associated elements shown in Fig. 1 for producing the desired synchronizing impulses. The specific circuit illustrated is designed to provide interlaced scanning as described and claimed in my United States Patent No. 2,178,218, issued October 31, 1939, and assigned to the Radio Corporation of America. As described in the said patent, a main oscillator 100, operating at double the horizontal scanning frequency, supplies voltage impulses to a chain of frequency dividers 101, 102 and 103 to produce rectangular impulses occurring at the picture frame frequency of 60 per second as indicated at 104.

The main oscillator 100 also supplies voltage impulses to an oscillator 106 which supplies rectangular voltage impulses, indicated at 107, occurring at one half the main oscillator frequency. In the generator illustrated, the horizontal and vertical synchronizing impulses occur at the proper frequencies to produce a 441-line interlaced picture.

The several oscillators may be of any suitable type such as multivibrators or blocking oscillators.

The desired horizontal synchronizing impulses having steep "front" and gradually sloping "backs" are produced as follows:

The impulses 107 are passed through a differentiating circuit comprising a small capacity condenser 108 and a resistor 109 in series, the resistor 109 being connected as the grid leak of a vacuum tube 111. The resulting voltage wave appearing on the grid of tube 111 is shown at 112.

The tube 111 is so biased and the amplitude of the input signal 112 is such that only the positive polarity impulses occurring at the rate of 13,230 per second appear in the plate circuit of tube 111, their polarity being inverted as indicated at 113.

Impulses 113 are impressed upon the grid of a vacuum tube 114 to produce a saw-tooth voltage in its plate circuit due to a condenser 116 of comparatively large capacity connected across the plate circuit. The saw-tooth voltage appearing across condenser 116 is indicated at 117. It will be seen that the voltage wave 117 is produced by the condenser 116 being charged through the plate resistor 118 while the tube 114 is driven to cut-off by impulses 113, and being discharged through tube 114 during the remaining period. It will be understood that the saw-tooth voltage 117 may be produced in other well-known ways.

In accordance with my invention the voltage wave 117 is supplied to the input of a vacuum tube 119 which is properly biased to pass only the peaks of the wave 117. That is, the wave 117 is clipped at the level indicated by the dotted line 121, to produce in the plate circuit of tube 119 the voltage impulses indicated at 122. It will be seen that they are recurring impulses having a time interval between them and having steep fronts and sloping backs.

The tube 119, like the other clipping tubes in the circuit, may be suitably biased by a battery (not shown) or by means of grid leak biasing, the latter means of biasing being employed in the electronic generator illustrated.

Preferably, the peaks of the impulses 122 are clipped off by means of another clipping tube 123 to produce the final horizontal synchronizing impulses indicated at H.

The vertical synchronizing impulses are produced as follows:

The 60-cycle rectangular impulses 104 supplied from oscillator 103 are passed through a differentiating circuit comprising a small capacity condenser 126 and a resistor 127 whereby the voltage impulses indicated at 128 are impressed upon the grid of a clipping tube 129. Only the positive impulses appear in the plate circuit of tube 129 and these are inverted by the vacuum tube 131 to produce the impulses indicated at 132 occurring at the rate of 60 per second.

The positive impulses 132 are impressed upon the grid of a vacuum tube 133 having a condenser 134 of comparatively large capacity connected across its plate circuit. As a result, the saw-tooth voltage indicated at 136 appears across the condenser 134. It will be noted that this saw-tooth voltage has a sloping "front" and a steep "back," just the opposite of the saw-tooth 117 produced in the other branch of the circuit.

The saw-tooth voltage 136 is produced by the condenser 134 being charged through the plate resistor 137 between the positive impulses 132, during which time tube 133 is biased substantially to cut-off by grid leak biasing, and then being discharged through tube 133 for the duration of a positive impulse 132. Of course, a suitable saw-tooth voltage may be produced in any well-known manner.

The saw-tooth wave 136 is impressed upon a tube 138 which is biased to clip the wave at the level indicated by the dotted line 139, thus passing only the positive peak of each saw-tooth. The resulting impulses which appear in the plate circuit of tube 138 are indicated at 141. It will be noted that their steep side is on the "back" of the wave rather than on the "front" of the wave, as in the case of the horizontal impulses 122.

As in the case of the horizontal impulses, the peaks of the vertical synchronizing impulses 141 are preferably clipped off by a clipping tube 142 to produce the final vertical synchronizing impulses indicated at V.

It may be noted that the synchronizing impulses H and V are not drawn to the same scale and that, because of this, the impulses V appear much closer together as compared with the spacing of the impulses H than they actually are.

The impulses H and V are added or combined by providing the tubes 123 and 142 with a common plate resistor 143. The resulting signal is indicated at 144 where the combined impulses H and V are shown in substantially their correct time relation. It will be understood that an impulse V may be made to occur in the desired time relation to the adjacent impulses H, for example, in the relation illustrated by curve 144, by delaying the various impulses a certain amount, if necessary, as taught by United States Patent No. 2,132,655, issued October 11, 1938, in the name of J. P. Smith, and assigned to the Radio Corporation of America.

Since in the above-described method of producing synchronizing impulses only a very small portion of a saw-tooth is utilized, it may be desirable to distort the saw-tooth before it is passed through the clipping tube. This is especially

true in the case of the vertical impulses where only about 1/2200 of a saw-tooth is utilized.

Less accuracy in clipping the horizontal saw-tooth voltage 117 is required if the coupling condenser 146 between tubes 114 and 119 is made of such small capacity that the low frequency components of the saw-tooth are greatly attenuated. This causes a voltage of the wave shape shown in Fig. 18 to be supplied to clipping tube 119 which clips the wave at the level indicated by the dotted line 147.

In producing the vertical synchronizing impulses, the saw-tooth may be distorted as shown in Fig. 17 by accentuating the low frequency components of the saw-tooth. This may be done by inserting between tubes 133 and 138 at the point indicated by the dotted line 130 the circuit shown in Fig. 19. Referring to Fig. 19, the saw-tooth wave appearing across condenser 134 (Fig. 16) is impressed upon an amplifier tube 140 which has in its plate circuit a filter comprising a resistor 148 and a condenser 149. The amplifier tube 150 inverts the saw-tooth wave whereby the tube 138 (Fig. 16) clips it at the level indicated by the dotted line 151 in Fig. 17. The low frequency components may be accentuated the desired amount by making condenser 149 of the proper capacity.

The desired blanking signals for the television system may be provided by suitable delay and shaping circuits represented by the blocks 152 and 153. Such circuits are described in the above-identified Smith patent.

Another suitable electronic generator for producing synchronizing signals in accordance with my invention is shown in Fig. 20. This specific generator is described and claimed in United States Patent No. 2,166,688, issued July 18, 1939, in the name of R. D. Kell, entitled "Television apparatus," and assigned to the Radio Corporation of America.

Referring to Fig. 20, there is shown another generator for a television system which produces a 441-line interlaced picture. It will be understood that the apparatus shown in Fig. 20, like the generator shown in Fig. 16, is located at the television transmitter and supplies horizontal and vertical synchronizing impulses to the deflecting circuits of both the cathode ray transmitter tube and the cathode ray tube at the receiver.

The horizontal and vertical synchronizing impulses are derived from a common source such as a multivibrator or other suitable oscillator 201. A second multivibrator 202 divides the frequency of the oscillator 201 by two to produce impulses at the line frequency, 13,230 cycles per second in the specific system being described.

A chain of multivibrators 203, 204 and 206 divide the frequency of oscillator 201 to produce impulses occurring at the picture frame frequency of 60 per second. It will be understood that the 60-cycle and 13,230-cycle impulses having the desired odd-line relationship for interlacing may be obtained in any other suitable way as by means of a rotating disc having suitable openings therein, as described and claimed in Patent 2,152,234, issued March 28, 1939, in the name of R. C. Ballard, entitled "Television systems," and assigned to the Radio Corporation of America, or by means of blocking oscillators as described and claimed in Patent 2,178,218, issued October 31, 1939, in the name of A. V. Bedford, entitled "Television systems," and assigned to the Radio Corporation of America.

The portion of the circuit which produces the horizontal synchronizing impulses will first be described. The saw-tooth voltage wave, which is to be combined with a rectangular impulse, is produced in this specific example by supplying a rectangular voltage impulse indicated at 205 from the oscillator 202 over a conductor 207 and through a resistor 208 to a condenser 209. The condenser 209 is connected across the input electrodes of a screen grid tube *e* and is shunted by a resistor 211, the resistor 211 having a high resistance, such as one megohm, as compared with the resistance of resistor 208. In practice, the resistor 208 may be the plate impedance of one of the multivibrator tubes.

Condenser 209 is charged suddenly through resistor 208 and discharged gradually through resistor 211, whereby a saw-tooth voltage wave indicated at 212 is impressed upon the control grid of tube *e*. Stated differently, the circuit 209, 211 integrates the impulses 205 to produce the saw-tooth wave 212.

The rectangular voltage which is to be combined with the saw-tooth wave is produced, in this specific example, by supplying rectangular voltage impulses indicated at 210 from oscillator 202 to a vacuum tube *c* through a differentiating circuit comprising a condenser 213 of small capacity and a resistor 214 of comparatively low resistance, the resistor 214 being connected across the input electrodes of the tube *c*. It will be understood that impulses 210 occur at the rate of 13,230 per second. A differentiating circuit of this character and its action is described and claimed in the above-mentioned Smith Patent No. 2,132,655.

The derivative of impulse 210 appears on the grid of tube *c* as indicated at 216.

Since tube *c* is adjusted to act as a "clipping tube," only the upper impulse portion of wave 216 passes through the tube. This portion appears inverted in the plate circuit of tube *c*, as indicated at 217, and is impressed upon a clipping tube *d* whereby a square-topped voltage wave appears in the output of tube *d* as indicated at 218. It will be noted that, by differentiating and clipping, the impulse 205 has been narrowed but not delayed.

Impulses 218 are combined with the saw-tooth waves 212 after impulses 218 have been suitably delayed in a delay network 219 to make the two groups of signals combine in the correct time relation. The desired addition of signals is obtained by impressing the delayed impulses 218 upon the screen grid of tube *e*. The combined signal, after being inverted by a tube *f*, is of the character indicated at 221.

Signal 221 is supplied to a clipping tube *g*, which clips signal 221 at the level indicated by the dotted line to produce the desired impulse, indicated at 222, having a steep front side and a gradually sloping back side.

The delay network 219 may be of any suitable design such as a conventional capacity-inductance network of recurrent sections, or it may be a network comprising vacuum tubes and wave shaping networks of the character described in the above-mentioned Smith United States Patent No. 2,132,655. In certain cases it will be preferable to insert the delay network 219 ahead of tube *c* in order that the delay network will not injure the wave shape obtained by the clipping action of tubes *c* and *d*.

Referring now to that portion of the circuit which produces the vertical synchronizing im-

pulses having a steep back side and a sloping front side, rectangular voltage impulses occurring at the framing frequency of 60 cycles per second and indicated at **225** are supplied from oscillator **206** over a conductor **226**, through a resistor **227** to a condenser **228** which is connected across the input electrodes of vacuum tube *e'*. Condenser **228** is shunted by a resistor **229** having comparatively high resistance. Thus, a saw-tooth voltage wave is supplied to the grid of tube *e'* as indicated at **231**. It will be seen that tube *e'* corresponds to tube *e* in the horizontal synchronizing circuit. Similarly, the vacuum tubes *c*,' *d'*, *f'* and *g'* now to be described correspond to tubes *c*, *d*, *f* and *g* in the horizontal synchronizing circuit.

The rectangular voltage impulse to be added to the saw-tooth **231** is obtained by taking from oscillator **206** a rectangular voltage impulse indicated at **232**, which occurs at the frame frequency of 60 per second, and supplying it to a differentiating circuit comprising a condenser **233** of small capacity and a resistor **234** of comparatively small resistance. The resulting signal indicated at **236** appearing on the grid of tube *c'* is clipped by tube *c'* as indicated by the dotted line and after further clipping by tube *d'* appears in the plate circuit of tube *d'* as a narrowed rectangular impulse indicated at **237**.

Impulses **237** are delayed by a delay network **238** which may be of the same type as delay network **219**. The delayed impulses **237** are added to the saw-tooth waves **231** by impressing them upon the screen grid of tube *e'*. The amount that impulses **237** are delayed is such as to make them add on the front side of the saw-tooth wave rather than on the back side as is the case in the horizontal synchronizing circuit. Thus, after being inverted by tube *f'*, the combined signal appears in the output circuit of tube *f'*, as indicated at **239**. This signal is then clipped by the tube *g'*, as indicated by the dotted line, to produce the desired signal having a steep back side and a sloping front side, as shown at **241**.

The vertical synchronizing signals **241** and the horizontal synchronizing signals **222** are combined in the common plate circuit of tubes *g* and *g'*, the combined signals then have their sharp peaks clipped off by a clipping tube *h* whereby there appears in the output circuit of tube *h* the desired signal of the character shown at **242**.

From the foregoing description, it will be apparent that various modifications may be made in my invention without departing from the spirit and scope thereof and I desire, therefore, that only such limitations shall be placed thereon as are necessitated by the prior art and are set forth in the appended claims.

I claim as my invention:

1. In a picture transmitting system, the method of synchronizing scanning at the receiver with scanning at the transmitter which comprises transmitting one group of synchronizing impulses each having a steep front side and having a gradually sloping back side and transmitting another group of synchronizing impulses each having a steep back side and a gradually sloping front side, intercepting said impulses at the receiver and substantially differentiating them, and utilizing the differentiated signals for synchronizing the scanning at the receiver.

2. The method of synchronizing the scanning of a view to be transmitted with the scanning at a receiver for receiving said view which comprises transmitting a group of synchronizing impulses occurring at a relatively high frequency and transmitting a group of synchronizing impulses occurring at a relatively low frequency, the impulses in one of said groups each having a steep front side and a gradually sloping back side, the impulses in the other of said groups each having a steep back side and a gradually sloping front side, intercepting both groups of said impulses at said receiver and substantially differentiating them whereby the steep sides of said impulses produce impulses of greater amplitude than the gradually sloping sides of said impulses and whereby the said impulses of greater amplitude produced by one of said groups of impulses are of opposite polarity to the said impulses of greater amplitude produced by the other of said groups of impulses, and utilizing the said impulses of greater amplitude for synchronizing the scanning at said receiver.

3. In a picture transmitting system, a picture transmitter including means for transmitting picture signals, means for generating and transmitting a group of recurring synchronizing impulses each having a front side which is steep as compared with its back side, means for simultaneously generating and transmitting another group of recurring synchronizing impulses each having a back side which is steep as compared with its front side, a picture receiver for receiving said picture signals and said groups of impulses, said receiver including means for differentiating said impulses whereby impulses of maximum amplitude and of a certain polarity are derived from one of said groups and whereby impulses of maximum amplitude and of the opposite polarity to said certain polarity are derived from the other of said groups, and means for utilizing said impulses of maximum amplitude for synchronizing the scanning at the receiver with the scanning at the transmitter.

4. A generator of synchronizing signals comprising means for producing a group of saw-tooth waves occurring at a comparatively high frequency, each of said waves having a front slope which differs from its back slope, means for clipping said waves near their peaks and passing said peaks to an output circuit, means for producing another group of saw-tooth waves occurring at a comparatively low frequency, each of said last-mentioned waves having a front slope which differs from its back slope, the ratio of the front slope to the back slope of the waves in one of said groups being greater than unity and the ratio of the front slope to the back slope of the waves in the other of said groups being less than unity, and means for clipping said low frequency waves near their peaks and passing said peaks to said output circuit.

5. In a television transmitting system, means for developing picture signals, means for developing line synchronizing signals having a leading edge of predetermined slope and a trailing edge of a different slope, means for developing a frame synchronizing signal having leading and trailing edges of different slopes, the slope of the leading and trailing edges of the frame synchronizing signal being different from the leading and trailing edges of the line synchronizing signal, and means for combining the picture, line and frame synchronizing signals.

6. In a television system means for developing picture signals, means for developing line synchronizing signals having a leading edge of a predetermined slope and a trailing edge of different slope, means for developing a frame syn-

chronizing signal having leading and trailing edges of different slopes which are different from the slopes of the leading and trailing edges of the line synchronizing signal, means for combining the picture, line and frame synchronizing signal, means for transmitting the combined signal to a receiving station, thermionic means at the receiving station for separating the picture signal from the synchronizing signals, a single induction coil in the output circuit of the thermionic means, and vertical and horizontal deflecting oscillators connected to the induction coil.

7. A television system adapted for the transmission and reception of a modulated-carrier wave, comprising means for developing and transmitting said carrier wave comprising means for generating a video-frequency wave of one polarity, means for developing a composite synchronizing signal of the other polarity including line-synchronizing and field-synchronizing impulses having leading and trailing edges of a predetermined difference in slope, the corresponding differences in slope of the line-synchronizing and field-synchronizing impulses being opposite in sense, means for modulating said carrier with said video-frequency wave and said composite synchronizing signal, means for receiving and utilizing said carrier comprising amplitude-limiting means for separating said synchronizing impulses from said composite signal, and means for deriving from the leading edges of one type of synchronizing impulses characteristic synchronizing pulses and for deriving from the trailing edges of the other type of synchronizing impulses different characteristic synchronizing pulses.

8. A television synchronizing system, comprising means for developing synchronizing impulses of a first predetermined frequency and having leading edges of steeper slope than their trailing edges, means for developing synchronizing impulses of a second predetermined frequency and having trailing edges of steeper slope than their leading edges, one of said predetermined frequencies being a fractional multiple of the other, and means for combining said synchronizing impulses of both of said frequencies to develop a composite synchronizing signal.

ALDA V. BEDFORD.